ROSE-HULMAN INSTITUTE OF TECHNOLOGY

2017-2018

Course Catalog

Rose-Hulman Institute of Technology Course Catalog

Programs of Study:

- Biochemistry
- Biochemistry & Molecular Biology (SMO)
- Biology
- Biomathematics
- Biomedical Engineering
- Chemical Engineering
- Chemistry
- Civil Engineering
- Computational Science Major (SMO)
- Computer Engineering
- Computer Science
- Economics
- Electrical Engineering
- Engineering Physics
- International Computer Science
- International Studies Major (SMO)
- Mathematics
- Mechanical Engineering
- Optical Engineering
- Physics
- Software Engineering
- ROTC: Air Force
- ROTC: Army
- Pre-Professional Programs
- Special Programs

*(SMO) = Second Major Only

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Minors:

- Anthropology
- Art
- Astronomy
- Biochemical Engineering
- Biochemistry and Molecular Biology
- Biomedical Engineering
- Chemical Engineering
- Chemistry
- Cognitive Science
- Data Science
- East Asian Studies
- Economics
- Electrical and Computer Engineering
- Electrical Engineering
- Entrepreneurial Studies
- Environmental Chemistry
- Environmental Engineering
- European Studies
- Geography
- History
- Imaging
- Language and Literature
- Latin American Studies
- Mathematics
- Medical Physics and Nanomedicine
- Modern Languages
    - German
    - Japanese
    - Spanish
- Music
- Optical Engineering
- Philosophy
- Physics
- Political Science
- Psychology
- Robotics
- Software Engineering
- Solid State Physics / Material Science
- Statistics
- Sustainability
- Theater
- Thermal Fluids

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Biochemistry

Graduates with a degree in biochemistry will be well prepared for employment, graduate study in biochemistry or other chemistry-related fields, or professional school. Biochemists are employed in research, quality control, design, sales and management. Many graduates pursue masters and doctoral degrees in biochemistry, medicinal chemistry, and in other life science fields. A biochemistry degree is excellent preparation for medical school and related fields, and also for careers in business, law or education.

The curriculum at Rose-Hulman Institute of Technology provides a rigorous introduction to all subdisciplines of chemistry along with biochemistry and applied biology. Students have access to modern instrumentation along with a well-equipped biochemistry lab. Rose-Hulman students are introduced to modern computational methods beginning in the sophomore year. There are many opportunities for research or other individual projects, and students are encouraged to present their results at regional and national chemistry conferences. Close interaction with engineering departments provides students with a point of view not available at most other undergraduate institutions.

List of Required Chemistry Courses

Course	**Numbers**	**Credits**
General Chemistry	111, 113, 115	12
Organic Chemistry	251, 252, 253	12
Analytical Chemistry	225, 326, 327	12
Physical Chemistry	361, 362, 363	12
Inorganic Chemistry	441	4
Biochemistry	330, 331, 430, 433	13
Research	291, 391, 395, 490, 491, 496, 497	8
Career Preparation	200	1
Electives		8
Total		**86**

Summary of minimum graduation requirements:

Course or areas	**Required**	**Elective**	**Total**
Chemistry	78	8	86

Physics	12	0	12
Mathematics	23	0	23
Biology	20	0	20
Humanities and Social Sciences	4	32	36
Electives	0	16	16
College and Life Skills	1	0	1
Total	**136**	**56**	**194**

Environmental Chemistry Minor for Most Students

Course Number	Course Title	Credits
CHEM111	General Chemistry I	4
CHEM113	General Chemistry II	4
CHEM115	General Chemistry III	4
CHEM225	Analytical Chemistry	4
CHEM251	Organic Chemistry I	4
CHEM264	Introduction to Environmental Science	4
CHEM371	Environmental Analytical Chemistry	4
CHE465	Energy and the Environment	4
Total		**32**

Environmental Chemistry Minor for Chemical Engineers and Applied Biology Majors Environmental Certificate for Chemistry and Biochemistry Majors

Course Number	Course Title	Credits
CHEM225	Analytical Chemistry	
or CHEM253	Organic Chemistry III	4
CHEM330	Biochemistry I	

or CHEM361	Physical Chemistry I	4
CHEM303	Chemical Engineering Thermodynamics	4
CHEM264	Introduction to Environmental Science	4
CHEM371	Environmental Analytical Chemistry	4
Total		**20**

Plan of Study

Freshman

Fall

Course	Credit
CHEM 111* General Chemistry I	4
MA 111 Calculus I	5
BIO 110 Cell Structure & Function	4
CLSK 100 College & Life Skills	1
RH 131 Rhetoric and Composition or HSS Elective	4
	Total Credits: 18

Winter

Course	Credit
CHEM 113* General Chemistry II	4
MA 112 Calculus II	5
PH 111 Physics I	4
RH 131 Rhetoric & Composition or HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CHEM 115 General Chemistry III	4
MA 113 Calculus III	5
PH 112 Physics II	4
HSS Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CHEM 251 Organic Chemistry I	3
CHEM 251L Organic Chemistry I Lab	1
PH 113 Physics III	4
MA 212 Matrix Algebra and Systems of Differential Equations	4
BIO 210 Mendelian & Molecular Genetics	4
	Total Credits: 16

Winter

Course	Credit
CHEM 200 Career Preparation	1
CHEM 252 Organic Chemistry II	3
CHEM 252L Organic Chemistry II Lab	1
CHEM 291 Intro to Undergradute Research	4
MA 381 Introduction to Probability with Applications to Statistics	4
BIO 220 Prokaryotic Cell & Molecular Biology	4
	Total Credits: 17

Spring

Course	Credit
CHEM 253 Organic Chemistry III	3
CHEM 253L Organic Chemistry III Lab	1
CHEM 225 Analytical Chemistry	4
BIO 230 Eukaryotic Cell & Mol. Biology	4
RH 330 Technical Communication (or HSS)	4
	Total Credits: 16

Junior

Fall

Course	Credit
CHEM 326 Bioanalytical Chemistry	4
CHEM 330 Biochemistry I	4

CHEM 361 **Physical Chemistry I	4
CHEM 391 Research Proposal (F, W or S)	1
CHEM 395 Chemistry Seminar	0
CHEM 490 Research	1
HSS Elective (or RH330)	4
	Total Credits: 18

Winter

Course	Credit
CHEM 327 Advanced Analytical	4
CHEM 362 **Physical Chemistry II	4
CHEM 331 Biochemistry II	4
CHEM 391 Research Proposal (F, W or S)	1
CHEM 490 Research	1
HSS Elective	4
	Total Credits: 18

Spring

Course	Credit
CHEM 363 Quantum Chemistry & Molecular Spectroscopy	4
CHEM 391 Research Proposal (F, W or S)	1
CHEM 430 Advanced Biochemistry	4
CHEM 433 Biochemistry Lab	1
HSS Elective	4
CHEM 490 Research	1
	Total Credits: 15

Senior

Fall

Course	Credit
CHEM 441 Inorganic Chemistry I	4
CHEM 495 Chemistry Seminar	0
CHEM 490 Chemistry Research	1
CHEM 491 Research Thesis (F, W or S)	4
##Advanced Chemistry or Biochemistry Elective	4

Advanced Biology Elective	4
Free Elective	4
	Total Credits: 21

Winter

Course	Credit
CHEM 496 Chemistry Seminar	0
CHEM 491 Research Thesis (F, W or S)	1
CHEM 497 Research Presentation (F, W or S)	1
HSS Elective	4
##Advanced Biology, Chemistry, Biochemistry Elective	4
Free Elective	4
	Total Credits: 14

Spring

Course	Credit
CHEM 491 Research Thesis (F, W or S)	1
CHEM 497 Research Presentation (F, W or S)	1
HSS Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 14

NOTES

Two degree or double major programs in biochemistry and either chemistry or biochemistry and molecular biology is not allowed.

*Subject to approval, CHEM 112 may be substituted for CHEM 111 and CHEM 113.

**CHE 303, CHE 304 and CHEM 360 may be substituted for CHEM 361 and CHEM 362.

^Students must complete at least 3 credits of CHEM 490 prior to the Spring quarter of their senior year.
Students may count up to 8 credits of research toward their electives, of which no more than 2 credits can come from CHEM 290.

^^Research and independent study do not meet this requirement.

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Biology

The twenty-first century will see unparalleled advances in the biological sciences. Disciplines such as biology and biomedical engineering are burgeoning and will greatly impact the way we live in the future. The areas of functional genomics and proteomics will drive discoveries in molecular medicine, gene therapy and tissue engineering. Drug discovery will be facilitated by the elucidation of new target molecules and many pharmaceutical compounds will be produced using biological processes. Environmental management, remediation and restoration will also benefit from advances in biology. Biologists will be at the forefront of these advances and will drive the medical, agricultural, environmental and industrial applications of biological sciences.

The biology program will produce biologists with the chemistry, mathematics, and physics background needed to solve biotechnological problems in the coming decades. Those students wishing to strengthen their engineering skills can earn the area minor in biomedical engineering. Other students may choose to pursue a second major in Biochemistry and Molecular Biology. The program will prepare graduates for professional careers in government and industrial research laboratories, and in the biotechnology and health-related industries.

Those wishing to continue their studies in graduate or health professions programs will be exceptionally well qualified to do so.

A BIO science/technical elective is any Rose-Hulman course that has a prefix of BE, BIO, BMTH, CE, CHE, CHEM, CSSE, ECE, GEOL, MA, ME, PH, OE, EP, ES, EM or any EMGT course that is not cross-listed with an RH, GS, IA or SV course. Courses that do not count as science or technical electives are those courses with AS, MS, RH, GS, IA, SV, GE, JP, SP, FL, GRAD and CLSK prefixes.

SUMMARY

Required BIO courses	52 credits
BIO electives	12 credits
Free electives	8 credits
HSS electives	24 credits
Required HSS	12 credits
Required MA, CHEM, PH	63 credits
Required CLSK	1 credit
Sci/Tech electives	16 credits
Total	**188 credits**

Biochemistry & Molecular Biology (Second Major Only)

The biochemistry & molecular biology program exists to give students an opportunity to augment their education in this technologically-important field. To support this effort, Rose-Hulman provides students with access to a modern and well-equipped biochemistry lab, along with an excellent biological sciences facility.

Biochemistry & molecular biology is available to Rose-Hulman students as a second major. This means that the student will receive a first degree in some other discipline and then can augment their education with this program. Students whose first degree programs are in chemistry or chemical engineering will find the program easiest since there is considerable overlap between those programs and the biochemistry & molecular biology requirements. Students from other disciplines are also encouraged to participate, but will have to take more courses. All students are encouraged to take individual courses in the program, regardless of whether or not they wish to fulfill the second major requirements, or to participate in related research projects under faculty supervision.

Two degree or double major programs in Biochemistry & Molecular Biology and Biochemistry are not allowed.

Required Courses

Course	**Description**	**Hours**
CHEM 111, 113, 115	General Chemistry	12
CHEM 251, 252, 253	Organic Chemistry	9
CHEM 251L, 252L, 253L	Organic Chemistry Lab	3
CHEM 330, 430, 433	Biochemistry	9
CHEM 361, 362 or CHEM 360 and		
CHE 303, 304	Physical Chemistry	8
BIO 110, 120, 130	Biology	12
BIO 210	Genetics	4
BIO 220, 230	Molecular Biology	8
BIO 411	Genetic Engineering	4
Total		**69**

Elective Courses

Choose 12 credits* from the following courses:

Course	**Description**
BIO 330	Evolutionary Biology
BIO 421	Microbiology
BIO 431	Genomics and Proteomics
BIO 441	Virology
BIO 451	Cancer Biology
BIO 492	Directed Study in Biology
CHEM 225	Analytical Chemistry
CHEM 291	Introduction to Research
CHEM 331	Biochemistry II
CHEM 431	Biochemical Instrumentation
CHEM 451	Organic Structure Determination
CHEM 290	

or	
CHEM 490	Chemical Research
PH 302	Biophysics

Total Credits for Second Major 81

*****Students with a major in chemistry need to take 8 credits of electives, with 4 credits from the BIO electives listed, and 4 credits chosen from any BIO or BE course.*

STUDENTS WITH A MAJOR IN BIOLOGY must take 12 credits of electives, with 8 credits from the elective courses listed above with a CHEM prefix, and 4 credits from any 300 level or above BIO course (total: 29 hours required beyond Biology major).

Biology Minor

Biology is an exciting subject that has applications relevant to all other fields of study at the Institute. Students who are interested in enriching their major area of study with a knowledge of life sciences can do so with the Biology Minor. With proper course selection, the Minor will provide another marketable dimension to any Bachelor of Science degree granted by the Institute.

The Minor in Biology has the following requirements.

1. All students must complete BIO110 (Cell Structure and Function) or BIO130 (Evolution and Diversity) and four more courses in biology (BIO) or allied areas, above those courses already specifically required to fulfill the student's major, subject to the following requirements:
   a. At least three of the four electives must be BIO courses.
   b. At least three of the electives must be 200-level or above.
2. Students electing to pursue the minor in Biology must follow a plan of study that is approved by the Minor Advisor. Current advisor information and a form for the planning and approval of a minor can be obtained from the BBE Department Secretary.
3. Allied area courses could include:

BE310	Analysis of Physiological Systems I	IA236	Communicating STEM to a Public Audience
BE320	Analysis of Physiological Systems II	IA239	Rhetoric of Science
BE570	Intro to Tissue Engineering	IA401	Philosophy of Science
BMTH310	Mathematical Biology	IA471	Computational Psychology
BMTH311	Systems Biology	MA482/BE482	Bioengineering Statistics
BMTH312	Bioinformatics	ME447	Visualizing Data
BMTH413	Computational Biology	PH302	Biophysics

CE460	Intro to Environmental Engineering	SV304	Bioethics
CHE545	Intro to Biochemical Engineering	SV371	Social Psychology
CHEM264	Intro to Environmental Science	SV373	Abnormal Psychology
CHEM330	Biochemistry	SV472	Studying Human Behavior
CHEM430	Advanced Biochemistry	SV386	Human Evolution

Additional courses not listed here can be considered on a case-by-case basis.

Biochemistry & Molecular Biology Minor

Completion of BIO110, CHEM111, CHEM113 and CHEM115. In addition, the student must complete five courses from the following list that are not already named required courses by the student's major or minor programs:

Course	Description
BIO 210	Mendelian and Molecular Genetics
BIO 220 or	Prokaryotic Cell and Molecular Biology
BIO 230	Eukaryotic Cell and Molecular Biology
BIO 411 or	Genetic Engineering
BIO 431	Genomics and Proteomics
CHEM 230 or	Introduction to Organic Chemistry and Biochemistry
CHEM 251 and	Organic Chemistry I
CHEM 252	Organic Chemistry II
CHEM 330	Biochemistry
CHEM 430 with	Advanced Biochemistry
CHEM 433	Biochemistry Laboratory

Biology is an exciting subject that has applications relevant to all other fields of study at the Institute. Students who are interested in enriching their major area of study with a knowledge of life sciences can do so with the Biology Minor. With proper course selection, the Minor will provide another marketable dimension to any Bachelor of Science degree granted by the Institute.

Plan of Study

Freshman

Fall

Course	Credit
BIO 130 Evolution and Diversity	4
CHEM 111 General Chemistry	4
MA 111 Calculus I	5
CLSK College & Life Skills	1
	Total Credits: 14

Winter

Course	Credit
BIO 110 Cell Structure & Function	4
CHEM 113 General Chemistry II	4
MA 112 Calculus II	5
RH 131 Rhetoric & Composition	4
	Total Credits: 17

Spring

Course	Credit
BIO 120 Comparative Anatomy & Physiology	4
CHEM 115 General Chemistry III	4
MA 113 Calculus III	5
HSS Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
BIO 210 Genetics	4
CHEM 251 Organic Chemistry I	3
CHEM 251L Organic Chemistry I Laboratory	1
PH 111 Physics I	4

MA 212 Matrix Algebra and Systems of Differential Equations	4
	Total Credits: 16

Winter

Course	Credit
BIO 220 Microbiology	4
CHEM 252 Organic Chemistry II	3
CHEM 252L Organic Chemistry II Lab	1
PH 112 Physics II	4
RH 330 Technical and Professional Communication	4
	Total Credits: 16

Spring

Course	Credit
BIO 230 Cell Biology	4
CHEM 253 Organic Chemistry III	3
CHEM 253L Organic Chemistry III Lab	1
PH 113 Physics III	4
MA 223 Engineering Statistics	4
	Total Credits: 16

Junior

Fall

Course	Credit
BIO 320 Ecology	4
CHEM 330 Biochemistry	4
HSS Elective	4
BIO 399 Practice of Science	4
	Total Credits: 16

Winter

Course	Credit
BIO 330 Evolutionary Biology	4
BIO 496 Senior Thesis Research I	2
BIO Elective	4
HSS Elective	4
	Total Credits: 14

Spring

Course	Credit
BIO 310 Plant Structure & Function	4
BIO 497 Senior Thesis Research II	4
SV 304 Bioethics	4
HSS Elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
BIO 498 Senior Thesis Research III	4
Science/Technical Elective	4
Science/Technical Elective	4
Free Elective	4
	Total Credits: 16

Winter

Course	Credit
BIO 499 Senior Thesis Research IV	2
Science/Technical Elective	4
BIO Elective	4
HSS Elective	4
	Total Credits: 14

Spring

Course	Credit
BIO Elective	4
Science/Technical Elective	4
HSS Elective	4
Free Elective	4
	Total Credits: 16

NOTES

A BIO science/technical elective is any Rose-Hulman course that has a prefix of BE, BIO, BMTH, CE, CHE, CHEM, CSSE, ECE, GEOL, MA, ME, PH, OE, EP, ES, EM or any EMGT course that is not cross-listed with an RH, GS, IA or SV course. Two of the four science/technical electives must be 300-level or above, to allow BIO students to specialize in a supporting topic. Courses that do not count as science or technical electives are those courses with AS, MS, RH, GS, IA, SV, GE, JP, SP, FL, GRAD and CLSK prefixes.

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Biomathematics

MISSION STATEMENT

An increasing number of problems in the biological sciences are being solved using sophisticated mathematical and computational tools. The biomathematics degree blends mathematics, biology, and computer science in preparation for continued graduate studies and for careers in the quantitative life sciences. The degree's mission is to provide a world class undergraduate education in applied mathematics used in support of the life sciences.

The degree's mission is supported and motivated by these facts:

- Biological data is being generated with unprecedented precision and in unfathomable volumes.
- Quantifying biological observations requires mathematical and statistical analysis.
- The basic principles of complex biological systems support mathematical and computational modeling, which can lead to testable hypotheses and new discoveries.

PROGRAM GOALS AND OBJECTIVES

The biomathematics degree will provide a broad based undergraduate experience that 1) prepares students with a rigorous education in applied mathematics, 2) educates students in the fundamental principles of biology, 3) trains students to work in a computational arena, 4) introduces students to several of the sister disciplines of computational biology, mathematical biology, bioinformatics, systems biology, and biostatistics, and 5) guides students through an advanced undergraduate research project. The degree will also liberally educate students through the study of the humanities and social sciences. Students of the program will be encouraged to participate in external and internal research programs and industrial internships and/or co-ops.

PROGRAM OUTCOMES

Graduates will be prepared for graduate study in any of the sister fields as well as for careers in the quantitative life sciences. Each graduate will complete a capstone research experience that will culminate in a written report and a public presentation.

***Requirements: 3 Free Electives 12 hours, 3 MA Electives 12 hours, 5 Tech Electives 20 hours, 1 Domain Elective 4 hours**

SUMMARY OF GRADUATION REQUIREMENTS

HSS		36 hours
CLSK	CLSK 100	1 hour
Math Core	MA 111, 112, 113, 200, 211, 212, 332, 371 or 373, 381, and 223 or 382	40 hours
Biomath Core	Four BMTH courses numbered 300 or above	16 hours
Basic Science	BIO 110, 130, 120 or 210, 220, and 230	40 hours

	CHEM 111, 113 PH 111, 112 one of CHEM 251 or PH 113	
Computer Science	CSSE 120	4 hours
Capstone Experience	BMTH 496, 497, 498	8 hours
Domain Elective	Any of the following, with no course substitutions permitted. BIO 330 Evolutionary Biology 4R-0L-4C W Prereq. BIO 130 CHEM 330 Biochemistry I 4R-0L-4C W Prereq. CHEM 252 CSSE 304 Programming Language Concepts 4R-0L-4C W Prereq. CSSE 230 and MA 275 MA 366 Functions of a Real Variable 4R-0L-4C W Prereq. MA 275 and MA 113	4 hours
Math Electives	Any mathematics course numbered 300 or above, or MA 275	12 Hours
Technical Electives	Courses numbered 200 or above in the physical sciences, life sciences, computer science, or engineering. Coursework in mathematics and biomathematics is not allowed.	20 Hours
Free Electives		12 Hours
Total		**193 hours**

FOCUS AREAS

Students earning a major in Biomathematics are encouraged to gain depth in a particular mathematical or scientific area. By pursuing focused coursework in the following suggested areas, students will advance their preparation for graduate studies or careers in mathematical life sciences. Gaining depth through advanced electives also provides biomathematics students with an opportunity to apply knowledge gained through BMTH coursework. The following focus areas are illustrative examples to consider.

Applied Mathematics

BE 350 Biocontrol Systems

MA 275/375 Discrete and Combinatorial Algebra I/II
MA 332 Intro. to Computational Science [required for major]
MA 330 Vector Calculus
MA 342 Computational Modelings
MA 366 Real Analysis
MA 367 Functions of a Complex Variable
MA 436 Introduction to Partial Differential Equations
MA 472 Graph Theory
MA 491 Introduction to Mathematical Modeling

Biochemistry

BMTH 312 Bioinformatics
BMTH 310 Mathematical Biology
CHEM 251/252/253 Organic Chemistry I/II/III
CHEM 326 Bioanalytical Chemistry
CHEM 330/331 Biochemistry I/II
CHEM 430 Advanced Biochemistry

Bioinformatics & Biostatistics

BMTH 312 Bioinformatics
MA 381 Intro. to Probability with Statistics [required for major]
MA 382 Intro. to Statistics with Probability
MA 382 Engineering Statistics II
MA 386 Statistical Programming
MA 482 Bioengineering Statistics

Biomechanics

BE 361 Biomaterials
BE 525 Biomedical Fluid Mechanics
BE 534 Soft Tissue Mechanics
BE 539 Multiscale Biomechanics
BE 545 Orthopedic Biomechanics

Biophysics

PH 302 Biophysics
BE 525 Biomedical Fluid Mechanics

Cellular and Molecular Biology

BIO 220/230 Prokaryotic/Eukaryotic Cell and Molecular Biology [required for major]
BIO 205 Cellular Physiology
BIO 411 Genetic Engineering
BIO 421 Applied Microbiology
BIO 431 Genomics and Proteomics
BMTH 310 Mathematical Biology
CHEM 455 Natural Products [offered irregularly]

Computational Biology

BMTH 310 Mathematical Biology
BMTH 413 Computational Biology
CSSE 220 Object Oriented Software Development
CSSE 333 Database Systems
CSSE 403 Programming Language Paradigms

CSSE 431 Artificial Intelligence
MA/CS 335 Introduction to Parallel Computing
MA 342 Computational Modeling
MA 433 Numerical Analysis
MA 435 Finite Difference Methods
MA/CS 473 Design and Analysis of Algorithms

Ecology

BIO 130 Evolution and Diversity
BIO 264 Introduction to Environmental Science
BIO 320 Ecology
BMTH 310 Mathematical Biology
CHEM 371 Environmental Analytical Chemistry

Epidemiology & Pathology

BE 310/320 Analysis of Physiological Systems I/II
BIO 410 Infection and Immunity
BIO 441 Virology
BIO 451 Cancer Biology
BIO 461 Evolutionary Medicine
BIO 471 Genetic and Molecular Analysis of Inherited Human Disease
BMTH 310 Mathematical Biology

Evolution

BIO 130 Evolution and Diversity
BIO 330 Evolutionary Biology
BIO 461 Evolutionary Medicine
SV 386 Human Evolution

Imaging and Optics

BE 435 Biomedical Optics
ECE 480 Introduction to Image Processing
BE 541 Medical Imaging Systems
MA 429 Mathematical Methods of Image Processing
PH 302 Biophysics

Medicine

BIO 120 Comparative Anatomy and Physiology
BIO 410 Infection and Immunity
BIO 441 Virology
BIO 451 Cancer Biology
BIO 461 Evolutionary Medicine
BIO 471 Genetic and Molecular Analysis of Inherited Human Disease
BE 541 Medical Imaging Systems
CHEM 251/252/253 Organic Chemistry I/II/III
CHEM 330/331 Biochemistry I/II
CHEM 420 Advanced Biochemistry

Physiology

BIO 120 Comparative Anatomy and Physiology
BIO 205 Cellular Physiology
BE 310/320 Analysis of Physiological Systems I & II
BE 520 Introduction to Brain Machine Interfaces

SECOND MAJOR IN BIOMATHEMATICS

The second major in biomathematics is open to all majors with the following requirements and restrictions. Eligibility and limitations

- The MA/BMTH double major must be seperated by at least 24 hours.

REQUIREMENTS (72 HOURS)

Math Core	MA 211. 332, 371 or 373, 381, and 223 or 382	20 hours
Biomath Core	any four BMTH courses numbered 300 or above	16 hours
Math Electives		12 hours
Biology	BIO 110 and three courses from different categories described below BIO 130 BIO 120 or 210 BIO 205 or 230 BIO 220	16 hours
Senior Capstone Experience	BMTH 496, 497, 498	8 hours

MINOR IN BIOMATHEMATICS

Any student not pursuing a major or second major in biomathematics may obtain a minor in biomathematics by taking the following courses:

REQUIREMENTS (47 HOURS)

Math Core	MA 111, 112, 113, 211, 212, and 223 or 382	27 hours
Biomath Core	any three BMTH courses numbered 300 or above	12 hours
Biology	BIO 110 and one of BIO 205, 210, 220, 230	8 hours

Approval and Biomathematics Minor Form

All minors must be approved by the biomathematics minor advisor and the student's advisor. The department has a form for the planning and approval of a biomathematics minor.

Notes and Limitations on Requirements:

- Almost all students are required to take six foundational courses as a requirement for their major; therefore only five "extra courses" are required for most students.

- Only MA 111, MA 112, MA 113, MA 211, MA 212 and one of MA 223, MA 381, or MA 382 can be counted towards any combination of the multiple minors offered by the mathematics department.
- Biomathematics courses cannot be used to count toward both Free Mathematics Electives for a mathematics major and also towards a Biomathematics minor.

Plan of Study

Freshman

Fall

Course	Credit
BIO 130 Evolution and Diversity	4
CHEM 111 General Chemistry	4
MA 111 Calculus I	5
RH 131 Rhetoric and Composition	4
CLSK 100 College and Life Skills	1
	Total Credits: 18

Winter

Course	Credit
PH 111 Physics I	4
CHEM 113 General Chemistry II	4
MA 112 Calculus II	5
BIO 110 Cell Structure and Function	4
	Total Credits: 17

Spring

Course	Credit
CSSE 120 Intro to Software Development	4
PH 112 Physics II	4
MA 113 Calculus III	5
HSS	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
BIO 210 Mendelian & Molecular Genetics	4

MA 211 Differential Equations	4
HSS	4
PH 113 or CHEM 251 Add'l Science	4
	Total Credits: 16

Winter

Course	Credit
BIO 220 Microbiology	4
MA 212 Matrix Algebra & Systems of D.E.	4
MA 381 Intro. to Probability	4
HSS	4
MA 200 Career Preparation	1
	Total Credits: 17

Spring

Course	Credit
BIO 230 Cell Biology	4
MA 371 Linear Algebra	4
HSS	4
Elective*	4
	Total Credits: 16

Junior

Fall

Course	Credit
BMTH 310 Mathematical Biology	4
MA 382 Intro. to Statistics w/Prob	4
HSS	4
Elective*	4
	Total Credits: 16

Winter

Course	Credit
BMTH 311 Systems Biology	4
MA 332 Intro to Computational Sci.	4
RH 330 Technical & Profess. Comm.	4
Elective*	4
	Total Credits: 16

Spring

Course	Credit
BMTH 312 Bioinformatics	4
HSS	4
Elective*	4
Elective*	4
	Total Credits: 16

Senior

Fall

Course	Credit
BMTH 496 Capstone Experience I	2
HSS	4
Elective*	4
Elective*	4
	Total Credits: 14

Winter

Course	Credit
BMTH 497 Capstone Experience II	4
Elective*	4
Elective*	4
Elective*	4
	Total Credits: 16

Spring

Course	Credit
BMTH 413 Computational Biology	4
BMTH 498 Capstone Experience III	2
Elective*	4
Elective*	4
	Total Credits: 14

NOTES

*Requirements:

3 Free Electives	12 hours
3 MA Electives	12 hours
5 Tech Electives	20 hours
1 Domain Elective	4 hours

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Biomedical Engineering

Biomedical engineers use science, engineering, and mathematics to understand and solve medical problems. We focus on improving people's quality of life. Biomedical engineers who specialize in biomechanics design and analyze biological systems or medical devices that have to do with forces, stresses, and strains. This includes studying the motions of bodies or joints, fluid flow, the deformation of tissues or materials, and the transport of molecules and chemicals through tissues and across membranes.

Biomedical engineers who specialize in bioinstrumentation use electronics and signal analysis to take measurements from and deliver stimuli to living cells and tissues. Examples include cochlear implants, pacemakers, and patient monitoring equipment. Biomedical engineers who specialize in biomaterials design and study materials to replace, repair, and interact with cells and tissues in the body. Examples include metal, ceramic, polymer, or tissue-engineered implants; these implants can be permanent or biodegradable. The United States Bureau of Labor Statistics has projected that jobs for biomedical engineers will increase by 23% between the years 2014 and 2024.

The biomedical engineering program at Rose-Hulman produces engineers with the medical and biological expertise needed to solve health care problems during careers in technical and health-related industries, as well as in government or industrial laboratories. Alumni wishing to continue their studies in graduate/professional school or health professions programs will be well-qualified to do so.

Biomedical Engineering Program Educational Objectives

Objectives are defined as "expected accomplishments of graduates during the first several years following graduation from the program."

- Graduates will apply the theories and concepts of biology, mathematics, physical science and engineering science essential to being a successful biomedical engineer.
- Graduates will apply practical and technical skills required for biomedical engineering practice.
- Graduates will work and communicate effectively with all of the people around them.
- Graduates will exercise their professional responsibilities towards society.
- Graduates will apply design principles to open-ended problems subject to technical, practical and societal constraints.

Biomedical Engineering Student Outcomes

By the time students graduate with an undergraduate Biomedical Engineering degree from Rose-Hulman, they will have:

1. An ability to apply knowledge of mathematics, science, and engineering.
2. An ability to design and conduct experiments, as well as to analyze and interpret data.

3. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. An ability to function on multidisciplinary teams.
5. An ability to identify, formulate, and solve engineering problems.
6. An understanding of professional and ethical responsibility.
7. An ability to communicate effectively.
8. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. A recognition of the need for, and an ability to engage in life-long learning.
10. A knowledge of contemporary issues.
11. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The biomedical engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

Biomedical Engineering Areas of Concentration

To receive the B.S. Degree Program in Biomedical Engineering, each student must satisfy the requirements of one of three Biomedical Engineering Areas of Concentration: Biomaterials, Biomechanics or Biomedical Instrumentation. The course options for each of these Areas are given below. A total of 16 credits (including required courses) from one of the lists must be taken.

It is not permissible to "mix and match" courses from different area lists without written permission from the BBE department head.

Biomedical courses that are offered as special topics courses (e.g. BE491 or BE597) may be used with the written permission of the department head. Students should work out their schedule in advance to ensure that all graduation requirements are met.

BIOMATERIALS CONCENTRATION

Course	Title
BE 516	Introduction to MEMS
BE 539	Multiscale Biomechanics
BE 560	Tissue-Biomaterial Interactions
BE 570	Introduction to Tissue Engineering
CHE 315*	Materials Science and Engineering
CHE 441	Polymer Engineering
ME 317	Design for Manufacturing
ME 328*	Materials Engineering

*CHE 315 OR ME 328 may be used, but not both

BIOMEDICAL INSTRUMENTATION CONCENTRATION

Course	Title

BE 340	Biomedical Instrumentation and Signal Processing
BE 350	Biocontrols
BE 435/535	Biomedical Optics
BE 516	Introduction to MEMS
BE 520	Introduction to Brain-Machine Interfaces
BE 541	Medical Imaging
BE 543	Neuroprosthetics
BE 555	Electrophysiology
ECE 230	Introduction to Embedded Systems
ECE 480	Introduction to Image Processing
ME 430	Mechatronic Systems

BIOMECHANICS CONCENTRATION

Course	Title
ME 317	Design for Manufacturing
BE 525	Biomedical Fluid Mechanics
BE 531	Biomechanics II
BE 534	Soft Tissue Mechanics
BE 539	Multiscale Biomechanics
BE 545	Orthopaedic Biomechanics
BE 550	Research Methods in Biomechanics
EM 403	Advanced Mechanics of Materials
ME 422	Finite Elements for Engineering Applications
ME 520	Computer-Aided Design and Manufacturing
ME 522	Advanced Finite Element Analysis

Biomedical Engineering Thesis Option:

The biomedical engineering thesis option is intended for students who complete a substantive research project in this field. In order to complete this thesis option a student must:

1. Pass a minimum of 8 credit hours of BE 492.

2. Perform research in BE492 that involves the same research project and is completed under the direction of a departmental faculty mentor. None of these credits may be used to fulfill the biomedical engineering area elective requirement.
3. Complete the course, BE 499 Thesis Research, in which the thesis is written and submitted to the department, and an oral research presentation is given to a minimum of three departmental faculty members, including the student's advisor. Successful completion of the biomedical engineering thesis will be noted on the student's transcript.

Biomedical Engineering Minor

The biomedical engineering minor is intended to provide a biomedical engineering background to undergraduate students who are interested in pursuing careers in the biomedical industry and healthcare related fields.

In order to complete the requirements of the biomedical engineering minor, a student must complete either BIO 110-Cell Structure & Function or BIO 120-Comparative Anatomy & Physiology AND complete four courses from the list shown below. Other BE courses may be substituted with approval by the BBE Department Head. At least three of the courses must have a BE prefix.

BIO411	Genetic Engineering
BE310	Analysis of Physiological Systems I
BE320	Analysis of Physiological Systems II
BE331 and BE352	Biomechanics and Biomechanics Lab
BE340 *	Biomedical Signal Processing *
BE350 **	Biocontrol Systems **
BE361 and BE353	Biomaterials and Biomaterials Lab
BE435/535	Biomedical Optics
BE/MA482	Bioengineering Statistics
BE520	Introduction to Brain Machine Interfaces
BE525	Biomedical Fluid Mechanics
BE531	Biomechanics II
BE534	Soft Tissue Mechanics
BE539	Multiscale Biomechanics
BE543	Neuroprosthetics
BE545	Orthopaedic Biomechanics
BE560	Tissue-Biomaterial Interactions
BE570	Introduction to Tissue Engineering

* BE340 cannot be used for a BE minor by students majoring in electrical or computer engineering.
** BE350 cannot be used for a BE minor by students who have taken ECE320 or ME406.

In addition to courses in the above area concentration, students are required to have completed at least 12 credits of basic engineering courses. These courses may be chosen from the list below:

BE201	Biomedical Instrumentation and Measurements

EM121	Statics & Mechanics of Materials I
EM204	Statics & Mechanics of Materials II
EM301	Fluid Mechanics
ECE180	Introduction to Signal Processing
ECE203 *	DC Circuits
ECE204	AC Circuits
ES201	Conservation & Accounting Principles
ES202	Fluid Systems
ES203 *	Electrical Systems
ES204	Mechanical Systems
CHE201	Conservation Principles and Balances
CHE202	Basic Chemical Process Calculations
CHE301	Fluid Mechanics

* Students may use either ECE203 or ES203 for a BE minor, but not both of these courses.

Successful completion of an area minor is indicated on the student's transcript. A student interested in pursuing an area minor in biomedical engineering should consult with the head of the Department of Biology and Biomedical Engineering.

Plan of Study

Freshman

Fall

Course	Credit
ENGD 100 Engineering Design Studio I	8
PH 111 Physics I	4
MA 101 Introduction to Engineering Mathematics I	4
CLSK 100 College & Life Skills	1
	Total Credits: 17

Winter

Course	Credit
ENGD 110 Engineering Design Studio II	6
PH 112 Physics II	4
MA 102 Introduction to Engineering Mathematics II	4
ENGD 200 Systems Accounting and Modeling I	2
	Total Credits: 16

Spring

Course	Credit
BIO 120 Anatomy and Physiology	4
ENGD 120 Engineering Design Studio III	6
MA 103 Applied Multivariate Calculus	4
ENGD 210 Systems Accounting and Modeling II	4
	Total Credits: 18

Sophomore

Fall

Course	Credit
MA 201 Applied Dynamical Systems I	4
CHEM 111 General Chemistry I	4
BIO 130 Ecology & Evolution	4
BE 202 Circuits, Sensors and Measurements	4
	Total Credits: 16

Winter

Course	Credit
ES 202 Fluid & Thermal Systems	3
ES 204 Mechanical Systems	3
MA 202 Applied Dynamical Systems II	4
CHEM 113 General Chemistry II	4
BIO 110 Cell & Molecular Biology	4
	Total Credits: 18

Spring

Course	Credit
PH 113 Physics III	4
ES 205 Analysis & Design of Engineering Systems	4
MA 223 Engineering Statistics	4
HSS Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
HSS Elective	4
BIO 205 Cellular Physiology	4
RH330 Tech & Profess'l Comm or HSS Elective	4
EM 204 Statics & Mechanics of Materials II	4
	Total Credits: 16

Winter

Course	Credit
BE 310 Physiological Systems I	4
BE 331 Biomechanics	3
BE 351 Biomedical Engineering Lab	2
BE 361 Biomaterials	3
RH330 Tech & Profess'l Comm or HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
SV 304 Bioethics	4
BE 320 Physiological Systems II	4
BE 390 Principles of Biomedical Engineering Design	2
BE Area	4
	Total Credits: 14

Senior

Fall

Course	Credit
BE 410 Biomedical Engineering Design I	4
BE Area Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 16

Winter

Course	Credit
BE 420 Biomedical Engineering Design II	4
HSS Elective	4
Free Elective	4
BE Area Elective	4
	Total Credits: 16

Spring

Course	Credit
BE 430 Biomedical Engineering Design III	2
HSS Elective	4
Free Elective	4
BE Area Elective	4
	Total Credits: 14

Rose-Hulman Institute of Technology Course Catalog

Chemical Engineering

As has been done since we awarded the nation's first degree in chemical engineering in 1889, the undergraduate program in chemical engineering undertakes to prepare individuals for careers in the chemical process industries. These include all industries in which chemical and energy changes are an important part of the manufacturing process, such as the petroleum, rubber, plastics, synthetic fiber, pulp and paper, fermentation, soap and detergents, glass, ceramic, photographic and organic and inorganic chemical industries. In view of the dynamic nature of this technology, the course of study stresses fundamental principles rather than technical details. It prepares the student either for advanced study at the graduate level or for immediate entrance into industry. Opportunities in the process industries are found in a variety of activities, including design, development, management, production, research, technical marketing, technical service, or engineering.

Mission: To provide an excellent chemical engineering education through a combination of theory and practice that prepares students for productive professional careers and advanced graduate studies.

Program Educational Objectives

Program Educational Objectives are broad statements that describe what graduates are expected to attain within a few years of graduation.

- Our graduates will attain a promotion and/or responsibilities beyond their entry-level position, or progress toward the completion of an advanced degree.
- Our graduates will continue to develop professionally.
- Our graduates will collaborate professionally within or outside of their organizations at a regional, national and/or international level.

Student Outcomes

Student Outcomes are statements that describe what students are expected to have by the time of graduation.

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to identify, formulate, and solve engineering problems
3. An ability to design and conduct experiments and analyze and interpret data
4. An ability to design a system or process to meet desired needs within realistic constraints
5. An ability to function on multidisciplinary teams
6. An ability to communicate effectively in presentations and reports
7. An ability to use the techniques, skills, and modern engineering tools (particularly computer-based tools) necessary for engineering practice
8. An understanding of the professional and ethical responsibilities of a chemical engineer
9. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
10. The preparation to engage in life-long learning
11. A knowledge of contemporary issues

Curriculum

The curriculum covers a breadth of fundamental principles so that the chemical engineering graduates have a working knowledge of advanced chemistry, material and energy balances applied to chemical processes; thermodynamics; heat, mass, and momentum transfer; chemical reaction engineering; separation operations, process design and control. The program provides students with appropriate modern experimental and computing techniques in unit operation laboratory and requires them to work in teams and submit written and oral reports on their laboratory projects. A capstone experience in senior year gives students an opportunity to integrate their knowledge. Also included is the study of health, safety, environmental and ethical issues in the chemical engineering profession.

Graduate work leading to the degrees of Master of Science in chemical engineering or Master of Chemical Engineering provides a more thorough understanding of the discipline and enhances a student's ability to handle complex problems. A thesis is required for the Master of Science degree, but not for the Master of Chemical Engineering degree. Most recent graduate students have chosen research topics in biotechnology, polymers, or automatic control, but other specialties also are possible.

The chemical engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

CHEMICAL ENGINEERING

Approximately one-half of the students will follow schedule A1, and one-half will follow schedule A2. Depending on the students' schedules, elective courses may be taken in terms other than the ones designated.

Electives

Chemical Engineering students must complete 28 credits of electives in humanities and social sciences in addition to RH 131 and RH 330. They are also required to take 20 credits of electives (8 credits of CHE electives, 8 credits of approved electives and 4 credits of free electives) in addition to the humanities and social sciences mentioned above. The courses listed below qualify as a CHE elective. In very specific circumstances, independent projects or other courses may qualify as a CHE elective if approved by the department.

CHE 310 Numerical Methods for Chemical Engineers
CHE 405 Introduction to MEMS: Fabrication and Applications
CHE 419 Advanced MEMS: Modeling and Packaging
CHE 441 Polymer Engineering
CHE 460 Particle Technology
CHE 461 Unit Operations in Environmental Engineering
CHE 465 Energy and the Environment
CHE 470 Safety, Health, and Loss Prevention
CHE 502 Transport Phenomena
CHE 504 Advanced Reactor Design
CHE 512 Petrochemical Processes
CHE 513 Advanced Thermodynamics
CHE 515 Nanomaterials Science and Engineering
CHE 540 Advanced Process Control
CHE 545 Introduction to Biochemical Engineering
CHE 546 Bioseparations

A minimum of eight credits, designated as approved electives, must be approved by the student's academic advisor. Approved electives can be chosen from economics, engineering, engineering management, mathematics (including biomathematics), or science courses. Students are encouraged to use their electives to focus their studies in a particular subject area.

The chemical engineering profession is rapidly changing and knowledge of specialty areas has become essential in the real world. Technical elective courses are intended to provide an opportunity to introduce students to a specialty area in science and engineering and help them to expand their knowledge and expertise in new areas of chemical engineering. Although it is recommended that a minimum of eight credit hours be focused in one subject area, students are encouraged to focus most or all of the 20 credit hours of electives in a particular subject area. In many cases students can use their electives to take a package of courses toward an area minor such as, biochemical engineering, applied biology, biomedical engineering, chemistry, environmental engineering, toward a certificate in semiconductor materials and devices, or toward an area of concentration (see below).

Undergraduate students have the opportunity to work on a research project under the guidance of one of the departmental faculty members. Students who are interested in learning about research should talk to members of the faculty to define a project of mutual interest and then enroll in CHE499, Directed Research. Credit hours of CHE499 can count toward an approved elective.

Minor in Chemical Engineering

The area minor in chemical engineering is designed to introduce principles of chemical engineering to students majoring in other disciplines. Participation in this area minor will help students to understand chemical engineering aspects of industrial processes and enter a graduate program in chemical engineering if they desire.

Students who complete the area minor in chemical engineering during their sophomore and junior years open the possibility of taking some chemical engineering electives during their senior years.

The area minor in chemical engineering has the following requirements:

CHE 201 Conservation Principles and Balances or equivalent
CHE 202 Basic Chemical Process Calculations
CHE 301 Fluid Mechanics or equivalent
CHE 303 Chemical Engineering Thermodynamics or equivalent
CHE 304 Multi-Component Thermodynamics
CHE 320 Fundamentals of Heat and Mass Transfer
CHE 321 Applications of Heat and Mass Transfer or equivalent

Completion of a minimum of 12 credit hours of courses with prefix CHE at 300 level or above is required toward the minor. Students interested in the CHE area minor should consult the CHE Department Head and receive approval for equivalent courses to be considered.

Minor in Biochemical Engineering

The biochemical engineering minor is designed to allow students to concentrate in an area of study that will give them a solid foundation for further work in the pharmaceutical or biotechnology process industry.

To successfully complete a minor in Biochemical Engineering, a student must take six courses as follows:

Four required courses:

- BIO110 - Cell Structure and Function
- CHEM330 - Biochemistry
- CHE545 - Introduction to Biochemical Engineering
- CHE 546 - Bioseparations

And then take 8 credit hours from the following list of electives (the courses cannot also be used towards another minor or second major):

- BIO210 - Mendelian and Molecular Genetics
- BIO220 - Microbiology
  or
  BIO230 - Cell Biology
- BIO411 - Genetic Engineering
- BIO421 - Applied Microbiology
- CHEM430 - Advanced Biochemistry
- CHEM433 - Biochemistry Lab (recommended but not required)

Interested students should obtain a form from the Chemical Engineering Department secretary. Students interested in the Biochemical Engineering area minor should consult the CHE Department head and receive prior approval for any equivalent courses to be considered.

AREAS OF CONCENTRATION

Although it is not a requirement, students may pursue a concentration in one or more of the following areas. Students who complete the requirements of a concentration may receive, upon request, a letter from the Department Head that attests to the fact that the requirements have been completed. With proper planning, a student should be able to complete the requirements for an area of concentration without overload.

Advanced Chemical Engineering Analysis

Students need to take CHE 502 (Transport Phenomena) and 3 additional courses from the list below. Other courses may be substituted only with prior approval by the Department Head.

- CHE 310 Numerical Methods
- CHE 499 Directed Research (4 credit hours)
- CHE 504 Advanced Reactor Design
- CHE 513 Advanced Thermodynamics
- MA 336 Boundary Value Problems

Energy Production and Utilization

Students need to take 4 courses from the list below. Other courses may be substituted only with approval of the Department Head.

- CHE 465 Energy and the Environment
- CHE 512 Petrochemical Processes
- ME 407 Power Plants
- ME 408 Renewable Energy
- ME 450 Combustion

Industrial and Process Engineering

Students need to take CHE 470 (Safety, Health, and Loss Prevention), CHE 540 (Advanced Process Control), 2 courses from the Math List below, and 1 course from the Engineering Management List below. Other courses may be substituted only with approval of the Department Head.

Math List

- MA 385 Quality Methods
- MA 487 Design of Experiments
- MA 387 Statistical Methods in Six Sigma
- MA 444 Deterministic Models in Operations Research

Engineering Management List

- EMGT524 Production/Operations Management
- EMGT527 Project Management
- EMGT562 Risk Analysis and Management
- EMGT581 Multi-objective Optimization
- EMGT586 Supply Chain Management
- EMGT587 Systems Engineering
- EMGT588 Quality Management I
- EMGT589 Manufacturing Systems

*Rose students who have changed their major to chemical engineering or students who have transferred to Rose and have credit for CHEM 105 and CHEM 107 (formerly CHEM 201 and CHEM 202) do not need to take CHEM111 and CHEM 113, but must take CHEM 115.

Plan of Study

Freshman (A1 Schedule)

Fall

Course	Credit
CHEM 111 General Chemistry I*	4
CLSK 100 College & Life Skills	1
MA 111 Calculus I	5
RH 131 Rhetoric & Composition	4
	Total Credits: 14

Winter

Course	Credit
CHEM 113 General Chemistry II*	4
MA 112 Calculus II	5
PH 111 Physics I	4
HSS Elective	4

	Total Credits: 17

Spring

Course	Credit
CHE 110 Programming & Computation for Chemical Engineers	2
CHEM 115 General Chemistry III	4
EM 103 Introduction to Design	2
MA 113 Calculus III	5
PH 112 Physics II	4
	Total Credits: 17

Sophomore (A1 Schedule)

Fall

Course	Credit
CHE 200 Career Preparation I	0
CHE 201 Conservation Principles & Balances	4
CHEM 251 Organic Chemistry I	3
CHEM 251L Organic Chemistry I Lab	1
MA 211 Differential Equations	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
CHE 202 Basic Chemical Process Calculations	4
CHEM 252 Organic Chemistry II	3
CHEM 252L Organic Chemistry II Lab	1
MA 212Matrix Algebra & Systems of Differential Equations	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
CHE 301 Fluid Mechanics	4
CHE 303 Chemical Engineering Thermodynamics	4
Elective (Approved)	4

HSS Elective	4
	Total Credits: 16

Junior (A1 Schedule)

Fall

Course	Credit
CHE 304 Multi-Component Thermodynamics	4
CHE 320 Fundamentals of Heat and Mass Transfer	4
CHE 315 Materials Science	4
CHEM 225 Analytical Chemistry I	4
	Total Credits: 16

Winter

Course	Credit
CHE 321 Applications of Heat & Mass Transfer	4
CHEM 360 Intro Physical Chemistry	4
MA 223 Engineering Statistics I	4
RH 330 Technical and Professional Communication	4
	Total Credits: 16

Spring

Course	Credit
CHE 404 Kinetics & Reactor Design	4
CHE 411 Chemical Engineering Lab I	3
ECE 206 Elements of Electrical Engineering	4
Elective (Free)	4
	Total Credits: 15

Senior (A1 Schedule)

Fall

Course	Credit
CHE 409 Professional Practice	1
CHE 412 Chemical Engineering Lab II	4
CHE 416 Design I	4
Free Elective(Free)	4

Free Elective(CHE)	4
	Total Credits: 17

Winter

Course	Credit
CHE 413 Chemical Eng. Lab III	4
CHE 417 Design II	4
CHE 440 Process Control	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
CHE 418 Design III	2
HSS Elective	4
HSS Elective	4
Elective(Approved)	4
Elective(CHE)	4
	Total Credits: 18

Freshman (A2 Schedule)

Fall

Course	Credit
CHEM 111 General Chemistry I*	4
CLSK 100 College & Life Skills	1
MA 111 Calculus I	5
RH 131 Rhetoric & Composition	4
	Total Credits: 14

Winter

Course	Credit
CHEM 113 General Chemistry II*	4
MA 112 Calculus II	5
PH 111 Physics I	4
HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CHE 110 Programming & Computation for Chemical Engineers	2

CHEM 115 General Chemistry III	4
EM 103 Introduction to Design	2
MA 113 Calculus III	5
PH 112 Physics II	4
	Total Credits: 17

Sophomore (A2 Schedule)

Fall

Course	Credit
CHE 200 Career Preparation I	0
CHE 201 Conservation Principles and Balances	4
CHEM 251 Organic Chemistry I	3
CHEM 251L Organic Chemistry I Lab	1
MA 211 Differential Equations	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
CHE 202 Basic Chemical Process Calculations	4
CHEM 252 Organic Chemistry II	3
CHEM 252L Organic Chemistry II Lab	1
MA 212 Matrix Algebra & Systems of Differential Equations	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
MA 223 Engineering Statistics I	4
CHEM 225 Analytical Chemistry I	4
HSS Elective	4
CHE 315 Materials Science	4
	Total Credits: 16

Junior (A2 Schedule)

Fall

Course	Credit
CHE 301 Fluid Mechanics	4
CHE 303 Chemical Engineering Thermodynamics	4
Elective (Approved)	4
RH 330 Technical & Professional Communication	4
	Total Credits: 16

Winter

Course	Credit
CHE 304 Multi-Component Thermodynamics	4
CHE 320 Fundamentals of Heat & Mass Transfer	4
ECE 206 Elements of Electrical Engineering	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
CHE 321 Applications of Heat & Mass Transfer	4
CHE 411 Chemical Engineering Lab I	3
CHEM 360 Intro Physical Chemistry	4
Elective (Free)	4
	Total Credits: 15

Senior (A2 Schedule)

Fall

Course	Credit
CHE 404 Kinetics & Reactor Design	4
CHE 409 Professional Practice	1
CHE 412 Chemical Engineering Lab II	4
CHE 416 Design I	4
Free Elective(Free)	4
	Total Credits: 17

Winter

Course	Credit
CHE 413 Chemical Eng. Lab III	4
CHE 417 Design II	4
CHE 440 Process Control	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
CHE 418 Design III	2
HSS Elective	4
Elective(CHE)	4
Elective(CHE)	4
Elective(Approved)	4
	Total Credits: 18

NOTES

*Rose students who have changed their major to chemical engineering or students who have transferred to Rose and have credit for CHEM 105 and CHEM 107 (formerly CHEM 201 and CHEM 202) do not need to take CHEM111 and CHEM 113, but must take CHEM 115.

Rose-Hulman Institute of Technology Course Catalog

Chemistry

Graduates with a degree in chemistry will be well prepared for employment, graduate study in a chemistry-related field, or professional school. Chemists are employed in research, quality control, design, sales and management. Many graduates pursue masters and doctoral degrees in chemistry, biochemistry, medicinal chemistry, materials science, or environmental science, among others. A chemistry degree is excellent preparation for medical school and related fields, and also for careers in business, law or education.

The curriculum at Rose-Hulman Institute of Technology provides a rigorous introduction to all subdisciplines of chemistry. Students have access to modern instrumentation, a new biochemistry lab, and a new environmental chemistry lab. Rose-Hulman students are introduced to modern computational methods beginning in the sophomore year. There are many opportunities for research or other individual projects, and students are encouraged to present their results at regional and national chemistry conferences. Close interaction with engineering departments provides students with a point of view not available at most other undergraduate institutions.

Students may broaden their education by choosing a minor or second major. Many students, including chemistry majors, may be interested in a second major or minor in biochemistry and molecular biology. Other common choices include biology, chemical engineering and mathematics.

List of Required Chemistry Courses

Course	Numbers	Credits
General Chemistry	111, 113, 115	12
Organic Chemistry	251, 252, 253	12
Analytical Chemistry	225, 326, 327	12
Physical Chemistry	361, 362, 363	12
Inorganic Chemistry	441, 442	4
Biochemistry	330	4
Organic Structure Determination	451	4
Research	291, 391,395, 490, 491, 496, 497	8
Career Preparation	200	1
Electives		8
Total		**85**

Summary of minimum graduation requirements:

Course or areas	Required	Elective	Total
Chemistry	77	8	85
Physics	12	0	12
Mathematics	23	0	23

Biology	4	0	4
Humanities and Social Sciences	4	32	36
Electives	0	32	32
College and Life Skills	1	0	1
Total	**121**	**76**	**193**

Minor in Chemistry

Students not taking a first or second major in chemistry may earn an Area Minor in Chemistry by successfully completing the sequence of courses listed below. The student desiring this minor must request the approval of the Department Head and file the appropriate form with the registrar. This form is available on the Department of Chemistry webpage.

The requirements for an area minor in chemistry for students with a first or second major in biology or chemical engineering are different from those majoring in other disciplines.

Minor in Chemistry for Most Students

Course Number	Course Title	Credits
CHEM 113	General Chemistry II	4
CHEM 115	General Chemistry III	4
CHEM 225	Analytical Chemistry	4
CHEM 251	Organic Chemistry I	4
CHEM 252	Organic Chemistry II	4
	*Approved List of Chemistry Electives	4
Total		**24**

*Approved list of chemistry electives include CHEM 253, CHEM 290 (up to two credit hours), CHEM 291, or any 300 or 400 level chemistry courses.

Minor in Chemistry for Chemical Engineering and Biology Majors

Course Number	Course Title	Credits
CHEM 225	Analytical Chemistry	4
CHEM 253	Organic Chemistry III	4
	Chemistry Electives*	12
Total		**20**

*The electives cannot count toward the student’s major. Students who have taken CHE 303, 304 and CHEM 360 cannot count CHEM 361 or CHEM 362 toward the minor. No more than 2 credits of CHEM 290 can count toward the minor.

Plan of Study

Freshman

Fall

Course	Credit
CHEM 111 General Chemistry I	4
MA 111 Calculus I	5
BIO 110 Cell Structure and Function	4
CLSK 100 College & Life Skills	1
RH 131 Rhetoric & Composition or HSS Elective	4
	Total Credits: 18

Winter

Course	Credit
CHEM 113 General Chemistry II	4
MA 112 Calculus II	5
PH 111 Physics I	4
RH 131 Rhetoric and Composition or HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CHEM 115 General Chemistry III	4
MA 113 Calculus III	5
HSS Elective	4
PH 112 Physics II	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CHEM 251 Organic Chemistry I	3
CHEM 251L Organic Chemistry I Lab	1
PH 113 Physics III	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
Free Elective	4

	Total Credits: 16

Winter

Course	Credit
CHEM 200 Career Preparation (take in winter or spring)	1
CHEM 252 Organic Chemistry II	3
CHEM 252L Organic Chemistry II Lab	1
CHEM 291 Intro to Undergraduate Research	4
MA 381 Introduction to Probability with Applications to Statistics	4
Free Elective	4
	Total Credits: 17

Spring

Course	Credit
CHEM 200 Career Preparation (take in winter or spring)	1
CHEM 253 Organic Chemistry III	3
CHEM 253L Organic Chemistry III Lab	1
CHEM 225 Analytical Chemistry I	4
HSS RH 330	4
Free Elective	4
	Total Credits: 17

Junior

Fall

Course	Credit
CHEM 326 Bioanalytical Chemistry	4
CHEM 361** Physical Chemistry I	4
CHEM 330 Biochemistry I	4
CHEM 391 Research Proposal (F,W or S)	1
CHEM 395 Chemistry Seminar	0
CHEM 490 Research	1
HSS Elective	4
	Total Credits: 18

Winter

Course	Credit
CHEM 327 Advanced Analytical	4
CHEM 362** Physical Chemistry II	4
CHEM 391 Research Proposal (F, W or S)	1
CHEM 490 Research	1
HSS Elective	4
Free Elective	4
	Total Credits: 18

Spring

Course	Credit
CHEM 363 Quantum Chemistry & Molecular Spectroscopy	4
CHEM 391 Research Proposal (F, W or S)	1
CHEM 451 Organic Structure Determination	4
HSS Elective	4
Free Elective	4
CHEM 490 Research	1
	Total Credits: 18

Senior

Fall

Course	Credit
CHEM 441 Inorganic Chemistry I	4
CHEM 490 Research	1
CHEM 491 Research Thesis (F, W or S)	1
CHEM 495 Chemistry Seminar	0
CHEM 497 Research Presentation (F, W or S)	1
Chemistry Elective	4
Free Elective	4
	Total Credits: 15

Winter

Course	Credit
CHEM 442 Inorganic Chemistry II	4

CHEM 491 Research Thesis (F, W or S)	1	
CHEM 496 Chemistry Seminar	0	
CHEM 497 Research Presentation (F, W or S)	1	
HSS Elective	4	
Chemistry Elective (400-level)###	4	
		Total Credits: 14

Spring

Course	Credit	
CHEM 491 Research Thesis (F, W or S)	1	
CHEM 497 Research Presentation (F, W or S)	1	
HSS Elective	4	
Free Elective	4	
Free Elective	4	
		Total Credits: 14

NOTES

Two degree or double major programs in biochemistry and either chemistry or biochemistry and molecular biology is not allowed.
*BIO 120 or BIO 130 may be substituted for BIO 110
**CHE 303, CHE 304 and CHEM 360 may be substituted for CHEM 361 and CHEM 362.
^Students must complete at least 3 credits of CHEM 490 prior to the Spring quarter of their senior year.
^^Research and independent study do not meet this requirement.

Civil Engineering

Civil engineering is a people-oriented profession that has long been in existence to serve the needs of mankind. It evolved as a formal discipline at the start of the 19th century with the advent of society’s need for increased mobility and convenience. The role of the civil engineer has always been one that deals primarily with public works: the planning, design, and construction of airports, bridges, buildings, and transportation, irrigation, flood control, water supply and waste disposal systems. These civil engineering works not only manage our environment, but are part of the environment itself and, by their very nature, have important social and economic impacts.

The civil engineering curriculum is designed to give the student a sound education in preparation for this role. The first two years include courses that deal with the principles of mathematics, physical and engineering sciences on which engineering concepts are based, as well as courses in humanities and social sciences and introductory courses in engineering and design. The last two years are devoted to developing the necessary technical competence, as well as the ability to apply the knowledge that the student has acquired to the design and synthesis of complex civil engineering projects. Project-based learning is an essential ingredient, and a year-long, client-based capstone design project highlights the senior year.

The entire curriculum is oriented to develop a student’s ability to think critically and logically. Upon graduation the student will be able to adapt this ability to the engineering environment of his or her choice. The curriculum in civil engineering will provide the student with the capacity for professional growth, either by advanced study or as a practicing professional engineer. A student may also use this academic background as a stepping stone to a position in management, administration, law, or some other non-engineering field.

Civil Engineering Department's Mission Statement

To provide an excellent civil engineering education that prepares graduates to develop into professionals who will exceed the needs of their employers, clients, and community in a continually changing world.

Civil Engineering Department’s Program Educational Objectives and Student Learning Outcomes*

Program Educational Objectives

I. Graduates will demonstrate the ability to perform **essential engineering functions** in the design, management, or construction industry.

II. Graduates will demonstrate the ability to **design/construct complex engineering systems** in the broad-based engineering industry.

III. Graduates will demonstrate their potential for **technical leadership and management.**

Student Learning Outcomes

1. **Technical Core** - Solve problems in mathematics (through differential equations), probability and statistics, calculus-based physics, chemistry, and an additional area of science.
2. **Experiments** - Design an experiment or experimental program to meet a need; conduct civil engineering experiments, and analyze and interpret the resulting data.
3. **Engineering Problems** - Develop problem statements and solve well-defined engineering problems in four technical areas appropriate to civil engineering.
4. **Engineering Impact** - Explain the impact of engineering solutions on the economy, environment, political landscape, and society; apply the principles of sustainability to the design of engineering systems.
5. **Contemporary Issues** - Explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems.
6. **Design** - Design a system or process in more than one civil engineering context to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.
7. **Multidisciplinary** - Function effectively as a member of a multidisciplinary team.
8. Professional/Ethical - Analyze a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action and explain the importance of professional licensure.
9. **Communication** - Organize and deliver effective verbal, written, and graphical communications.
10. **Engineering Tools** - Apply relevant techniques, skills, and modern engineering tools to solve engineering problems.
11. **Life Long Learning** - Explain the need for and demonstrate the ability to learn on their own, without the aid of formal instruction.
12. **Leadership** - Apply leadership principles to direct the efforts of a small group.
13. **Service** - Use one's time and skills to benefit an individual or community without cost to the recipient.
14. **Project Management** - Explain key concepts in project management, and develop solutions to well-defined project management problems.
15. **Business and Public Administration** - Explain key concepts and processes used in business, public policy, and public administration.
16. **Cultural and Global Awareness** - Analyze and interpret cultural perspectives and social systems that define human characteristics.

* *The civil engineering program uses the term "educational objective" to describe the expected accomplishments of our students in three to five years following graduation. The term "student learning outcome" is used to describe knowledge and skills at the time of graduation.*

The civil engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

Environmental Engineering Minor

The Environmental Engineering minor includes 6 required courses and 8 elective credit hours. The required courses provide an introduction to the overall field of environmental engineering. The elective courses allow the student to tailor the minor to their interests.

The 6 required courses are as follows:

CE 460	Introduction to Environmental Engineering
CE 471	Water Resources Engineering
CHEM 264	Introduction to Environmental Science
CE 463/CHE 461	Unit Operations in Environmental Engineering
CE 564	Aquatic Environmental Chemistry
CHEM 251 CHEM 251L	Organic Chemistry I Organic Chemistry I Laboratory

And 8 credit hours from the following courses:

CE 562	Advanced Wastewater Treatment
CE 563	Advanced Water Treatment
CE 565	Solid and Hazardous Waste Regulation and Treatment
CE 566	Environmental Management
CE 567	Applied Hydrologic Modeling
CE 568	Applied Contaminant Transport Modeling
CE 569	Treatability Studies
CE 570	Modeling Open Channel Hydraulics
CE 573	Groundwater Analysis
CE 590	Special Problems
CE 598	Stream Restoration (Environmental River Mechanics)
CHE 465	Energy and the Environment
CHE 470	Safety, Health, and Loss Prevention
BIO 320	Ecology and Environmental Biology

Advisor:	Dr. Michael A. Robinson, Department of Civil Engineering Olin 225D, 812/877-8286 michael.robinson@rose-hulman.edu

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
PH 111 Physics I	4
RH 131 Rhetoric & Composition or Elective (HSS)	4
CLSK 100 College & Life Skills	1
CE 101 Engineering Surveying	2
	Total Credits: 16

Winter

Course	Credit
MA 112 Calculus II	5
PH 112 Physics II	4
RH 131 Rhetoric & Composition or Elective(HSS)	4
CE 111 Geographic Info Systems	2
EM 102 Graphical Communications for CE	2
	Total Credits: 17

Spring

Course	Credit
MA 113 Calculus III	5
EM 103 Introduction to Design	2
EM 120 Engineering Statics	4
Elective (HSS)	4
	Total Credits: 15

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
CHEM 111 General Chemistry I	4
EM 202 Dynamics	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra & Systems of Differential Equations	4
EM 203 Mechanics of Materials	4
CHEM 113 General Chemistry II	4
CE 250 Sustainable CE Design	2
Elective (Science)***	4
	Total Credits: 18

Spring

Course	Credit
MA 223 Statistics for Engineers	4
EM 301 Fluid Mechanics	4
CE 320 C.E. Materials	4
CE 380 Transportation Engineering	4
	Total Credits: 16

Junior

Fall

Course	Credit
CE 321 Structural Mechanics I	4
CE 336 Soil Mechanics	4
CE 205 Thermodynamics or CHE 201 Conservation Principles & Balances	4
CE 371 Hydraulic Engineering	4
	Total Credits: 16

Winter

Course	Credit
ECE 206 Elements of Electrical Eng. or CHE 202 Basic Chemical Process Calculations	4
CE 441 Construction Engineering	2
CE 432 Concrete Design I	3
CE 471 Water Resources Engineering	4
Elective (Science)***	4
	Total Credits: 17

Spring

Course	Credit
CE 310 Civil Engineering Numerical Methods	2
CE 431 Steel Design I	3
CE 460 Environmental Engineering	4
RH 330 Technical & Professional Communication	4
CE 461 Environmental Engineering Lab	2
	Total Credits: 15

Senior

Fall

Course	Credit
CE 486 C.E. Design & Synthesis I	2
CE **C.E. Elective	4
CE 450 C.E. Codes & Regulations	4
HSS Elective	4
HSS Elective	4
	Total Credits: 18

Winter

Course	Credit
CE 487 Technical System Design & Synthesis	2
CE 488 C.E. Design & Synthesis II	2
CE **C.E. Elective	4
*Elective (Technical)	4
CE 303 Engineering Economy	4
	Total Credits: 16

Spring

Course	Credit
CE 489 C.E. Design & Synthesis III	2
*Elective(Technical)	4
HSS Elective	4
HSS Elective	4
CE 400 Career Preparation Seminar	0
	Total Credits: 14

NOTES

*A Technical elective is any four (4) credit course in chemistry, computer science, engineering, life science, geology, mathematics, biomathematics, or physics.
**Student shall choose any 400 or 500 level CE elective course, designated with the"CE" prefix, as a CE Elective, in consultation with their advisor.
***At least 4 hours of science elective must be in a natural science outside Chemistry or Physics.

Rose-Hulman Institute of Technology Course Catalog

Computer Engineering

Computer Engineers (CPE) are electrical engineers that have additional training in the areas of software design and hardware-software integration. Common CPE tasks include writing embedded software for real-time microcontrollers, designing VLSI chips, working with analog sensors, designing mixed signal circuit boards, and designing operating systems. Computer engineers are also well-suited for research in the field of robotics, which relies on using computers together with other electrical systems. Below is a recommended plan of study for CPE.

CPE program educational objectives

Computer Engineering graduates shall:

1. Practice excellence in their profession using a systems approach encompassing technological, economic, ethical, environmental, social, and human issues within a changing global environment;
2. Function independently and in leadership positions within multidisciplinary teams;
3. Continue life-long learning by acquiring new knowledge, mastering emerging technologies, and using appropriate tools and methods;
4. Adapt and independently extend their learning to excel in fields about which they are passionate;
5. Strengthen teams and communities through collaboration, effective communication, public service, and leadership.

CPE student outcomes

At the time of graduation, students will have demonstrated:

1. an ability to apply knowledge of mathematics, science, and engineering
2. an ability to design and conduct experiments, as well as to analyze and interpret data
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4. an ability to function on multidisciplinary teams
5. an ability to identify, formulate, and solve engineering problems
6. an understanding of professional and ethical responsibility
7. an ability to communicate effectively
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context
9. a recognition of the need for, and an ability to engage in life-long learning
10. a knowledge of contemporary issues
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The computer engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

COMPUTER ENGINEERING CORE COURSES

Course Number	Course Title	Credits
ECE160	Engineering Practice	2
ECE180	Introduction to Signal Processing	4
ECE203	DC Circuits	4
ECE204	AC Circuits	4
ECE205	Circuits and Systems	4
ECE230	Introduction to Embedded Systems	4
ECE233	Introduction to Digital Systems	4
ECE250	Electronic Device Modeling	4
ECE300	Continuous-Time Signals Systems	4
ECE312	Communication Networks	4
ECE332	Computer Architecture II	4
ECE343	High Speed Digital Design	4
ECE362	Principles of Design	3
ECE380 or ECE320	Discrete-Time Signals and Systems or Linear Control Systems	4
ECE460	Engineering Design I	3
ECE461	Engineering Design II	4
ECE462	Engineering Design III	2

SECOND MAJOR IN COMPUTER ENGINEERING

The ECE Department will not allow the following second major combinations:

1. Degree in Electrical Engineering and a Second Major in Computer Engineering.
2. Degree in Computer Engineering and a Second Major in Electrical Engineering.

Other students outside of ECE can get a second major in CPE by completing all of the courses in a required plan.

Course Number	Course Title	Credits
ECE160	Engineering Practice	2
ECE180	Introduction to Signal Processing	4
ECE203	DC Circuits	4
ECE204	AC Circuits	4
ECE205	Circuits and Systems	4

ECE230	Introduction to Embedded Systems	4
ECE233	Introduction to Digital Systems	4
ECE250	Electronic Device Modeling	4
ECE300	Continuous-Time Signals Systems	4
ECE312	Communication Networks	4
ECE332	Computer Architecture II	4
ECE343	High Speed Digital Design	4
ECE380 or ECE320	Discrete-Time Signals and Systems or Linear Control Systems	4
CSSE120	Introduction to Software Development	4
CSSE220	Object-Oriented Software Development	4
CSSE232	Computer Architecture I	4
CSSE332 or CSSE230	Operating Systems or Data Structures & Algor Analysis	4
MA381	Intro to Probability w/ Apps to Stats	4
Total		**66**

MINOR IN ELECTRICAL AND COMPUTER ENGINEERING (ECE)

The Minor in ECE is designed to allow students to add another dimension to their Rose-Hulman degree.

Advisor ECE Department Head

Requirements for Minor in ECE

- ECE203 or ES203 (not both)
- Plus five additional ECE courses, except ECE362, ECE460, ECE461, ECE462, ECE466, and ECE206

AREAS OF CONCENTRATION

Optical Communications Certificate

Faculty advisors: B. Black and S. Granieri

Rose-Hulman has become a leader in providing opportunities for students to choose a great mainstream degree program with flexibility to specialize in other areas of interest. This leadership is in no way limited to only traditional areas of study. One of these new areas that had a high impact in technology is optical communications. It is a rapidly growing field requiring investment beyond the traditional program structure, and is well suited to the students at Rose-Hulman All these topics are closely related to well established disciplines as optics and electronics. Considerable R&D efforts are allocated in both university and industrial laboratories enhancing the demand for both researchers and engineers with expertise in the field.

We propose the creation of a new certificate program in Optical Communications to enhance the programs currently offered. Combining expertise in Optical and Electrical Engineering, this program requires an interdisciplinary emphasis that is beyond the traditional content of either of its parent programs. This program is more than just the creation of the certificate program Optical Communications. This program will be critical to help developing a more interdisciplinary interaction for students and faculty. The creation of a workgroup within the faculty of both departments will coordinate current courses and resources, create new courses of interest for the field, and develop a showcase testbed education and research laboratory. Primary objectives include the removal of redundancy from existing courses, increasing interaction between the PHOE and ECE departments, and improving opportunities for students in the field.

This certificate is designed to give the student a firm theoretical and practical working knowledge in the area of fiber optic devices, optical communications, networks and its applications. The main purpose is to couch these fundamentals in a context that serves as the backbone for device, components and sub-system development for use in high-speed optical data and information links and networks. At the end of the program the student will be expected to:

1. Understand the fundamental operation characteristics of high speed optoelectronic components, such as laser transmitters, light modulators and receivers and passive fiber optic components as connectors, couplers, filters, and switches.
2. Understand the technology and performance of analog and digital fiber optic links, optical amplification and optical wavelength division multiplexing and optical time division multiplexing networks.
3. Have a hands-on working knowledge of the use of fiber optic test equipment and techniques used by industry and telecommunication companies to test the performance of optical fiber links and components, such as, optical time domain reflectometry, optical spectrum analyzers and optical bit error testing equipment.

The Certificate will consist of 20 credit hours of which 12 credit hours will be required courses. Students interested in pursuing this Certificate should contact an ECE/PHOE certificate advisor (Professors Black, Bunch, and Granieri)

Required Courses

- ECE 310 Communication Systems
- OE 393 Fiber Optics and Applications
- OE 493 Fundamentals of Optical Fiber Communications

Elective Courses (two from the list)

Only courses not required for the student’s major will count for electives in the certificate.

- ECE 380 Discrete-Time Signals and Systems

- ECE 410 Communication Networks
- ECE 414 Wireless Systems
- OE 360 Optical Materials and Opto-mechanics
- OE 435 Biomedical Optics
- OE 450 Laser Systems and Applications
- OE 485 Electro-Optics and Applications

Plan of Study

Freshman

Fall

Course	Credit
PH 111 Physics I	4
MA 111 Calculus I	5
CLSK 100 College & Life Skills	1
RH 131 Rhetoric & Composition or HSS Elective	4
ECE 160 Engineering Practice	2
	Total Credits: 16

Winter

Course	Credit
PH 112 Physics II	4
MA 112 Calculus II	5
CSSE 120 Intro to Software Development	4
RH 131 Rhetoric & Composition or HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
PH 113 Physics III	4
MA 113 Calculus III	5
ECE 203 DC Circuits	4
ECE 180 Introduction to Signal Processing	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
CHEM 111 General Chemistry I	4
ECE 204 AC Circuits	4
ECE 233 Introduction to Digital Systems	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra & Systems of Differential Equations	4
ECE 230 Introduction to Embedded Systems	4
ECE 205 Circuits & Systems	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
MA 381 Introduction to Probability with Applications to Statistics	4
ECE 300 Continuous-Time Signals & Systems	4
CSSE 220 Object Oriented Software Development	4
ECE 250 Electronic Device Modeling	4
	Total Credits: 16

Junior

Fall

Course	Credit
MA 275 Discrete & Combinational Algebra I	4
CSSE 232 Computer Architecture I	4
ECE 380 Discrete-Time Signals & Sys or ECE 320 Linear Control Systems	4
RH 330 Technical & Professional Communication	4
	Total Credits: 16

Winter

Course	Credit
ECE 312 Communication Networks	4
HSS Elective	4
CSSE 332 Operating Systems or CSSE 230 Data Structures & Algorithm Analysis	4
Math/Science Elective	4
	Total Credits: 16

Spring

Course	Credit
ECE 332 Computer Architecture II	4
Area Elective	4
HSS Elective	4
ECE 362 Principles of Design	3
	Total Credits: 15

Senior

Fall

Course	Credit
ECE 460 Engineering Design I	3
ECE 343 High Speed Digital Design	4
Area Elective	4
HSS Elective	4
	Total Credits: 15

Winter

Course	Credit
ECE 461 Engineering Design II	4
Tech Elective	4
Area Elective	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
ECE 462 Engineering Design III	2
Tech Elective	4
HSS Elective	4
Free Elective	4

Free Elective	4	
		Total Credits: 18

NOTES

AREA ELECTIVES

At least two of the three Area Electives must bear an ECE prefix at the 400 level or above

At most one of the Area Electives can bear an ECE or CSSE prefix at the 300 level or above

Exceptions to this requirement may be granted by the ECE Department Head

TECHNICAL ELECTIVE - Any course NOT bearing a GS, RH, IA, SV, GE, JP, and SP prefix

1. MA 351-356 Problem Solving Seminar may not be combined and substituted for the math elective.
2. CPE majors are not permitted to take ECE 206 Elements of Electrical Engineering as a free elective or technical elective. Free electives may be selected from any other Rose-Hulman courses.
3. CPE majors may take any additional mathematics or biomathematics classes to satisfy the departmental mathematics requirement, and any biology, chemistry, geology or physics courses to satisfy the departmental science requirement. Courses that are cross-referenced with any engineering courses will not satisfy either the mathematics or science requirements.

Computer Science

The Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

Computer science is a rapidly changing discipline. The lifetime of a particular computer system or software package can be very short. The computer science curriculum is designed to prepare students for multiple careers in a rapidly changing environment. The department's courses emphasize fundamental concepts and techniques that will last longer than present technology.

Computer science majors complete a core of basic computer science courses that includes the study of algorithms, data structures, database concepts, computer architecture, programming languages, operating systems, and software engineering. Majors also complete important courses in closely related fields, e.g., discrete mathematics, digital logic design, and probability and statistics. The major requires students to study all aspects of the science of computing, including hardware, software, and theory.

Courses in database systems, compilers, computer graphics, fractals and chaotic dynamical systems, artificial intelligence, theory of computation, analysis of algorithms, computer networks, computer vision, web-based information systems, and cryptography are available as advanced electives. A three-term senior project provides valuable practical experience in the specification, design, implementation, and documentation of large software systems. Qualified students can undertake independent study in advanced topics in computer science, participate in a research project with a faculty member, or complete a senior thesis.

Programming assignments and large projects are part of most computer science courses. These assignments familiarize students with the wide variety of tasks performed by software professionals. Programming assignments include system specification, system feasibility studies, system design, system maintenance studies, and user interface design in addition to system implementation (i.e., coding), testing (verification and validation), and documentation. Projects include both individual and team activities and require appropriate written and oral presentations.

Computer science majors have diverse interests and career goals. Five free elective courses allow students to tailor their undergraduate education to their specific goals. Students planning to undertake graduate study in computer science usually take additional advanced courses in computer science, electrical engineering, and mathematics.

The department has its own local area network. This network is connected to the campus-wide network and the Internet. Laboratory machines are mostly Sun Ultra workstations. Computer science majors have unlimited access to the department's laboratories. Computer science majors are frequently employed by the computing center as user consultants, and by the department as system managers and course assistants.

The student chapter of the Association for Computing Machinery provides seminars and other technical activities throughout the year and sponsors the school’s programming teams which compete in local, regional, and national contests. The national computer science honor society, Upsilon Pi Epsilon, has chartered its Indiana Alpha Chapter at Rose-Hulman.

Computer Science Program Educational Objectives

Graduates from the computer science program will be prepared for many types of careers in the field of computing and be prepared for graduate study in computer science and in closely related disciplines. In the early phases of their careers, we expect Rose-Hulman computer science graduates to be:

1. Computing professionals in a variety of organizations, including ones doing traditional software development, technological innovation, and cross-disciplinary work
2. Business and technological leaders within existing organizations
3. Entrepreneurial leaders
4. Recognized by their peers and superiors for their communication, teamwork, and leadership skills
5. Actively involved in social and professional service locally, nationally, and globally
6. Graduate students and researchers
7. Leaders in government and law as government employees, policy makers, governmental advisors, and legal professionals

Computer Science Student Outcomes

By the time students graduate with a computer science degree from Rose-Hulman, they will be able to:

1. Effectively apply a variety of computing resources, programming languages, programming paradigms, operating systems, networks, and software development tools
2. Anticipate complexities and problems involved in the development of large computing systems
3. Analyze requirements, design computing systems that satisfy those requirements, and implement that system
4. Analyze problems and design solutions using ideas of problem complexity, models of computation, decidability, and scalability
5. Analyze algorithms in terms of correctness, as well as time and space efficiency
6. Evaluate and discuss the legal, social, and ethical aspects of significant events that arise in the field of computing both domestically and internationally
7. Interact effectively with colleagues and clients located abroad and overcome challenges that arise from geographic distance, cultural differences, and multiple languages
8. Communicate effectively, both orally and in writing
9. Collaborate effectively in teams
10. Recognize the need for, and engage in, lifelong learning

The faculty strives to maintain an open atmosphere that encourages mutual respect and support as well as learning and sharing of knowledge.

The computer science program is accredited by the Computing Accreditation Commission of ABET,www.abet.org

CSSE electives cannot include any of CSSE 372, 373, 375, 376, and 477. Science elective is any CHEM, PH, GEOL, or BIO courses totaling at least 4 credits.

HSS electives must be distributed as required by HSS.

Summary of graduation requirements for the computer science major

To complete the major in computer science a student must complete the following:

1. All required courses listed by number in the schedule of courses above: CSSE120, CSSE132, CSSE220, CSSE230, CSSE232, CSSE304, CSSE332, CSSE333, CSSE371, CSSE374, CSSE473 or MA473 and CSSE474 or MA474, and either CSSE487-9 or CSSE494-6 or CSSE497-9; MA111, MA112, MA113, MA212, MA275, MA375, MA381; ECE332; PH111, PH112; CHEM111; RH131, RH330; CLSK100.
2. Sixteen credits of additional computer science courses numbered between 200 and 492. No more than four credits may be at the 200 level, and none of the credits may be from CSSE372, 373, 375, 376, and 477. The student’s academic advisor must approve the courses to satisfy this requirement. (Use of computer science courses numbered 490 through 492 to fulfill this requirement must be approved by the department head).
3. Four credits of science electives, which can be any CHEM, PH, BIO, or GEOL courses not already required for the computer science major.
4. Eight additional credits of technical electives, consisting of any courses in biology, chemistry, engineering (except software engineering and engineering management), geology, mathematics, biomathematics, or physics.
5. Twenty-eight credits of additional courses offered by the Department of Humanities and Social Sciences. The distribution of these courses must meet the requirements of the Department of Humanities and Social Sciences.
6. Twenty credits of free elective courses. These courses must have the approval of the student’s academic adviser. Free electives may be selected from any Rose-Hulman course.
7. A total of 192 credits.

Area Minor in Computer Science

Advisor: J.P. Mellor

Students majoring in Software Engineering may not receive a Computer Science minor.

Required courses

- CSSE120 Introduction to Software Development
- CSSE220 Object-Oriented Software Development
- CSSE230 Data Structures and Algorithm Analysis
- 16 additional credits of computer science courses numbered above 200.
- None of these may be CSSE 371-376, CSSE 477 or CSSE 493. Use of CSSE 490, CSSE 491 or CSSE 492 toward these 16 credits requires department head approval.

Plan of Study

Freshman

Fall

Course	Credit
CSSE 120 Introduction to Software Development	4
PH 111 Physics I	4
MA 111 Calculus I	5
CLSK 100 College & Life Skills	1
RH 131 Rhetoric &Composition	4
	Total Credits: 18

Winter

Course	Credit
CSSE 220 Object-Oriented Software Development	4
PH 112 Physics II	4
MA 112 Calculus II	5
HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CSSE 132 Introduction to Computer Systems	4
MA 113 Calculus III	5
HSS Elective	4
Science Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CHEM 111 General Chemistry I	4
CSSE 232 Computer Architecture I	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
MA 275 Discrete & Combinatorial Algebra I	4

	Total Credits: 16

Winter

Course	Credit
CSSE 230 Data Structures & Algorithm Analysis	4
RH 330 Technical & Professional Communication	4
MA 375 Discrete & Combinatorial Algebra II	4
CSSE 332 Operating Systems	4
	Total Credits: 16

Spring

Course	Credit
ECE 332 Computer Architecture II	4
MA 381 Introduction to Probability with Applications to Statistics	4
CSSE 333 Database Systems	4
HSS Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
CSSE 371 Software Requirements Engineering	4
CSSE 304 Programming Lang. Con.	4
CSSE Elective	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
CSSE/MA 473 Design & Analysis of Algorithms	4
CSSE 374 Software Design	4
CSSE Elective	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE/MA 474 Theory of Computation	4
Technical Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
CSSE 487 Senior Research Project I or CSSE 497 Senior Capstone Project I or CSSE 494 Senior Thesis I	4
CSSE Elective	4
HSS Elective	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
CSSE 488 Senior Research Project II or CSSE 498 Senior Capstone Project II or CSSE 495 Senior Thesis II	4
CSSE Elective	4
HSS Elective	4
Technical Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 489 Senior Research Project III or CSSE 499 Senior Capstone Project III or CSSE 496 Senior Thesis III	4
Free Elective	4
Free Elective	4
	Total Credits: 12

NOTES

CSSE electives cannot include any of CSSE 372, 373, 375, 376, and 477.
Science elective is any CHEM, PH, GEOL, or BIO courses totaling at least 4 credits.

HSS electives must be distributed as required by HSS.

Economics

The degree program in Economics is offered by the Department of Humanities and Social Sciences.

The curriculum in Economics is designed to respond to a growing demand for students of economics who are rigorously trained in mathematical methods of analysis. The Rose-Hulman program gives students a broad background in economic analysis and an ability to use sophisticated analytical techniques in their thinking and decision-making. The quantitative training prepares the graduate for further graduate study or for economic analysis work in government or industry.

Students may also obtain a degree with a double major in Economics and another field: mathematics, computer science, etc.

Learning Outcomes:
Upon graduating, Rose-Hulman Economics majors will be able to:

1. explain core economic terms, concepts and theories
2. use economic theory to define, analyze and solve a wide range of problems.
3. collect, process, and interpret data using econometric techniques and statistical inference, especially to test hypotheses and support recommended actions.
4. communicate complex economics topics in both oral and written form.
5. independently undertake in-depth economic analysis.

In order to permit tailoring each student's program to best suit that student's needs and interests, no specific courses other than in Economics are required in the junior or senior years. However, each student's program must satisfy the following minimum requirements:

1. 24 credits of required Economics courses:
   - SV150 Introduction to Microeconomics
   - SV152 Introduction to Macroeconomics
   - IA350 Intermediate Microeconomics
   - IA351 Intermediate Macroeconomics
   - SV450 Introduction to Econometrics
   - XX456 Seminar for HSS Senior Projects
   - XX457 Directed Study for HSS Senior Project
2. 20 additional credits in Economics electives.
3. 27 credits in required Mathematics courses:
   - MA111, 112, 113 Calculus I, II, III
   - MA211, 212 Differential Equations, and Matrix Algebra and Systems of Differential Equations
   - MA223 Engineering Statistics I or MA381 Introduction to Probability
4. 12 additional credits in mathematics or biomathematics other than MA351-356.
5. 36 credits in Humanities and Social Sciences. Each student must fulfill the HSS graduation requirements.
6. 24 credits in Physical or Life Sciences (Biology, Chemistry, Geology and Physics), with at least four credits each in Biology, Chemistry and Physics.
7. 4 credits in Engineering Management

8. 4 credits in Computer Science: CSSE 120
9. CLSK 100 (1 credit)

SUMMARY	**Credits**
Economics	44
Mathematics	39
Humanities and Social Sciences	36
Physical or Life Science	24
Engineering Management	4
Computer Science	4
Free Electives	40
Other:	
CLSK 100	1
TOTAL	**192**

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
CLSK 100 College & Life Skills	1
RH 131 Rhetoric & Composition or HSSElective	4
SV 150 Intro to Microeconomics or SV 152 Intro to Macroeconomics	4
Physical or Life Science	4
	Total Credits: 18

Winter

Course	Credit
MA 112 Calculus II	5
CSSE 120 Intro to Software Development	4
RH 131 Rhetoric and Composition or SV 150 Intro to Microeconomics or SV 152 Intro to Macroeconomics	4
Physical or Life Science	4
	Total Credits: 17

Spring

Course	Credit
MA 113 Calculus III	5
RH 131 Rhetoric & Composition or or SV 150 Intro to Microeconomics or or SV 152 Intro to Macroeconomics	4
Physical or Life Science	4
*HSS Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
Economics Elective	4
*HSS Elective	4
Physical or Life Science	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra & Systems of Differential Equations	4
Economics Elective	4
*HSS Elective	4
Physical or Life Science	4
	Total Credits: 16

Spring

Course	Credit
MA 381 Intro to Probability with Applications to Statistics or MA 223 Engineering Statistics	4
Economics Elective	4
*HSS Elective	4
Physical or Life Science	4
	Total Credits: 16

NOTES

*Humanities and Social Science courses are denoted by the prefixes GS, IA, RH, SV, GE, JP, and SP.

Last updated: 08/16/2017

Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511

Rose-Hulman Institute of Technology Course Catalog

Electrical Engineering

Electrical Engineering (EE) is a professional engineering discipline that deals with the study and application of electricity, electronics and electromagnetism. Common EE tasks include designing communication systems, energy conversion and power delivery, control systems applications, design of analog and digital systems, and others. Below is a recommended plan of study for EE

EE Program Educational Objectives

Electrical Engineering graduates shall:

1. Practice excellence in their profession using a systems approach encompassing technological, economic, ethical, environmental, social, and human issues within a changing global environment;
2. Function independently and in leadership positions within multidisciplinary teams;
3. Continue life-long learning by acquiring new knowledge, mastering emerging technologies, and using appropriate tools and methods;
4. Adapt and independently extend their learning to excel in fields about which they are passionate;
5. Strengthen teams and communities through collaboration, effective communication, public service, and leadership.

EE student outcomes

At the time of graduation, students will have demonstrated:

- an ability to apply knowledge of mathematics, science, and engineering
- an ability to design and conduct experiments, as well as to analyze and interpret data
- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an ability to function on multidisciplinary teams
- an ability to identify, formulate, and solve engineering problems
- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and social context
- a recognition of the need for, and an ability to engage in life-long learning
- a knowledge of contemporary issues
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The electrical engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

ELECTRICAL ENGINEERING CORE COURSES

Course Number	Course Title	Credits
ECE160	Engineering Practice	2

ECE180	Introduction to Signal Processing	4
ECE203	DC Circuits	4
ECE204	AC Circuits	4
ECE205	Circuits and Systems	4
ECE230	Introduction to Microcontrollers	4
ECE233	Introduction to Digital Systems	4
ECE250	Electronic Device Modeling	4
ECE300	Continuous-Time Signals Systems	4
ECE310	Communication Systems	4
ECE320	Linear Control Systems	4
ECE340	Electromagnetic Fields	4
ECE341	Electromagnetic Waves	4
ECE351	Analog Electronics	4
ECE362	Principles of Design	3
ECE370 or ECE 371	Power & Energy Systems or Sustainable Energy Systems	3
ECE380	Discrete-Time Signals and Systems	4
ECE460	Engineering Design I	3
ECE461	Engineering Design II	4
ECE462	Engineering Design III	2

SECOND MAJOR IN ELECTRICAL ENGINEERING

The ECE Department will not allow the following second major combinations:

1. Degree in Electrical Engineering and a Second Major in Computer Engineering.
2. Degree in Computer Engineering and a Second Major in Electrical Engineering.

Other students outside of ECE can get a second major in EE by completing all of the courses in a required plan.

EE Second Major

Course Number	**Course Title**	**Credits**
ECE160	Engineering Practice	2
ECE180	Introduction to Signal Processing	4
ECE203	DC Circuits	4
ECE204	AC Circuits	4

ECE205	Circuits Systems	4
ECE230	Introduction to Microcontrollers	4
ECE233	Introduction to Digital Systems	4
ECE250	Electronic Device Modeling	4
ECE300	Continuous-Time Signals Systems	4
ECE310	Communication Systems	4
ECE320	Linear Control Systems	4
ECE340	Electromagnetic Fields	4
ECE341	Electromagnetic Waves	4
ECE351	Analog Electronics	4
ECE370 ECE371	Power & Energy Systems or Sustainable Energy Systems	4
ECE380	Discrete-Time Signals and Systems	4
MA381	Introduction to Probability with Applications to Statistics	4
Total		**66**

MINOR IN ELECTRICAL AND COMPUTER ENGINEERING (ECE)

The Minor in ECE is designed to allow students to add another dimension to their Rose-Hulman degree.

Advisor - ECE Department Head

Requirements for Minor in ECE

- ECE203 or ES203 (not both)
- Plus five additional ECE courses, except ECE362, ECE460, ECE461, ECE462, ECE466, and ECE206

AREAS OF CONCENTRATION

Concentration In Energy Production, Utilization, And Forecasting

Rising energy costs, air pollution, climate change, petrochemical production, environmental friendly and green processes and machines, alternative power sources and renewable energy are some of the topics topping local, national and international news. Rose-Hulman offers a series of courses, across several disciplines that broadens, educates and addresses solutions to these relevant contemporary issues.

Students who complete any five of the recommended courses in Energy Production, Utilization, and Forecasting area of concentration may receive, upon request, a letter from their Department Head, a certificate and transcript annotation attesting to the fact that the student has completed the requirements in this area of concentration in the Energy Production, Utilization, and Forecasting. With proper planning, students should be able to take these course offerings without overload.

Recommended Energy Production, Utilization, and Forecasting Concentration Courses.

- CE 561 Air Pollution
- CE 590 Climate Change Assessment
- CHE 490 Energy and the Environment
- CHE 512 Petrochemical Processes
- ECE 370 Power & Energy Systems
- ECE 371 Sustainable Energy Systems
- ME 407 Power Plants
- ME 408 Renewable Energy

ENHANCED STUDY IN COMMUNICATION SYSTEMS

Communications Concentration (intended for students majoring in EE or CPE)

ECE 310 Communication Systems plus any three courses from the list

- ECE 312 Communication Networks
- ECE 412 Software Defined Radio
- ECE 414 Wireless Systems
- ECE 415 Wireless Electronics
- ECE 418 Fiber Optic Systems
- ECE 510 Error Correcting Codes
- ECE 511 Data Communication
- ECE 553 Radio-Frequency Integrated Circuit Design

Communications Certificate (intended for students majoring in EE or CPE)

- ECE 300 Continuous-Time Signals Systems
- ECE 380 Discrete-Time Signals and Systems
- ECE 310 Communication Systems
- MA 381 Introduction to Probability with Applications to Statistics

plus any four courses from the above Communications Concentration list.

Minor in Communications (Minor in ECE with a Communications Focus) (intended for students not majoring in EE or CPE)

- ECE203 DC Circuits
- ECE204 AC Circuits
- ECE205 Circuits and Systems
- ECE300 Continuous-Time Signals Systems
- ECE310 Communication Systems

plus one additional course from the above Communications Concentration list.

ENHANCED STUDY IN POWER SYSTEMS

Power Certificate

Take all of the following courses:

- ECE 473 Control of Power Systems, Pre: ECE 470
- ECE 472 Power Systems II, Pre: ECE 470
- ECE 471 Industrial Power Systems, Pre: ECE 370
- ECE 470 Power Systems I, Pre: ECE 370
- ECE 371 Sustainable Energy Systems ,Pre: ECE 204
- ECE 370 Power & Energy Systems, Pre: ECE 204
- ECE 204 AC Circuits, Pre: ECE203 with a grade of C or better and PH113
- ECE 203 DC Circuits, Pre: MA111 and PH112

Optical Communications Certificate

Faculty advisors: B. Black and S. Granieri

Rose-Hulman has become a leader in providing opportunities for students to choose a great mainstream degree program with flexibility to specialize in other areas of interest. This leadership is in no way limited to only traditional areas of study. One of these new areas that had a high impact in technology is optical communications. It is a rapidly growing field requiring investment beyond the traditional program structure, and is well suited to the students at Rose-Hulman All these topics are closely related to well established disciplines as optics and electronics. Considerable R&D efforts are allocated in both university and industrial laboratories enhancing the demand for both researchers and engineers with expertise in the field.

We propose the creation of a new certificate program in Optical Communications to enhance the programs currently offered. Combining expertise in Optical and Electrical Engineering, this program requires an interdisciplinary emphasis that is beyond the traditional content of either of its parent programs. This program is more than just the creation of the certificate program Optical Communications. This program will be critical to help developing a more interdisciplinary interaction for students and faculty. The creation of a workgroup within the faculty of both departments will coordinate current courses and resources, create new courses of interest for the field, and develop a showcase testbed education and research laboratory. Primary objectives include the removal of redundancy from existing courses, increasing interaction between the PHOE and ECE departments, and improving opportunities for students in the field.

This certificate is designed to give the student a firm theoretical and practical working knowledge in the area of fiber optic devices, optical communications, networks and its applications. The main purpose is to couch these fundamentals in a context that serves as the backbone for device, components and sub-system development for use in high-speed optical data and information links and networks. At the end of the program the student will be expected to:

1. Understand the fundamental operation characteristics of high speed optoelectronic components, such as laser transmitters, light modulators and receivers and passive fiber optic components as connectors, couplers, filters, and switches.
2. Understand the technology and performance of analog and digital fiber optic links, optical amplification and optical wavelength division multiplexing and optical time division multiplexing networks.
3. Have a hands-on working knowledge of the use of fiber optic test equipment and techniques used by industry and telecommunication companies to test the performance of optical fiber links and components, such as, optical time domain reflectometry, optical spectrum analyzers and optical bit error testing equipment.

The Certificate will consist of 20 credit hours of which 12 credit hours will be required courses. Students interested in pursuing this Certificate should contact an ECE/PHOE certificate advisor (Professors Black, Bunch, and Granieri)

Required Courses

- ECE 310 Communication Systems
- OE 393 Fiber Optics and Applications
- OE 493 Fundamentals of Optical Fiber Communications

Elective Courses (two from the list)

Only courses not required for the student's major will count for electives in the certificate.

- ECE 380 Discrete-Time Signals and Systems
- ECE 312 Communication Networks
- ECE 414 Wireless Systems
- OE 360 Optical Materials and Opto-mechanics
- OE 435 Biomedical Optics
- OE 450 Laser Systems and Applications
- OE 485 Electro-Optics and Applications

Plan of Study

Freshman

Fall

Course	Credit
PH 111 Physics I	4
MA 111 Calculus I	5
CLSK 100 College & Life Skills	1
RH 131 Rhetoric & Composition or HSS Elective	4
ECE 160 Engineering Practice	2
	Total Credits: 16

Winter

Course	Credit
PH 112 Physics II	4
MA 112 Calculus II	5
CSSE 120 Introduction to Software Development	4
RH 131 Rhetoric & Composition or HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
PH 113 Physics III	4
MA 113 Calculus III	5
ECE 203 DC Circuits	4
ECE 180 Introduction to Signal Processing	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
CHEM 111 General Chemistry	4
ECE 204 AC Circuits	4
ECE 233 Introduction to Digital Systems	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra and Systems of Differential Equations	4
ECE 230 Introduction to Embedded Systems	4
ECE 205 Circuits & Systems	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
MA 381 Introduction to Probability with Applications to Statistics	4
ECE 300 Continuous-Time Signals & Systems	4
ECE 370 Power & Energy Systems or ECE 371 Sustainable Energy Systems	4
ECE 250 Electronice Device Modeling	4
	Total Credits: 16

Junior

Fall

Course	Credit
ECE 380 Discrete-Time Signals & Systems	4
ECE 351 Analog Electronics	4
ECE 340 Electromagnetic Fields	4
RH 330 Technical & Professional Communication	4
	Total Credits: 16

Winter

Course	Credit
ECE 320 Linear Control Systems	4
HSS Elective	4
ECE 341 Electromagnetic Waves	4
Math/Science Elective	4
	Total Credits: 16

Spring

Course	Credit
ECE 310 Communications Systems	4
Area Elective	4
HSS Elective	4
ECE 362 Principles of Design	3
	Total Credits: 15

Senior

Fall

Course	Credit
ECE 460 Engineering Design I	3
Math Elective	4
Area Elective	4
HSS Elective	4
	Total Credits: 15

Winter

Course	Credit
ECE 461 Engineering Design II	4

Tech Elective	4
Area Elective	4
HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
ECE 462 Engineering Design III	2
Tech Elective	4
HSS Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 18

AREA ELECTIVES

At least two of the three Area Electives must bear an ECE prefix at the 400 level or above
At most one of the Area Electives can bear an ECE or CSSE prefix at the 300 level or above
Exceptions to this requirement may be granted by the ECE Department Head

TECHNICAL ELECTIVE - Any course NOT bearing a GS, RH, IA, SV, GE, JP, and SP prefix

NOTES

1. MA 351-356 Problem Solving Seminar may not be combined and substituted for the math elective.
2. EE seniors are strongly encouraged to take MA 371 Linear Algebra I or MA 373 Applied Linear Algebra for Engineers
3. EE majors are not permitted to take ECE 206 Elements of Electrical Engineering as a free electives or technical elective. Free electives may be selected from any other R-HIT courses.
4. EE majors may take any additional mathematics or biomathematics classes to satisfy the departmental mathematics requirement, and any biology, chemistry, geology or physics courses to satisfy the departmental science requirement. Courses that are cross-referenced with any engineering courses will not satisfy either the mathematics or science requirements.

Rose-Hulman Institute of Technology Course Catalog

Engineering Physics

The Department of Physics and Optical Engineering has provided both science and engineering foundation at Rose-Hulman Institute of Technology through its physics and optics engineering programs. Physics is the foundation subject to all engineering and through the study in engineering physics we aim at blending a strong physics component with relevant engineering backgrounds that are usually necessary to work in areas such as semiconductor, optical technologies, biomedical applications, mechanical, electrical, and civil engineering, and polymer and biochemistry. The students will get their traditional undergraduate engineering education that has a broad foundation in mathematics, engineering sciences and technology. This program emphasizes problem solving skills and an understanding of engineering design to address the needs and challenges of the technology age and allow students to take a broad range of engineering careers.

Engineering Physics at Rose-Hulman will provide students with a unique opportunity to learn the foundation concepts of physics and make a concentrated study in micro and nano technology. Engineering physicist will be able to apply both scientific and engineering approaches to a wide variety of problems which otherwise is not possible with any traditional engineering or science degree. Rose-Hulman's engineering physics graduates will be trained to take up challenging jobs in engineering and development of new technologies or to pursue further studies in engineering or physics.

Mission: To provide a coherent foundation of physics for all majors and a strong foundation of physics, engineering physics and optical engineering for our majors so that all students can acquire education appropriate to their majors. The engineering disciplines of optical engineering and engineering physics enable students to practice in their dynamic and progressive engineering professional careers with responsibility to society.

Vision: To cultivate in the students responsibility, independence, and knowledge that allows them to be fully engaged in all disciplines, to continuously improve the curriculum, and to be engaged in professional development.

EP Program Educational Objectives

1. Our graduates will set their career path and advance beyond their entry-level position or progress toward the completion of an advanced degree.
2. Our graduates will contribute to society locally, nationally or globally
3. Our graduates will collaborate within their organization; and be active in research and development in a relevant area of science and technology.
4. Our graduates will continue to develop professionally.

EP Student Learning Outcomes

Outcome A:	Knowledge of the Fundamentals: An understanding of the fundamentals of science and engineering.
Outcome B1:	Interpreting Data: Ability to interpret graphical, numerical, and textual data.

Outcome B2:	System Level Modeling: Ability to model components and system level engineering problems.
Outcome B3:	Experimentation: Ability to design and conduct experiments to understand the relationships between variables in a problem which may or may not have been mathematically modeled before.
Outcome C:	Design: Ability to design a product or process to satisfy client's needs subject to constraints.
Outcome D:	Team work and Deliverables: Ability to work in teams and understand the effective team dynamics and be able to deliver a product.
Outcome E:	Problem Solving: Ability to apply relevant scientific and engineering principles to solve real world engineering problems.
Outcome F:	Professional Practice and Ethics: Sound understanding of what a Materials professional is, and an awareness and understanding of professional ethics.
Outcome G:	Communication: Ability to communicate effectively in oral, written and visual forms.
Outcome H:	Contemporary issues, non-technical issues, global awareness: An awareness of contemporary and non-technical issues in engineering profession and the role of professionals in an interdependent global society.
Outcome I:	Life Long Learning: A facility for independent learning and continued professional development.

Courses taken in the respective departments:

Subjects	**#Classes**	**Hours**
Physics(PH)	10	40
Math(MA)	6	27
Chemistry(CHEM)	2	8
ME	1	4
EM	3	8
CLSK	1	1
Electrical Engineering	2	8
Optical Engineering (OE)	2	6
HSS	9	36
Engineering Physics (EP)	6	24
Engineering Physics Project(EP)	3	12
Elective(SEM, Eng. and Free)	5	20
Total	**50**	**194**

SUMMARY OF GRADUATION REQUIREMENTS FOR ENGINEERING PHYSICS

1. All the courses listed above by the number.
2. The program must be approved by the EP advisor.
3. A list of the engineering electives is provided.
4. SEM (Science, Engineering, Math) electives are courses that need to be taken at the 200 level (CHEM115 is allowed) or above in biology, biomathematics, chemistry, computer science, engineering, mathematics or physics.
5. A free electives is any course in engineering, science, humanities, military science, or air science.

Classes by Subjects	Hours
Physics Coursework*	40
Chemistry and Mathematics Coursework**	35
Humanities and Social Science(Standard requirement)	36
EM, ME, CLSK Courses	13
Electrical Engineering Courses	8
Optical Engineering Courses	6
EP Courses	24
EP Projects	12
Engineering Electives	12
SEM and Free Electives	8
Total	**194**

Foundation Physics Classes

Course	Description	Hours
PH 235	Many Particle Physics	4
PH 255	Modern Physics	4
PH 316	Electric & Magnetic Fields	4
PH 317	Electromagnetism	4
PH 327	Thermodynamics and Statistical Mechanics	4
PH 401	Introduction to Quantum Mechanics	4
Total		**24**

General Foundation Classes

Course	Description	Hours
PH 111	Physics I	4
PH 112	Physics II	4
PH 113	Physics III	4
MA 111	Calculus I	5

MA 112	Calculus II	5
MA 113	Calculus III	5
MA 211	Differential Equations	4
MA 212	Matrix Algebra and Systems of Differential Equations	4
MA 223	Engineering Statistics	4
CHEM 111	General Chemistry I	4
CHEM 113	General Chemistry II	4
Total		**47**

Engineering Sciences Foundation

Course	**Description**	**Hours**
EM 104	Graphical Communications	2
EP 180	Engineering at Nanoscale	2
EM 121	Statics I	4
ECE 203	DC Circuits	4
ECE 204	AC Circuits	4
EP 280	Introduction to Nano-engineering	4
EP 380	Nanotechnology, Entrepreneurship and Ethics	4
OE 295	Photonic Devices and Systems	4
PH 405	Semiconductor Materials and Applications	4
EP 406	Semiconductor Devices and Fabrication	4
EP 410	Introduction to MEMS; Fabrication and Applications	4
EP 411	Advance Topics in MEMS	4
EP 407	Semiconductor Fabrication % Characterization	4
	Engineering Elective	12
ME123	Computer Applications	4
Total		**64**

Design Sequence

Course	Description	Hours
EM 103	Introduction to Design	2
EP 415	Engineering Physics Projects I	4
EP 416	Engineering Physics Projects II	4
EP 417	Engineering Physics Projects III	4
Total		**14**

Approved Engineering 200-Level Electives (4 credit hours required)

- ECE 205 Circuits and Systems
- ES 201 Conservation and Accounting Principles
- ES 202 Fluid and Thermal Systems
- EM 204 Statics II
- OE 280 Geometric Optics
- EP 290 Directed Study
- EP 490 Directed Study

Approved Engineering Electives

- OE 360 Optical Materials
- OE 393 Fiber Optics
- OE 437 Introduction to Image Processing
- OE 450 Laser Systems and Applications
- OE 495 Optical Metrology
- EP 330 Materials Failure
- EP 450 Nanomedicine
- EP 470 Special Topics in Engineering Physics
- EP 490 Directed Study
- CHE 315 Materials Science and Engineering
- ME 328 Materials Engineering
- ME 417 Advanced materials Engineering
- ME 422 Finite Elements for Engineering Applications
- EM 403 Advanced Mechanics of Materials
- ECE 351 Analog Electronics
- ECE 250 Electronic Device Modeling

Plan of Study

Freshman

Fall

Course	Credit
PH 111 Physics I	4

MA 111 Calculus I	5
CLSK 100 College & Life Skills	1
CHEM 111 General Chemistry I	4
EM 104 Graphical Communications	2
	Total Credits: 16

Winter

Course	Credit
PH 112 Physics II	4
MA 112 Calculus II	5
CHEM 113 General Chemistry II	4
RH 131 Rhetoric and Composition	4
	Total Credits: 17

Spring

Course	Credit
PH 113 Physics III	4
MA 113 Calculus III	5
ME 123 Computer Applications I	4
EP 180 Engineering at Nanoscale*	2
EM 103 Introduction to Design**	2
	Total Credits: 17

Sophomore

Fall

Course	Credit
ECE 203 DC Circuits	4
PH 235 Many Particle Physics	4
MA 211 Differential Equations	4
Science, Engineering or Math Elective	4
	Total Credits: 16

Winter

Course	Credit
EP 280 Intro to Nano Engineering	4
PH 255 Foundations of Modern Physics	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
ECE 204 AC Circuits	4
	Total Credits: 16

Spring

Course	Credit
EP 380 Nano Technology Entrepreneurship & Ethics	4
OE 295 Optical Systems	4
SV 151 Principles of Economics	4
EM 121 Statics	4
	Total Credits: 16

Junior

Fall

Course	Credit
PH 316 Electric & Magnetic Fields	4
ENG 200 Level Engineering Elective	4
PH 405 Semiconductor Materials & Applications	4
MA 223 Engineering Statistics I	4
	Total Credits: 16

Winter

Course	Credit
HSS Elective	4
PH 317 Electromagnetism	4
RH 330 Technical & Professional Communication.	4
EP 406 Semiconductor Devices & Fabrication	4
	Total Credits: 16

Spring

Course	Credit
PH 327 Thermodynamics & Stat Mech	4
EP 410 Intro to MEMS	4
EP 415 Engineering Physics Project I	4
HSS Elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
EP 416 Engineering Physics Project II	4
EP 407 Semiconductor Fabrication & Characterization	4
EP 411 Advanced MEMS	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
EP 417 Engineering Physics Project III	4
ENG 300/400 Engineering Elective	4
HSS Elective	4
PH 401 Intro Quantum Mechanics	4
	Total Credits: 16

Spring

Course	Credit
HSS Elective	4
HSS Elective	4
ENG Engineering Elective	4
Free Free Elective	4
	Total Credits: 16

NOTES

*If students miss EP 180 in the freshmen or sophomore year, this requirement must be replaced with a 300 or 400-level EP course of at least 2 credits.
EP course descriptions are listed under the Physics and Optical Engineering Department.

International Computer Science

The International Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

Computer science is a rapidly changing discipline. The lifetime of a particular computer system or software package can be very short. The international computer science curriculum is designed to prepare students for multiple careers in a rapidly changing, global environment. The program's courses emphasize fundamental concepts and techniques that will last longer than present technology.

International computer science majors complete a core of basic computer science courses that includes the study of algorithms, data structures, database concepts, computer systems, computer architecture, programming languages, operating systems, and software engineering. Advanced courses in theory of computation, computer networks, distributed systems, security, and real time systems add depth to the degree program. A three-term senior thesis provides students the opportunity to research in depth an area of computer science that is of interest to them under the mentorship of a faculty member. Majors also complete important courses in closely related fields, e.g., discrete mathematics and probability and statistics, as well as study a foreign language. The major requires students to study all aspects of the science of computing, including hardware, software, and theory.

Five free electives allow students to tailor their undergraduate education to their specific goals and pursue topics of interest to them. Students may choose to do advanced elective work in computer science and software engineering and/or in the humanities and social sciences, and/or pursue a minor or double major in another discipline.

Programming assignments and large projects are part of most computer science courses. These assignments familiarize students with the wide variety of tasks performed by software professionals. Programming assignments include system specification, system feasibility studies, system design, system maintenance studies, and user interface design in addition to system implementation (i.e., coding), testing (verification and validation), and documentation. Projects include both individual and team activities and require appropriate written and oral presentations.

The department has its own local area network. This network is connected to the campus-wide network and the Internet. Department laboratories provide docking stations and large screen monitors for students to attach their laptops to. International computer science majors have unlimited access to the department's laboratories.

The department has active programming teams that compete in the ACM Programming Contest and the Collegiate Cyber Defense Competition. The national computer science honor society, Upsilon Pi Epsilon, has chartered its Indiana Alpha Chapter at Rose-Hulman; it sponsors several seminars throughout the year.

International Computer Science Program Educational Objectives

Graduates from the international computer science program will be prepared for many types of careers in the field of computing and prepared for graduate study in computer science and in closely related disciplines. In the early phases of their careers, we expect Rose-Hulman international computer science graduates to be:

1. Computing professionals in a variety of organizations, including ones doing traditional software development, technological innovation, and cross-disciplinary work
2. Business and technological leaders within existing organizations
3. Entrepreneurial leaders
4. Recognized by their peers and superiors for their communication, teamwork, and leadership skills
5. Actively involved in social and professional service locally, nationally, and globally
6. Graduate students and researchers
7. Leaders in government and law as government employees, policy makers, governmental advisors, and legal professionals

International Computer Science Student Outcomes

By the time students graduate with an international computer science degree from Rose-Hulman, they will be able to:

1. Effectively apply a variety of computing resources, programming languages, programming paradigms, operating systems, networks, and software development tools
2. Anticipate complexities and problems involved in the development of large computing systems
3. Analyze requirements, design computing systems that satisfy those requirements, and implement that system
4. Analyze problems and design solutions using ideas of problem complexity, models of computation, decidability, and scalability
5. Analyze algorithms in terms of correctness, as well as time and space efficiency
6. Evaluate and discuss the legal, social, and ethical aspects of significant events that arise in the field of computing both domestically and internationally
7. Interact effectively with colleagues and clients located abroad and overcome challenges that arise from geographic distance, cultural differences, and multiple languages
8. Communicate effectively, both orally and in writing
9. Collaborate effectively in teams
10. Recognize the need for, and engage in, lifelong learning
11. Understand the structure and functionality of modern computer systems
12. Live and work in the computing field in a country other than their native country
13. Demonstrate proficiency in a second language that allows them to interact effectively with colleagues and clients in their field

The faculty strives to maintain an open atmosphere that encourages mutual respect and support as well as learning and sharing of knowledge.

Summary of graduation requirements for the international computer science major

HSS electives must be distributed as required by HSS. Science elective is any CHEM, PH, GEOL, or BIO course(s) totaling at least 4 credits.

To complete the major in international computer science a student must complete the following:

1. All required courses listed by number, symbol, or name in the schedule of courses above: CSSE 120, CSSE 132, CSSE 212, CSSE 220, CSSE 230, CSSE 232, CSSE 304, CSSE333, CSSE or MA 473, CSSE or MA 474, and CSSE 494-6; MA 111, MA 112, MA 113, MA 212, MA 275, MA 371 or MA 373, MA 375, MA 381; PH 111, PH 112; CHEM 111; RH 131, RH 330; GE 111, GE 112, GE 113; CLSK 100; Software Project (CSSE 371), Seminar (CSSE 400), Programming 3 (CSSE 225), Digital Systems(ECE 233), Software Engineering (CSSE 374), Operating Systems (CSSE 332), Computer Networks (CSSE-432), Technical German.
2. Eight credits of additional computer science courses (Special Subject A (Module I) and Special Subject A (Module II)) numbered between 200 and 492. No more than four credits may be at the 200 level, and none of the credits may be from CSSE 372, 373, 375, 376, and 477. The students academic advisor must approve the courses to satisfy this requirement. (Use of computer science courses numbered 490 through 492 to fulfill this requirement must be approved by the department head).
3. Four credits of science electives, which can be any CHEM, PH, BIO, or GEOL courses not already required for the international computer science major.
4. Twelve credits of additional courses offered by the Department of Humanities and Social Sciences and/or appropriate humanities or social science courses offered at Hochschule Ulm. The distribution of these courses must meet the requirements of the Department of Humanities and Social Sciences at Rose-Hulman.
5. Sixteen credits of free elective courses. These courses must have the approval of the student's academic adviser. Free electives may be selected from any Rose-Hulman course.
6. A total of 192 credits.

See Computer Science for course descriptions.

Plan of Study

Freshman

Fall

Course	Credit
CSSE 120 Introduction to Software Development	4
MA 111 Calculus I	5
PH 111 Physics I	4
RH 131 Rhetoric & Composition	4
CLSK 100 College & Life Skills	1
	Total Credits: 18

Winter

Course	Credit
CSSE 220 Object-Oriented Software Development	4
MA 112 Calculus II	5
PH 112 Physics II	4
HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CSSE 132 Inroduction to Computer Systems	4
MA 113 Calculus III	5
CHEM 111 General Chemistry I	4
HSS Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CSSE 232 Computer Architecture I	4
GE 111 German Language and Culture I	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
CSSE 230 Data Structures & Algorithm Analysis	4
	Total Credits: 16

Winter

Course	Credit
CSSE 304 Programming Language Concepts	4
RH 330 Technical & Professional Communication	4
GE 112 German Language & Culture II	4
MA 275 Discrete & Combinatorial Algebra I	4
	Total Credits: 16

Spring

Course	Credit
MA 375 Discrete & Combinatorial Algebra II	4
GE 113 German Language and Culture III	4
MA 381 Introduction to Probability with Statistical Applications	4
CSSE 333 Database Systems	4
	Total Credits: 16

Junior

Fall

Course	Credit
(CSSE225) Programming 3	4
(CSSE371) Software Project	4
(CSSE400) Seminar	4
(CSSE Elective) Special Subject A (Module 1)	4
(HSS Elective) Technical German	4
(ECE233) Digital Systems	4
	Total Credits: 24

Winter

Course	Credit
(CSSE212) Hardware-oriented Programming	4
(CSSE332) Operating Systems	4
(CSSE374) Software Engineering	4
(CSSE432) Computer Networks	4
(CSSE Elective) Special Subject A (Module 2)	4
Free Elective	4
	Total Credits: 24

Senior

Fall

Course	Credit
CSSE 494 Senior Thesis I	4

MA371 Linear Algebra I or MA373 Applied Linear Algebra for Engrs	4
Science Elective	4
Free Elective	4
	Total Credits: 16

Winter

Course	Credit
CSSE 495 Senior Thesis II	4
CSSE/MA 474 Theory of Computation	4
HSS Elective	4
Free Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 496 Senior Thesis III	4
CSSE/MA 473 Design & Analysis of Algorithms	4
Free Elective	4
	Total Credits: 12

NOTES:

*Junior Year is at Hochschule Ulm, Germany and is two semesters.

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Mathematics

Why study mathematics? Many of the new wonders that we take for granted in our modern technological society have mathematical ideas and applications as their basis, though this role is often hidden from view. Complex economic and planning decisions, scientific discoveries that improve our lives, and new technologies and products are often possible only after mathematical or statistical analysis, or a computer visualization, simulation, design and implementation based on mathematics. Therefore, mathematicians, as well as mathematically educated scientists, engineers and economists, make important daily contributions in the understanding and advancement of science, the improvement and discovery of new technology, and decision-making and planning in business, industry and government. Students interested in using their mathematical skills in solving real world problems are well prepared, by majoring or minoring in mathematics, for careers such as in the insurance industry, software design, data and systems analysis, scientific computing, combustion research, the animated movie industry, and cryptanalysis to name a few, or a graduate degree in a related technical field. Those students with a very strong interest in mathematics itself can pursue graduate study in mathematics in preparation for careers as university or college mathematics teachers and in the development of new mathematical and statistical concepts and methods as researchers in academia, government and industry.

The curriculum of the program in the Department of Mathematics is designed to provide a broad education in both theoretical and applied mathematics. It also develops the scientific knowledge and the problem solving, computing, and communications skills that are critical to a successful mathematically based career. This preparation is greatly enhanced by taking advantage of the wide variety of science and engineering courses available to students and developing good communications skills, both through technical courses and the strong humanities program. The program offers a solid grounding in the foundational areas of calculus, differential equations, linear algebra, discrete and combinatorial algebra, and probability and statistics. These basic courses are complemented by a varied selection of upper division courses for further elective study in areas such as numerical analysis, operations research, advanced statistics, mathematical modeling, optimization, and other advanced topics in mathematics. Students are encouraged to develop a strong background in an area of science or engineering through election of courses leading to a minor or double major. By appropriate course selection students may complete a double major in mathematics and another field such as computer science, physics, chemistry, applied biology, or economics.

PROGRAM GOALS AND OBJECTIVES

To provide a foundation for further learning as well as contributing to the general education of students, the programs at Rose-Hulman all have a heavy investment in mathematics and science in the first two years. The freshman and sophomore mathematics curriculum is designed to contribute to this foundation by ensuring that students are familiar with basic mathematical and statistical concepts, and mathematical and statistical reasoning and modeling. Students will also understand the use of mathematics in other disciplines as well as developing an appreciation of mathematics as a discipline in its own right. In addition, students will learn to be competent users of mathematics, especially in problem solving, and be able to effectively communicate mathematically. The curriculum makes strong use of computer methods to develop students' mathematical understanding and to enhance their ability to use the computer in modeling, computation and problem solving.

For students seeking a major in mathematics, the curriculum prepares them for a mathematically based career after graduation or further graduate study. The major builds upon the goals and objectives of the freshman and sophomore curriculum. In addition to a deeper and broader study of mathematics, majors will further develop their ability to formulate and solve problems from a mathematical perspective, become familiar with the use of mathematics in other fields, and develop competence at the application of mathematics to at least one other field. Graduates will also be able to use technology effectively in mathematics and the application of mathematics. To complement these technical skills graduates will learn the professional skills of effective communication with both technical and non-technical audiences and the ability to work cooperatively with others.

DEGREE REQUIREMENTS

Major Concentrations: Mathematics majors choose to complete their program in one of four concentrations: Mathematics, Continuous Applied Mathematics, Discrete Applied Mathematics, or Statistics and Operations Research. The Mathematics concentration provides the foundational mathematical depth of a traditional mathematics major and is intended for students planning on graduate study in an area of mathematics. In applied mathematics there are two areas: the Continuous Applied Mathematics concentration and the Discrete Applied Mathematics concentration. Students selecting these concentrations may tailor their programs to interface with another major or to enhance industrial employment or graduate school opportunities. The Statistics and Operations Research concentration is recommended for students pursuing careers in actuarial science, graduate study in statistics, or employment in government or industry in a statistical capacity. It is strongly recommended that students considering graduate education in mathematics include MA 376 Abstract Algebra among their elective mathematics courses. Upon graduation a student may request the Head of the Mathematics Department to issue a letter attesting to the fact that the requirements in the chosen concentration have been completed.

Mathematics Coursework Requirements: All mathematics majors must complete a common core consisting of 39 credit hours of mathematics coursework, which provides breadth across the main areas of mathematics. A mathematics major must also complete an additional 12 credit hours of mathematics coursework specified for the selected major concentration plus an additional 12 credit hours earned in free elective mathematics or biomathematics courses. In addition, a mathematics major must complete 8 credit hours of either a senior thesis or project, meant as a capstone experience to the major. A total of 71 credit hours of mathematics courses is required for the major. None of the credits in the 71 hours above may be taken from the courses MA190, MA351-MA356, MA450 or MA223 (unless approved by the department head). These courses (except MA190) may be taken as free electives. Finally, a student taking a degree program in which mathematics is the primary major must also take MA190. A student whose second major is mathematics is not required to take MA 190, but is strongly encouraged to do so.

Common Required Core	**39 hrs.**
MA 111, 112, 113 Calculus I, II, III	15 hrs.

MA 211 Differential Equations	4 hrs.
MA 212 Matrix Algebra and Systems of Differential Equations	4 hrs.
MA 275 Discrete and Combinatorial Algebra I	4 hrs.
MA 366 Functions of a Real Variable	4 hrs.
MA 371 Linear Algebra I	4 hrs.
MA 381 Introduction to Probability with Applications to Statistics	4 hrs.

Mathematics Concentration Core **12 hrs.**

Three courses selected as follows:

MA 367	Functions of a Complex Variable	4 hrs.
MA 376	Abstract Algebra	4 hrs.
One of the following		4 hrs.
MA 433	Numerical Analysis	
MA 436	Introduction to Partial Differential Equations	
MA 446	Combinatorial Optimization	
MA 481	Introduction to Mathematical Statistics	

Continuous Applied Mathematics Concentration Core **12 hrs.**

Three courses selected per the list below. Students completing the Continuous Applied Mathematics Concentration are strongly urged to complete mathematics coursework in statistics as elective coursework.

MA 330	Vector Calculus	4 hrs.
MA 336	Boundary Value Problems	4 hrs.
MA 433	Numerical Analysis	4 hrs.

Discrete Applied Mathematics Concentration Core **12 hrs.**

Three courses selected per the list below. Students completing the Discrete Applied Mathematics Concentration are strongly urged to complete mathematics coursework in statistics as elective coursework.

MA 375	Discrete and Combinatorial Algebra II	4 hrs.
MA 444	Deterministic Models in Operations Research	4 hrs.
One of the following		4 hrs.
MA 376	Abstract Algebra	
MA 475	Topics in Discrete Mathematics	

MA 476	Algebraic Codes	
MA 477	Graph Theory	

Statistics and Operations Research Concentration Core 12 hrs.

Three courses selected per the list below. Students completing the Statistics and Operations Research Concentration are strongly urged to complete mathematics coursework in applied mathematics as elective coursework.

MA 382	Introduction to Statistics with Probability	4 hrs.
MA 444	Deterministic Models in Operations Research	4 hrs.
One of the Following		4 hrs.
MA 445	Stochastic Models in Operations Research	
MA 446	Combinatorial Optimization	
MA 481	Introduction to Mathematical Statistics	
MA 485	Applied Regression Analysis and Introduction to Time Series	
MA 487	Design of Experiments	

It is strongly suggested that the student take as many of the above courses as possible.

Free Mathematics Electives—12 hrs.

Additional mathematics and biomathematics coursework in courses numbered 300 or above (MA 351- MA 356, MA 450, BMTH496-498 not allowed).

MA 190 – Contemporary Mathematical Problems (2 hrs.) A student taking a degree program in which mathematics is the primary major must also take MA 190. A student whose second major is mathematics is not required to take MA190, but is strongly encouraged to do so.

Senior Project or Thesis (8 hrs.) A student must complete either a Senior Project, equivalent to the 8 credit hours of MA 491 – 494, or a Senior Thesis, equivalent to the 8 credit hours of MA 496 – 498. The project and thesis are each important capstone experiences for the mathematics major, representing sustained efforts to solve a complex problem from industry, mathematics modeling or application, or mathematical research.

Senior Project Option: Students seeking to do a senior project must complete a written project involving effort equivalent to the 8 credit hours of MA491 – 494. Specifically,

- MA 493 and MA 494 must be taken in separate terms.

- The requirement of MA 491-492 may be fulfilled through some project experience (such as an internship) and another 300-level or above mathematics course (4 hours), as approved by the project advisor. The course substitution procedure must be used.
- The project must involve work done by the student(s) to solve a problem presented by an external sponsor or a problem with a substantial mathematical modeling, application and/or computational content. The written project submission must be approved by the advisor and/or sponsor and must be presented publicly to the department.

Senior Thesis Option: Students seeking to do a senior thesis must complete a written thesis involving effort equivalent to the 8 credit hours of MA496 – MA 498. Specifically,

- MA 497 and MA 498 must be taken in separate terms.
- The requirement of MA 496 may be fulfilled through some undergraduate research experience and an additional 300-level or above mathematics course (4 hours), as approved by the thesis advisor. The course substitution procedure must be used.
- The thesis must involve creative work done by the student and a significant portion of this work must have been done by the student individually (not as part of a team).
- The approved written thesis must be submitted to the department for archiving and must be publicly presented to the department.

Summary of Requirements

Mathematics Coursework - core, concentration and electives (MA351-MA356, MA450, BMTH496-498 not allowed)	63 hrs.
Mathematics Senior Project/Thesis	8 hrs.
MA 190 - Contemporary Mathematical Problems (primary major only)	2 hrs.
Physical and Life Sciences*	24 hrs.
Computer Science**	8 hrs.
Humanities and Social Science (standard requirement, one course must be RH330)	36 hrs.
Technical Electives***	24 hrs.
Free Electives	28 hrs.
Miscellaneous****	2 hr.
Total hours required for graduation	**195 hrs.**

*	PH 111, 112, and 113 — Physics I, II, and III	12 hrs.
	BIO 101 — Essential Biology (or higher-level BIO course)	4 hrs.
	CHEM 111 — General Chemistry I	4 hrs.

	4 additional credit hours in Physical or Life Sciences	4 hrs.
**	CSSE 120 — Introduction to Software Development	4 hrs.
	CSSE 220 — Object-Oriented Software Development	4 hrs.
	MA 332 - Introduction to Computational Science - may be taken instead of CSSE 220 but then MA 332 cannot be counted towards the 63 hours of mathematics coursework	
***	200 level or above coursework, approved by the major advisor, in areas of science, engineering, or economics in which 12 credit hours constitute a coherent set of three courses representing a specific area of technical depth and 12 credit hours represent technical breadth. Coursework in mathematics and biomathematics is not allowed.	24 hrs.
****	CLSK 100 — College and Life Skills	1 hr.
	MA 200 - Career Preparation (primary major only)	1 hr.

SUGGESTED SCHEDULE

The schedule (Course Sequence) on the right is a suggested schedule only. Scheduling of courses may be altered, subject to the approval of the advisor, in order to take advantage of advanced placement or to accommodate a second major, area minor or other special program. However, note that some courses are offered only at certain times during the year, and all prerequisites must be met. In the schedule an MA elective is either a concentration elective or free math elective, as described above, and a science elective is a physical or life science elective as defined on this page.

Alternate Science Schedule: The recommended science schedule of six science courses starts with PH 111. If CHEM 111 is required in the fall quarter because of a double major or minor, then the alternate science sequence may be completed by taking the second science course in each place where a choice is given. Two science courses are to be taken in the winter quarter of freshman year.

COMPUTATIONAL SCIENCE MAJOR (CPLS) (Second Major Only)

Computational methods are widely employed in science and engineering for simulation, experimentation, analysis, and design. In many areas the use of high-performance computing is essential. The Computational Science major provides Rose-Hulman students with the opportunity to add to their primary major a second major that increases their knowledge and skill in applied scientific and engineering computation.

Requirements for a second major in Computational Science (71 credit hours)
The second major in Computational Science is open to all students. It requires 71 credit hours, including a 55 credit hour core and a 16 credit hour specialization. The courses used to satisfy the requirements in the Advanced Core may not be counted toward any other major or minor. All Computational Science programs of study are subject to approval by the Chair of the Computational Science Steering Committee

Computational Science Core (51 credit hours)

Fundamentals (31 credit hours)

- MA 111, 112, 113 Calculus I, II, III
- MA 211 Differential Equations
- MA 212 Matrix Algebra and Systems of Differential Equations
- CSSE 120 Introduction to Software Development, or any of BE 100, CE 111 (plus 2 cr.), CHE 110 (plus 2 cr.), ME 123
- MA 332 Introduction to Computational Science

Advanced (20 credit hours; these courses may not be counted toward any other major or minor)

- CSSE/MA 335 Introduction to Parallel Computing
- MA 336 Boundary Value Problems
- MA 342 Computational Modeling
- MA 435 or ME 422 Finite Difference Methods, Finite Element Methods for Engineering Applications

Any course from the list of Approved Computational Science Electives (or another upper-level course if approved by the Chair of the Computational Science Steering Committee):

- BE 340 Biomedical Signal Processing
- BE 510 Biomedical Signal and Image Processing
- BMTH 312 Bioinformatics
- BMTH 413 Computational Biology
- CHE 310 Numerical Methods for Chemical Engineers
- CE 310 Computer Applications in Civil Engineering
- CSSE 304 Programming Language Concepts
- ECE 480/OE 437 Introduction to Image Processing
- ECE 483 DSP System Design
- EMGT 534/MA 534 Management Science
- MA 323 Geometric Modeling
- MA 384 Data Mining
- MA 433 Numerical Analysis
- MA 434 Topics in Numerical Analysis
- MA 435 Finite Difference Methods
- MA 439 Mathematical Methods of Image Processing
- MA 444 Deterministic Models in Operations Research

- MA 446 Combinatorial Optimization
- ME 422 Finite Element Methods for Engineering Applications
- ME 427 Introduction to Computational Fluid Dynamics
- ME 430 Mechatronic Systems
- ME 522 Advanced Finite Elements Analysis
- ME 536 Computational Intelligence in Control Engineering
- PH 540 Computer Physics

Area of Concentration (20 credit hours): Each student must complete 20 credit hours of advanced work reflecting an Area of Concentration within Computational Science. Courses used to satisfy the core requirements may not be used to satisfy the area of concentration requirements. The 20 credit hours shall consist of at least 16 credit hours within a single Area of Concentration, as specified below, and an additional 4 credit hours from any of the Areas of Concentration, or from the list of Approved Computational Science Electives. Exceptions may be made on occasion (e.g. when an appropriate special topics course has been taken).

Computational Methods

- MA 371 or MA 373 Linear Algebra I, Applied Linear Algebra for Engineers
- MA 433 Numerical Analysis
- Eight credit hours chosen from BMTH 413, CSSE 304, CSSE/MA 473, MA 384, MA 386, MA 434, MA 435, MA439, MA 444, MA 446, MA 485, ME 422

Computational Mechanics

- MA 435 or ME 422 Finite Difference Methods, Finite Element Methods for Engineering Applications
- ME 401 Foundations of Fluid Mechanics
- ME 427 Introduction to Computational Fluid Dynamics
- ME 522 Advanced Finite Element Analysis

Computational Signals and Image Processing

- ECE 380 Discrete-Time Signals and Systems
- ECE 480/OE 437 Introduction to Image Processing
- ECE 483 DSP System Design
- MA 439 Mathematical Methods of Image Processing

Computational Physics and Chemistry

- CHEM 361 Physical Chemistry I
- CHEM 362 Physical Chemistry II
- CHEM 363 Quantum Chemistry & Molecular Specroscopy
- OE 570 Nanomedicine
- PH 540 Computer Physics

Computational Biomedics

- BE 482/MA 482 Bioengineering Statistics
- BE 535/OE 535 Biomedical Optics
- BE 541/ECE 584 Medical Imaging

- BMTH 310 Mathematical Biology
- BMTH 413 Computational Biology

MINOR IN MATHEMATICS

Any student not pursuing a major or second major in either mathematics or in biomathematics may obtain a minor in mathematics by taking 10 or more mathematics courses as follows:

- **Six courses in foundational mathematics**
  - Calculus, Differential Equations and Matrix Algebra: MA 111, MA 112, MA 113, MA 211, MA 212
  - Basic Probability and Statistics or Basic Statistics: one of MA 223, MA 381, or MA382
- **Sixteen additional credit hours of "upper division" courses:**
  - Courses selected from MA 275, all MA courses numbered 300 or higher (except MA351-356 and MA450, MA492-494, and MA496-498), all BMTH courses numbered 300 or higher (except BMTH 496-498), or other MA courses approved by the minor advisor for mathematics. Computer Science majors cannot use either MA 473 or MA 474 to satisfy both their computer science major requirements and the requirements of the mathematics minor.

Approval and Math Minor Form

All minors must be approved by the area minor advisor and the student's advisor. The department has a form for the planning and approval of a mathematics minor.

Notes and Limitations on Requirements:

- Almost all students are required to take six foundational courses as a requirement for their major; therefore only four "extra courses" are required for most students.
- Only MA111, MA112, MA113, MA211, MA212 and one of MA223, MA381, or MA382 can be counted towards any combination of the multiple minors offered by the mathematics department.
- No student can take both MA 371 and MA 373 for credit.
- No student can take both MA223 and MA382 for credit
- Except as noted above, if MA 381 is being counted towards the four additional courses then, MA 223 may be taken and counted towards the Basic Probability and Statistics.
- Science and engineering, especially the most recent "high tech" developments, have sophisticated mathematical and statistical concepts and methodologies as their foundation. Thus a well chosen set of courses for a mathematics minor (or a second major in mathematics) will greatly enhance a student's analytical and computational skills. Students thinking of going on to graduate school should especially give consideration to this option.

AREA MINOR IN COMPUTATIONAL SCIENCE

Any student may obtain an area minor in Computational Science by taking the following courses:

- Five courses in foundational mathematics: MA111, MA112, MA113, MA211, MA212

- Basic computing course: CSSE 120 or departmental equivalent of at least 4 credit hours
- Introductory Computational Science courses:
  - MA332 Introduction to Computational Science
  - MA342 Computational Modeling
- Four credit hours of applied Computational Science course from list A
- Four credit hours of additional Computational Science course from list B

List A: Applied Computational Science courses

- MA323 – Geometric Modeling
- MA439 – Mathematical Methods of Image Processing
- MA444 – Deterministic Models in Operations Research
- CSSE351 – Computer Graphics
- CSSE451 - Advanced Computer Graphics
- CSSE413 – Artificial Intelligence
- CSSE453 – Topics in Artificial Intelligence
- CSSE461 – Computer Vision
- CSSE463 - Image Recognition
- CE522 - Advanced Finite Element Analysis
- ME422 – Finite Elements for Engineering Applications
- ME427 - Introduction to Computational Fluid Dynamics
- ME511 - Numerical Methods for Dynamic Systems Analysis
- ME522 - Advanced Finite Elements Analysis
- 4XX – Introduction to MEMS:Fabrication and Applications
- 5XX – Advanced Topics in MEMS
- CHE521 – Advanced Chemical Engineering Computation
- BE510 – Biomedical Signal and Image Processing
- EMGT526 - Technology Forecasting
- MA534/EMGT534 - Management. Science
- ECE420 - Nonlinear Control Systems
- ECE480//PH437 – Introduction to Image Processing
- ECE582/PH537 – Advanced Image Processing
- ECE483 - DSP System Design

List B: Additional Computational Science courses

- MA/CSSE335 - Introduction to Parallel Computing
- MA433 - Numerical Analysis
- MA434 – Topics in Numerical Analysis
- MA348 - Continuous Optimization
- MA446 - Combinatorial Optimization
- CSSE304 - Programming Language Concepts
- CSSE371 - Software Requirements and Specification

Electives not on list A or B may be substituted with other courses with the approval of the area minor advisor.

The minor must be approved by the area minor advisor for Computational Science and the student's advisor. The department has a form for the planning and approval of a minor.

Notes and limitations on requirements

- Almost all students are required to take the five foundational courses as a requirement for their major
- Most majors should be able to apply the basic computing requirement and/or one of the elective courses towards their major.
- Math majors or double majors are not allowed to count MA332 and MA342 for both the minor and the major.
- A student may not apply the four upper-division courses toward both this minor and a math or statistics minor.

AREA MINOR IN STATISTICS

Any student not pursuing a major or second major in mathematics nor in biomathematics may obtain an area minor in statistics by taking ten or more mathematics courses (43 credit hours) including the following:

- **19 credit hours - Foundational Mathematics Courses:**
  - MA 111 Calculus I
  - MA 112 Calculus II
  - MA 113 Calculus III
  - MA 212 Differential Equations and Matrix Algebra
- **8 credit hours - Required Statistics and Probability Courses**
  - MA 381 Introduction to Probability with Applications to Statistics
  - One of the following:
  - MA223 Engineering Statistics I
  - MA382 Introduction to Statistics with Probability
  - If MA 381 is taken before MA223/MA382, it will be strongly recommended the student take MA382 instead of MA223.
- **16 credit hours - Secondary Statistics Courses**
  - Four courses selected from the following list, at least two of which must be starred (*). Statistics courses not on this list may count towards the minor if approved by the statistics minor advisor.
  - MA 383* Engineering Statistics II
  - MA 385 Quality Methods
  - MA 386* Statistical Programming
  - MA 387 Statistical Methods in Six Sigma
  - MA 445 Stochastic Models in Operations Research
  - MA 481 Mathematical Statistics
  - MA 482* Bioengineering Statistics
  - MA 485* Applied Regression and Time Series Analysis
  - MA 487* Design of Experiments
  - MA 480 Topics in Probability and Statistics

All area minors in Statistics must be approved by the statistics minor advisor and the student's advisor. The department has a form for the planning and approval of a statistics minor.

Notes and Limitations on Requirements

- Almost all students are required to take the foundational mathematics courses plus one probability or statistics course as a requirement for their major; therefore, only five "extra courses” are required for most students.
- Only MA111, MA112, MA113, MA211, MA212 and one of MA223, MA381, or MA382 can be counted towards any combination of the multiple minors offered by the mathematics department.
- No student can take both MA223 and MA382 for credit.

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
PH 111 Physics I or CHEM 111 General Chemistry I	4
RH 131 Rhetoric & Composition or HSS Elective	4
CLSK 100 College & Life Skills	1
CSSE 120 Introduction to Software Development	4
	Total Credits: 18

Winter

Course	Credit
MA 112 Calculus II	5
PH 112 Physics II or PH 111 Physics I	4
CHEM 111 General Chemistry I or BIO 101 Essential Biology (or higher level BIO course)	4
HSS Elective or RH 131 Rhetoric Composition	4
	Total Credits: 17

Spring

Course	Credit
MA 113 Calculus III	5
PH 113 Physics III or PH 112 Physics II	4
MA 190 Contemporary Mathematics Problems	2
HSS Elective	4
	Total Credits: 15

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
MA 275 Disc. & Comb. Algebra I	4
BIO 101 Essential Biology (or higher level BIO course) or PH 113 Physics III	4
*CSSE 220 Object-Oriented Software Development	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra & Systems of Differential Equations	4
Science Elective	4
Technical Elective	4
HSS Elective	4
**MA 200 Career Preparation	1
	Total Credits: 17

Spring

Course	Credit
MA 381 Introduction to Probability	4
MA 371 Linear Algebra I	4
Technical Elective	4
HSS Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
MA Elective	4
Technical Elective	4
Technical Elective	4
HSS Elective or RH 330 Technical & Professional Communication	4
	Total Credits: 16

Winter

Course	Credit
MA 366 Functions of a Real Variable	4
MA Elective	4
Technical Elective	4
HSS Elective or RH 330 Technical & Professional Communication	4
	Total Credits: 16

Spring

Course	Credit
MA Elective	4
MA Elective	4
Technical Elective	4
HSS Elective or RH 330 Technical & Professional Communication	4
	Total Credits: 16

Senior

Fall

Course	Credit
MA 491 Intro to Math Modeling (2 hours) and MA 492 Senior Project I (2 hrs.), or MA 496 Senior Thesis I (4 hrs.)	4
Free Elective	4
Free Elective	4
HSS	4
	Total Credits: 16

Winter

Course	Credit
MA 493 Senior Project II (2 hrs.) or MA 497 Senior Thesis II (2 hrs.)	2
MA Elective	4
Free Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 18

Spring

Course	Credit
MA 494 Senior Project III (2 hrs.) or MA 498 Senior Thesis III (2 hrs.)	2
MA Elective	4
Free Elective	4
Free Elective	4
	Total Credits: 14

Notes:

*MA 332 - Introduction to Computational Science - may be taken instead of CSSE 220 but then MA 332 cannot be counted towards the 63 hours of mathematics coursework
**MA 200 - Career Preparation - may be taken in the winter quarter of the sophomore year

Notes and Definitions

- The suggested four year plan is a guideline.
- Close consultation with the advisor on electives is required, especially for electives after the freshman year, or if a double major or minor is planned.

The following definitions of electives are specific to the Mathematics Department.

- **Math Elective:** A course either required by the concentration or a true math elective.
- **Science Elective:** Any Physical or Life Sciences elective (not Computer Science) at any level.
- **Technical Elective:** Non-mathematics courses numbered 200 or above in Engineering, Science or Economics; coursework in mathematics and biomathematics is not allowed.
- **Free Elective:** Any course.

Mechanical Engineering

The mechanical engineering curriculum is designed to prepare students for productive careers in industry, government, education and private consulting as well as for graduate study. Thus, it is based on the fundamental principles of science and engineering. These provide a strong foundation that enables students to apply what they have learned to the complex technological problems of today and to teach themselves the new technologies of tomorrow. Since mechanical engineering is a broad field of endeavor, the curriculum offers a strong technical elective program to allow each student to craft a broad educational experience and to develop the flexibility to pursue diverse career goals.

No less than any professional, the mechanical engineering graduate must work within the social and environmental context of our world. To be effective and successful, he or she must be aware of the roles of engineering and science in solving complex technological and social problems as well as of the impacts of social and environmental factors on engineering activities such as design. To foster this awareness, the curriculum allows the student an unusually wide choice of social science and humanities electives and emphasizes the links between society and engineering through courses such as Engineering Design Processes and Methodology.

The strength of any department is its faculty. The mechanical engineering faculty is committed to providing a dynamic and innovative learning environment and to maintaining and increasing their technical competence in a rapidly changing world. Stereotypes notwithstanding, they understand that people are more important than things. Thus, they encourage each student to seek them out when he or she has academic problems or needs guidance in career planning.

The freshman year of the mechanical engineering program includes courses in mathematics, physics, humanities and social science as well as introductory courses in engineering and design. The sophomore year features courses in mathematics, chemistry and the engineering sciences. The final two years of the program stress the design and analysis of systems, machines and their components, and the transfer and transformation of energy. The required courses provide the basic mathematical and scientific fundamentals underlying the practice of mechanical engineering, while 20 cr. hrs. of technical elective courses and 8 cr. hrs. of free elective courses allow flexibility in adapting the program to the interests and abilities of the individual student. The student is not encouraged to specialize in a particular area but rather to seek a broad background in basic engineering principles. For the student who wishes to pursue a career in the field of aerospace engineering, however, extensive sequences of courses are available as elective offerings.

The mechanical engineering program is designed to encourage the best students to continue their education at the graduate level. For those who choose to study at Rose-Hulman, graduate work leading to a Master of Science degree is offered by the Mechanical Engineering Department. Options in the general areas of Thermal/ Fluids Systems and Solid Systems Design are available. These options are devoted to developing a deeper understanding of engineering and are not intended to constrain the student to a high degree of specialization.

Mission: To provide the curriculum, the educational environment, and the individual support necessary to graduate mechanical engineers who are technically competent, effective in practice, creative, ethical and mindful of their responsibility to society.

Vision: To graduate the best baccalaureate mechanical engineers.

Mechanical Engineering Program Educational Objectives and Student Outcomes

Program Educational Objectives

The mechanical engineering curriculum is designed to prepare students for productive careers in industry, government, education, and private consulting as well as for graduate study. Thus, it is based on the fundamental principles of science and engineering. These provide a strong foundation that enables students to apply what they have learned to the complex technological problems of today and to teach themselves the new technologies of tomorrow. Thus, we expect our graduates to attain the educational objectives listed below within a few years of graduation. Our educational objectives are based on the needs of our constituencies.

1. Our graduates will be successful in their careers.
2. Our graduates set and meet their own goals for career fulfillment.
3. Our graduates will continue professional development.
4. Our graduates will engage the international dimensions of their profession.

Student Outcomes

Student outcomes describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire as they progress through the program.

1. an ability to apply knowledge of mathematics, science, and engineering
2. an ability to design and conduct experiments, as well as to analyze and interpret data
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4. an ability to function on multi-disciplinary teams
5. an ability to identify, formulate, and solve engineering problems
6. an understanding of professional and ethical responsibility
7. an ability to communicate effectively
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
9. a recognition of the need for, and an ability to engage in life-long learning
10. a knowledge of contemporary issues
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Minor* in Thermal-Fluids

To complete the requirements of the thermal-fluids minor, a student must fulfill the following three expectations:

(1) Completion of a set of 2 courses covering basic fluid mechanics and basic thermodynamics. These are commonly required for most engineering majors. Acceptable sets include:

- ES 201 Conservation & Accounting Principles
  ES 202 Fluid Systems
  or
- CE 205 Thermodynamics
  EM 301 Fluid Mechanics
  or
- CHE 201 Conservation Principles & Balances
  CHE 301 Fluid Mechanics

(2) One of the following foundational prerequisites.

- ME 301 Applications of Thermodynamics
- CHE 303 Chemical Engineering Thermodynamics
- ME 302 Heat Transfer
- CHE 320 Fundamentals of Heat and Mass Transfer

(3) Three of the thermal-fluids electives listed below.
Thermal Fluid Systems

- ME 407 Power Plants**
- ME 408 Renewable Energy
- ME 409 Air Conditioning***
- ME 410 Internal Combustion Engines
- ME 411 Propulsion Systems**
- ME 426 Turbomachinery
- ME 462 Thermal Design

Thermal Fluid Sciences

- ME 401 Foundations of Fluid Mechanics
- ME 405 Theoretical Aerodynamics
- ME 427 Introduction to Computational Fluid Dynamics
- ME 450 Combustion
- ME 501 Advanced Thermodynamics**
- ME 510 Gas Dynamics

Successful completion of a minor is indicated on the student's transcript. A student interested in pursuing a minor in thermal-fluids should consult with the head of the Department of Mechanical Engineering.

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* ME Majors do **not** qualify for the Thermal Fluids Minors, but may pursue ME Concentrations.

** Requires one of the thermodynamics prerequisites from section 2 above.
*** Requires one of the heat transfer prerequisites from section 2 above.

Areas of Concentration

Students who complete recommended courses in an area of concentration may receive, upon request, a letter from the Department Head attesting to the fact that the student has completed the requirements in the selected area of concentration in the Mechanical Engineering Department. With proper planning, students should be able to take these course offerings without overload. Students may add special topics courses or new courses not yet listed in the catalog to the list of acceptable courses for a concentration with written permission from the mechanical engineering department head

Advanced Transportation Area of Concentration
To better prepare our students for the interdisciplinary field of Advanced Transportation, an area of concentration is offered to expose students to modern automotive, aviation, and off-highway design methodologies and technologies. Five elective courses are required which permit students to provide either depth or breadth according to their interests.

Elective Courses

- CHEM 470 Combustion Chemistry
- ECE 320 Linear Control Systems
  or
- ME 406 Control Systems
- ECE 420 Nonlinear Control Systems
  or
- ME 506 Advanced Control Systems
- ECE 370 Machines & Power
- ECE 410 Communication Networks
- ECE 452 Power Electronics
- ME 401 Foundations of Fluid Mechanics
- ME 405 Theoretical Aerodynamics
- ME 408 Renewable Energy
- ME 410 Internal Combustion Engines
- ME 411 Propulsion Systems
- ME 422 Finite Elements for Engineering Applications
- ME 426 Turbomachinery
- ME 427 Introduction to Computational Fluid Dynamics
- ME 447 Visualizing Data
- ME 450 Combustion
- ME 497 Three Dimensional Dynamics
- ME 522 Advanced Finite Element Analysis

Aerospace Engineering Area of Concentration
The aerospace industry provides job opportunities each year for many mechanical engineering graduates. The aerospace engineering area of concentration is intended to provide specialty courses which focus the application of basic mechanical engineering skills to aerospace systems.

The courses required to complete the concentration are as follows:

- ME 305 Introduction to Aerospace Engineering
    - Plus any 4 of the following
    - MA 336 Boundary Value Problems
    - EM 505 Theory of Elasticity
    - ME 401 Foundations of Fluid Mechanics
    - ME 405 Theoretical Aerodynamics
    - ME 410 Internal Combustion Engines
    - ME 411 Propulsion Systems
    - ME 422 Finite Elements for Engineering Applications
    - ME 426 Turbomachinery
    - ME 427 Introduction to Computational Fluid Dynamics
    - ME 461 Aerospace Design
    - ME 510 Gas Dynamics
    - ME 522 Advanced Finite Element Analysis
    - PH 322 Celestial Mechanics

Industrial Leadership Area of Concentration

Many mechanical engineering students are attracted to industry for both technical and leadership opportunities. Graduates often are responsible for project management and may develop over time into more significant leadership roles. This area of concentration is intended to take advantage of Rose-Hulman offerings in Mathematics, Engineering Management, and Humanities and Social Sciences to provide skills and knowledge that would be useful for graduates with increasing managerial responsibilities. Since part of leadership is also practice, the area of concentration requires one industrial internship and one significant leadership experience.

To complete the requirements of the area of concentration in industrial leadership, each student must take a total of six courses, two from the Math list, two from the Engineering Management list, and two from the Humanities, Social Sciences list

Math List

- MA 385 Quality Methods
- MA 487 Design of Experiments
- MA 387 Statistical Methods in Six Sigma

Engineering Management List

- EMGT 330 Introduction to Engineering Management
- EMGT 520 Accounting for Technical Managers
- EMGT 522 Organizational Management
- EMGT 523 Marketing Issues in a Technical Environment 4
- EMGT 524 Production/Operations Management
- EMGT 525 Human Resources Management
- EMGT 526 Innovation Management and Forecasting
- EMGT 527 Project Management
- EMGT 531 Economics for Technical Managers
- EMGT 532 Technical Entrepreneurship
- EMGT 533 Intercultural Communication
- EMGT 535 Strategies for Organizational Change

- EMGT 567 Economic Analysis of Engineering Projects
- EMGT 586 Supply Chain Management
- EMGT 587 Systems Engineering
- EMGT 588 Quality Management l
- EMGT 589 Manufacturing Systems
- EMGT 598 Operational Research for Technical Managers

Humanities, Social Sciences List

- GS 350 International Trade
- GS 351 International Finance
- IA 230 Fundamentals of Public Speaking
- IA 352 Game Theory
- SV 150 Introduction to Microeconomics
- SV 152 Introduction to Macroeconomics
- SV 351 Managerial Economics
- SV 357 Labor Economics
- SV 303 Business and Engineering Ethics
- SV 304 Bioethics
- SV 352 Money & Banking
- SV 353 Industrial Organization
- SV 354 Environmental Economics
- SV 356 Corporate Finance

In addition to coursework, students must complete one Industrial Internship (of approximately three month duration) and one significant co-curricular leadership experience. To get credit for the leadership experience, the student must submit an application with reference support which is approved by the department head. Possible examples of qualifying leadership could include leadership experience in design-build competitions or serving as a Resident Assistant in the residence halls.

Manufacturing and Production Engineering Area of Concentration

Many mechanical engineering graduates will work in tasks related to the manufacture of various products. The manufacturing and production engineering area of concentration is intended to bridge the gap between the analytical and design courses which are the heart of the professional program and the practical problems of producing acceptable hardware, on time, at a profit.

The courses that comprise this area of concentration are:

List 1:

- EMGT 330 Introduction to Engineering Management
- EMGT 524 Production/Operations Management
- EMGT 527 Project Management
- EMGT 588 Quality Management
- EMGT 589 Manufacturing Systems
- EMGT 598 Lean Six Sigma
- MA 385 Quality Methods
- MA 387 Statistical Methods in Six Sigma
- ME 317 Design for Manufacturing
- ME 397 Advanced CAD

- ME 397 Design for Additive Manufacturing
- ME 435 Robotics
- ME 497 Lean Manufacturing
- ME 520 Computer Aided Design and Manufacturing

When choosing humanities and social science electives (HSS), we suggest that the following are most pertinent to the manufacturing/production working environment:

List 2:

- SV 150 Introduction to Microeconomics
- SV 152 Introduction to Macroeconomics
- SV 171 Principles of Psychology
- SV 351 Managerial Economics
- SV 356 Corporate Finance
- IA 453 The Entrepreneur

Students must complete five courses from List 1 and three of the recommended HSS courses from List 2 to obtain the concentration in manufacturing and production.

Dynamic Systems & Control Area of Concentration

Mechanical engineering graduates may work in industries, such as the automotive and aerospace industries, in which the understanding and control of a system's dynamic response is critical. The dynamic systems & control concentration provides students with experiences in modeling, analysis, and simulation of the dynamic behavior of systems with and without feedback control, as well as opportunities to explore data collection for vibratory systems and control algorithm implementation in a laboratory setting.

To complete the requirements of the area of concentration in Dynamics Systems & Control, students must complete five courses from this list:

- ME 403 Kinematics of Machinery
- ME 406 Control Systems
- ME 497 Three-Dimensional Dynamics
- ME 506 Advanced Control Systems
- ME 536 Computational Intelligence in Control Engineering
- EM 406 Vibration Analysis
- EM 502 Advanced Dynamics
- EM 503 Advanced Vibration Analysis
- PH 322 Celestial Mechanics

Thermal Fluid Area of Concentration

Many Mechanical Engineering graduates will work with engineering systems that are based on the principles of thermodynamics, heat transfer and fluid mechanics. The Mechanical Engineering curriculum offers an opportunity for the student to concentrate his studies on the analysis and design of these systems. The courses that comprise the thermal fluid area of concentration may be classified according to whether the main emphasis is on the system or on the thermal or fluid concepts which underpin its design and operation.

Thermal Fluid Systems

- ME 407 Power Plants
- ME 408 Renewable Energy
- ME 409 Air Conditioning
- ME 410 Internal Combustion Engines
- ME 411 Propulsion Systems
- ME 426 Turbomachinery
- ME 462 Thermal Design

Thermal Fluid Sciences

- ME 401 Foundations of Fluid Mechanics
- ME 405 Theoretical Aerodynamics
- ME 427 Introduction to Computational Fluid Dynamics
- ME 450 Combustion
- ME 501 Advanced Thermodynamics
- ME 510 Gas Dynamics

In order to complete the requirements in the thermal fluid area of concentration a student must select five elective from the lists such that at least one course is taken from the **Thermal Fluid Systems**list and at least two courses are taken from the **Thermal Fluid Sciences**list.

The mechanical engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
PH 111 Physics I	4
CLSK 100 College & Life Skills	1
EM 104 Graphical Communications	2
RH 131 Rhetoric & Composition or split or HSS fall or winter with Elective	4
	Total Credits: 16

Winter

Course	Credit
MA 112 Calculus II	5
PH 112 Physics II	4
EM 121 Statics & Mechanics of Materials I	4
RH 131 Rhetoric & Composition split or HSS fall or winter with Elective	4

	Total Credits: 17

Spring

Course	Credit
MA 113 Calculus III	5
PH 113 Physics III	4
EM 103 Introduction to Design	2
ME 123 Computer Applications I	4
	Total Credits: 15

Sophomore

Fall

Course	Credit
MA 211 Differential Equations	4
ES 201 Conservation & Accounting Principles	4
ES 203 Electrical Systems	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
MA 212 Matrix Algebra & Systems of Differential Equations	4
ES 212 Fluid Systems	4
ES 214 Mechanical Systems	4
CHEM 111 General Chemistry I	4
	Total Credits: 16

Spring

Course	Credit
MA 223 Statistics for Engineers	4
ES 205 Analysis & Design of Engineering Systems	4
CHEM 113 General Chemistry II	4
HSS Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
ME 301 Applications of Thermodynamics	4
EM 204 Statics & Mechanics of Materials	4
ME406 Control Systems or EM 406 Vibration Analysis	4
Free* Elective	4
	Total Credits: 16

Winter

Course	Credit
ME 317 Design for Manufacturing	4
ME 327 Numerical Methods in Engineering Analysis	4
ME 328 Materials Engineering	4
RH 330 Technical Communications split winter or spring with HSS Elective	4
	Total Credits: 16

Spring

Course	Credit
ME 302 Heat Transfer	4
ME 321 Measurement Systems	4
ME 480 Machine Component Design	4
HSS Elective split winter or spring with RH 330 Technical Communications	4
	Total Credits: 16

Senior

Fall

Course	Credit
ME 470 Capstone Design I	4
ME 421 Lab	2
HSS Elective	4
Tech* Elective	4
Tech* Elective	4
	Total Credits: 18

Winter

Course	Credit
ME 471 Capstone Design II	4
ME 430 Mechatronic Systems	4
HSS Elective	4
Free* Elective	4
	Total Credits: 16

Spring

Course	Credit
ME 472 Capstone Design III	4
Tech* Elective	4
Tech* Elective	4
HSS Elective	4
	Total Credits: 16

NOTES:

*24 credit hours. in electives composed of 16 cr. hrs. in technical electives and 8 cr. hrs. in free electives.

*A **technical elective** is any course (at the 200 level or above) in biomathematics, chemistry, computer science, engineering, engineering management, geology, life science, mathematics, or physics that is not cross-listed with HSS or similar in content to a required course. A **math elective** has an MA or BMTH prefix. A **science elective** is any course in biology, chemistry, geology or physics except those courses that are cross-referenced with an engineering course.

Rose-Hulman Institute of Technology Course Catalog

Optical Engineering

The science of light, once confined to research labs and science fiction novels, has found its way into our everyday lives. The applications of optics can be seen everywhere. A list of more common examples of these applications include laser printers, fiber optic communication, internet switches, fiber optic telephone lines, compact disc players, credit cards bearing holograms, grocery checkout scanners, computers and eye surgery. The field of optics is an enabling technology and is growing at a rapid pace. Optical techniques are found in a wide range of areas such as surveying and construction, measurements of material parameters and deformation, flow measurements, communications, machine vision, laser cutting, drilling and welding, data storage, internet switches, optical computers and sensors etc. Surveys show that there is a growing demand for optical designers/scientists/ engineers every year. Opportunities for graduates in Optical Engineering are available in many industries, including automated inspection, consumer electronics, fiber optic communications, optical instrumentation, laser devices, radar systems, data storage etc.

The Optical Engineering bachelor's degree program is one of the few in the country. This program provides a firm foundation for those interested in continuing thier studies in optics at the graduate level, as well as for those going into industry. The curriculum was developed by the faculty with input from industrial representatives as well as from renowned national and international optics educators. Because of the diverse applications of optics, the curriculum contains a mix of courses in physics and mathematics as well as humanities and social sciences. The Optical Engineering program at Rose-Hulman stresses laboratory instruction. We also encourage students to look at options for a double major, especially Optical Engineering with electrical, computer or mechanical engineering.

Students majoring in degree programs other than Optical Engineering are eligible to obtain an area minor in Optical Engineering.

The Department of Physics and Optical Engineering also offers an M.S. (Optical Engineering) degree. The masters level degree program complements the B.S. (Optical Engineering) degree program. Highly motivated students may obtain both a B.S. and an M.S. in Optical Engineering in a five-year period. A plan of study for this program must be approved by the end of the student's junior year.

You may view all information regarding Physics and Optical Engineering at our web site: **http://www.rose-hulman.edu/physics.aspx**

OE Program Educational Objectives

1. Our graduates will set their career path and advance beyond their entry-level position or progress toward the completion of an advanced degree.
2. Our graduates will make a positive impact on society.
3. Our graduates will behave ethically and act as responsible members of the engineering and science community.
4. Our graduates will continue to develop professionally

OE Student Learning Outcomes

Outcome A:	An ability to apply knowledge of mathematics, science, and engineering
Outcome B:	An ability to design and conduct experiments, as well as to analyze and interpret data
Outcome C:	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
Outcome D:	An ability to function on multidisciplinary teams
Outcome E:	An ability to identify, formulate, and solve engineering problems
Outcome F:	An understanding of professional and ethical responsibility
Outcome G:	An ability to communicate effectively
Outcome H:	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
Outcome I:	A recognition of the need for, and an ability to engage in life-long learning
Outcome J:	A knowledge of contemporary issues
Outcome K:	An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

The optical engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

Optical Engineering graduation data http://www.rose-hulman.edu/media/1262267/oe.pdf

OPTICAL ENGINEERING

SUMMARY OF GRADUATION REQUIREMENTS FOR OPTICAL ENGINEERING

1. All the courses listed above by the number.
2. The program must be approved by the advisor.
3. A technical elective is any RHIT course in biology, biomathematics, chemistry, computer science, engineering, mathematics, or physics

Classes by subjects	**Hours**
Optics Coursework	46
Physics Coursework	20
Freshmen Physics, Chemistry and Mathematics Coursework	47
Humanities and Social Science (Standard requirement)	36
Electives (8 credits engineering electives, and 12 credits of free electives; cannot include ECE 340)	20
Miscellaneous	25
Total	**194**

Physics Classes

Course	Description	Hours
PH235	Many particle physics	4
PH255	Foundations of Modern Physics	4
PH292	Physical Optics	4
PH316	Elec & Mag Fields	4
PH405	Semiconductor Materials & Applications	4
Total		**20**

Freshman Physics, Math and Chemistry Classes

Course	Description	Hours
PH111	Physics I	4
PH112	Physics II	4
PH113	Physics III	4
MA111	Calculus I	5
MA112	Calculus II	5
MA113	Calculus III	5
MA211	Differential Equations	4
MA212	Matrix Algebra and Systems of Differential Equations	4
MA223	Engineering Statistics	4
CHEM111	Engineering Chemistry I	4
CHEM113	Engineering Chemistry II	4
Total		**47**

Miscellaneous and Engineering Classes

Course	Description	Hours
CLSK 100	College and Life Skills	1
EM 104	Graphical Communication	2
ME 123	Computer Applications I	4
EM 103	Introduction to Design	2
ECE 203	DC Circuits	4
ECE 204	AC Circuits	4
Total		**17**

Area Minor
The course requirements and advisors for Area Minors in Optical Engineering, Solid State Physics/Materials Science, and Electronics are listed below. Successful completion of an Area Minor is indicated on the student's grade transcript. A student interested in pursuing an Area Minor should consult with the appropriate advisor.

Area Minor in Astronomy
(Eligibility: students in any major degree program)
Advisors: Drs. Ditteon, Duree, Kirkpatrick, McInerney and Syed

Required Courses

Course	Hours	Course Description
PH 230	4	Introduction to Astronomy and Astrophysics
PH 240	4	Planetary Science and Cosmology
PH 310	2	Introduction to Relativity
PH 322	4	Celestial Mechanics
PH 490	2	Directed Research
Plus four hours of:		
PH 270	2	Special Topics in Physics
PH 290	2	Directed Research
PH 460	4	Directed Study
PH 470	4	Special Topics in Physics
PH 490	4	Directed Research

The optional courses must be on a topic approved by one of the astronomy advisors.

Area Minor in Optical Engineering
(Eligibility: students in any degree program, except programs where Optical Engineering is designated as one of the majors.)
Advisors: Drs. Bunch, Ditteon, Duree, Granieri, Joenathan, Leisher, Siahmakoun, and Wagner.

Required Courses (12 hours)

Course	Hours	Course Description
OE 280	4	Geometrical Optics
PH 292	4	Physical Optics
OE 295	4	Photonic Devices and Systems

Plus at least two courses (8 hours) from the list below:

Course	Hours	Course Description
OE 360	4	Optical Materials

OE 392	4	Linear Optical Systems
OE 393	4	Fiber Optics and Applications
OE 395	4	Optomechanics & Optial Engineering Lab
OE 434	4	Non-Imaging Optics
OE 435	4	Biomedical Optics
OE 437	4	Introduction to Image Processing
OE 450	4	Laser Systems and Applications
OE 470	4	Special Topics in Optical Engineering
OE 480	4	Optical System Design
OE 493	4	Fundamentals of Optical Fiber Communications
OE 495	4	Optical Metrology

In order to have the area minor posted to your transcripts you must submit an area-minor completion form to the registrar. Forms are available in the Physics and Optical Engineering department office.

Also see Certificate Program in Semiconductor Materials and Devices

Area Minor in ECE: (Eligibility: Only students in Physics and Optical Engineering)
Advisors: Optical Engineering faculty and ECE faculty

Course	Hours	Course Description
ECE 203	4	DC Circuits
ECE 204	4	AC Circuits
ECE 205	4	Dynamical Systems
ECE 300	4	Continuous-Time Signals and Systems
ECE 310	4	Communication Systems
ECE 380	4	Discrete-Time Signals and Systems

required courses

In order to have the area minor posted to your transcript you must submit an area-minor completion form to the registrar. Forms are available in the Electrical and Computer Engineering office.

Optical Communications Certificate

Faculty advisors: B. Black, R. M. Bunch and S. Granieri

Rose-Hulman has become a leader in providing opportunities for students to choose a great mainstream degree program with flexibility to specialize in other areas of interest. This leadership is in no way limited to only traditional areas of study. One of these new areas that had a high impact in technology is optical communications. It is a rapidly growing field requiring investment beyond the traditional program structure, and is well suited to the students at Rose-Hulman All these topics are closely related to well established disciplines as optics and electronics. Considerable R&D efforts are allocated in both university and industrial laboratories enhancing the demand for both researchers and engineers with expertise in the field.

We propose the creation of a new certificate program in Optical Communications to enhance the programs currently offered. Combining expertise in Optical and Electrical Engineering, this program requires an interdisciplinary emphasis that is beyond the traditional content of either of its parent programs. This program is more than just the creation of the certificate program Optical Communications. This program will be critical to help developing a more interdisciplinary interaction for students and faculty. The creation of a workgroup within the faculty of both departments will coordinate current courses and resources, create new courses of interest for the field, and develop a showcase testbed education and research laboratory. Primary objectives include the removal of redundancy from existing courses, increasing interaction between the PHOE and ECE Departments, and improving opportunities for students in the field.

This certificate is designed to give the student a firm theoretical and practical working knowledge in the area of fiber optic devices, optical communications, networks and its applications. The main purpose is to couch these fundamentals in a context that serves as the backbone for device, components and sub-system development for use in high-speed optical data and information links and networks. At the end of the program the student will be expected to:

1. Understand the fundamental operation characteristics of high speed optoelectronic components, such as laser transmitters, light modulators and receivers and passive fiber optic components as connectors, couplers, filters, and switches.
2. Understand the technology and performance of analog and digital fiber optic links, optical amplification and optical wavelength division multiplexing and optical time division multiplexing networks.
3. Have a hands-on working knowledge of the use of fiber optic test equipment and techniques used by industry and telecommunication companies to test the performance of optical fiber links and components, such as, optical time domain reflectometry, optical spectrum analyzers and optical bit error testing equipment.

The Certificate will consist of 20 credit hours of which 12 credit hours will be required courses. Students interested in pursuing this Certificate should contact an ECE/PHOE certificate advisor (Professors Black, Bunch, and Granieri)

Required Courses

- ECE 310 Communication Systems
- OE 393 Fiber Optics and Applications
- OE 493 Fundamentals of Optical Fiber Communications

Elective Courses (two from the list)

Only courses not required for the student's major will count for electives in the certificate.

- ECE 380 Discrete Time & Continuous Systems
- ECE 410 Communication Networks
- ECE 414 Wireless Systems
- OE 360 Optical Materials
- OE 435 Biomedical Optics
- OE 450 Laser Systems and Applications

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
PH 111 Physics I	4
CLSK 100 College & Life Skills	1
CHEM 111 General Chemistry I	4
EM 104 Graph Comm	2
	Total Credits: 16

Winter

Course	Credit
PH 112 Physics II	4
MA 112 Calculus II	5
CHEM 113 General Chemistry II	4
RH 131 Rhetoric & Composition	4
	Total Credits: 17

Spring

Course	Credit
PH 113 Physics III	4
MA 113 Calculus III	5
ME 123 Computer Applications I	4
OE 172 Lasers & Fiber Optics *	2
EM 103 Intro Eng. Design	2
	Total Credits: 17

Sophomore

Fall

Course	Credit
PH 235 Many-Part Physics	4
PH 292 Physical Optics	4
MA 211 Differential Equations	4
ECE 203 DC Circuits	4
	Total Credits: 16

Winter

Course	Credit
ECE 204 AC Circuits	4
PH 255 Fnd. of Mod. Phys.	4
MA 212 Matrix Algebra & Sys of Diff Equat	4
OE 280 Geometrical Optics	4
	Total Credits: 16

Spring

Course	Credit
OE 295Photonic Devices & Systems	4
SV 150 Introduction to Microeconomics -or- SV 152 Introduction to Macroeconomics	4
MA 223 Engineering Statistics	4
Free Elective	4
	Total Credits: 16

Junior

Fall

Course	Credit
OE 392 Linear Optical Systems	4
OE 395 Opto-Mech & Optical Eng Lab	4
PH 316 Elec & Mag Fields	4
HSS Elective	4
	Total Credits: 16

Winter

Course	Credit
OE 393 Fiber Optics & Applications or OE 360 Optical Materials	4
RH 330 Tech & Prof Communications	4
HSS Elective	4

Free Elective	4	
		Total Credits: 16

Spring

Course	Credit	
OE 415 Opt Eng Des I	4	
OE 450 Laser Systems & Applications	4	
HSS Elective	4	
Engineering Elective**	4	
		Total Credits: 16

Senior

Fall

Course	Credit	
OE 416 Optical Eng Design II	4	
OE 480 Optical System Design	4	
PH 405 Semiconductor Materials & Appl	4	
HSS Elective	4	
		Total Credits: 16

Winter

Course	Credit	
OE 417 Optical Engineering Design III	4	
OE 495 Optical Metrology	4	
OE 393 Fiber Optics and Applications or OE 360 Optical Materials	4	
PH/OE/EP Elective***	4	
		Total Credits: 16

Spring

Course	Credit	
HSS Elective	4	
HSS Elective	4	
Engineering Elective**	4	
Free Elective	4	
		Total Credits: 16

NOTES:

*If OE 172 is not taken during the freshman or sophomore year, the requirement must be replaced with a 300 or 400-level OE course of at least 2 credits.

**An engineering elective is any 200, 300,or 400-level course listed as OE, EP, ECE, ME, CE, BE, EM or ES.
***A PH/OE/EP elective is any 200, 300,or 400-level course listed as OE, EP or PH.

Physics

The physics curriculum is designed to develop a strong foundation in classical and modern physics, which will serve as a basis for future specialization, for additional study at the graduate level, and for design and development work in industrial laboratories. The curriculum emphasizes basic physical concepts, and includes extensive work in mathematics and related areas. Laboratory facilities are available for work in optics, acoustics, X-ray diffraction, nuclear physics, and solid-state physics. Course topics included in the curriculum are Many Particle Physics, Physical Optics, Biophysics, Biomedical Optics, Theoretical Mechanics, Electromagnetism, Celestial Mechanics, Acoustics, Microsensors, Semiconductor Materials and Devices, X-rays and Crystalline Materials, Electro-Optics, and Laser Physics.

The Physics program places an emphasis on laboratory courses with a hands-on approach. The students have the opportunity to take a variety of courses in disciplines such as math and chemistry allowing them to tailor their education. The Physics curriculum is flexible enough that one can double major in computer science, mathematics, electrical engineering, and mechanical engineering. National interest in our program has been generated by our basic physics courses that use new methodologies of teaching such as studio format lectures.

We have a wide range of research programs accessible to undergraduates including areas such as: Astronomy, Solid State Devices, Electro-optics, Non-linear Optics, X-ray absorption, Semiconductor Materials and Devices, Magnetics, Chaos, Lasers, Fiber Optics, Holography, Microsensors. In addition, we are very successful in placing our students in summer internship positions with various research facilities such as NASA, Argonne National Laboratory, Sandia National Laboratory, National Radio Astronomy Observatory, and CSPAAR.

PHYSICS

SUMMARY OF GRADUATION REQUIREMENTS FOR PHYSICS MAJORS

1. All the courses listed above by the number.
2. The program must be approved by the advisor.
3. Twelve credits of physics courses, besides those listed by number. At least two of these credits must be directed research (PH290 or PH490) with at least one credit of PH490.
4. Twenty credits of technical electives of which at least eight must be in courses other than physics courses (cannot include ECE340).
5. Cross reference for the following courses:
   ECE340 and ECE341 for PH316 and PH317
   ES202 and ES204 for PH235
6. Sixteen credits of free electives (cannot include ECE340).
7. Thirty-six credits of humanities or social sciences courses. The distribution of these courses must meet the requirements of the Department of Humanities and Social Sciences.
8. A technical elective is any RHIT course in biology, biomathematics, chemistry, computer science, engineering, mathematics, or physics.
9. A free elective is any course offered at RHIT.

Course by Subjects	**Hours**
Physics Course work	56
Physics Electives*	12
Chemistry and Mathematics Course work**	35
Mathematics Electives***	8
Humanities and Social Science (Standard	36
requirement)	20
Technical Electives†	16
Free Electives††	9
Miscellaneous and OE450†††	**192**
Total	

*Listed below are the PH elective courses, from which a physics major is required to take 12 hours.

Course	**Course Title**	**Hours**
PH 215	Introduction to Chaos	2
PH 231	Intro to Astronomy and	4
PH 241	Astrophysics	4
PH 250	Physics of Stars	4
PH 265	Planets and Galaxies	4
PH 270	Fundamentals of Nuclear	Arranged
PH 290	Physics	Arranged
PH 302	Special Topics in Physics	4
PH 310	Directed Research	2
PH 315	Biophysics	4
PH 322	Intro to Relativity	4
PH 402	Theoretical Mechanics II	4
PH 404	Celestial Mechanics and	4
PH 407	Solar	4
PH 410	Introduction to Atomic	4
PH 440	Physics	4
PH 460	Acoustics	Arranged
PH 470	Solid State Physics	Arranged
PH 480	General Relativity	Arranged
PH 490	X-rays and Crystalline	Arranged
PH 496+	Materials	Arranged
PH 497+	Directed Study	Arranged
PH 498+	Directed Research	Arranged
PH 499	Seminar	4
PH 512	Directed Research	4
PH 514	Senior Thesis	4
PH 530	Senior Thesis	4
PH 537	Senior Thesis	4
PH 538	Physics Ethics and	4
	Communication	
	Methods of Mathematical	
	Physics	
	Quantum Mechanics	

	Advanced Acoustics	
	Advanced Image Processing	
	Introduction to Neural Networks	

+Students wanting to pursue the Senior Thesis option must find a faculty advisor (from the Physics and Optical Engineering Faculty) by the Fall Term of their Senior Year. At that time, the thesis topic should be decided and the research plan developed. Students in the thesis option should enroll in Senior Thesis courses for each of the three terms of their Senior Year for a total number of 8 credit hours over the three quarter sequence. Students working on a Senior Thesis will present their thesis near the end of the Spring Term of their Senior Year.

**Math and Chemistry Courses:

Course	**Course Title**	**Hours**
MA 111	Calculus I	5
MA 112	Calculus II	5
MA 113	Calculus III	5
MA 211	Differential Equations	4
MA 212	Matrix Algebra and Systems of Differential Equations	4
MA 371	Linear Algebra	4
CHEM 111	General Chemistry I	4
CHEM 113	General Chemistry II	4
Total		**35**

***Listed below are the mathematics elective courses, of which a physics major must choose two, or have the consent of the advisor to take any other mathematics courses.

Course	**Course Title**	**Hours**
MA 336	Boundary Value Problems	4
MA 330	Vector Calculus	4
MA 367	Functions of a Complex Variable	4
MA 433	Numerical Analysis	4

†Twenty credits of technical electives are required for a physics major, of which at least eight must be in courses other than physics courses (cannot include ECE340).

††A physics major may take sixteen credit hours of free electives, which may include any of the electives mentioned above or any other course offered at RHIT.

†††Miscellaneous Courses

Course	Course Title	Hours
CLSK 100	College and Life Skills	1
EM 104	Graph Comm.	2
OE 450	Laser System and	4
	Applications	2
Total	Computing Elective	**9**

The course requirements and advisors for Minors in Physics, Astronomy, Solid State Physics/Materials Science, and Optical Engineering are listed below. Successful completion of an minor is indicated on the student's grade transcript. A student interested in pursuing an minor should consult with the appropriate advisor.

Minor in Physics

Eligibility: Students in any major degree program except for Physics and Engineering Physics

Advisors: all Physics and Optical Engineering faculty members.

Required courses:

Course	Course Title	Hours
PH 314	Theoretical Mechanics I	4
PH 325	Advanced Laboratory I	4

Plus 12 credit hours from the following courses:

Course	Course Title	Hours
PH 270/470	Special Topics in Physics	ARR
PH 290/490	†	ARR
PH 292*	Directed Research †	4
PH 310	Physical Optics	2
PH 315	Introduction to Relativity	4
PH 316**	Theoretical Mechanics II	4
PH 327	Electric and Magnetic	4
PH 401	Fields	4
PH 410	Thermodynamics and	4
PH 460	Statistical Mechanics	ARR
	Quantum Mechanics	
	General Relativity	
	Directed Study †	

† A maximum of 4 credit hours total from PH270/470, PH290/490, and PH460 may be counted towards the area minor.

*Students majoring in Optical Engineering may not count PH292 for the minor requirements. Such students may substitute here any PH course numbered 300 or greater which is not a named requirement for the OE major.

**ECE340 may be substituted here for students who take it as part of their major degree requirements.

A Minor Completion Form must be submitted to the Registrar's Office in order for the Area Minor to be posted on your official transcript. The forms are available in the Physics and Optical Engineering Departmental Office, CL106.

Minor in Astronomy
Eligibility: Students in any major degree program

Advisors: Drs. Ditteon, Duree, Kirkpatrick, McInerney and Syed

Required Courses

Course	Course Title	Hours
PH 231	Observational Astronomy	2
PH 241	Physics of Stars	4
PH 250	Planets and Galaxies	4
PH 490	Directed Study	2

It is recommended, but not required, that the required courses be taken in the order listed above.

Plus eight hours of:

PH 270	Special Topics in Physics	2
PH 310	Introduction to Special Relativity	2
PH 322	Celestial Mechanics	4
PH 410	General Relativity	4
PH 460	Directed Study	1
PH 470	Special Topics in Physics	2
PH 290/490	Directed Research	1

The optional courses must be on a topic approved by one of the astronomy advisors.

Normally, only one credit of directed research or directed study is taken each quarter. Directed study and directed research may be repeated (4 hours maximum) and must be on a topic approved by one of the astronomy advisors.

In order to have the area minor posted to your transcript you must submit an area minor completion form to the registrar. Forms are available in the Physics and Optical Engineering office.

Minor in Solid State Physics/Materials Science
Eligibility: Students in any degree program, except students who are working for the Semiconductor Materials and Devices Certificate.

Advisors: Dr. Bunch, Dr. McInerney, Dr. Moloney, Dr. Siahmakoun, Dr. Syed, Dr. Wagner

Required courses:

Course	Description	Hours

PH 405	Semiconductor Materials and Applications	4
EP 406	Semiconductor Devices and Fabrication	4
ME 328/CHE 315	Materials Engineering/ Material Science & Engineering	4

Plus at least two of:

Course	Description	Hours
OE 360	Opto-mechanics and Optical Materials	4
EP 330	Material Failure	4
PH 407	Solid State Physics	4
EP 408	Microsensors	4
PH 440	X-Rays and Crystalline Materials	4
PH 490/ME 490	Directed Research	4
ME 408	Heat Transfer	4
ME 417	Advanced Materials Engineering	4

A Minor Completion Form must be submitted to the Registrar's Office in order for the Area Minor to be posted on your official transcript. The forms are available in the Physics and Optical Engineering Departmental Office, CL106.

Minor in Optical Engineering

Eligibility: Students in any degree program, except Optical Engineering.

Advisors: Drs. Bunch, Ditteon, Duree, Granieri, Joenathan, Lepkowicz, Siahmakoun, Wagner, F. Berry, and Black.

Required courses:

Course	Description	Hours
OE 280	Paraxial Optics	4
PH 292	Physical Optics	4
OE 295	Optical Systems	4

Plus at least two* courses from one of the areas listed below:

Lens Design Area

OE 360	Optical Materials and	4
OE 415	Opto-mechanics	4
OE 480	Optical Engineering	4
OE 490	Design I	4

	Lens Design and Aberrations	
	Directed Research (4 Credits Only)	

Photonics/Electro-optics Area

Course	Description	Hours
OE 360	Optical Materials and	4
OE 415	Opto-mechanics	4
OE 450	Optical Engineering	4
OE 485	Design I	4
OE 490	Laser Systems and	4
OE 493	Applications	4
	Electro-optics and Applications	
	Directed Research (4 Credits Only)	
	Fundamentals of Optical Fiber Communications	

Image Processing Area

Course	Description	Hours
OE 360	Optical Materials and Opto-mechanics	
OE 415	Optical Engineering	4
OE 490	Design I	4
	Directed Research (4 Credits Only)	
OE 437/ECE 480	Introduction to Image Processing	4
PH 537/ECE 582	Advanced Image Processing	4

A Area Minor Completion Form must be submitted to the Registrar's Office in order for the Area Minor to be posted on your official transcript. The forms are available in the Physics and Optical Engineering Departmental Office, CL106.

Minor in ECE

Eligibility: Only students in Physics and Optical Engineering

Advisors: Physics and Optical Engineering faculty and Electrical and Computer Engineering faculty

Course Number	Course Title	Credits
ECE 203 Required	**DC Circuits**	**4**
ECE 204 Required	**AC Circuits**	**4**
ECE 205	Dynamical Systems	4
ECE 300	Continuous-Time Signals	4
ECE 310	and Systems	4
ECE 380	Communication Systems	4
	Discrete-Time Signals and Systems	

To see the complete list of optional courses available for this minor, please see the Electrical and Computer Engineering Department Minor Listing. Taking courses other than the ones listed here may require the student to take additional courses to fulfill the prerequisites for the other courses.

A Minor Completion Form must be submitted to the Registrar's Office in order for the Area Minor to be posted on your official transcript. The forms are available in the Electrical and Computer Engineering Departmental Office.

Minor in Medical Physics and Nanomedicine

Eligibility: Students in any major degree program

Advisors: Dr. Letfullin, Dr. Duree, Dr. McInerney, Dr. Kirtley, Dr. Siahmakoun

A student interested in pursuing a Minor should consult with the appropriate Minor Advisor, listed above for planning a course schedule.

Required Courses

PH 302 Biophysics **or** BE 201 Biomedical Instrumentation and Measurements (4 cr)
BE 435/OE 435 Biomedical Optics **or** BE 541 Medical Imaging Systems (4 cr)
EP 450 Nanomedicine (4 cr)

Plus 8 hours from the following list (not limited and open for student's choice/suggestion of courses followed by program adviser's approval):

Course Number	Course Name	Credits
BIO 120	Comparative Anatomy & Physiology	4
BE 201	Biomedical Instrumentation and Measurements	4
BIO 205	Cellular Physiology	4
BIO 451	Cancer Biology	2
BE 541	Medical Imaging Systems	4
PH 265	Fundamentals of Nuclear Physics and Radiation	4
EP 280	Introduction to Nano-engineering	4
PH 302	Biophysics	4
EP 380	Nanotechnology, Entrepreneurship and Ethics	4
PH 470	Introduction to Physics of Medical Imaging	2
BE 435/OE 435	Biomedical Optics	4
MA 482	Bioengineering Statistics	4
ECE 480/OE 437	Introduction to Image Processing	4
CHEM 330	Biochemistry I	4

Course Number	Course Name	Credits
CHEM 331	Biochemistry II	4
CHEM 532	Biochemical Pharmacology	4

Also see Certificate Program in Semiconductor Materials and Devices

Plan of Study

Freshman

Fall

Course	Credit
MA 111 Calculus I	5
PH 111 Physics I	4
CLSK 100 College & Life Skills	1
RH 131 Rhetoric & Comp or HSS Elective	4
EM 104 Graphical Communications	2
	Total Credits: 16

Winter

Course	Credit
PH 112 Physics II	4
MA 112 Calculus II	5
CHEM 111 General Chemistry I	4
Computing Elective*	2 or 4
	Total Credits: 15, or 17

Spring

Course	Credit
PH 113 Physics III	4
MA 113 Calculus III	5
CHEM 113 General Chemistry II	4
HSS Elective or RH131 Rhetoric & Composition	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
Free Elective†	4

Course	Credit
PH 235 Many Particle Physics	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
PH 292 Physical Optics	4
	Total Credits: 16

Winter

Course	Credit
PH 255 Fund. of Modern Physics	4
HSS Elective	4
Technical Elective	4
MA 211 Differential Equations	4
	Total Credits: 16

Spring

Course	Credit
PH 314 Theoretical Mechanics I	4
HSS Elective	4
MA 371 Linear Algebra I or MA 373 Applied Linear Algebra for Engr	4
Math Elective†	4
	Total Credits: 16

Junior

Fall

Course	Credit
HSS Elective	4
PH 316 Electric & Magnetic Fields	4
Technical Elective†	4
PH 405 Semiconductor Materials & Applications	4
	Total Credits: 16

Winter

Course	Credit
PH 317 Electromagnetism	4
PH 401 Intro Quantum Mechanics	4
HSS Elective	4
Physics Elective†	4
	Total Credits: 16

Spring

Course	Credit
PH 325 Advanced Physics Lab I	4
HSS Elective	4
OE 450 Laser Sys & App or Physics Elective†	4
PH 327 Thermodynamics & Statistical Mechanics	4
	Total Credits: 16

Senior

Fall

Course	Credit
Math Elective†	4
Technical Elective†	4
HSS Elective	4
Free Elective	4
	Total Credits: 16

Winter

Course	Credit
PH 425 Advanced Physics Lab II	4
HSS Elective	4
Technical Elective†	4
Free Elective†	4
	Total Credits: 16

Spring

Course	Credit
Technical Elective†	4
OE 450 Laser Sys & App or Physics Elective	4
Free Elective	4
Physics Elective†	4
	Total Credits: 16

NOTES:

* Computing elective: 2 or 4 credit course on computing from the following course: BIO 100, CHE 110, CSSE 120, and ME 123. CSSE 120 is required for physics majors who are planning to double major with CSSE, CPE, EE, MA, and ME

†Free, Math and technical electives are only suggestions and can change subject to offering. Electives must be approved by PHOE advisor.

ROTC: Air Force

Air Force ROTC is designed as a four year training program that culminates in a student's becoming an Officer in the United States Air Force. This program is designed to run concurrently with the four year college curriculum and is open to all college students at no obligation.*

We also offer modified programs which can be completed in three or two years which also earn a commission in the Air Force. Once students have completed Air Force ROTC and college requirements they are off to serve at least the next four years in leadership positions throughout the Air Force.

*Based on individual situations, Air Force ROTC will ask for an obligation before more advanced training or monies are paid to a student. Until such time, the classes are free and at no obligation-contact Air Force ROTC for more details.

SCHOLARSHIPS

The Air Force is looking for the best and brightest students the country has to offer. To assist these students with their college education, a variety of scholarships are offered on a nationwide competitive basis. Scholarship winners attending Rose-Hulman can receive up to the full cost of tuition, plus payment of most school fees. Scholarships also pay for books along with a monthly tax-free stipend, during the school year. In addition, Rose-Hulman offers financial incentives to students bringing their ROTC scholarship to Rose-Hulman. For more information on Air Force scholarships, contact Rose-Hulman Admissions or Air Force ROTC Detachment 218 at Indiana State University, Technology Center Room 203, Terre Haute, IN 47809-2245. Phone (812) 237-2657.

The Air Force ROTC courses are designed to develop the leadership and management skills required to be an effective Air Force officer. Topics range from Air Force history to ethics and values. The curriculum is separated into four (4) major areas:

Profession of Arms Designed specifically for the continued development of professional knowledge and skills unique to the Air Force profession. Subject areas include officership, military law, laws of armed conflict, military customs and courtesies, and the individual's role in supporting organizational and Air Force policies.

Communications Skills Designed specifically to enhance professional development, which is integrated throughout the AFROTC curriculum. Emphasis is on a progressive study of the various communication skills required of Air Force junior officers. The curriculum is designed to provide both instruction and application of principles and concepts in written communications, staff communication instruments, oral communication, and the nature and art of effective listening.

Leadership Studies Designed to examine aspects of military leadership and management functions as a part of the overall concept of leadership. An examination of leader variables and characteristics provides a lead-in to a protracted study of leadership theory. Leadership and management skills are developed and applied in Leadership Laboratory and cadet corps activities. Leadership training is emphasized at Field Training where team sports, military drill, and special leadership problems are mandatory.

Military Studies/International Security Studies Designed to develop an understanding of the nature of conflict and how the United States military forces, particularly aerospace forces, are developed, organized, and employed. Subjects include the need for national security, the evolution and formulation of American defense policy and strategy, regional security issues, and joint doctrine.

Benefits
Air Force ROTC classes, text books, and uniforms are free to all fully-enrolled cadets. Once enrolled as a full member of the program, cadets are eligible to attend a variety of professional development programs during the summer months. Successful completion of the Air Force ROTC program results in a commission as a Second Lieutenant in the active duty US Air Force.

Plan of Study

Freshman

Fall

Course	Credit
AS 101 Found. of the US Air Force I	1
AS 101L Leadership Laboratory	0
AS 102 Found.of the US Air Force II	1
AS 102L Leadership Laboratory	0
AS 103 Found.of the US Air Force III	1
AS 103L Leadership Laboratory	0
	Total Credits: 3

Sophomore

Fall

Course	Credit
AS 201 Evol. of Air & Space Power I	2
AS 201L Leadership Laboratory	0
AS 202 Evol. of Air & Space Power II	2
AS 202L Leadership Laboratory	0
AS 203 Evol. of Air & Space Power III	2
AS 203L Leadership Laboratory	0
	Total Credits: 6

Junior

Fall

Course	Credit
AS 301 Air Force Lead. Studies I	4
AS 301L Leadership Laboratory	0
AS 302 Air Force Lead. Studies II	4
AS 302L Leadership Laboratory	0
AS 303 Air Force Lead. Studies III	4
AS 303L Leadership Laboratory	0
	Total Credits: 12

Senior

Fall

Course	Credit
AS 401 Nat.Sec.Aff./Prep. for Active Duty I	4
AS 401L Leadership Laboratory	0
AS 402 Nat.Sec.Aff./Prep. for Active Duty II	4
AS 402L Leadership Laboratory	0
AS 403 Nat.Sec.Aff./Prep. for Active Duty III	4
AS 403L Leadership Laboratory	0
	Total Credits: 12

NOTES:

Leadership Laboratory is part of the curriculum for all four years of study. This lab is designed to give students hands-on application of the skills taught in the classes. In addition, students practice the various customs and courtesies and leadership skills they will be use once they enter active duty.

ROTC: Army

The completion of the Army ROTC program leads to a commission as a Second Lieutenant in the Active Army, Army Reserve or Army National Guard. Students completing the program receive their commissions upon graduation and serve a specified period of active duty ranging from three months to four years, depending upon the student's choice of commissioning program and Army requirements.

CURRICULUM

The ROTC program specializes in teaching leadership and management skills required by the military and sought by civilian employers. ROTC cadets learn how to motivate co-workers and how to plan, organize and implement large projects and tasks. They also learn skills in demand in civilian businesses, such as teamwork, tact problem solving, decision making, and effective communication. The program includes the Basic Course for freshmen and sophomores and the Advanced Course for juniors and seniors. Students incur active duty and reserve commitments only upon enrollment in the Advanced Course or through the ROTC scholarship program and successful completion of the curriculum.

Students who miss out on the basic ROTC Freshman and Sophomore curriculum can attend a four-week (LTC) leadership training course at Fort Knox, KY., during the summer between their sophomore and junior years.

In the Advanced Course, students must complete 18 credit hours of Military Science and the 5-week ROTC Leadership Development and Assessment Course (MS 304) at Fort Lewis, WA. Qualified students may also participate in Army Airborne, Air Assault, Northern Warfare, or Mountain Warfare training.

Veterans and students who received ROTC training in high school should contact the Department concerning possible constructive credit for part or all of the Basic Course. Graduate students, transfer students and students who expect to complete degree requirements in less than four years should contact the Department concerning an accelerated program if they desire to obtain a commission. Other programs are available for selected students to complete the program in 2 years or less.

Allowances

Uniforms are furnished, when appropriate, to all students without charge. Students on scholarship and/or enrolled in the Advanced Course receive a monthly subsistence allowance that ranges from $250-400 per month during the school year and approximately $20 per day during the ROTC Advanced Camp, plus free room and board (meals).

Scholarships

ROTC awards Full-Tuition scholarships plus free Room/Board per year, providing money for tuition and educational fees. Scholarships are awarded strictly on merit, although the Institute provides an additional financial incentive. Scholarship winners also receive a designated textbook allowance of $900 per year and a tax-free stipend allowance from $300-500 per month for up to 10 months for each year the scholarship is in effect. Four-year scholarships are open to high school graduates prior to entering Army ROTC as freshmen. The three and two year scholarships are available to students enrolled in ROTC at Rose-Hulman. Full details on the scholarship program may be obtained by contacting the ROTC office at 1 (800)-248-7448, extension 8348 or 8236, or by visiting the Army ROTC home page at http://www.rose-hulman.edu/AROTC/

Partnership Institutions

Through a cooperative agreement, students at Indiana State University, Saint Mary-of-the-Woods College, University of Southern Indiana (USI) and DePauw University may participate in the Rose-Hulman Military Science program.

*All contracted cadets must attend Leadership Laboratories and Physical Training..

Plan of Study

Freshman

Full Year

Course	Credit
MS 101 Leadership & Personal Development	1
MS 102 Introduction to Tactical Leadership	1
MS 103 Basic Tactical Leadership	1
	Total Credits: 3

Sophomore

Full Year

Course	Credit
MS 201 Innovative Team Leadership	2
MS 202 Foundations of Tactical Leadership	2
MS 203 Foundations of Tactical Leadership II	2
	Total Credits: 6

Junior

Full Year

Course	Credit
MS 301 Adaptive Team Leadership	4
MS 302 Leadership Under Fire	4
MS 303 Leadership Under Fire II	4
	Total Credits: 12

Senior

Full Year

Course	Credit
MS 401 Developing Adaptive Leaders	4
MS 402 Leadership in a Complex World	4
MS 403 Leadership in a Complex World II	4
	Total Credits: 12

NOTES:

*All contracted cadets must attend Leadership Laboratories and Physical Training..

SUMMER COURSE:
MS 206 ROTC Basic Camp - no credits

Rose-Hulman Institute of Technology Course Catalog

Software Engineering

Software engineering is the creation of software using a process similar to other engineering disciplines. It allows for software to be reliable and developed within time and cost estimates. The software engineering curriculum prepares students for a career in reliable, economical software development.

Programming is only one phase (construction) of software engineering. There are many other aspects of the software engineering process, such as requirements definition, architectural design, and quality assurance, which need to be applied in order to develop reliable software on time and within budget constraints. The software engineering curriculum provides students a solid background in both the theory and practice of all phases in the software engineering process, beginning with their first course of study in the Department of Computer Science and Software Engineering, and continuing to the end of the senior year.

Since software is a non-physical product developed and executed on computers, the software engineering curriculum has computer science as its primary engineering science. The computer science courses taken by software engineering majors include the study of algorithms, data structures, database concepts, computer architecture, programming languages and operating systems. Software engineering majors also complete important courses in other closely related fields, such as discrete mathematics, digital logic design, and engineering statistics.

Coverage of software engineering topics begins in a three-term introduction to software development during the freshman and sophomore years. This study continues with coverage of core software engineering areas in the junior year, including software requirements, software architecture, software design, software project management, software construction, software maintenance, software evolution, software quality assurance, and formal methods in software specification and design. All of these courses include individual and team projects relevant to that particular area of software engineering. These projects generally include both written and oral presentations, building upon a technical communication course which introduces the student to the skills necessary for this important aspect of being a software professional. Throughout the senior year, a capstone team project develops and delivers software for a “real-world” client, which is put on display locally at a public exposition.

Throughout society, software exists for a wide variety of application domain areas. Each student is required to take at least three courses in a particular application domain, so that RHIT software engineering graduates can more effectively apply the software engineering principles they learn to that domain area. Students can choose from a variety of domain areas, including engineering, scientific and commercial applications.

Courses in various computer science topics such as computer graphics, artificial intelligence, computer networks, computer vision, web-based information systems, and cryptography are among those available as advanced electives. In addition, free elective courses allow students to tailor their undergraduate education to their specific goals.

The department has its own local area network. This network is connected to the campus-wide network and the Internet. Laboratory machines are mostly Sun Ultra workstations. Software engineering majors have unlimited access to the department's laboratories. Software engineering students are frequently employed by the computing center as user consultants and by the department as system managers and course assistants.

The student chapter of the Association for Computing Machinery provides seminars and other technical activities throughout the year. The national honor society in the computing and engineering disciplines, Upsilon Pi Epsilon and Tau Beta Pi, both have chapters at Rose-Hulman. Software engineering majors are also eligible to join the Order of the Engineer, which focuses on the ethical and professional responsibilities of an engineer, during the spring of their last year of study.

Software Engineering Program Educational Objectives

The software engineering program prepares its graduates for many types of careers in the computing industry as well as for graduate study in software engineering and in closely related disciplines. Within a few years after completing the software engineering degree program, our graduates will:

1. Advance beyond their entry-level position to more responsible roles, or progress towards completion of advanced degree(s).
2. Continue to keep pace with advancements in their disciplines, and develop professionally in response to changes in roles and responsibilities.
3. Demonstrate that they can collaborate professionally within or outside of their disciplines at local, regional, national, or international levels.
4. Contribute to the body of computing products, services, or knowledge.

Software Engineering Student Outcomes

By the time students graduate with a Software Engineering degree from Rose-Hulman, they will be able to:

1. Apply software engineering theory, principles, tools and processes, as well as the theory and principles of computer science and mathematics, to the full lifecycle of complex, scalable software systems
2. Elicit, analyze and specify software requirements through a productive working relationship with project stakeholders
3. Design and construct software using contemporary software design and architecture principles and patterns so relevant tradeoffs can be analyzed to produce effective solutions
4. Apply appropriate codes of ethics and professional conduct to the solution of software engineering problems
5. Evaluate and discuss the legal, social, and ethical aspects of significant events that arise in the field of computing both domestically and internationally
6. Interact effectively with colleagues and clients located abroad and overcome challenges that arise from geographic distance, cultural differences, and multiple languages
7. Communicate effectively through oral and written reports as well as software documentation
8. Participate productively on software project teams involving colleagues from a variety of disciplines

9. Recognize the need for, and engage in, lifelong learning

The Computer Science and Software Engineering faculty strives to maintain an open atmosphere that encourages mutual respect and support as well as learning and sharing of knowledge.

The software engineering program is accredited by the Engineering Accreditation Commission of ABET,www.abet.org

SOFTWARE ENGINEERING

Summary of graduation requirements for the software engineering major

To complete the major in software engineering a student must complete the following:

1. All required courses listed by number in the schedule of courses above: CSSE120, CSSE132, CSSE220, CSSE230, CSSE232, CSSE304, CSSE332, CSSE333, CSSE371, CSSE372, CSSE373, CSSE374, CSSE375, CSSE376, CSSE477, CSSE497, CSSE498, CSSE499; MA111, MA112, MA113, MA212, MA275, MA375, MA381; PH111, PH112, CHEM111; RH 131, RH330; CLSK100.
2. Four additional credits of CSSE courses except CSSE325, CSSE473, CSSE474, and CSSE479. In addition, use of CSSE49x to satisfy the CSSE elective requires approval of the Director of Software Engineering or the CSSE department head.
3. A Domain Track set of courses.
   a. SE Domain Track Process:

      As part of the Bachelor of Science in Software Engineering (BSSE) degree requirements, the domain track provides a means of applying software engineering in an application domain outside of computing (e.g., biology is a domain where software applications are commonly developed).

      SE Domain Tracks

      Domain Track Declaration Form

1. Four additional credits of courses offered by the Department of Mathematics excluding MA351 – MA356. The student's academic advisor must approve the course used to satisfy this requirement. Where appropriate, a course in the student's application domain track can be used to satisfy this requirement.
2. Four credits of science electives, which can be any CHEM, GEOL, PH, or BIO courses not already required for the software engineering major.
3. Twenty-eight credits of additional courses offered by the Department of Humanities and Social Sciences; the distribution of these courses must meet the requirements of that department. Where appropriate, one or more courses in the student's application domain track can be used to satisfy part of this requirement.
4. Sufficient free elective courses to meet the minimum credit hour requirement of 192 hours for a software engineering major. These courses must have the approval of the student's academic advisor. Free electives may be selected from any Rose-Hulman course.

Area Minor in Software Engineering

Advisor: Dr. Shawn Bohner

Required Courses

CSSE 120, Introduction to Software Development

CSSE 220, Object-Oriented Software Development
CSSE 230, Data Structures and Algorithm Analysis
CSSE 371, Software Requirements Engineering
CSSE 374, Software Design

Two additional courses in software engineering chosen from CSSE 372, 373, 375, 376, and 477.

Plan of Study

Freshman

Fall

Course	Credit
CSSE 120 Introduction to Software Development	4
MA 111 Calculus I	5
PH 111 Physics I	4
RH 131 Rhetoric & Composition	4
CLSK 100 College & Life Skills	1
	Total Credits: 18

Winter

Course	Credit
CSSE 220 Object-Oriented Software Development	4
MA 112 Calculus II	5
PH 112 Physics II	4
HSS Elective	4
	Total Credits: 17

Spring

Course	Credit
CSSE 132 Introduction to Computer Systems Design	4
MA 113 Calculus III	5
HSS Elective	4
Science Elective	4
	Total Credits: 17

Sophomore

Fall

Course	Credit
CHEM 111 General Chemistry I	4
CSSE 232 Computer Architecture I	4
MA 212 Matrix Algebra & Systems of Differential Equations	4
MA 275 Discrete & Combinatorial Algebra I	4
	Total Credits: 16

Winter

Course	Credit
CSSE 230 Data Structures & Algorithm Analysis	4
CSSE 304 Programming Lang. Con	4
MA 375 Discrete & Combinatorial Algebra II	4
RH 330 Technical & Professional Communication	4
CSSE 332 Operating Systems	4
	Total Credits: 20

Spring

Course	Credit
CSSE 376 Software Quality Assurance	4
MA Elective	4
CSSE 333 Database Systems	4
Domain track course	4
	Total Credits: 16

Junior

Fall

Course	Credit
CSSE 371 Software Requirements Engineering	4
CSSE 372 Software Project Management	4
MA 381 Introduction to Probability with Statistical Applications	4
Domain track course	4
	Total Credits: 16

Winter

Course	Credit
CSSE 374 Software Design	4
Domain track course	4
HSS Elective	4
	Total Credits: 12

Spring

Course	Credit
CSSE 373 Formal Methods in Specification & Design	4
CSSE 375 Software Construction & Evolution	4
HSS Elective	4
Domain track course or free elective	4
	Total Credits: 16

Senior

Fall

Course	Credit
CSSE 477 Software Architecture	4
CSSE 497 Senior Capstone Project I	4
HSS Elective	4
Domain track course or free elective	4
	Total Credits: 16

Winter

Course	Credit
CSSE 498 Senior Capstone Project II	4
CSSE Elective	4
HSS Elective	4
Free Elective	4
	Total Credits: 16

Spring

Course	Credit
CSSE 499 Senior Capstone Project III	4
HSS Elective	4
Free Elective	4
	Total Credits: 12

PRE-PROFESSIONAL PROGRAMS

Many graduates of Rose-Hulman choose to pursue professional or graduate studies after completion of their undergraduate studies. Engineering and science curricula provide excellent backgrounds for careers in business, law, and medicine. A student planning to enter a professional or graduate school should seek information as to the requirements for entrance into the institution of their choice and should arrange their undergraduate program accordingly. Advisors are available on the campus to advise and assist students interested in pursuing such studies after graduation.

PRE-BUSINESS

Any of the prescribed curricula at Rose-Hulman are satisfactory for entrance into a professional school of business administration. Students interested in this area will find courses in economics, statistics, operations research, and computer sciences particularly helpful.

PRE-LAW

Law schools accept superior students from a wide variety of undergraduate backgrounds. The analytical training and problem-solving techniques inherent in engineering and science programs are particularly helpful to students interested in pursuing law careers. Law schools require that the Law School Admission Test (LSAT) be taken prior to consideration for admission. Contact the Pre-Law Adviser for more information.

PRE-MEDICINE

Because of the increased importance of engineering and instrumentation technology in modern medicine, medical schools are very interested in attracting superior students with engineering and science backgrounds. The various curricula at Rose- Hulman, when supplemented with elective courses available, enable the student to meet all course requirements for admission to medical school.

Each medical school has its own specific minimum academic requirements but the generally include basic courses in general chemistry, physics, organic chemistry, and biology. Programs in chemistry and chemical engineering provide especially helpful backgrounds for this purpose, but many Rose-Hulman graduates from a variety of disciplines such as mathematics, physics, mechanical engineering, and electrical engineering, have completed medical school and are successful practicing physicians.

Application to a medical school should be made between May and October of the year previous to that in which the applicant expects to enter. The Medical College Admissions Test (MCAT) is required for consideration for admission. Interested students should contact the Health Professions Adviser for additional information.

Rose-Hulman Institute of Technology Course Catalog

Download PDF

FAST TRACK CALCULUS

Integral and multivariable calculus, is offered during the summer (late July through late August) for selected members of our entering freshman class who have demonstrated outstanding ability in mathematics and studied a year of calculus during high school. Participants are expected to have scored at least 700 on the mathematics portion of the SAT or 31 on the mathematics portion of the ACT. Students, who have a 700 Math Score or 680 math/700 critical reading or better on the SAT, or a 30 mathematics score and at least a 31 English score on the ACT have also been admitted to the program. Participants who successfully complete Fast Track Calculus satisfy Rose-Hulman's freshman Calculus requirement, are awarded 15 quarter hours of credit toward graduation, and begin their college careers as "mathematical sophomores."

Admission to Fast Track Calculus is competitive. Interested students should contact the Head of the Mathematics Department or Director of Fast Track Calculus.

ACCELERATED MATH PHYSICS

An integrated calculus and physics course is offered during the summer (late July through late August) for selected members of our entering freshman class who have demonstrated outstanding ability in mathematics and physics having taken a year of college level calculus during high school and one year of high school physics. Participants are expected to have scored at least 700 on the mathematics portion of the SAT or 31 on the mathematics portion of the ACT. Students, who have a 700 mathematics score or 680 mathematics/700 critical reading or better on the SAT, or a 30 mathematics score and at least a 31 English score on the ACT have also been admitted to the program. Participants who successfully complete the Accelerated Math Physics Program will earn credit for MA113, PH111, and PH112. Selected students are expected to have the ability to place out of MA111 and MA112, so will start in the Fall quarter having credit for MA111, MA112, MA113, PH111, PH112 – effectively as sophomores. Admission to the Accelerated Math Physics Program is competitive. Interested students should contact the Directors of the Accelerated Math Physics Program.

NEW STUDENT ORIENTATION

To aid entering students in their adjustment to college life, a five-day orientation period for students precedes regular classroom instruction prior to the start of the academic year. Each freshman is required to be present for this program. The program offers a number of advantages to both the students and faculty. The students become acquainted with the facilities and surroundings, with each other, and with the regulations and routines of college life. Students learn about the various student organizations, opportunities for co-curricular activities and Rose-Hulman student traditions.

Further, students are introduced to the nature of science and engineering studies, and they meet with their faculty advisers and resident assistants. Talks and discussions offer them insight into the kinds of work engineers and scientists do and into the satisfactions to be derived from a career in science and engineering.

The orientation period also permits the faculty an opportunity to administer a number of diagnostic tests. These tests seek to determine achievement levels in academic areas and are useful for two purposes: they are tools to be used by the faculty advisers and counselors to do effective counseling, and they help to identify students who may need special attention.

Although Rose-Hulman uses the best available criteria to select its students, the undeniable fact is that students come to college with widely varying degrees of motivation and with widely differing qualities of high school preparation. The diagnostic efforts of the orientation period help to identify those students who could immediately qualify for advanced work in certain areas, and those who indicate a need for additional help. Students at Rose-Hulman normally complete their degree requirements in four years, but the Institute also wishes to provide for those students who, with encouragement and opportunity, do more than the normal student in four years and for those who may need special help or a slower pace of study.

SUSTAINABILITY MINOR

1. Curricular Requirement
    a. Core Courses (16 credits)
        i. GS130 Introduction to Sustainability (4 credits)
        ii. BIO191 Environmental Science (4 credits)
        iii. SV150 Microeconomics (4 credits)
        iv. MDS302 Sustainability in Practice (2 credits): prerequisites: GS130, BIO191, SV150
        This is a project-based course to provide hands-on experiences for student teams working on real-world problems related to sustainability. This could include design projects, scientific research, modeling-based projects, or studies to improve campus sustainability. The course instructor will mentor teams with routine assignments that relate to their design or research process through oral and written communication.
        v. MDS402 Seminar in Sustainability (2 credits): prerequisite MDS302
        This course provides students with the opportunity to examine, analyze, and reflect upon sustainability as it related to their project or research work. Course work includes weekly readings and discussions, individual essays, and in-class and public presentations. Successful completion of this course will require students to have completed the co-curricular requirements.

b. Three electives (4 credits each = 12 credits) Students must take a total of at least four credits from a list of Social courses and at least eight credits from a list of Technical and Scientific courses. Alternatively, students can design their own plan of study for elective courses that suit their particular interests and field of study with approval of the HERE Co-directors, Jenny Mueller Price and Mark Minster.
    i. Social (HSS requirement)
    SV201 Religion and Ecology
    SV303 Business and Engineering Ethics
    SV304 Bioethics
    SV322 Disasters and Modern Society
    SV 354 Environmental Economics
    SV339 Literature and the Environment
    GS 425 Cities and Technology in the Industrial Age
    ii. Technical and Scientific (Discipline Specific Tech Elective)
    BIO320 Ecology (prerequisite: BIO130)
    CE250 Sustainable Civil Engineering Design (2 credits)
    CE460 Introduction to Environmental Engineering
    CE471 Water Resources Engineering
    CHEM470 Green Chemistry (Special Topics)
    CHE465 Energy and the Environment
    CSSE241 Computing in a Global Society
    ECE371 Sustainable Energy Systems (prerequisite: ECE204)
    ECE398 Appropriate Technologies for Developing Countries (Special Topics)
    EMGT587 Systems Engineering
    ME408 Renewable Energy (prerequisite: ES202)

2. Co-curricular requirements: Students record via Co-curricular Report on Banner Web. Students will need to complete these requirements to pass MDS402 Seminar, which is taken senior year. Requirements will be prorated for students joining the program after their freshman year.
    a. Three professional development activities per year (guest speakers; trips to St. Louis, Bloomington, Chicago, and Subaru plant each year; Terre Haute Farmer’s Market; etc.)
    b. Six project hours per year (Campus garden and greenhouse, Ryves neighborhood, RHIT Campus Day of Service, RHIT Campus Beautification, Keep Terre Haute Beautiful, Student-led initiatives, etc.)

MULTIDISCIPLINARY MINOR IN COGNITIVE SCIENCE

The Multidisciplinary Minor in Cognitive Science has the following requirements:

1. Cognitive Psychology (IA 371).
2. Object-Oriented Software Development (CSSE 220) or Fundamentals of Software Development Honors (CSSE 221)
3. Philosophy of Mind (IA 301) or Philosophy of Science (IA 401) or Human Nature (SV 472)
4. Three additional courses from the list below. At least two courses must be from the same group. A course may not satisfy more than one requirement of the minor.
5. Substitutions may be made with the approval of the Minor Advisor.

Courses:

Mind and Behavior group

- IA 301 Philosophy of Mind
- IA 352 Game Theory
- SV 171 Introduction to Psychology
- SV 402 Human Nature
- SV 472 Studying Human Behavior

Computation and Artificial Intelligence group

- CSSE 290 Cognitive Computing
- CSSE 413 Artificial Intelligence
- CSSE 453 Topics in Artificial Intelligence
- CSSE 463 Image Recognition
- IA 471 Computational Psychology
- MA 490 Deep Learning

Neuroscience group

- BE 310 Analysis of Physiological Systems I
- BE 520 Introduction to Brain Machine Interfaces
- BE 543 Neuroprosthetics

CONSULTING ENGINEERING PROGRAM

Through the generosity of J. B. Wilson, a prominent consulting engineer of Indianapolis, a program was established in 1973 to emphasize career opportunities in the field of consulting engineering and to provide selected courses which would be beneficial to students interested in consulting engineering careers.

Listed below is a program guide of recommended courses for a student interested in consulting engineering. This is not a degree program but is a supplement to the normal engineering degree programs. Some of the courses are in addition to the normal engineering degree programs and may result in a student earning more credits than are required for the B.S. degree in a specific discipline.

Students desirous of pursuing the Consulting Engineering Program should enroll in the Program by filing a declaration-of-intent form with the Chairman of the Commission. In order to be certified as having completed the Program, a student is required to successfully complete the prescribed list of courses, complete the requirements for a degree in Engineering, and take the Fundamentals of Engineering examination prior to graduation.

Upon completion of the program, students will receive a Certificate of Completion at the time of their graduation from Rose-Hulman Institute of Technology. Completion of the program will be noted on the student's official transcript but not on the diploma. The Consulting Engineer Program advisor is Dr. Kevin Sutterer P.E., Ph.D., Department of Civil and Environmental Engineering.

Download the Consulting Engineering Intention Form

Credit

EM102/EM104 Graphical Communications	2
RH330 Technical Communications	4
Or	
IA230 Fundamentals of Public Speaking	4
SV351 Managerial Economics	4
Or	
EMGT 432/532 Technical Entrepreneurship	4
CE303 Engineering Economy	4
Or	
CHE416 Design I: Process Economics and Equipment Design	4
EMGT552 Business Law for Technical Managers	4
CE420/CHE420/ECE466 or ME420 Consulting Engineering Seminar	2
Engineering Design (any senior Engineering design course)	4
Total	24

Exceptions to these program course requirements require approval by the Consulting Engineering Program Advisor.

Registration for & sitting for the Fundamentals of Engineering Exam required.

MULTIDISCIPLINARY MINOR IN DATA SCIENCE

Any student may obtain a Multidisciplinary Minor in Data Science by taking the following courses:

Introductory Statistics Course (4 credit hours):
One of the following courses

- MA223 Engineering Statistics I
- MA382 Introduction to Statistics with Probability

Introductory Computer Science Courses (8 credit hours):

- CSSE120 Introduction to Software Development
- CSSE220 Object Oriented Software Development

Electives (16 credit hours):
Two courses from the list below:

- MA386 Statistical Programming
- MA384 Data Mining
- CSSE 230 Data Structures & Algorithm Analysis

A minimum of two additional course from the list below: (See degree separation requirement below.)

- BMTH312 Bioinformatics
- CSSE333 Database Systems
- CSSE413 Artificial Intelligence
- CSSE433 Advanced Database Systems
- CSSE434 Introduction to the Hadoop Ecosystem
- CSSE463 Image Recognition
- CSSE481 Web-Based Info Systems
- CSSE490 Internet of Things
- CSSE335/MA335 Introduction to Parallel Computing
- MA384 Data Mining
- MA386 Statistical Programming
- MA480 Bayesian Inference
- MA482 Bioengineering Statistics
- MA485 Applied Regression and Time Series
- MA490 Machine Learning
- MA490 Deep Learning
- ME447 Visualizing Data
- ME497 Reproducible Research
- PH327 Thermodynamics and Statistical Mechanics
- SV450 Econometrics

Notes and limitations on requirements:

- Degree Separation Requirement: The Multidisciplinary Minor in Data Science must be separated from any other minor and the named required courses of any major by a minimum of 16 credit hours. Exceptions to this requirement must be approved by the minor advisor for Data Science and the heads of both the Department of Mathematics and the Department of Computer Science and Software Engineering.
- Electives not listed above may be substituted with other courses with the approval of the minor advisor for Data Science.
- The minor plan of study must be approved by the minor advisor for Data Science and the student's advisor.

STUDY ABROAD

Students are provided the opportunity to enhance their academic experience by studying at an institution abroad. The Office of Global Programs offers information and support for students interested in immersive study abroad. To ensure the integrity of the experience, the following policies have been established.

- Students with a cumulative grade point average of 2.75 or higher, and who will have completed at least 45 earned credit hours at Rose-Hulman by the time of study abroad may apply for approval to enroll in a study abroad program.
- Students must be in good academic standing to apply for study abroad, including dual degree programs. Students who fall out of good academic standing between approval and the beginning of study abroad will be ineligible to study abroad until they are back in good standing.
- Students must remain in good standing during their study abroad program.
- Approved study abroad students will remain enrolled at the institute during the quarter or academic-year study abroad period.

- Students studying in a single location where English is not an official language are expected to study the official language of that country while studying abroad if they do not already have proficiency in that language.
- Students must maintain full-time status at the host institution and must receive a grade of “C” or better (converted to US system) in order for courses to be transferred in. Courses taken abroad for pass/fail credit will not be considered for transfer in.
- All study abroad credit, including dual degree, will be treated as transfer credit and will not be factored into cumulative GPA.
- Students may not have already graduated at the time of study abroad.
- Academic Misconduct will be taken into consideration as part of the approval process.
- Students will be subject to Rose-Hulman’s Code of Ethics while participating in study abroad.

Exceptions to the above policies may be considered for transfer students and on a case-by-case basis by the Office of Global Programs.

A full listing of study abroad opportunities is available from the Office of Global Programs.

INTEGRATED CIRCUIT TESTING CERTIFICATE

Testing integrated circuits is a critical element in the integrated circuit industry. In fact, testing has become the bottle-neck for many companies, with inefficient test programs preventing the release of products onto the market. With few colleges offering courses in this area, students at RHIT have a unique specialization opportunity, making them marketable and extremely valuable in the integrated circuit industry.

This certificate intends to provide the student with a solid background in test and product engineering and broaden that background with other courses pertinent to the test and product engineering field. A strong test/product engineer requires knowledge about integrated circuit design, systems design, board design, semiconductor fabrication, and statistics. Therefore, courses in these areas can be chosen for the elective portion of the certificate.

The test and product engineering certificate could be completed by an electrical or computer engineering student without overloading if the certificate courses are mapped to all but one of the Area, Technical, and Free electives. Electives have been chosen so that students can pursue the semiconductor certificate or a math minor in conjunction.

Certificate Requirements

ECE351: Analog Electronics is required.

Two of the three testing courses are required.

ECE557: Analog Test and Product Engineering
ECE558: Mixed-Signal Test and Product Engineering
ECE531: Digital Test and Product Engineering

Three of ten elective courses are required.

ECE551: Digital VLSI
ECE552: Analog Integrated Circuit Design
ECE553: RF Integrated Circuit Design
ECE343: High-Speed Digital Design (required for CPE program)

ECE416: Intro to MEMS
ECE419: Advanced MEMS
ECE454: System Level Analog Electronics
ECE557: Analog Test and Product Engineering (if not used for required testing course)
ECE558: Mixed-Signal Test and Product Engineering (if not used for required testing course)
ECE531: Digital Test and Product Engineering (if not used for required testing course)
PH405: Semiconductor Materials and Device I
EP406: Semiconductor Materials and Devices II
MA385: Quality Methods Engineering
MA387: Statistical Methods in Six Sigma

For further information about the certificate program, please contact Tina Hudson (hudson@rose-hulman.edu).

MULTIDISCIPLINARY MINOR IN IMAGING

Imaging concerns the collection, manipulation, analysis, generation, understanding and processing of images. It includes computer graphics, computer vision, optical imaging and filtering, signal processing and aspects of artificial intelligence. Rose-Hulman Institute of Technology offers a multidisciplinary minor in imaging. Hands-on experience is emphasized in the Imaging Systems Laboratory, which is used for project work by imaging students and graduate students whose theses involve imaging.

The minor recognizes undergraduate students who have gained a grounding in imaging systems while at Rose-Hulman. The minor requires 6 courses (at least 22 credits). Three courses are required core courses, two are electives, and one is the imaging systems project. A student would expect to take these courses starting in the junior year. A student in any major should be able to obtain an imaging minor with minimal, if any, course overload. Students interested in pursuing the minor should see the certificate advisor (listed below).

Required Courses

CSSE351 - Computer Graphics, Prerequisites: CSSE220, or CSSE221, and MA212 (Fall)

ECE480/PH437 - Introduction to Image Processing, Prerequisites: MA212, Junior standing (Winter)

OE295 - Optical Systems, Prerequisites: PH113, MA211 (Spring)

Elective Courses (choose 2 that are not named courses required for your major)

CSSE325/MA325 - Fractals and Chaotic Dynamical Systems, Prerequisites: MA212, and CSSE220 or CSSE221 (Spring)

CSSE451 - Advanced Computer Graphics, Prerequisites: CSSE351 (Winter)

CSSE461 - Computer Vision, Prerequisites: MA212, CSSE220 or CSSE221(Spring)

CSSE463 – Image Recognition, Prerequisites MA212, Junior Standing, Programming Experience (Winter)

ECE580 - Digital Signal Processing, Prerequisites: ECE380 or consent (Winter)

ECE582/PH537 - Advanced Image Processing, Prerequisites: CSSE 220 or CSSE221 or ME 323 or ECE 380 or consent; MA 212 (Spring)

MA323 - Geometric Modeling, Prerequisites: MA113 (Winter)

MA439 - Mathematical Methods of Image Processing, Prerequisites: MA212 (Fall)

OE480 - Lens Design and Aberrations, Prerequisites: OE 280 or SR/GR standing or consent of instructor (Fall)

OE592 - Fourier Optics and Applications, Prerequisites: SR/GR standing or consent of instructor (Fall)

ECE497 - Medical Imaging Systems, Prerequisites: ECE300 (Spring)

BE491 - Biomedical Imaging, Prerequisites: SR/GR standing or consent of instructor (Fall)

Other courses and independent studies which are consistent with an individual's imaging systems studies may also be used to satisfy the elective course requirements, subject to approval by the imaging systems faculty.

Imaging Project

A project with a significant imaging component is required. This may be done in any discipline. Projects must be approved by the Imaging Faculty. Projects must include both a written report and a public presentation, and be made available for future use. Students may meet this requirement in three ways: (1) A student may complete a 4-credit independent study, approved by the Imaging Faculty. (2) A student may begin the project in a course and then extend and document the project and make a public presentation during an independent study approved by the Imaging Faculty. (3) A student may complete an approved senior thesis or project involving imaging and substitute a senior thesis or project course for the independent study.

Imaging Systems Program Director

Matt Boutell, Department of Computer Science and Software Engineering

Imaging Systems Faculty

Matt Boutell, Department of Computer Science and Software Engineering
S. Allen Broughton, Department of Mathematics
Robert M. Bunch, Department of Physics and Optical Engineering
Kurt Bryan, Department of Mathematics
Ed Doering, Department of Electrical and Computer Engineering
David L. Finn, Department of Mathematics
Charles Joenathan, Department of Physics and Optical Engineering
Cary Laxer, Department of Computer Science and Software Engineering
Michael F. McInerney, Department of Physics and Optical Engineering
J.P. Mellor, Department of Computer Science and Software Engineering
Wayne T. Padgett, Department of Electrical and Computer Engineering
Deborah Walter, Department of Electrical and Computer Engineering
Alan Chiu, Department of Biology and Biomedical Engineering
Kosta Popovic, Department of Physics and Optical Engineering

CERTIFICATE IN SEMICONDUCTOR MATERIALS AND DEVICES

The Certificate will consist of 20 credit hours of which 12 credit hours will be required courses. Students interested in pursuing this Certificate should see a PHOE certificate advisor (S. Kirkpatrick, Liptak, McInerney, Siahmakoun, Syed and Wagner). Students taking solid state/material science minor cannot take this certificate.

Required Courses

1. PH405 Semiconductor Materials and Applications -- 3R-3L-4C F Pre: PH113 or PH255 or PH265 or consent of instructor.
2. EP406 Semiconductor Devices and Fabrication -- 3R-3L-4C W Pre: PH405 or consent of instructor.
3. EP410 Intro to MEMS: Fabrication and Applications -- 3R-3L-4C S Pre: JR or SR standing or consent of the instructor.
   or:
   CHE440 Process Control 4R-0L-4C W Pre: CHE202

Electives

Course	Hours	Course Title
OE 450	4	Laser Systems and Applications
OE 485	4	Electro-Optics and Applications
PH 330	4	Material Failure
PH 401	4	Introduction to Quantum Mechanics
PH 440	4	X-rays and Crystalline Materials
EP 408	4	Microsensors
EP 411	4	Advanced Topics in MEMS
ECE 351	4	Analog Electronics
ECE 551	4	Digital Integrated Circuit Design
ECE 552	4	Analog Integrated Circuit Design
ME 302	4	Heat Transfer
ME 328	4	Materials Engineering
ME 424	4	Composite Materials & Mechanics
ME 415	4	Corrosion and Engineering Materials
CHE 314	4	Heat Transfer
CHE 315	4	Material Science and Engineering
CHE 440	4	Process Control
CHE 441	4	Polymer Engineering
CHEM 441	4	Inorganic Chemistry I
CHEM 451	4	Organic Structure Determination

CHEM 457	4	Synthetic Polymer Chemistry
CHEM 462	4	Physical Polymer Chemistry
MA 381	4	Intro to Probability with Applications to Statistics
MA 385	4	Quality Methods
MA 487	4	Design of Experiments

Overall aim of the Certificate

A certificate holder will understand how semiconductor devices work, have practical experience in the main stages of device production, have practical experience in the more common forms of device testing and characterization, and have broad understanding of the mechanical and chemical properties of the material used.

A Certificate holder will be well suited for jobs requiring an understanding of semiconductor devices and their production. These jobs include not only those directly related to device fabrication, but also those involved with testing and trouble-shooting electronic equipment and the design of machines that contain electronic equipment. The experience in simple device fabrication that the Certificate provides is particularly useful for future engineers in “process” industries.

THE MANAGEMENT STUDIES PROGRAM

The Management Studies Program is a selected group of courses which develops a broad understanding of management in business and society. Like the Rose-Hulman Technical Translators Program, the Management Studies Certificate is a supplement to an engineering or science degree. The curriculum is a core of required courses in ethics, engineering management, economics, and technical communication with electives dealing with the role of management in society and specific tools for managers.

Statement of Objectives

The Management Studies Program broadens the education of engineers and scientists through a curriculum which:

- teaches the quantitative and economic concepts needed in management decision-making;
- promotes productivity through people;
- stresses communication skills required in management;
- examines intended and unintended impacts of management decisions;
- explores the social, legal, and ethical contexts of management.

Although the nine courses necessary to receive the certificate are a challenging addition to the undergraduate’s academic load, many of them may simultaneously be used to fulfill Humanities and Social Science, technical elective, and other degree requirements. Science majors should be able to complete the program easily within the regular four year pattern, but engineering majors may have to overload. In order to minimize conflicts and meet individual needs, each student will design a specific program with the Management Studies Adviser in the first quarter of the sophomore year.

Requirements:

1. All of the following core Courses:
   SV151 Principles of Economics
   SV303 Business and Engineering Ethics
   RH330 Technical and Professional Communication
   SV350 Managerial Accounting or SV356 Corporate Finance
   SV351 Managerial Economics

2. Two of the following Management in Society Courses (in addition to the core courses):
   SV171 Principles of Psychology
   EMGTXXX Engineering Management
   SV304 Bioethics
   EMGT533 Intercultural Communication
   GS432 Literature and Film of the Global Economy
   SV353 Industrial Organization
   SV357 Labor Economics
   IA352 Game Theory
   SV463 Seminar on America's Future
   IA453 The Entrepreneur
   EMGT526 Technology Management and Forecasting

3. Two courses from the following list. The student may choose to emphasize a strength area such as quantitative analysis, economics, or engineering management. Courses not included in this list may be approved by the Management Studies Advisor:
   CE303 Engineering Economy
   SV353 Industrial Organization
   IA350 Intermediate Microeconomics
   IA351 Intermediate Macroeconomics
   GS350 International Trade: Globalization
   GS351 International Finance
   CE441 Construction Engineering
   CE442 Cost Engineering
   MA444 Deterministic Models in Operations Research
   MA445 Stochastic Models in Operations Research
   CSSEXXX Courses beyond CSSE 120 in Computer Science
   MAXXX Any statistics courses
   EMGTXXX Any engineering management course

GERMAN TECHNICAL TRANSLATOR'S CERTIFICATE PROGRAM

A student may earn, in addition to one of the regular degree programs in science or engineering, a certificate of proficiency in German technical translation. Successful completion of this non-degree program partially fulfills the graduation requirements in humanities and social sciences.

Certificate Requirements

A student must have a 3.0 in the first two years of the foreign language and in his/her major, as well as permission of the instructor, to enter the third year language courses. Exceptions may be made by the instructor in charge of the program.

1. A student must complete all the technical courses required by one of the Institute's degree-granting programs.
2. A student must successfully complete the third and fourth year courses of the German Studies program (GE 311/312/313 and GE 411/412/413). See the Humanities and Social Sciences (HSS) section of this catalogue for a description of these courses.
3. A student who successfully completes the requirements for the German Technical Translator Certificate is exempted from RH 131 Rhetoric and Composition, and from both courses in Global Studies (GS). This generally means that the student will only need to take thre HSS courses other than German (one IA, one SV, and RH330 Technical and Professional Communication).

Commentary

A student who qualifies through the Foreign Language Examination administered at Rose-Hulman during Freshman orientation week, will be permitted to enroll in the appropriate level of German as determined by the foreign language faculty. A student who successfully completes a quarter of more advanced language at Rose-Hulman with a grade of C or better will be granted 4 hours of Credit by Examination for each quarter of language by-passed. (Note: a minimum of two terms of college language must be completed in order to receive HSS graduation credit.)

1. A student who is in the German Studies Program in Culture and Technology is not required to take RH131, Rhetoric and Composition.
2. In order to obtain the Translator's Certificate, some students in some curricula may have to take more than the minimum number of credits required for graduation.
3. Due to scheduling requirements of some regular degree programs, a student may also have to carry an overload in some terms. This means that the student will have to maintain a better-than-average grade point average to meet the Institute requirements permitting an overload. See the Student Handbook for details.
4. A student is strongly urged, but not required, to spend at least one summer studying in an approved program for foreigners in Germany. Some small grants may be available to help defray expenses.

Summary	**Credits**
First Year German (GE 111, 112, and 113 or approved equivalent)	12
Second Year German (GE211, 212, 213 or approved equivalent)	12
Third Year German (GE311 Topics in German Culture I; GE312 Reading German Texts; and GE313 Advanced Grammar and Translation Methods	12

Fourth Year German (GE411 Technical Translation; GE412 Topics in German Culture II; and GE413 Contemporary Germany)	12
One IA course (any)	4
One SV course (any)	4
RH330 (required for most majors)	4
TOTAL	**60**

MULTIDISCIPLINARY MINOR IN ROBOTICS

Robotics is a fast-growing field that is inherently multidisciplinary, incorporating mechanical systems, electrical systems, and software. It includes mobile robotics, mechatronics, and assistive technologies. Rose-Hulman Institute of Technology offers a multidisciplinary minor in robotics to recognize students who have gained experience in these areas while at Rose-Hulman.

To earn the Multidisciplinary Minor in Robotics, a student needs to complete the three courses listed below plus additional courses listed below per the student's major.

Courses that all majors must complete [12 credit hours]

- CSSE120 Introduction to Software Development[1]
- ME435/CSSE435 Robotics Engineering
- ECE425 Introduction to Mobile Robotics

[1] Note for ME and BE students: CSSE120 can be used as a course substitution for the required introduction to programming course (ME123 or BE100). However, ME and BE students may take both the required class AND CSSE120. CSSE120 will then count as a free elective.

In addition to the courses listed above students completing the robotics minor need to complete the courses below that apply to their major. (Students with a double major or double degree may choose which major to use. If a student decides to switch majors, that student must complete a track below appropriate for their final degree. These degree requirements are evaluated only at the time of your graduation.)

(1) CS and SE majors - Additional required courses:

- ME430 Mechatronic Systems
- 8 credits of Robo Electives (see list below)

(2) CPE majors - Additional required courses:

- CSSE463 Image Recognition
- 8 credits of Robo Electives (see list below)

(3) EE majors - Additional required courses:

- CSSE220 Object-Oriented Software Development
- 8 credits of Robo Electives (see list below)

(4) ME majors - Additional required courses:

- CSSE220 Object-Oriented Software Development
- ME403 Kinematics of Machinery -or- ME497 Robot Dynamics and Control
- ME406 Control Systems[2]
- 4 credits of Robo Electives (see list below)

[2] Note, the list of additional required ME courses appears to be 1 course longer than other tracks, but ME students are required to take either Control Systems (ME406) or Vibration Analysis (EM406) already, so the requirement to take ME406 should not cause the ME track to be any longer.

(5) For majors not listed above - Additional required courses:

- CSSE220 Object-Oriented Software Development
- ME430 Mechatronic Systems
- BE350 or ECE 320 or ME 406 [or a Controls course from any major][3]
- 4 credits of Robo Electives (see list below)

[3] For BE majors, a controls course will fill an area requirement. So, much like the ME track, the requirement to have a controls course should not cause this track to be longer for BE majors than tracks for other majors.

Robotics Electives

Students choose Robotics Electives from the list below subject to the restrictions that a student's Robotics Elective courses(s) cannot be any course listed above as an additional required course for the student's major, and cannot be a course listed as a named requirement for the student's major.

- BE350 Biocontrol Systems
- BE520 Brain Machine Interfaces
- BE543 Neuroprosthetics
- CSSE413 Artificial Intelligence
- CSSE480 Web App Frameworks with AppEngine
- CSSE483 Android Application Development
- CSSE484 iOS Application Development
- CSSE461 Computer Vision
- CSSE463 Image Recognition
- CSSE490 Swarm Intelligence
- CSSE290/490 Teamwork and Robotics
- CSSE290/490 Software Challenges in Robotics
- ECE320 Linear Controls
- ECE300 Continuous Time Signals and Systems
- ECE414 Wireless Systems
- ECE420 Discrete-time Control Systems
- ECE480/PH437 Image Processing
- ECE483 Digital Signal Processing System Design

- ECE582/PH537 Advanced Image Processing
- ECE583 Pattern Recognition
- IA471 Computational Psychology
- ME403 Kinematics of Machinery
- ME406 Control Systems
- ME497 Robot Dynamics and Control
- ME497 Three Dimensional Dynamics
- ME506 Advanced Control Sys
- ME518 Advanced Kinematics
- EM502 Advanced Dynamics
- EP408 Microsensors
- CSSE490/ME497/ECE497 Robotics Studio
- Independent study courses in robotics [requires approval BEFORE the course is taken]

MINOR IN ENTREPRENEURIAL STUDIES

In a globally competitive environment, the need to rapidly transition from an innovative idea to a viable product necessitates that 21st Century engineers and scientists think and act in an entrepreneurial manner. Not everyone must be interested in starting a technology-based company, but it is important to understand the business requirements of technology commercialization. These skills help students become leaders.

To prepare students for this new workplace, the Department of Engineering Management offers a minor in Entrepreneurial Studies to complement their undergraduate technical education. The five course curriculum (20 credits) introduces students to the fundamentals of an entrepreneurial mindset.

Two required courses (total of 8 credits):

EMGT 330 - Introduction to Engineering Management
EMGT 532 - Technical Entrepreneurship

Three elective courses (total of 12 credits) from the following:

EMGT 100 - Introduction to Entrepreneurship
EMGT 520 - Accounting for Technical Managers
EMGT 523 - Marketing in New Product Development
EMGT 526 - Innovation Management & Forecasting
EMGT 527 - Project Management
SV 150 - Introduction to Microeconomics
SV 152 - Introduction to Macroeconomics
SV 303 - Business and Engineering Ethics
SV 356 - Corporate Finance
GS 350 - International Trade
GS 351 - International Finance

Note: There are no prerequisites for the EMGT courses, but the GS and SV courses have prerequisites of either SV 150 or SV 152. Please refer to the course catalog.

With approval from the Department Head of Engineering Management, course substitutions may be considered to align with a student's professional aspirations. No more than one course may be transferred in to count toward the minor.

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Advanced Placement

During freshman orientation, students are given the opportunity to qualify for credit by exam in a selected number of courses. Other exams may be given by making arrangements with the appropriate department head. Students may also qualify for advanced placement through the Advanced Placement Examinations of the College Board. The required score and corresponding course at Rose-Hulman are listed below.

AP Score of 4 or 5	RHIT Credit Hours	RHIT Equivalent
ART HISTORY	4	SV (HSS SV Elective)
BIOLOGY	4	Score 4=BIO101; Score 5=BIO110
CALCULUS AB	5	MA111
CALCULUS BC	10	MA111 & MA 112
CHEMISTRY	**	Score 4=8 cr hrs for CHEM 111, 113; Score 5=12 cr hrs for CHEM 111, 113, 115
CHINESE LANG & CULTURE	**	Score 4=8 cr hrs of foreign lang; Score 5=12 cr hrs of foreign lang
COMPUTER SCIENCE PRINCIPLES	4	Score of 4 or 5=4 cr hrs 200-level CSSE elective
COMPUTER SCIENCE A	8	Eligible for CSSE 220. Upon successful completion of CSSE 220, student is awarded 4 credits for CSSE 120 and 4 credits for CSSE 220.
ECON - MAC	4	SV152
ECON - MIC	4	SV150
ENG LANG/COMP	4	RH131
ENG LIT/COMP	4	IA (HSS IA Elective)
ENVIRONMENTAL SCIENCE	0	No credit
EUROPEAN HISTORY	4	GS (HSS GS Elective)
FRENCH LANG & CULTURE	**	Score 4=8 cr hrs of foreign lang; Score 5=12 cr hrs of foreign lang
GERMAN LANG & CULTURE	**	Score 4=GE 111 & GE 112 (8cr hrs); Score 5=GE 111, GE 112, & GE 113 (12cr hrs)
GOV & POL COMP	4	GS161
GOV & POL US	4	SV166

HUMAN GEOGRAPHY	4	GS291
ITALIAN LANG & CULTURE	**	Score 4=8 cr hrs of foreign lang; Score 5=12 cr hrs of foreign lang
JAPANESE LANG & CULTURE	**	4=8 hours of foreign language; Score 5=12 hours of foreign language
LATIN - VERGIL	4	4 additional hours of foreign language
MUSIC THEORY	4	IA246
PHYSICS B, or 1 and 2	0	No credit
PHYSICS C - E&M	4	PH112
PHYSICS C - MECH	4	PH111
PSYCHOLOGY	4	SV171
SPANISH LANG & CULTURE	**	Score 4=SP 111 & SP 112 (8cr hrs); Score 5=SP 111, SP 112, & SP 113 (12 cr hrs)
SPANISH LIT	4	4 additional hours of foreign language
STATISTICS	4	MA223
STUDIO ART: DRAWING	4	IA142
STUDIO ART:2D DESIGN	4	No credit
STUDIO ART:3D DESIGN	4	No credit
US HISTORY	4	SV (HSS SV Elective)
WORLD HISTORY	4	GS223

TRANSFER STUDENTS

A student transferring from another college or university is required to be in good academic standing. Credit may be given at Rose-Hulman for work done elsewhere which is considered to be equivalent of the corresponding course at Rose-Hulman if a grade of C or better was earned.

Credits earned elsewhere will be evaluated by the head of the department in which the courses would be taught at Rose-Hulman. Final acceptance of the credit is at the discretion of the head of the department in which the student is seeking a degree.

Students enrolled at Rose-Hulman who plan to take courses at another institution with the intention of transferring the credit to Rose-Hulman should obtain approval in advance from the head of the department concerned.

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Rose-Hulman Institute of Technology Course Catalog

Course Descriptions:

- Biochemistry
- Biology
- Biomathematics
- Biomedical Engineering
- Chemical Engineering
- Chemistry
- Civil Engineering
- College and Life Skills
- Computer Engineering
- Computer Science
- Electrical Engineering
- Engineering Design
- Engineering Management
- Engineering Mechanics
- Engineering Physics
- Engineering Science
- English Second Language
- Geology
- Humanities & Social Sciences
- Mathematics
- Mechanical Engineering
- Multi-Disciplinary Studies
- Optical Engineering
- Physics
- ROTC-Air Force
- ROTC-Army
- Software Engineering

Rose-Hulman Institute of Technology Course Catalog

Biology and Biomedical Engineering Faculty: Ahmed, Anthony, Buckley, Chiu, Coppinger, Dee, Hill, Ingram, Livesay, O'Connor, Rogge, Waite, and Weiner.

Biology and Biomedical Engineering - Course Descriptions

BIO 101 Essential Biology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys basic concepts in the biological sciences and describes how new advances related to these concepts affect contemporary society. Students who have completed BIO110, BIO120 or BIO130 cannot receive credit for taking BIO101.

BIO 102 Nutrition 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course surveys essential concepts in the nutritional sciences, including food composition, diet construction and analysis, physiological processes, and special nutritional needs for certain groups. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 103 Core Biology Advances and Applications 04R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course promotes comprehension of core biological concepts and systems to enable a more sophisticated understanding of advances in biology and applications of biological sciences. Current advances in our understanding of living systems and the application of biotechnologies to various challenges in medicine, forensics, agriculture, and energy are also discussed. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 104 Science in Practice 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course explores the dispositions and applications of science relevant to understanding a broad range of popular scientific topics. Major concepts include distinguishing science from pseudoscience, information flow and use in science, misinformation tactics used to advance dubious science, and the influence of perspective on interpretation of both science and non-science information. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 105 Human Health and Disease 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course examines the human body in states of health and disease. Various diseases such as infections, cancer, heart disease, genetic conditions, and autoimmunity and the mechanisms leading to these diseases are studied. This course counts as a free elective, not a BIO elective, for BIO and BE majors.

BIO 110 Cell Structure and Function 3R-3L-4C F,W

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course explores cellular and molecular biology structures, mechanisms, and laboratory techniques with respect to five core concepts: (1) evolution, (2) structure/function interdependence, (3) information flow, (4) bioenergetics and (5) systems perspective and interdependence.

BIO 120 Comparative Anatomy & Physiology 3R-3L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course surveys animal tissues and organ systems and laboratory techniques (including dissections and recordings from biological specimens/living tissues) with respect to five core concepts: (1) evolution, (2) structure/function interdependence, (3) information flow, (4) bioenergetics, and (5) systems perspective and interdependence.

BIO 130 Evolution and Diversity 3R-3L-4C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course explores ecological and evolutionary patterns and processes, including field and laboratory approaches to develop knowledge with respect to five core concepts: (1) evolution, (2) structure/functio interdependence, (3) information flow, (4) bioenergetics, and (5) systems perspective and interdependence.

BIO 191 Special Topics in Biology XR-0L-XC
Prerequisites: Arranged prerequsite by consent of instructor
Corequisites: There are no corequisites for this course.
Introduces structures, mechanisms, and laboratory techniques in cellular and molecular biology. Discusses biomolecules, bioenergetics, biosynthesis, enzymatic function, genetics, and cellular regulatory systems.

BIO 205 Cellular Physiology 4R-0L-4C F
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
The flow of information in biological systems provides a framework for detailed discussion of cell structure and function, with particular attention paid to the physiology of excitable cells. Cellular communication and the interactions of cells in tissues and the immune system are also examined. Reproduction and organismal development will also be addressed at the cellular level. A student who earns credit for BIO205 cannot earn credit for BIO210 or BIO230 without departmental consent.

BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W or instructor consent
Corequisites: There are no corequisites for this course.
A discussion of Mendelian genetics including the molecular mechanisms of nuclear and cytoplasmic inheritance. Information flow and control of gene expression are addressed at the molecular level. Basic genetic techniques are covered in both lecture and laboratory.

BIO 220 Microbiology 3R-3L-4C W
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W or instructor consent.

Corequisites: There are no corequisites for this course.
Discusses the essential properties of eubacteria and archea. Bacterial nutrition, growth, genetics and structural and metabolic diversity are discussed in detail. The basics of virology are also addressed. Fundamental laboratory methodologies are also covered.

BIO 230 Cell Biology 3R-3L-4C S
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W or instructor consent
Corequisites: There are no corequisites for this course.
Examines the structure and function of various eukaryotic cells. Biomembranes, organelles, the cytoskeleton, energetics, protein sorting, signal transduction and cell interactions are discussed in detail. Essential methods in cell biology are addressed in both lectures and laboratories.

BIO 310 Plant Structure & Function 3R-3L-4C S
Prerequisites: BIO 130 Evolution and Diversity 3R-3L-4C F or instructor consent.
Corequisites: There are no corequisites for this course.
Surveys the structure, physiology, diversity, evolution, and ecological importance of plants and related groups of organisms.

BIO 320 Ecology 3R-3L-4C F
Prerequisites: BIO 130 Evolution and Diversity 3R-3L-4C F or instructor consent
Corequisites: There are no corequisites for this course.
Surveys adaptations of organisms, population dynamics, species interactions, and the structure and function of natural communities and ecosystems.

BIO 330 Evolutionary Biology 4R-0L-4C W
Prerequisites: BIO 130 Evolution and Diversity 3R-3L-4C F or instructor consent
Corequisites: There are no corequisites for this course.
Surveys three major themes of evolutionary biology: adaptation, diversity of life, and the shared characteristics of life. Mechanisms of evolution, speciation, phylogeny, and macroevolutionary processes are discussed.

BIO 340 Introduction to Biomedical Research: Clinical Methodology 1R-1L-1C
Prerequisites: BIO 120 Comparative Anatomy & Physiology 3R-3L-4C S and Jr/Sr standing or consent of instructor.
Corequisites: There are no corequisites for this course.
Designed to introduce biology/bioengineering students to the basics of biomedical research using the clinical methodology typical of patient sample analysis. Students will learn to relate testing procedures with specific diseases and to use data obtained from laboratory testing to understand more about specific patient health problems.

BIO 350 Principles of Synthetic Biology 2R-0L-2C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Open to all majors. This course covers the biological foundations of synthetic biology. It is directed at understanding how biological information is stored and processed, and how it is expressed as biological function. Particular attention will be paid to how the expression of this information is regulated and how cells can be engineered to solve contemporary problems in health, energy, manufacturing and sustainability.

BIO 351 Synthetic Biology Design 2R-0L-2C S

Prerequisites: BIO 350 Principles of Synthetic Biology 2R-0L-2C W
Corequisites: There are no corequisites for this course.
Open to all majors. This course focuses on the design of novel biological parts, devices and systems, and their use in engineering cell function. Bioengineering principles and the design of genetic logic circuits, memory modules, biosensors and other cellular devices will be addressed. For the final project, students will design a novel biological system that meets the standards and goals of the International Genetically Engineered Machine Competition.

BIO 352 Synthetic Biology Laboratory 4C (studio format, 4 days x 3 hrs) Su1
Prerequisites: Instructor Consent
Corequisites: There are no corequisites for this course.
Open to all majors. This project-based studio laboratory course focuses on the fundamental laboratory techniques employed in the synthetic biology laboratory. Relevant background and theory will be discussed and applied in the hands-on learning of core laboratory techniques. In practice, students will build and test novel genetic devices designed to advance the current International Genetically Engineered Machine Competition (iGEM) Team project. Significant contribution to the project will earn students membership on the Rose-Hulman iGEM team and attribution in iGEM competition materials.

BIO 399 Practice of Science 4R-0L-4C
Prerequisites: BIO 330 Evolutionary Biology 4R-0L-4C W, and MA 223 Engineering Statistics I 4R-0L-4C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on skills required for implementing scientific research, including reading the primary literature, experimental design, scientific writing, oral presentations, research proposal writing, poster presentations, and investigation of research programs (through seminars or individual meetings). Each student chooses a project and research mentor by the end of the course.

BIO 410 Infection and Immunity 4R-0L-4C Arranged
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W or instructor consent
Corequisites: There are no corequisites for this course.
Discussion of various pathogens, how they cause disease, and how they elicit the innate and adaptive immune responses employed to combat them. Cellular and molecular mechanisms of immunity are addressed, as is the epidemiology of various human diseases.

BIO 411 Genetic Engineering 4R-0L-4C Assigned
Prerequisites: BIO 205 Cellular Physiology 4R-0L-4C F or BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
Discusses the basics of molecular biology and the genetic and molecular techniques used to engineer prokaryotic and eukaryotic cells, plants, and animals for the production of useful traits or compounds. The application of DNA technology to the diagnosis and treatment of disease is also addressed.

BIO 421 Applied Microbiology 4R-0L-4C Assigned

Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W *Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Discusses the fundamental biology of microprobes and the processes underlying their use in the production of chemicals, therapeutics and foods. The basics of microbial ecology and the environmental applications of microbial biotechnology are also discussed.

BIO 431 Genomics and Proteomics 4R-0L-4C S
Prerequisites: BIO 205 Cellular Physiology 4R-0L-4C F or BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
Exploration of the methodologies used to generate systems-level sets of genetic and protein data, and the tools used to access and analyze the prodigious amounts of data emerging from such projects. The application of these technologies to investigate biological questions and model complex biological systems is also discussed.

BIO 441 Virology 3R-3L-4C
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W or instructor consent
Corequisites: There are no corequisites for this course.
Virology focuses on the study of viruses as well as non-viral entities such as prions and viroids. In this course, students will learn about the structures, genomes, replication strategies, and pathogenic mechanisms of various viruses. Viruses causing diseases of medical and economic importance will be emphasized. In addition, the techniques used to study viruses and the uses of viruses in the treatment of disease will be addressed.

BIO 451 Cancer Biology 4R-0L-4C
Prerequisites: BIO 205 Cellular Physiology 4R-0L-4C F or BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on cancer at the molecular and cellular level. Specific cellular molecules and the changes to these cellular molecules that contribute to transformational and immortalization of cells and tumor progression will be studied. The mechanisms behind these molecular changes, cancer promotion and initiation events, and cancer molecule-specific treatment options will be addressed. In addition, students will study a variety of specific cancer types.

BIO 461 Evolutionary Medicine 4R-0L-4C Arranged
Prerequisites: BIO 130 Evolution and Diversity 3R-3L-4C F*, and BIO 205 Cellular Physiology 4R-0L-4C F* or BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F* *Arranged prerequisite or instructor consent.
Corequisites: There are no corequisites for this course.
This course examines medicine and medical practice from the perspective of evolutionary constraints, challenges, and diversity. Topics include theoretical foundations of the field, cancer patterns, mental health, genetic disease, evolutionary health promotion, and others.

BIO 471 Genetic & Molecular Analysis of Inherited Human Disease 4R-0L-4C S
Prerequisites: BIO 205 Cellular Physiology 4R-0L-4C F* or BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F* *Arranged prerequisite or consent of instructor

Corequisites: There are no corequisites for this course.
Strategies and methods used to identify and understand the genetic and molecular bases of inherited human disease are addressed. Topics include, human population genetics, pedigrees, genetic and physical mapping of human genes, linkage analysis, and diagnostic testing. Primary literature is routinely utilized.

BIO 491 Special Topics in Biology XR-0L-XC
Prerequisites: Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Covers upper level material of mutual interest to student and instructor which cannot be acquired in any other listed BIO course.

BIO 492 Directed Study in Biology XR-XL-XC
Prerequisites: Arranged prerequisite or instructor consent
Corequisites: There are no corequisites for this course.
Covers biology material of mutual interest to the student and instructor which cannot be experienced in any other listed BIO course. A student may take between 1-4 credits in any given term, and a maximum of 8 credits of this course are permitted. Prior approval of the BBE department is required to use this course to fulfill BIO elective credit requirements.

BIO 496 Senior Thesis Research I 0R-6L-2C F,W,S
Prerequisites: BIO 399 Practice of Science 4R-0L-4C F and consent of instructor
Corequisites: There are no corequisites for this course.
Initiation of senior thesis under the direction of an BBE faculty mentor. Major tasks include creation and submission of a research proposal and piloting procedures. Additional requirements for adequate progress determined by each faculty mentor.

BIO 497 Senior Thesis Research II 0R-12L-4C F,W,S
Prerequisites: BIO 399 Practice of Science 4R-0L-4C F and consent of instructor
Corequisites: There are no corequisites for this course.
Continuation of research under the direction of an BBE faculty mentor. Major tasks include data acquisition and methodological refinement. Additional requirements for adequate progess determined by each faculty mentor.

BIO 498 Senior Thesis Research III 0R-12L-4C F,W,S
Prerequisites: BIO 399 Practice of Science 4R-0L-4C F and consent of instructor
Corequisites: There are no corequisites for this course.
Continuation of research under the direction of an BBE faculty mentor. Major tasks include data acquisition and preliminary analysis. Additional requirements for adequate progress determined by each faculty mentor.

BIO 499 Senior Thesis Research IV 0R-6L-2C W
Prerequisites: BIO 399 Practice of Science 4R-0L-4C F and consent of instructor
Corequisites: There are no corequisites for this course.
Completion of senior thesis under the direction of an BBE faculty mentor. Major tasks include final analysis, public presentation of results, and submission of the written thesis. Additional requirements for adequate progress determined by each faculty mentor.

BIO CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head

Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

Last updated: 07/20/2017

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Rose-Hulman Institute of Technology Course Catalog

Biomathematics - Course Descriptions

BMTH 295 Research Seminar in Biomathematics 1R-0L-1C Arranged
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
A seminar-style course that introduces novel problems in biomathematics. Problems will be drawn from the modern literature in biomathematics, computational biology, bioinformatics, systems biology, and biostatistics. This course may be taken at most twice for credit.

BMTH 310 Mathematical Biology 4R-0L-4C F
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
This course emphasizes the application of differential equations and probability theory to modeling and analyzing dynamic biological systems. Mathematical topics include ordinary and partial differential equations, discrete dynamical systems, bifurcations, limit cycles, chaos, and probabilistic and stochastic modeling. Biological applications may include, but are not limited to, biochemistry, molecular and cellular biology, epidemiology, neurophysiology, ecology, sociology, and pattern formation.

BMTH 311 Systems Biology 4R-0L-4C W
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S* *MA 212 may be taken concurrently with instructor permission.
Corequisites: There are no corequisites for this course.
The study of how to combine detailed biological information to build models of entire systems. Nearly any biological scale can be considered. For example, at the biochemistry level the course will consider topics such as gene regulatory networks, protein interaction networks, and metabolisms. Moving toward larger scales, systems biology can be used to study the growth of cancerous tumors, and on an even larger scale, the mating and social structure of populations. The course's focus is on how to use relational information to perform model based inquiries of an entire system.

BMTH 312 Bioinformatics 4R-0L-4C S (odd years)
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
This course will study how to combine mathematical, statistical, probabilistic, and computational methods to analyze biological data. Example topics are sequence alignment, locating genes, structural alignment, microarray analysis, and drug design. The course emphasizes how to search and compare biological datasets to make scientific inferences.

BMTH 413 Computational Biology 4R-0L-4C S (even years)
Prerequisites: MA 332 Introduction to Computational Science 4R-0L-4C F,W, and BMTH 310 Mathematical Biology 4R-0L-4C F or BMTH 311 Systems Biology 4R-0L-4C W or BMTH 312 Bioinformatics 4R-0L-4C S (odd years)

Corequisites: There are no corequisites for this course.
The study of how to build and validate computational models to conduct biological studies. Ex-emplary topics include molecular dynamics, haplotyping, phylogenetics, neuroscience, and population dynamics. The course will consider the implementation and analysis of algorithms that are specifically germane to the life sciences.

BMTH 490 Topics in Biomathematics Variable Credit
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Varies

BMTH 496 Capstone Experience I 2C F
Prerequisites: Senior standing or permission of instructor.
Corequisites: There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

BMTH 497 Capstone Experience II 4C W
Prerequisites: BMTH 496 Capstone Experience I 2C F
Corequisites: There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

BMTH 498 Capstone Experience III 2C S
Prerequisites: BMTH 497 Capstone Experience II 4C W
Corequisites: There are no corequisites for this course.
Independent study in a thesis project to be directed by a faculty member. The project and faculty adviser are to be identified prior to starting BMTH 496, and a plan of study is to be agreed upon by the student and adviser prior to the initiation of the thesis sequence. The thesis will culminate in a written report and a public presentation/ defense that will be evaluated by a thesis committee consisting of at least the adviser and two other members of the faculty. BMTH 496/497/498 must be taken in consecutive quarters.

FOCUS AREAS
Students earning a major in Biomathematics are encouraged to gain depth in a particular mathematical or scientific area. By pursuing focused coursework in the following suggested areas, students will advance their preparation for graduate studies or careers in mathematical life sciences. Gaining depth through advanced electives also provides biomathematics students with an opportunity to apply knowledge gained through BMTH coursework. The following focus areas are illustrative examples to consider.

Applied Mathematics

	BE 350	Biocontrol Systems
	MA 275/375	Discrete and Combinatorial Algebra I/II
	MA 332	Intro. to Computational Science [required for major]
	MA 330	Vector Calculus
	MA 342	Computational Modelings
	MA 366	Real Analysis
	MA 367	Functions of a Complex Variable
	MA 436	Introduction to Partial Differential Equations
	MA 472	Graph Theory
	MA 491	Introduction to Mathematical Modeling

Biochemistry

	BMTH 312	Bioinformatics
	BMTH 310	Mathematical Biology
	CHEM 251/252/253	Organic Chemistry I/II/III
	CHEM 326	Bioanalytical Chemistry
	CHEM 330/331	Biochemistry I/II
	CHEM 430	Advanced Biochemistry

Bioinformatics & Biostatistics

	BMTH 312	Bioinformatics
	MA 381	Intro. to Probability with Statistics [required for major]
	MA 382	Intro. to Statistics with Probability
	MA 382	Engineering Statistics II
	MA 386	Statistical Programming
	MA 482	Bioengineering Statistics

Biomechanics

	BE 361	Biomaterials
	BE 525	Biomedical Fluid Mechanics
	BE 534	Soft Tissue Mechanics
	BE 539	Multiscale Biomechanics
	BE 545	Orthopedic Biomechanics

Biophysics

PH 302	Biophysics
BE 525	Biomedical Fluid Mechanics

Cellular and Molecular Biology

BIO 220/230	Prokaryotic/Eukaryotic Cell and Molecular Biology [required for major]
BIO 205	Cellular Physiology
BIO 411	Genetic Engineering
BIO 421	Applied Microbiology
BIO 431	Genomics and Proteomics
BMTH 310	Mathematical Biology
CHEM 455	Natural Products [offered irregularly]

Computational Biology

BMTH 310	Mathematical Biology
BMTH 413	Computational Biology
CSSE 220	Object Oriented Software Development
CSSE 333	Database Systems
CSSE 403	Programming Language Paradigms
CSSE 431	Artificial Intelligence
MA/CS 335	Introduction to Parallel Computing
MA 342	Computational Modeling
MA 433	Numerical Analysis
MA 435	Finite Difference Methods
MA/CS 473	Design and Analysis of Algorithms

Ecology

BIO 130	Evolution and Diversity
BIO 264	Introduction to Environmental Science
BIO 320	Ecology
BMTH 310	Mathematical Biology
CHEM 371	Environmental Analytical Chemistry

Epidemiology & Pathology

	BE 310/320	Analysis of Physiological Systems I/II
	BIO 410	Infection and Immunity
	BIO 441	Virology
	BIO 451	Cancer Biology
	BIO 461	Evolutionary Medicine
	BIO 471	Genetic and Molecular Analysis of Inherited Human Disease
	BMTH 310	Mathematical Biology
Evolution		
	BIO 130	Evolution and Diversity
	BIO 330	Evolutionary Biology
	BIO 461	Evolutionary Medicine
	SV 386	Human Evolution
Imaging and Optics		
	BE 435	Biomedical Optics
	ECE 480	Introduction to Image Processing
	BE 541	Medical Imaging Systems
	MA 429	Mathematical Methods of Image Processing
	PH 302	Biophysics
Medicine		
	BIO 120	Comparative Anatomy and Physiology
	BIO 410	Infection and Immunity
	BIO 441	Virology
	BIO 451	Cancer Biology
	BIO 461	Evolutionary Medicine
	BIO 471	Genetic and Molecular Analysis of Inherited Human Disease
	BE 541	Medical Imaging Systems
	CHEM 251/252/253	Organic Chemistry I/II/III
	CHEM 330/331	Biochemistry I/II
	CHEM 420	Advanced Biochemistry
Physiology		
	BIO 120	Comparative Anatomy and Physiology

BIO 205	Cellular Physiology
BE 310/320	Analysis of Physiological Systems I & II
BE 520	Introduction to Brain Machine Interfaces

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Rose-Hulman
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Rose-Hulman Institute of Technology Course Catalog

Professors Anastasio, Chenette, D. Henthorn, K. Henthorn, McClellan, Neumann, Nolte, Reizman, Sauer, Serbezov, and Tousley.

Chemical Engineering - Course Descriptions

CHE 110 Programming & Computation for Chemical Engineers 2R-0L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to problem solving and structured programming concepts using spreadsheets and computational software. Spreadsheet applications include graphical analysis, curve-fitting, parameter estimation, numerical differentiation and integration, solution of systems of algebraic (linear and nonlinear) equations and ordinary differential equations.

CHE 200 Career Preparation I 1R-0L-0C F
Prerequisites: There are no prerequisites for this course.
Corequisites: CHE 201 Conservation Principles and Balances 4R-0L-4C F
Career choices in chemical engineering. Internships and co-ops. Resume preparation. Interview skills.

CHE 201 Conservation Principles and Balances 4R-0L-4C F
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S, PH 111 Physics I 3.5R-1.5L-4C F,W, and either CHEM 113 General Chemistry II 3R-0L-3C W,S or concurrent registration in CHEM 112
Corequisites: There are no corequisites for this course.
An introduction to engineering calculations, the use of common process variables, and conservation and accounting of extensive properties as a common framework for engineering analysis and modeling. Applications of conservation of mass and energy in the analysis of non-reactive chemical engineering processes will be addressed. There will be an introduction to equipment, flowcharts, techniques and methodologies used by practicing chemical engineers.

CHE 202 Basic Chemical Process Calculations 4R-0L-4C W
Prerequisites: CHE 201 Conservation Principles and Balances 4R-0L-4C F, and MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
The course continues to develop concepts from CHE 201 and provides a more extensive treatment of energy balances. Applications of the principles of conservation of mass and energy to reactive and transient systems will also be addressed.

CHE 301 Fluid Mechanics 4R-0L-4C F,S
Prerequisites: CHE 201 Conservation Principles and Balances 4R-0L-4C F, and MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Physical properties of fluids, fluid statics, laminar and turbulent flow. Design of pipe networks and pumps. Fluid flow as momentum transport. Flow through porous media. Non-Newtonian fluid flow. Flow past objects and boundary layer concept. Emphasis is placed on general methods of analysis applicable to any fluid.

CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S
Prerequisites: CHE 202 Basic Chemical Process Calculations 4R-0L-4C W, and MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: CHE 110 Programming & Computation for Chemical Engineers 2R-0L-2C S
First and second laws of thermodynamics and their application including thermodynamic cycles, closed and open systems. Thermodynamic properties of pure components. Phase equilibria of pure components. Equations of state, state diagrams. Thermodynamic analysis of processes.

CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Prerequisites: CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Properties of mixtures. Phase equilibria for mixtures. Equations of state and activity coefficient models. Chemical reaction thermodynamics. Thermodynamic analysis of processes. Study of phase equilibria involving the use of a process simulator.

CHE 310 Numerical Methods for Chemical Engineers 4R-0L-4C W
Prerequisites: CHE 110 Programming & Computation for Chemical Engineers 2R-0L-2C S, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S or concurrent enrollment
Corequisites: There are no corequisites for this course.
The objective of this course is to learn the fundamentals of several important numerical methods and how to apply them to solve chemical engineering problems. This will include the study of algorithms to solve systems of algebraic and differential equations, toperform numerical integration, to apply linear and nonlinear regression techniques, and to perform stochastic Monte Carlo simulations. Matlab and Excel will be used as the programming and computing software.

CHE 315 Materials Science and Engineering 4R-0L-4C F,S
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to the properties and processing of metals, ceramics, polymers, and semiconductors. The influences of crystal structure, interatomic bonding, and electronic structure on physical, mechanical, and electrical properties are emphasized. Causes and mitigation of various types of corrosion are explored. Properties and design of composite materials are introduced.

CHE 320 Fundamentals of Heat & Mass Transfer 4R-0L-4C F,W
Prerequisites: CHE 202 Basic Chemical Process Calculations 4R-0L-4C W, and CHE 301 Fluid Mechanics 4R-0L-4C F,S, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Discussion of fundamental heat and mass transfer principles: conduction, forced and free convection, radiation, and diffusion. Mathematical analysis and computation of heat transfer, mass transfer, temperature, and concentration profiles in systems with simple geometries. Finite difference equations. Estimation of local and overall heat and mass transfer coefficients.

CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S
Prerequisites: CHE 320 Fundamentals of Heat & Mass Transfer 4R-0L-4C F,W, and CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Use, design, and selection of heat exchangers and heat exchange systems for various applications in the chemical process industries. Study of gas-liquid and liquid-liquid mass transfer operations including gas absorption, extraction, and distillation in equilibrium staged tray columns and packed columns. Quantitative treatment of mass transfer based on material and energy balances, phase equilibrium, and rates of heat and mass transfer. Applications of radiation heat transfer, boiling, and condensation.

CHE 404 Kinetics & Reactor Design 4R-0L-4C F,S
Prerequisites: CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S, and CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
The course covers homogeneous kinetics, differential and integral data analysis, batch, mixed, and plug flow reactors, systems with multiple reactions, reactor cascades, and temperature and energy effects.

CHE 405 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S, and EP 510 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S and Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers, wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with ECE 416, EP 410, and ME 416.

CHE 409 Professional Practice 1R-0L-1C F
Prerequisites: Senior standing in Chemical Engineering
Corequisites: There are no corequisites for this course.
Topics on professional practice, ethics, and contemporary and global issues in the profession are discussed.

CHE 411 Chemical Engineering Laboratory I 2R-3L-3C S
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C S, and CHEM 225 Analytical Chemistry 3R-0L-3C F,S, and CHEM 252 Organic Chemistry II 3R-0L-3C W, and CHE 320 Fundamentals of Heat & Mass Transfer 4R-0L-4C F,W, and MA 223 Engineering Statistics I 4R-0L-4C F,W,S, and RH 330 Technical & Professional Communication 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Principles underlying momentum, mass and energy transfer and the applications of equipment used to accomplish such transfer, introduction to laboratory concepts in data collection, record keeping, interpretation and analysis, and instrumentation including experimental error analysis, regression, model formulation, experimental design, and instrumentation. Written and oral reports are required. Formal instruction on written and oral communication and teaming will be provided.

CHE 412 Chemical Engineering Laboratory II 2R- 6L-4C F

Prerequisites: CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S, and CHE 411 Chemical Engineering Laboratory I 2R-3L-3C S or consent of instructor
Corequisites: There are no corequisites for this course.
Continuation of principles underlying momentum, mass and energy transfer with some emphasis on kinetics, applications of equipment used to accomplish such transfer.

CHE 413 Chemical Engineering Laboratory III 2R- 6L-4C W
Prerequisites: CHE 412 Chemical Engineering Laboratory II 2R- 6L-4C F
Corequisites: There are no corequisites for this course.
Continuation of CHE 412 with emphasis on process control and kinetics.

CHE 416 Chemical Engineering Design I 4R-0L-4C F
Prerequisites: CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S
Corequisites: There are no corequisites for this course.
Introduction to the design process; simulation to assist in process creation; synthesis of separation trains; design of separation equipment; and capital cost estimation.

CHE 417 Chemical Engineering Design II 4R-0L-4C W
Prerequisites: CHE 416 Chemical Engineering Design I 4R-0L-4C F, and CHE 404 Kinetics & Reactor Design 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Design of reactor-separator-recycle networks; heat and power integration; batch process scheduling; annual costs, earnings and profitability; preliminary work on a capstone design project.

CHE 418 Chemical Engineering Design III: Capstone Design Project 0R-6L-2C S
Prerequisites: CHE 417 Chemical Engineering Design II 4R-0L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
Completion of an open-ended design project that will include written and oral communication of intermediate results and a final written report.

CHE 419 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent (See EP 411/511.)
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, and physics. Students enrolled in CHE 419/519, must do project work on a topic selected by the instructor. Cross-listed with EP 411, and ECE 419.

CHE 420 Consulting Engineering Seminar 2R-0L-2C
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Discusses problems in the field of consulting engineering. Seminars presented by practicing consulting engineers. Cross-listed with CE 420, ECE 466, ME 420, and BE 400.

CHE 440 Process Control 4R-0L-4C W

Prerequisites: CHE 202 Basic Chemical Process Calculations 4R-0L-4C W, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
The mathematics of process dynamics, control system design, Laplace transforms, feedback control theory, characteristics of sensors, transmitters and control elements, stability criteria, and frequency response. Use of control design software is emphasized.

CHE 441 Polymer Engineering 4R-0L-4C F
Prerequisites: CHE 404 Kinetics & Reactor Design 4R-0L-4C F,S*, and CHEM 251 Organic Chemistry I 3R-0L-3C F** *or concurrent registration **or consent of instructor
Corequisites: There are no corequisites for this course.
Interrelation of polymer structure, properties and processing. Polymerization kinetics. Methods for molecular weight determination. Fabrication and processing of thermoplastic and thermosetting materials. Student projects.

CHE 460 Particle Technology 4R-0L-4C
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and CHE 202 Basic Chemical Process Calculations 4R-0L-4C W, and CHE 301 Fluid Mechanics 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Introduction to the fundamentals of particle technology including particle characterization, transport, sampling, and processing. Students will learn about the basic design and scale-up of some industrial particulate systems (including fluidized beds, mixers, pneumatic conveying systems, cyclone separators, and hoppers) as well as environmental and safety issues related to particulate handling.

CHE 461 Unit Operations in Environmental Engineering 4R-0L-4C F or W
Prerequisites: EM 301 Fluid Mechanics 4R-0L-4C S or CHE 301 Fluid Mechanics 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Physical-chemical unit operations pertinent to wastewater treatment such as membrane separations, filtration, coagulation, flocculation, ion exchange, carbon adsorption. Applications for unit operations from the chemical process industries are also covered. Cross-listed with CE563.

CHE 465 Energy and the Environment 4R-0L-4C W or S
Prerequisites: CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S or CHEM 361 Physical Chemistry I 4R-2L-4C F or CE 205 Thermodynamics 4R-0L-4C F or ME 301 Applications of Thermodynamics 4R-0L-4C F,W or consent of instructor
Corequisites: There are no corequisites for this course.
This is a survey course in which the energy needs of the world, the ways in which those needs are currently being met, the development and current usage of renewable energy, and the impact of these on the environment, specifically the impact on climate change, are examined. Life cycle analysis is also considered.

CHE 470 Safety, Health, and Loss Prevention 4R-0L-4C F or S
Prerequisites: CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.

Fundamentals of chemical process safety including toxicology, industrial hygiene, toxic release and dispersion models, fires and explosions, designs to prevent fires and explosions. Informal safety review.

CHE 490 Special Topics in Chemical Engineering 4R-0L-4C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in chemical engineering.

CHE 499 Directed Research Variable Credit F,W,S
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
A special project is assigned to or selected by the student. The publication of research is encouraged. Variable credit. May be repeated up to a maximum of eight credits.

CHE 502 Transport Phenomena 4R-0L-4C
Prerequisites: CHE 320 Fundamentals of Heat & Mass Transfer 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Most of the course focuses on the derivation, simplification, and solution of the equations of change for momentum, energy, and mass transport. Mathematical determination of velocity profiles and momentum flux for isothermal, laminar flows in both steady and unsteady systems will be covered. Mathematical determination of temperature profiles and heat flux, and concentration profiles and mass flux both in solids and in laminar flows will also be covered. Boundary layer theory will be discussed. Turbulent flow theories may also be addressed.

CHE 504 Advanced Reactor Design 4R-0L-4C W
Prerequisites: CHE 404 Kinetics & Reactor Design 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Strategies for modeling the effects of real reactor systems, including non-ideal flow and multiple phases. Applications in catalysis, combustion, biotechnology, polymerization, and materials processing. Computer methods and software for reactor engineering.

CHE 505 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, ECE 516, EP 510, and ME 516.

CHE 512 Petrochemical Processes 4R-0L-4C W
Prerequisites: CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S or consent of instructor
Corequisites: There are no corequisites for this course.
Multicomponent separation of petroleum by flash vaporization. Processes for production of light petroleum products from heavier derivatives. Production of petrochemicals such as ethylene, methanol, and ammonia from natural gas and other fossil fuels. Group projects and presentations on refinery and petrochemical processes. Material balances and economic evaluations of the processes.

CHE 513 Advanced Chemical Engineering Thermodynamics 4R-0L-4C
Prerequisites: CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Review of thermodynamic principles including fundamental equations and the laws of thermodynamics. Thermodynamics of mixtures, phase equilibria, and thermodynamic analysis of processes. Project based in-depth study of phase equilibria, equations of state, and activity coefficient models. Use of process simulator for phase equilibria calculations. Introduction to statistical thermodynamics.

CHE 515 Nanomaterials Science & Engineering 4R-0L-4C
Prerequisites: CHE 315 Materials Science and Engineering 4R-0L-4C F,S or ME 328 Materials Engineering 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Current research trends and industrial activity in the field of nanotechnology. Contains an overview of nanoscale characterization and production methods and emphasizes the roles that chemical functionality, thermodynamics, and physics play in determining the unique properties of nanoscale materials systems. Independent student reviews of current research literature form an integral part of the course.

CHE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with EP 511, ME 519, and ECE 519.

CHE 540 Advanced Process Control 4R-0L-4C
Prerequisites: CHE 440 Process Control 4R-0L-4C W and consent of instructor
Corequisites: There are no corequisites for this course.
Control topics beyond those covered in CHE 440. Topics will be selected from among the following: advanced control using cascade, feed forward, nonlinear, and adaptive control; multivariable systems including RGA analysis and decoupling; a major control system design and implementation project using a modern distributed control system.

CHE 545 Introduction to Biochemical Engineering 4R-0L-4C
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W, and CHEM 330 Biochemistry I 4R-0L-4C F, and CHE 404 Kinetics & Reactor Design 4R-0L-4C F,S or ES 201 Conservation & Accounting Principles 4R-0L-4C F,W or consent of instructor
Corequisites: There are no corequisites for this course.
Survey course introducing biochemical terminology and processes. Enzyme kinetics, cellular genetics, biochemical transport phenomena, and design and operation of biochemical reactors. Emphasis on applying engineering principles to biochemical situations.

CHE 546 Bioseparations 4R-0L-4C
Prerequisites: BIO 110 Cell Structure and Function 3R-3L-4C F,W, and CHE 321 Applications of Heat & Mass Transfer 4R-0L-4C W,S or ES 201 Conservation & Accounting Principles 4R-0L-4C F,W or consent of instructor

Corequisites: There are no corequisites for this course.
An analysis of bioseparation processes. Filtration, centrifugation, adsorption, electrophoresis, and chromatography are the primary topics of the course. Applications are emphasized.

CHE 590 Special Topics in Chemical Engineering 4R-0L-4C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in chemical engineering. May be repeated.

CHE 597 Special Projects in Chemical Engineering Variable Credit F,W,S
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
A special project, or series of problems, or research problem is assigned to or selected by the student. A comprehensive report must be submitted at the conclusion of the project. Not to be used as a substitute for CHE 599, Thesis Research. Variable credit. May be repeated up to a maximum of eight credits.

CHE 598 Graduate Seminar 1R-0L-0C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected topics in chemical engineering are discussed by graduate students, faculty, and guest speakers.

CHE 599 Thesis Research As assigned F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CHE CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Professors Allison, Brandt, R. DeVasher, Erwin, Hoffman, Morris, Mottel, Mueller, Tilstra, Weatherman and Wilson.

Chemistry and Biochemistry - Course Descriptions

CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Topics include stoichiometry, nomenclature, phases, and writing balanced chemical equations. Quantum theory is introduced in relation to chemical applications. Atomic structure is introduced. Bonding principles and molecular structure are discussed in terms of Lewis Dot Structures, Valence Bond Theory, VSEPR Theory, Hybridization, and Molecular Orbital Theory.

CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM111 recitation.

CHEM 112 Chemistry Honors 4R-3L-5C F
Prerequisites: Advanced placement
Corequisites: There are no corequisites for this course.
An accelerated course covering topics in CHEM 111 and CHEM 113. Upon successful completion of this course, an additional 3 credits will be awarded. Enrollment is limited to those students who complete the Rose-Hulman online Chemistry Advanced Placement Examination given prior to the freshman orientation period.

CHEM 113 General Chemistry II 3R-0L-3C W,S
Prerequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S, and CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Corequisites: CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S
Topics in this course include the fundamentals of thermodynamics and kinetics. The fundamentals of chemical equilibrium are introduced. Definitions of acid and bases are discussed utilizing the Bronsted-Lowry and Lewis models. Nuclear chemistry is also included.

CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S
Prerequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S, and CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S
Corequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 115 General Chemistry III 3R-0L-3C
Prerequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S, and CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S or CHEM 112 Chemistry Honors 4R-3L-5C F
Corequisites: CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S

Topics in this course include acid-base reactions, electrochemistry, and coordination chemistry.

CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S
Prerequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S, and CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S or CHEM 112 Chemistry Honors 4R-3L-5C F
Corequisites: CHEM 115 General Chemistry III 3R-0L-3C W,S
Fundamental chemistry laboratory skills are introduced along with data analysis in support of topics presented in CHEM113 recitation.

CHEM 200 Career Preparation 1R-0L-1C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for chemistry and biochemistry majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with MA200, and SV200.

CHEM 225 Analytical Chemistry 3R-0L-3C F,S
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C F, and CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S
Corequisites: CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
This laboratory-driven course is an introduction to classical and modern quantitative analysis with emphasis on calculations, separations, and precise and accurate measurements. Theoretical and practical perspectives of chemical analysis are considered. Chemical instrumentation includes recording pH/mV meters, constant rate burets, colorimeters, spectrophotometers, high performance liquid chromatographs and gas-liquid chromatographs.

CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C W,S, and CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S
Corequisites: CHEM 225 Analytical Chemistry 3R-0L-3C F,S
This course represents the laboratory component of analytical chemistry. Practicums are part of the grade along with reports.

CHEM 251 Organic Chemistry I 3R-0L-3C F
Prerequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S, and CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S or CHEM 112 Chemistry Honors 4R-3L-5C F
Corequisites: CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F
An introduction to the classification of organic compounds, their structural features, including stereochemistry, and concepts related to reaction mechanisms and synthetic methods.

CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F
Prerequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S, and CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S or CHEM 112 Chemistry Honors 4R-3L-5C F
Corequisites: CHEM 251 Organic Chemistry I 3R-0L-3C F

Organic Laboratory techniques are developed along with appropriate spectroscopic methods. Assessment is in part via practicums. Computational chemistry methods and green chemistry approaches are also introduced.

CHEM 252 Organic Chemistry II 3R-0L-3C W
Prerequisites: CHEM 251 Organic Chemistry I 3R-0L-3C F, and CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F
Corequisites: CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W
Continuation of Organic Chemistry I with greater emphasis on reaction mechanisms and synthesis, and an introduction to the methods used to determine structure, including IR and NMR spectroscopy and mass spectrometry.

CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W
Prerequisites: CHEM 251 Organic Chemistry I 3R-0L-3C F, and CHEM 251L Organic Chemistry I Laboratory 0R-3L-1C F
Corequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W
A continuation of CHEM251L where additional, more complicated synthetic techniques and methods along with additional spectroscopic techniques are introduced. Assessment is in part via practicums.

CHEM 253 Organic Chemistry III 3R-0L-3C S
Prerequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W, and CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W
Corequisites: CHEM 253L Organic Chemistry III Laboratory 0R-4L-1C S
Study of carbanions, classical and non-classical carbocations, polyfunctional compounds, heterocyclics, orbital symmetry and more advanced reaction mechanisms, molecular rearrangements and syntheses.

CHEM 253L Organic Chemistry III Laboratory 0R-4L-1C S
Prerequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W, CHEM 252L Organic Chemistry II Laboratory 0R-3L-1C W
Corequisites: CHEM 253 Organic Chemistry III 3R-0L-3C S
Project based laboratory where techniques and skills developed in the previous organic laboratories are applied to more open-ended problems.

CHEM 275 Special Topics in Chemistry (1-4)R-0L-(1-4)C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Studies in topics of current chemical interest not addressed in other named courses.

CHEM 276 Directed Laboratory Study in Chemistry 0R-3L-1C F
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Laboratory studies designed to supplement the background of entering students with an exceptional high school background in chemistry. This course is recommended for students entering with an AP 5 score.

CHEM 290 Chemical Research 0R-(4-8)L-(1-2)C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Research performed under the direction of a faculty member selected by mutual agreement. This course is designed for research performed before taking CHEM291. Students may register for 1 to 2 credit hours per quarter.

CHEM 291 Introduction to Chemical Research 2R-4L-3C W
Prerequisites: CHEM 113 General Chemistry II 3R-0L-3C W,S, and CHEM 113L General Chemistry II Laboratory 0R-3L-1C W,S or CHEM 112 Chemistry Honors 4R-3L-5C F
Corequisites: There are no corequisites for this course.
Students will be introduced to skills necessary for conducting chemical research. Students will gain proficiency in: (1) literature searching of primary, secondary, and tertiary sources emphasizing the use of online databases; (2) laboratory skills involving synthesis, characterization, analysis, and keeping a notebook; (3) safety practice including MSDS interpretation; and (4) ethical conduct in collecting and reporting data and results. Students will also discuss research projects with at least three faculty members and be required to attend all seminars during the quarter.

CHEM 304 Glassblowing 1R-3L-1C S
Prerequisites: Chemistry majors only or consent of instructor
Corequisites: There are no corequisites for this course.
A laboratory course in the manufacture, use and repair of scientific glassware. Six types of seals are constructed; a student-designed project is required.

CHEM 326 Bioanalytical Chemistry 3R-4L-4-C F
Prerequisites: CHEM 225 Analytical Chemistry 3R-0L-3C F,S, and CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
Corequisites: There are no corequisites for this course.
Addresses instrumental methods of analysis applicable to biochemistry including instrument design, operating principles, theory and application. Topics include molecular spectroscopic techniques in the infrared, visible and ultraviolet regions, including luminescence and Raman spectroscopy. Separation techniques including liquid chromatography and capillary electrophoresis are also addressed.

CHEM 327 Advanced Analytical Chemistry 3R-4L-4C W
Prerequisites: CHEM 225 Analytical Chemistry 3R-0L-3C F,S, and CHEM 225L Analytical Chemistry Laboratory 0R-3L-1C F,S
Corequisites: There are no corequisites for this course.
Addresses theory, operating principles, and application of instrumental methods for chemical analysis in the areas of atomic spectroscopy, x-ray techniques, gas chromatography and electroanalytical methods.

CHEM 330 Biochemistry I 4R-0L-4C F
Prerequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Includes the structure and function of biological molecules, enzyme kinetics and mechanisms, and the reactions, strategy, and regulation of carbohydrate metabolism.

CHEM 331 Biochemistry II 4R-0L-4C W
Prerequisites: CHEM 330 Biochemistry I 4R-0L-4C F, and BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F
Corequisites: There are no corequisites for this course.

Includes the reactions, strategy, and regulation of the major metabolic pathways in humans and of selected pathways in plants, and the storage, repair, and transmission of genetic information.

CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S
Prerequisites: CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S, CHE 304 Multi-Component Thermodynamics 4R-0L-4C F,W, and CHEM 115 General Chemistry III 3R-0L-3C F,W
Corequisites: There are no corequisites for this course.
Introduction to quantum chemistry, statistical thermodynamics, electrochemistry, chemical kinetics, surface chemistry and colloid science.

CHEM 361 Physical Chemistry I 4R-2L-4C F
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C F,W, CHEM 115L General Chemistry III Laboratory 0R-3L-1C W,S, MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Covers the laws of thermodynamics, free energy, gases, phase equilibria and solutions. Emphasizes the applications of differential and integral calculus and includes an introduction to statistical thermodynamics and surface chemistry. The laboratory will meet for 4 hours on alternate weeks and will investigate topics associated with thermodynamics and phase equilibrium.

CHEM 362 Physical Chemistry II 3R-2L-4C W
Prerequisites: CHEM 361 Physical Chemistry I 4R-2L-4C F
Corequisites: There are no corequisites for this course.
Covers chemical equilibria, statistical mechanics, kinetics and electrochemistry. The laboratory will meet for 4 hours on alternate weeks.

CHEM 363 Quantum Chemistry & Molecular Spectroscopy 4R-0L-4C S
Prerequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S, CHEM 111L General Chemistry I Laboratory 0R-3L-1C F,W,S, MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and PH 112 Physics II 3.5R-1.5L-4C W,S,F
Corequisites: There are no corequisites for this course.
Covers elementary quantum mechanics with emphasis on applications in molecular structure.

CHEM 391 Research Proposal 1R-0L-1C
Prerequisites: CHEM 291 Introduction to Chemical Research 2R-4L-3C W
Corequisites: There are no corequisites for this course.

CHEM 395 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend and/or present research seminars, the number to be determined by the department. The students will register for the course in the fall of the third year and if all the requirements are met, the students will receive a grade of Satisfactory. Failure to meet the requirements during the fall quarter will result in No Grade and the student must complete the requirements by the end of the third year. If the requirements are not completed by the end of the third year, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 420 Electronics for Scientists 3R-4L-4C
Prerequisites: CHEM 326 Bioanalytical Chemistry 3R-4L-4-C F or CHEM 327 Advanced Analytical Chemistry 3R-4L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument.

CHEM 430 Advanced Biochemistry 4R-0L-4C
Prerequisites: CHEM 330 Biochemistry I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules.

CHEM 433 Biochemistry Laboratory 0R-3L-lC
Prerequisites: CHEM 330 Biochemistry I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Fundamental techniques employed in isolation, characterization and study of biomolecules, and enzyme kinetics. Techniques used may include homogenization, solvent extraction, centrifugation, salt fractionation, chromatography, and electrophoresis.

CHEM 441 Inorganic Chemistry I 4R-0L-4C
Prerequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W, CHEM 362 Physical Chemistry II 3R-2L-4C W, CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S
Corequisites: There are no corequisites for this course.
The chemistry of non-metals. This course consists of a systematic study of the properties and reactions of the elements and their compounds based upon modern theories of the chemical bond, as well as from the viewpoint of atomic structure and the periodic law.

CHEM 442 Inorganic Chemistry II 3R-4L-4C
Prerequisites: CHEM 441 Inorganic Chemistry I 4R-0L-4C W,S
Corequisites: There are no corequisites for this course.
The chemistry of metals. Modern theories such as valence bond, molecular orbital, electrostatic and ligand field are used to explain the properties of complex ions. Synthesis and characterization of complexes are done in the lab.

CHEM 451 Organic Structure Determination 2R-8L-4C
Prerequisites: CHEM 253 Organic Chemistry III 3R-0L-3C S or instructor consent
Corequisites: There are no corequisites for this course.
Chemical and spectroscopic identification of organic compounds. Study of nuclear magnetic resonance and mass spectrometry, infrared spectroscopy and other techniques applied to structure elucidation and stereochemistry.

CHEM 470 Special Topics in Chemistry (1-4)R-0L-(1-4)C
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses.

CHEM 476 Directed Laboratory Study in Chemistry 0R-4L-1C
Prerequisites: To be taken concurrently with the appropriate elective not accompanied by an identified laboratory component.
Corequisites: There are no corequisites for this course.
Laboratory studies designed to supplement an area concentration in organic, inorganic, analytical, physical, or some other field of chemistry.

CHEM 477 Directed Study in Chemistry (1-4)R-0L-(1-4)C
Prerequisites: or instructor consent
Corequisites: There are no corequisites for this course.
Allows individual study in a topic not usually offered. A student may take 1 to 4 credits. A maximum of 4 credits is permitted.

CHEM 490 Chemical Research 0R-(4-12)L-(1-3)C
Prerequisites: CHEM 291 Introduction to Chemical Research 2R-4L-3C W
Corequisites: There are no corequisites for this course.
Research performed under the direction of a faculty member selected by mutual agreement. Students may register for 1 to 3 credit hours per quarter.

CHEM 491 Research Thesis 1R-0L-1C
Prerequisites: CHEM 490 Chemical Research 0R-(4-12)L-(1-3)C W
Corequisites: There are no corequisites for this course.
Students will publish a thesis on their undergraduate research. The thesis will be written under the direction of a faculty member of record for the student's CHEM490 or by other faculty member selected by mutual agreement.

CHEM 495 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 496 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 497 Research Presentation 1R-0L-1C
Prerequisites: CHEM 490 Chemical Research 0R-(4-12)L-(1-3)C W
Corequisites: There are no corequisites for this course.
Students will deliver a professional seminar on their undergraduate research. A student must have at least three credit hours of CHEM490. The seminar will be prepared under

the direction of a faculty member of record for the student's CHEM490 or by other faculty member selected by mutual agreement.

CHEM 520 Electronics for Scientists 3R-4L-4C
Prerequisites: CHEM 326 Bioanalytical Chemistry 3R-4L-4-C F or CHEM 327 Advanced Analytical Chemistry 3R-4L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
A fundamental course on understanding important electronic systems as they pertain to chemical signals and instrumentation. Topics include analog systems (RC circuits, diodes, transistors, and operational amplifiers), digital systems (logic gates, shift registers, and lock-in amplifiers), and signal enhancement and noise reduction modules. The laboratory component will showcase basic circuit design and construction, and will culminate with a student-built chemical instrument. For graduate credit there will be an additional project beyond the requirements for CHEM420. A student may not take both CHEM420 and CHEM520 for credit.

CHEM 530 Advanced Biochemistry 4R-0L-4C
Prerequisites: CHEM 330 Biochemistry I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
An in-depth exploration of selected topics from the current biochemistry scientific literature, including molecular mechanisms of infectious diseases and genetic disorders, methods for rational drug design, and relationships between structure and function for biological molecules. Students enrolled in CHEM 530 must complete a project not covered in CHEM 430. A student may not receive credit for both CHEM 430 and CHEM 530.

CHEM 531 Biochemical Instrumentation 3R-4L-4C
Prerequisites: BIO 210 Mendelian & Molecular Genetics 3R-3L-4C F, and CHEM 330 Biochemistry I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
This project-based course includes approaches for the analysis of biochemical experimental problems, experimental design for molecular biology and biochemistry, and the theoretical basis and practical aspects of operating instruments used in biochemical research.

CHEM 532 Biochemical Pharmacology 4R-0L-4C
Prerequisites: CHEM 330 Biochemistry I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Topics include medicinal chemistry and molecular pharmacology. The topics will also include a survey of potential drug targets, the molecular interactions between drugs and their targets, the drug discovery and development process and case studies of drugs treating diseases such as cancer, bacterial and viral infection, and neurological disorders.

CHEM 545 Organometallic Chemistry 4R-0L-4C
Prerequisites: CHEM 115 General Chemistry III 3R-0L-3C F, and CHEM 252 Organic Chemistry II 3R-0L-3C W
Corequisites: There are no corequisites for this course.
A survey of the chemistry of main group organometallic compounds and organo-transition metal complexes. Reaction mechanisms and uses in organic synthesis and catalysis are studied.

CHEM 552 Synthetic Organic Chemistry 4R-0L-4C
Prerequisites: CHEM 253 Organic Chemistry III 3R-0L-3C S
Corequisites: There are no corequisites for this course.
A survey of contemporary methodology in organic synthesis. Retrosynthetic analysis, functional group transformations, condensation chemistry, and organometallic reagents will be stressed. Includes computer assisted synthesis.

CHEM 554 Theoretical Organic Chemistry 4R-0L-4C
Prerequisites: CHEM 253 Organic Chemistry III 3R-0L-3C S, and CHEM 361 Physical Chemistry I 4R-2L-4C F or CHEM 360 Introduction to Physical Chemistry for Engineers 4R-0L-4C W,S or permission of instructor
Corequisites: There are no corequisites for this course.
Study of physical and chemical methods used to investigate organic reaction mechanisms; the chemistry of carbenes; organic photochemistry.

CHEM 555 Natural Products 4R-0L-4C
Prerequisites: CHEM 253 Organic Chemistry III 3R-0L-3C S or permission of instructor
Corequisites: There are no corequisites for this course.
A study of naturally occurring materials such as carbohydrates, lipids, amino acids, terpenes and steroids. The course also entails a discussion of synthesis, biosynthesis, structure elucidation, selected degradation and other reactions as well as some medicinal characteristics of selected natural products.

CHEM 557 Synthetic Polymer Chemistry 4R-0L-4C
Prerequisites: CHEM 252 Organic Chemistry II 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Polymer synthesis, reactions, and applications. Organic chemistry of polymer synthesis and modification. Design of polymer systems that meet certain performance criteria or have desirable physical properties.

CHEM 561 Advanced Physical Chemistry 4R-0L-4C
Prerequisites: CHEM 363 Quantum Chemistry & Molecular Spectroscopy 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Addresses a variety of topics in quantum mechanics, statistical thermodynamics or kinetics.

CHEM 562 Physical Polymer Chemistry 4R-0L-4C
Prerequisites: CHEM 361 Physical Chemistry I 4R-2L-4C F or CHE 303 Chemical Engineering Thermodynamics 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Physical behavior of polymers. Physical properties, molecular weight determination, relationship between morphology and mechanical properties.

CHEM 570 Special Topics in Chemistry (1-4)R-0L-(1-4)C
Prerequisites: permission of instructor
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current chemical interest not addressed in other named courses. If cross-listed with CHEM470, students in CHEM570 will need to complete an additional project.

CHEM 595 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 596 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 597 Chemistry Seminar 0R-0L-0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Chemistry graduate students will be required to attend research seminars. If the requirement is not completed by the end of the quarter, a grade of Unsatisfactory is assigned and must be rectified to meet graduation requirements.

CHEM 599 Thesis Research As assigned
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CHEM CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of Department Head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Institute of Technology
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Rose-Hulman Institute of Technology Course Catalog

Professors Aidoo, Chapman, Hanson, Kershaw, Lovell, Marincel Payne, McKinney, Mueller Price, Robinson, and Sutterer.

Civil Engineering - Course Descriptions

CE 101 Engineering Surveying 0R-6L-2C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers basic principles and practices of surveying. Measurement through the application of surveying techniques; theory of errors and their analysis; concepts of horizontal, vertical, and angular measurement; coordinate systems; basic surveying operations and computations; reading and interpretation of building, highway, and/or bridge plans; traverse computations; applications to construction and design.

CE 111 Geographical Information Systems 2R-0L-2C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The course covers introductory concepts of geographical information systems and related technologies. Topics covered will relate to the use, collection, creation, and analysis of spatial data in applying GIS and related technologies to civil engineering projects.

CE 205 Thermodynamics 4R-0L-4C F
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Covers first law of thermodynamics, second law of thermodynamics, concept of entropy, simple process analysis, properties of pure substances, equations of state, and state diagrams. Stresses use of property tables and charts and application of the first and the second laws to open and closed systems undergoing changes.

CE 250 Sustainable Civil Engineering Design 2R-0L-2C W
Prerequisites: EM 103 Introduction to Design 1R-3L-2C S
Corequisites: There are no corequisites for this course.
An introduction to sustainable design of civil engineering systems. Includes treatment of current issues as they relate to design and construction for economic, environmental and social aspects of civil engineering.

CE 303 Engineering Economy 4R-0L-4C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Emphasizes time value of money and factors related thereto. Familiarizes students with concepts of annual cost, present worth, and minimum rate of return as tools for consideration of economic factors pertinent to the selection of alternate solutions to engineering problems.

CE 310 Computer Applications in Civil Engineering 2R-0L-2C S
Prerequisites: CE 371 Hydraulic Engineering 3R-3L-4C F, and CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.

Students develop solutions to a variety of civil engineering problems using application programs such as Mathcad, Excel, and Matlab. Emphasis is made on problem solving approach and structured programming with software tools useful to civil engineering computation and design.

CE 320 Civil Engineering Materials 3R-3L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
A study of the origin, nature, performance and selection criteria of various basic materials used in the practice of civil engineering. These include aggregates, portland cement, concrete, and bituminous materials. Emphasis will be placed on standard methods of testing and characterization as related to the mechanical behavior of materials.

CE 321 Structural Mechanics I 4R-0L-4C F
Prerequisites: EM 203 Mechanics of Materials 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Classical structural analysis. Idealizations, stability, reactions and internal forces, influence lines, approximate analysis, and displacements.

CE 336 Soil Mechanics 3R-3L-4C F
Prerequisites: EM 203 Mechanics of Materials 4R-0L-4C W, and EM 301 Fluid Mechanics 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Introduces the student to the fundamental concepts of soil mechanics. Covers types and properties of soils, lateral and vertical pressures, settlement and consolidation, strength and seepage studies. Includes laboratory investigation of soil properties.

CE 371 Hydraulic Engineering 3R-3L-4C F
Prerequisites: EM 301 Fluid Mechanics 4R-0L-4C S or equivalent
Corequisites: There are no corequisites for this course.
Application of basic fluid mechanics principles to the fields of hydraulics and water resources. Topics covered include: open channel flow, closed conduit flow, flow measurement, and turbomachinery. Stresses practical applications in the laboratory.

CE 380 Introduction to Transportation Engineering 4R-0L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S, and CE 320 Civil Engineering Materials 3R-3L-4C S
Study of transportation functions and transportation systems; measuring and estimating demand; characteristics of transportation modes, interactions between modes, and mode interfaces; social, environmental, technological, economic, and public policy impacts; techniques of transportation system planning, design, and operation, with an emphasis on highway geometric design.

CE 400 Career Preparation Seminar 1R-0L-0C S
Prerequisites: CE 488 Civil Engineering Design & Synthesis II 1R-2L- 2C W
Corequisites: There are no corequisites for this course.
Preparation for the student to become a practicing engineer. Topics include Civil Engineering job expectations, continuing education, legal considerations, professionalism, consumer topics, and financial considerations.

CE 420 Consulting Engineering Seminar 2R-0L-2C S
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Discusses problems in the field of consulting engineering; includes seminars presented by practicing consulting engineers and a suitable project to practice consulting skills. Cross-listed with BE 400, CHE 420, ECE 466, and ME 420.

CE 421 Structural Mechanics II 4R-0L-4C W
Prerequisites: CE 321 Structural Mechanics I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Hand methods for structural analysis of indeterminate structures: approximating drift of frames and solid walls, force method, moment distribution method, distribution of shear when there is a rigid diaphragm, and in-plane diaphragm forces.

CE 431 Structural Design in Steel I 3R-0L-3C S
Prerequisites: CE 321 Structural Mechanics I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Covers the analysis and design of the basic elements of a steel structure using Load and Resistance Factor Design specifications. Includes tension and compression members, beams, beam-columns and connections.

CE 432 Structural Design in Concrete I 3R-0L-3C W
Prerequisites: CE 321 Structural Mechanics I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Deals with the analysis and design of reinforced concrete beams, floor slabs, and columns using the Ultimate Strength Design procedure.

CE 436 Foundation Engineering 4R-0L-4C F
Prerequisites: CE 336 Soil Mechanics 3R-3L-4C F, and CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Covers the application of soil mechanics principles to foundation problems. Includes design of building foundations and retaining walls, stability analysis of open cuts and slopes, dewatering methods, and a study of the influence of local geology.

CE 441 Construction Engineering 2R-0L-2C W
Prerequisites: Junior class standing or consent of instructor
Corequisites: There are no corequisites for this course.
Covers planning and scheduling techniques for construction engineering: Gantt charts, critical path method, precedence diagramming method, activity on arrow and PERT methods, resource allocation, and time-cost tradeoffs.

CE 442 Cost Engineering 4R-0L-4C W
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
An investigation of some of the cost accounting, cost management and estimating techniques which are used in the construction industry. Various types of estimates will be considered, as will their multiple applications for project management. Special attention will be given to the preparation of detailed estimates based on quantity take-offs and to analyses of production productivity.

CE 445 Construction Methods & Equipment 4R-0L-4C F

Prerequisites: Senior class standing or consent of instructor
Corequisites: There are no corequisites for this course.
A study of economics, fundamental concepts and functional applications of major categories of construction equipment. Operational characteristics, capability and applicability of equipment to heavy, highway and major building construction projects.

CE 450 Civil Engineering Codes & Regulations 4R-0L-4C F
Prerequisites: CE 321 Structural Mechanics I 4R-0L-4C F, and CE 471 Water Resources Engineering 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Examination of typical codes and regulations in the civil engineering profession. Local, state, and national building codes; Americans with Disabilities Act (ADA); zoning regulations; etc. Will look at major environmental regulations and sustainability assessment tools. Includes major building code evaluation and site development exercises.

CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Prerequisites: EM 301 Fluid Mechanics 4R-0L-4C S or CHE 301 Fluid Mechanics 4R-0L-4C F,S or ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduction to water pollution control, air pollution control, and solid and hazardous waste management. Topics include water treatment, wastewater treatment, impacts of pollutants on lakes and streams, and stream and air quality modeling.

CE 461 Environmental Engineering laboratory 1R-3L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Emphasizes laboratory methods and interpretation of laboratory results for chemical analysis of water and wastewater.

CE 463 Unit Operations in Environmental Engineering 4R-0L-4C F
Prerequisites: CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Covers the physical, chemical, and biological operations and processes of interest to water and wastewater treatment systems. Topics include sedimentation, mixing, activated sludge coagulation, flocculation, granular filtration and adsorption. Cross-listed with CHE461.

CE 471 Water Resources Engineering 4R-0L-4C W
Prerequisites: EM 301 Fluid Mechanics 4R-0L-4C S or CHE 301 Fluid Mechanics 4R-0L-4C F,S or ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Presents an overview of the engineering, planning, design, and operation of various water resources projects. Topics include surface and groundwater hydrology, sanitary and storm sewer design, dams and reservoirs, water law, wetlands, and nonpoint source pollution.

CE 480 Geometric Design of Highways and Streets 4R-0L-4C W
Prerequisites: CE 101 Engineering Surveying 0R-6L-2C F, and CE 380 Introduction to Transportation Engineering 4R-0L-4C S
Corequisites: There are no corequisites for this course.

Highway planning and design with evaluation of multiple alignment alternatives; geometric design of highways: horizontal and vertical alignment, cross-sectional design; intersection design; earthwork measurements and quantities; reverse curve design; legal aspects of transportation engineering; proper use of the American Association of State Highway and Transportation Officials (AASHTO) design guidelines.

CE 481 Traffic Analysis & Design 4R-0L-4C F
Prerequisites: CE 380 Introduction to Transportation Engineering 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Study of fundamentals of traffic engineering; components of the traffic system; intersection types and design elements; basic variables of the traffic system (flow, capacity, level of service, delay); design and analysis of traffic signals and intersections; traffic control and traffic impact analysis; safety performance and traffic crash analysis; use of the Highway Capacity Manual and traffic analysis software.

CE 482 Urban Transportation Planning 4R-0L-4C F or W
Prerequisites: CE 380 Introduction to Transportation Engineering 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Applies general principles of planning, evaluation, selection, adoption, financing, and implementation of alternative urban transportation systems to urban and regional planning; formulation of community goals and objectives, inventory of existing conditions; transportation modeling-trip generation, distribution, modal choice, assignment, technological characteristics and operation of modern transit and other movement systems.

CE 483 Railroad Engineering 4R-0L-4C S
Prerequisites: Junior standing or consent of instructor
Corequisites: There are no corequisites for this course.
Provides an overview of rail transportation: history, organizations, economics, safety, freight operations, track-train dynamics, signals and communications, motive power and equipment, track components, construction and maintenance. The basic objective of the course is to gain an understanding of railroads as a transportation industry that merges a number of engineering fields as well as other disciplines that contribute to the success of a complex, growth- oriented industry.

CE 486 Civil Engineering Design & Synthesis I 1R-3L-2C F
Prerequisites: RH 330 Technical & Professional Communication 4R-OL-4C S, and CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Corequisites: CE 450 Civil Engineering Codes & Regulations 4R-0L-4C F
Civil engineering projects submitted by corporate and governmental sponsors will be initiated by small teams of students to implement principles used in planning, design, and synthesis. Learning objectives include contracting, concept development, concept feasibility, planning and scheduling design work, data collection for subsequent design.

CE 487 Technical System Design & Synthesis 2R-2L-2C W
Prerequisites: CE 486 Civil Engineering Design & Synthesis I 1R-3L-2C F
Corequisites: CE 488 Civil Engineering Design & Synthesis II 1R-2L- 2C W
Technical system design of subdisciplinary elements of civil engineering projects submitted by corporate and governmental sponsors will be completed by individual team members to fulfill the needs of a team project initiated with CE486 and continuing in CE488. The “x” will be used to identify subdiscipline designation (c = general civil

design, e= environmental, g = geotechnical, s = structural, t = transportation, w = water resources).

CE 488 Civil Engineering Design & Synthesis II 1R-2L- 2C W
Prerequisites: CE 486 Civil Engineering Design & Synthesis I 1R-3L-2C F
Corequisites: CE 487 Technical System Design & Synthesis 2R-2L-2C W
Project management by small teams for civil engineering projects submitted by corporate and governmental sponsors will continue. Learning objectives include coordinate of major design work in subdisciplines, progress reporting to the client, critical path model management to keep the project on schedule to fulfill the needs of a team project initiated with CE486 and continuing in CE487.

CE 489 Civil Engineering Design & Synthesis III 1R-3L-2C S
Prerequisites: CE 487 Technical System Design & Synthesis 2R-2L-2C W, and CE 488 Civil Engineering Design & Synthesis II 1R-2L- 2C W
Corequisites: There are no corequisites for this course.
Civil engineering projects submitted by corporate and governmental sponsors will be completed. Final recommendations and engineering designs will be presented to the sponsors with due attention to the social, economic, and environmental constraints of the project. Learning objectives include construction planning and cost, final reporting, and public presentation of findings.

CE 490 Directed Studies CE 490 Directed Studies 1-4C Arranged F,W,S
Prerequisites: Approval of department head, adviser, and course instructor
Corequisites: There are no corequisites for this course.
Provides the opportunity for the civil engineering students to do a selected project of mutual interest to them and a faculty member or make up for deficiencies in transfer credit hours and topics. Credit is assigned up to 4 credits per term with a maximum of 8 credits toward graduation.

CE 520 Structural Engineering Practicum 0R-12L-4C
Prerequisites: Grad or consent of instructor
Corequisites: There are no corequisites for this course.
Structural engineering practicum approved by the department.

CE 521 Matrix Methods for Structural Analysis 4R-0L-4C F
Prerequisites: CE 321 Structural Mechanics I 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Derivation of the direct stiffness method for truss and frame elements. Derivation of the finite element method for 2D plate elements. Requires development of computer programs to implement the direct stiffness method.

CE 522 Structural Dynamics 4R-0L-4C W
Prerequisites: Grad or consent of instructor
Corequisites: CE 521 Matrix Methods for Structural Analysis 4R-0L-4C F
Analysis and behavior of structural members and systems subject to dynamic loads including basic theory for single-degree-of-freedom and multi-degree-of-freedom analytical models of civil engineering structures; seismic hazard analysis and methods of analysis for seismic loads; response spectra; time history; and linear and nonlinear methods.

CE 523 Advanced Solid Mechanics 4R-0L-4C W

Prerequisites: Grad or consent of instructor
Corequisites: There are no corequisites for this course.
The fundamentals of elasticity are introduced and related to various problems such as beams on elastic foundations, unsymmetrical bending, torsion of thin walled members, and curved beams. Introduction to the analysis and modeling techniques for existing and repaired structures. Design of retrofit measures for a variety of structures using advanced composite materials.

CE 524 Building Design 4R-0L-4C S
Prerequisites: CE 421 Structural Mechanics II 4R-0L-4C W* *Graduate standing, or consent of instructor and CE 421
Corequisites: There are no corequisites for this course.
Advanced structural analysis and design concepts for buildings: material nonlinearity, plastic design, pushover analysis, bracing, floor vibrations. Course culminates in a design project.

CE 525 Bridge Engineering 4R-0L-4C S
Prerequisites: CE 421 Structural Mechanics II 4R-0L-4C W, and CE 431 Structural Design in Steel I 3R-0L-3C S, and CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Deals with the various types of bridge structures, the materials of which they are constructed and the manner in which loads are transmitted to the foundation. Introduces concepts of bridge engineering by providing the students with the necessary knowledge and skills to apply the AASHTO LRFD specifications for the analysis and design of highway and bridge superstructure components.

CE 530 Structural Design in Timber 4R-0L-4C On Demand
Prerequisites: Senior class standing or consent of instructor
Corequisites: There are no corequisites for this course.
Presents the analysis and design of structures constructed of timber.

CE 532 Structural Design in Concrete II 3R-3L-4C F
Prerequisites: CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Advanced topics in reinforced concrete analysis and design such as serviceability. slender columns, two-way slabs, and strut-and-tie modeling.

CE 533 Connections & Detailing 4R-0L-4C S
Prerequisites: CE 431 Structural Design in Steel I 3R-0L-3C S, and CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Analysis and design of structural systems with emphasis on detailing requirements; behavior of bolted and welded connections, including gusset plates, moment-resistant connections, and simple connections; design and analysis of base plate and anchoring systems; and an introduction to seismic detailing requirements.

CE 534 Structural Design in Masonry 4R-0L-4C On Demand
Prerequisites: CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Presents the analysis and design of structures constructed of masonry. Material properties, beam design, unreinforced and reinforced walls, columns and pilasters,

seismic provisions, diaphragms, shear-walls, connections, other masonry units - stone, marble, etc.

CE 535 Structural Design in Prestressed Concrete 4R-0L-4C F
Prerequisites: CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Analysis and design of prestressed concrete stru ctures. Beams, slabs, loss of prestress, deflections, precast construction.

CE 536 Advanced Soil Mechanics 4R-0L-4C On Demand
Prerequisites: CE 436 Foundation Engineering 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Presents a comprehensive treatment of principles of soil mechanics in relation to soil compaction, effective stress, influence of fluid flow on soil behavior, pore pressure development in undrained loading, consolidation, settlement problems, lateral soil pressures, shear strength and stability problems.

CE 537 Retaining Structure Design 4R-0L-4C W
Prerequisites: CE 336 Soil Mechanics 3R-3L-4C F, and CE 432 Structural Design in Concrete I 3R-0L-3C W
Corequisites: There are no corequisites for this course.
Covers the determination of earth pressures, selection of appropriate retaining wall types, and design of commonly used retaining structures. Includes both external (geotechnical) and internal (structural) analysis.

CE 562 Advanced Wastewater Treatment 4R-0L-4C
Prerequisites: CE 463 Unit Operations in Environmental Engineering 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Covers the theory, design and analysis of biological processes for the treatment of wastewater. Treatment processes include suspended and attached growth processes, aerobic and anaerobic processes, biological nutrient removal, aeration and gas transfer, and biosolids processing.

CE 563 Advanced Water Treatment 4R-0L-4C
Prerequisites: CE 463 Unit Operations in Environmental Engineering 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Covers the theory, design and analysis of physical and chemical processes for the treatment of drinking water. Treatment processes include coagulation and flocculation, gravity separation, granular and membrane filtration, disinfection, air stripping, adsorption, ion exchange, and disinfection.

CE 564 Aquatic Environmental Chemistry 4R-0L-4C F
Prerequisites: Senior or Graduate student standing
Corequisites: There are no corequisites for this course.
Emphasis equilibrium relationships of importance in understanding both natural waters and wastewaters. The carbonate system and the concept of pH as a master variable are stressed.

CE 565 Solid & Hazardous Waste Regulation & Treatment 4R-0L-4C On Demand
Prerequisites: CE 460 Introduction to Environmental Engineering 4R-0L-4C S
Corequisites: There are no corequisites for this course.

Covers solid and hazardous waste management, including characterization, collection system design, waste minimization, design of landfills and incinerators, and remediation principles.

CE 566 Environmental Management 4R-0L-4C On Demand
Prerequisites: Graduate student standing
Corequisites: There are no corequisites for this course.
Environmental management at an industrial facility is examined in detail. Topics include the determination of environmental impacts, summaries of main environmental laws and standards, decision-making tools, and case studies of various industries.

CE 567 Applied Hydrologic Modeling 4R-0L-4C
Prerequisites: CE 471 Water Resources Engineering 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Watershed planning and stormwater management strategies are examined using computer simulation models. With an emphasis on conceptual foundation, students will be introduced to some of the most widely used models in the fields of hydrology and stormwater quantity management. Topics examined include watershed loss, transform, and routing methods, as well as model configuration, calibration, and evaluation.

CE 568 Surface Water Quality Modeling 4R-0L-4C S
Prerequisites: CE 460 Introduction to Environmental Engineering 4R-0L-4C S or consent of instructor
Corequisites: There are no corequisites for this course.
Covers the mathematical analysis of transport and fate of pollutants in natural surface waters and their impact on water quality using analytical and numerical models. Includes one- and two-dimensional steady-state and transient models. Pollutants examined include oxygen-demanding organics, nutrients and toxic compounds.

CE 569 Treatability Studies 2R-6L-4C On Demand
Prerequisites: CE 463 Unit Operations in Environmental Engineering 4R-0L-4C F or CHE 461 Unit Operations in Environmental Engineering 4R-0L-4C F or W
Corequisites: There are no corequisites for this course.
Emphasizes use of laboratory bench scale evaluations of unit operations and processes important in the treatment and disposal of specific types of organic and inorganic wastes of significance in industrial and site remediation situations. Student laboratory projects and presentations.

CE 570 Modeling Open Channel Hydraulics 4R-0L-4C W
Prerequisites: CE 371 Hydraulic Engineering 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Presents steady and unsteady flow problems in open channels and pipes, dealing with mechanics of flow over rigid and mobile boundaries. Covers analysis of river dynamics and hydraulic principles in stormwater conveyance through numerical and computer modeling.

CE 571 Environmental River Mechanics 3R-3L-4C S
Prerequisites: CE 371 Hydraulic Engineering 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Concepts of fluvial geomorphology and fluvial hydraulics are examined, including natural stream flow, sediment transport, and ecological processes in alluvial rivers. Students will apply these principles to solve common design problems of channel

instability and rehabilitation of impaired streams. Students will visit local streams to perform field data collection of channel geometry, bed and bank material, and water quality.

CE 573 Groundwater Analysis 4R-0L-4C
Prerequisites: CE 471 Water Resources Engineering 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Covers hydrodynamics of flow through porous media. The primary emphasis is on the analysis of steady and unsteady flow in confined and unconfined aquifers. Groundwater modeling is introduced.

CE 589 Environmental Engineering Design & Synthesis 4R-12L-8C F,W,S
Prerequisites: Graduate Standing
Corequisites: There are no corequisites for this course.
Environmental engineering projects submitted by external sponsors are undertaken by small teams of students to develop advanced principles used in planning, design, and synthesis. Final recommendations and engineering designs are presented to the sponsors with due attention to the social, economic, and ethical constraints of the project. Each student team also prepares a manuscript of the completed project that is suitable for publication n a peer-reviewed professional journal. The final report to the sponsor and the manuscript prepared by the team must be approved by the team's graduate committee comprised of at a minimum, the course instructor, a faculty mentor from the CE department, and a faculty external to the CE department.

CE 590 Special Problems 2/4R-0L-2/4C F,W,S
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special problems or reading by special arrangement with the faculty.

CE 597 Special Projects in Civil Engineering Variable Credit F,W,S
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
A special project, or series of problems, or research problem is assigned to or selected by the student. A comprehensive report must be submitted at the conclusion of the project. Not to be used as a substitute for CE 599, Thesis Research. Variable credit. May be repeated up to a maximum of eight credits.

CE 598 Special Topics in Civil Engineering Variable Credit
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies in advanced topics of current interest.

CE 599 Thesis Research As assigned F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as assigned; however, not more than 12 credits will be applied toward the requirements of the M.S. degree.

CE CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.

Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511

Rose-Hulman Institute of Technology Course Catalog

College and Life Skills - Course Descriptions

CLSK 100 College & Life Skills 1R-0L-1C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course will assist first-year students in acquiring skills that will facilitate a smooth transition from high school to college and will empower students to be successful at Rose-Hulman and beyond. Throughout the course, students will learn more about themselves as well as Rose-Hulman faculty, staff, and resources that will assist in creating a positive educational experience.

CLSK 122 English Language & Culture in Academic Texts 3R-3L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Reviews English grammar and introduces and develops deeper understanding of academic vocabulary. Familiarizes students with essential essay structures in academia. Introduces academic readings in select topics of academic concern in American socio-culture. The course does not satisfy any Rose-Hulman degree requirement.

CLSK 123 English Language in Academic Research & Composition 3R-3L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Introduces students to formal research and composition of research papers. Strengthen students' formal research and writing skills for research papers. Guides students through readings in academic journals and articles. The course does not satisfy any Rose-Hulman degree requirement.

CLSK 124 English Language & Culture in Academic Speech, Presentation, & Argumentation 3R-3L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Emphasizes fluency in spoken English. Rehearses academic vocabulary. Prepares students for academic presentations including technology. Develops students' academic listening and note-taking skills focusing on topics of American socio-cultural study. Introduces students to Socratic discussion and argumentation. The course does not satisfy any Rose-Hulman degree requirement.

CLSK 125 English Rhetoric & Culture in Academia 3R-3L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Prepares students for full-length lectures in courses related to their majors, focusing on oral rhetoric devices. The course does not satisfy any Rose-Hulman degree requirement.

Last updated: 07/20/2017

Rose-Hulman
Institute of Technology
5500 Wabash Avenue

Terre Haute, IN 47803
812-877-1511

Rose-Hulman Institute of Technology Course Catalog

Professors Anderson, Bohner, Boutell, Chenoweth, Defoe, Fisher, Galluzzi, Hays, Hewner, Laxer, Mellor, Mohan, Mutchler, Rupakheti, Stamm, Stouder, Taylor, Wilkin, and Wollowski.

Computer Science and Software Engineering - Course Descriptions

CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to procedural and object-oriented programming with an emphasis on problem solving. Problems may include visualizing scientific or commercial data, interfacing with external hardware such as robots, or solving numeric problems from a variety of engineering disciplines. Procedural programming concepts covered include data types, variables, control structures, arrays, and data I/O. Object-oriented programming concepts covered include object creation and use, object interaction, and the design of simple classes. Software engineering concepts covered include testing, incremental development, understanding requirements, and teamwork.

CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Provides students with an understanding of system level issues and their impact on the design and use of computer systems. Examination of both hardware and software layers. Basic computation structures and digital logic. Representation of instructions, integers, floating point numbers and other data types. System requirements, such as resource management, security, communication and synchronization, and their hardware and/or software implementation. Exploration of multiprocessor and distributed systems. Course topics will be explored using a variety of hands-on assignments and projects.

CSSE 212 Hardware-oriented Programming 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Simple computer architecture. Special hardware-oriented programming. Introduction to the C programming language, especially the use of pointers. Interrupt programming. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Object-oriented programming concepts, including the use of inheritance, interfaces, polymorphism, abstract data types, and encapsulation to enable software reuse and assist in software maintenance. Recursion, GUIs and event handing. Use of common object-based data structures, including stacks, queues, lists, trees, sets, maps, and hash tables. Space/time efficiency analysis. Testing. Introduction to UML.

CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C
Prerequisites: A score of 4 or 5 on the APCS A exam or permission of instructor

Corequisites: There are no corequisites for this course.
This course is intended for students who have sufficient programming experience to warrant placement in an accelerated course covering the topics from CSSE 120 and CSSE 220. This course will satisfy the prerequisite requirements for courses that have CSSE 220 as a prerequisite.

CSSE 225 Programming 3 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Differences between Java and C++. C++ concepts of object-oriented programming (classes, objects, inheritance, polymorphism). Storage management. Multiple inheritance, operator overloading, friend-concept, exception handling, I/O. Error analysis of programs. Generic programming and introduction to C++ - standard library. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S with a grade of C or better
Corequisites: There are no corequisites for this course.
This course reinforces and extends students' understanding of current practices of producing object-oriented software. Students extend their use of a disciplined design process to include formal analysis of space/time efficiency and formal proofs of correctness. Students gain a deeper understanding of concepts from CSSE 220, including implementations of abstract data types by linear and non-linear data structures. This course introduces the use of randomized algorithms. Students design and implement software individually, in small groups, and in a challenging multi-week team project.

CSSE 232 Computer Architecture I 3R-3L-4C F,W
Prerequisites: CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S, or both ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, and CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Computer instruction set architecture and implementation. Specific topics include historical perspectives, performance evaluation, computer organization, instruction formats, addressing modes, computer arithmetic, single-cycle and multi-cycle data paths, and processor control. Assembly language programming is used as a means of exploring instruction set architectures. The final project involves the complete design and implementation of a miniscule instruction set processor.

CSSE 241 Computing in a Global Society 2R-6L-4C
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
The ability to work with colleagues from other cultures and to work on international projects are key assets in today's job market. The centerpiece of this course is a real-world computing project that students develop in cooperation with peers from an institution of higher education in a foreign country. Exposes students to the procedures and complexities of working on projects that span many time-zones and cultures.

Additionally, students examine the use and impact of computing in a global community. International travel is required; students will be expected to incur additional expenses (will vary depending on the project, institution, and country). May be repeated once (for free elective credit only) if the country involved is different.

CSSE 280 Introduction to Web Programming 3R-3L-4C W
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduction to the client-side and server-side mechanisms for creating dynamic web pages with persistent data storage. Browser-webserver interaction via HTTP. Static web page creation using HTML5 and CSS3. Client-side programming using JavaScript, DOM, JSON. Server-side programming and data storage using PHP and mySQL. Asynchronous client-server communication using AJAX and extensions of JavaScript. Session maintenance using cookies. Security considerations. This course provides breadth of knowledge of many tools/technologies rather than deep knowledge of any particular tool/language. No previous experience with web page creation is required.

CSSE 290 Special Topics in Computer Science 4C
Prerequisites: Arranged prerequiste - permission of instructor
Corequisites: There are no corequisites for this course.
Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 304 Programming Language Concepts 4R-0L-4C F,W
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Syntax and semantics of programming languages. Grammars, parsing, data types, control flow, parameter passing, run-time storage management, binding times, functional programming and procedural abstraction, syntactic extensions, continuations, language design and evaluation. Students will explore several language features by writing an interpreter that implements them.

CSSE 325 Fractals & Chaotic Dynamical Systems 4R-0L-4C
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Emphasis on the mathematical and computer graphics foundations behind fractal images and the relationship between chaotic dynamics and fractal geometry. Self-similar fractals, random fractals with Brownian motion, and fractals generated from dynamical systems. Fractal dimensions. Iterated Function Systems. Chaos in one-dimensional maps. Controlling chaos. Mandelbrot and Julia sets. Computer graphics. Same as MA 325.

CSSE 332 Operating Systems 3R-3L-4C W,S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S, and CSSE 132 Introduction to Computer Systems 3R-3L-4C F,S or CSSE 232 Computer Architecture I 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.

Students learn fundamental concepts of modern operating systems by studying how and why operating systems have evolved. Topics include CPU scheduling, process synchronization, memory management, file systems, I/O systems, privacy and security, and performance evaluation. Students implement parts of an operating system as a means of exploring the details of some of these topics.

CSSE 333 Database Systems 3R-3L-4C W,S
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W, and CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S (or concurrent enrollment in CSSE230)
Corequisites: There are no corequisites for this course.
Relational database systems, with emphasis on entity relationship diagrams for data modeling. Properties and roles of transactions. SQL for data definition and data manipulation. Use of contemporary API's for access to the database. Enterprise examples provided from several application domains. The influence of design on the use of indexes, views, sequences, joins, and triggers. Physical level data structures: B+ trees and RAID. Survey of object databases.

CSSE 335 Introduction to Parallel Computing 4R-0L-4C S (odd years)
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S and programming experience
Corequisites: There are no corequisites for this course.
Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as MA 335.

CSSE 351 Computer Graphics 4R-0L-4C F
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Computer graphics algorithms, hardware and software. Line generators, affine transformations, line and polygon clipping, interactive techniques, perspective projection, solid modeling, hidden surface algorithms, lighting models, shading, and graphics standards. Programming assignments and a final project are required.

CSSE 352 Computer Game Development 4R-0L-4C
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to designing and developing computer games. Topics include game genres, game design, sprites, game physics, collisions, characters, scripting, graphics, and sound. Students will design and implement their own game using an available game engine.

CSSE 371 Software Requirements Engineering 3R-3L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S, and RH 330 Technical & Professional Communication 4R-OL-4C F,W,S and Junior standing
Corequisites: There are no corequisites for this course.
Basic concepts and principles of software requirements engineering, its tools and techniques, and methods for modeling software systems. Topics include requirements

elicitation, prototyping, functional and non-functional requirements, object-oriented techniques, and requirements tracking.

CSSE 372 Software Project Management 4R-0L-4C F
Prerequisites: There are no prerequisites for this course.
Corequisites: CSSE 371 Software Requirements Engineering 3R-3L-4C F
Major issues and techniques of project management. Project evaluation and selection, scope management, team building, stakeholder management, risk assessment, scheduling, quality, rework, negotiation, and conflict management. Professional issues including career planning, lifelong learning, software engineering ethics, and the licensing and certification of software professionals.

CSSE 373 Formal Methods in Specification and Design 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S, and MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Introduction to the use of mathematical models of software systems for their specification and validation. Topics include finite state machine models, models of concurrent systems, verification of models, and limitations of these techniques.

CSSE 374 Software Design 3R-3L-4C W
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S and Junior standing
Corequisites: There are no corequisites for this course.
Introduction to the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, and relationships between levels of abstraction.

CSSE 375 Software Construction and Evolution 3R-3L-4C S
Prerequisites: CSSE 374 Software Design 3R-3L-4C W
Corequisites: There are no corequisites for this course.
Issues, methods and techniques associated with constructing software. Topics include detailed design methods and notations, implementation tools, coding standards and styles, peer review techniques, and maintenance issues.

CSSE 376 Software Quality Assurance 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Theory and practice of determining whether a product conforms to its specification and intended use. Topics include software quality assurance methods, test plans and strategies, unit level and system level testing, software reliability, peer review methods, and configuration control responsibilities in quality assurance.

CSSE 400 CSSE Seminar 4R-0L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
This course presents an overview of current application areas within computer science and software engineering through the use of practical case studies. Students will undertake their own preparation of one or more case studies and present their results. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 402 Theory and Practice of Garbage Collection 4R-0L-4C
Prerequisites: CSSE 332 Operating Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Garbage collection (GC) is a method of automatically reclaiming dynamically allocated storage that an application no longer needs. In this course, students will explore the classical problems of garbage collection such as detecting unused objects and reclaiming the space allocated to them. Students will survey the GC literature to become familiar with the current state-of-the-art and future research directions. Students will explore techniques used to implement state-of-the-art garbage collection algorithms and will design and implement garbage collectors for a memory-managed language (e.g.,Java, C#, php, or Python).

CSSE 403 Programming Language Paradigms 4R-0L-4C F (even years)
Prerequisites: CSSE 304 Programming Language Concepts 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
A survey of some current and emerging programming languages, focusing on unique language paradigms-ways of structuring solutions or manipulating data. Examples of paradigms include dynamic programming languages, object-oriented programming, highly parallelizable code, and functional programming. Emphasizes developing independent learning techniques that will allow students to acquire skills in new languages quickly. Students will develop basic skills in at least three different languages representing distinct paradigms. They will also be exposed to a selection of other languages. Includes a substantial team project.

CSSE 404 Compiler Construction 4R-0L-4C S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W, and CSSE 304 Programming Language Concepts 4R-0L-4C F,W, and CSSE 474 Theory of Computation 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Theory and practice of programming language translation. Lexical analysis, syntax analysis, parser generators, abstract syntax, symbol tables, semantic analysis, intermediate languages, code generation, code optimization, run-time storage management, error handling. Students will construct a complete compiler for a small language.

CSSE 413 Artificial Intelligence 4R-0L-4C F
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Students investigate how to model and implement intelligent behavior using computers. Topics are chosen from how machines can: solve problems; reason and use knowledge; learn from experience; and perceive and act. Students explore these topics by implementing many of the ideas in software. Readings are drawn both from a textbook and from technical papers in recent conferences and journals.

CSSE 432 Computer Networks 4R-0L-4C S
Prerequisites: CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Organization, design, and implementation of computer networks, especially the Internet. Network protocols, protocol layering, flow control, congestion control, error control, packet organization, routing, gateways, connection establishment and maintenance,

machine and domain naming, security. Each of the top four layers of the Internet protocol stack: application (FTP, HTTP, SMTP), transport (TCP, UDP), network (IP), link (Ethernet).

CSSE 433 Advanced Database Systems 4R-0L-4C S
Prerequisites: CSSE 333 Database Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Topics selected from object-oriented databases, object-relational databases, query processing, transactions, transaction logging, concurrency control, database recovery, parallel and distributed databases, security and integrity, data mining and data warehousing.

CSSE 434 Introduction to the Hadoop Ecosystem 4R-0L-4C
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
*Some Experience with SQL recommended
Corequisites: There are no corequisites for this course.
This advanced course examines emergent Big Data techniques through hands-on introductions to the various technologies and tools that make up the Hadoop ecosystem. Topics covered include internals of MapReduce and the Hadoop Distributed File system (HDFS), internals of the YARN distributed operating system, MapReduce for data processing, transformation & analysis tools for data at scale (processing terabytes and petabytes of information quickly), scheduling jobs using workflow engines, data transfer tools & real time engines for data processing.

CSSE 435 Robotics Engineering 3R-3L-4C S
Prerequisites: ME 430 Mechatronic Systems 3R-3L-4C F,W or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Same as ME 435.

CSSE 442 Computer Security 4R-0L-4C W
Prerequisites: CSSE 332 Operating Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
This course introduces ethical, theoretical, and practical issues of information security in computing systems. Implications of relevant professional codes of ethics are a recurring theme of the course. Foundational topics include access control matrices and standard system models, as well as policies for security, confidentiality, and integrity. Implementation issues include key management, cipher techniques, authentication, principles of secure design, representation of identity, access control mechanisms, information flow, life cycle issues, and formal evaluation and certification techniques. Additional topics include malicious logic, vulnerability analysis, and auditing. Computer network attack techniques are discussed and explored in a closed environment to motivate and inform discussion and exploration of computer network defense techniques.

CSSE 443 Distributed Systems & IT Security 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Building complex distributed information systems requires a systematic approach. This course covers the analysis of existing distributed information systems and provides the ability to model simple new distributed applications with special attention to the trustworthiness, reliability and security of information systems. Topics covered include the main architectural models of distributed systems, describing simple distributed applications according to architecture and function, defining simple communication protocols, the benefits of using middleware, the risks of using distributed systems, and safety measures. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 444 Real-time Systems 3R-3L-4C
Prerequisites: ICS major
Corequisites: There are no corequisites for this course.
Students will learn the features and specifications of real-time systems. Topics covered include real-time operating systems and programming languages, design patterns for real-time systems, scheduling, synchronization, hybrid task sets, and applications of real-time systems. This course is taught as part of the International Computer Science dual degree program at Hochschule Ulm, Germany.

CSSE 451 Advanced Computer Graphics 4R-0L-4C W (even years)
Prerequisites: CSSE 351 Computer Graphics 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Advanced topics in computer graphics. Topics will be drawn from current graphics research and will vary, but generally will include ray tracing, radiosity, physically-based modeling, animation, and stereoscopic viewing. Programming assignments and a research project are required.

CSSE 453 Topics in Artificial Intelligence 4R-0L-4C
Prerequisites: CSSE 413 Artificial Intelligence 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Advanced topics in artificial intelligence. Topics will vary. Past topics have included machine game playing and machine learning. May be repeated for credit if topic is different.

CSSE 461 Computer Vision 4R-0L-4C S (odd years)
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S *Also recommended (but not required) either MA371 or MA373.
Corequisites: There are no corequisites for this course.
An introduction to 3D computer vision techniques. Both theory and practical applications will be covered. Major topics include image features, camera calibration, stereopsis, motion, shape from x, and recognition.

CSSE 463 Image Recognition 4R-0L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S Junior standing and programming experience
Corequisites: There are no corequisites for this course.

Introduces statistical pattern recognition of visual data; low-level visual feature extraction (color, shape, edges); clustering and classification techniques. Applies knowledge to various application domains through exercises, large programming projects in Matlab, and an independent research project. Familiarity with probability distributions will be helpful, but not required.

CSSE 473 Design and Analysis of Algorithms 4R-0L-4C W
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S, and MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as MA 473.

CSSE 474 Theory of Computation 4R-0L-4C S
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S, and MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as MA 474.

CSSE 477 Software Architecture 4R-0L-4C F
Prerequisites: CSSE 374 Software Design 3R-3L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
This is a second course in the architecture and design of complete software systems, building on components and patterns. Topics include architectural principles and alternatives, design documentation, relationships between levels of abstraction, theory and practice of human interface design, creating systems which can evolve, choosing software sources and strategies, prototyping and documenting designs, and employing patterns for reuse. How to design systems which a team of developers can implement, and which will be successful in the real world.

CSSE 479 Cryptography 4R-0L-4C S
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography. Same as MA 479.

CSSE 480 Web App Frameworks with AppEngine 3R-3L-4C F

Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S, and CSSE 280 Introduction to Web Programming 3R-3L-4C W
Corequisites: There are no corequisites for this course.
Development of desktop and mobile web applications using Google AppEngine. Additional web frameworks include Jinja2, Cloud Datastore, jQuery, Bootstrap, DataTables, Cloud Storage, Cloud Endpoints, and AngularJS. Topics covered using these frameworks include the HTML, CSS, and JavaScript development of client side web apps, sending and receiving REST requests, designing Datastore models, HTML5 and CSS3 features including CSS animations, file storage, Ajax requests, and user OAuth. Emphasis is on hands-on use of these frameworks in web application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 481 Web-Based Information Systems 4R-0L-4C F (odd years)
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
In this course, students learn about several aspects of research: thinking creatively about interesting research problems, researching existing work in a chosen area, and keeping current in a field. Students are exposed to the process of research by writing a pre-proposal for a project that advances the web. Projects either develop new web-technologies or applications or investigate a topic of importance. Based on feedback received, groups of students write a research proposal which goes through a formal peer review process. Approved projects are pursued for the remainder of the quarter. Students present current research as well as give a final presentation of their group project. Selected web-technologies are introduced; in the past, these have included CGI programming and XML technologies.

CSSE 483 Android Application Development 4R-0L-4C
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to programming mobile applications using the Android stack. Topics include the activity lifecycle, resources, layouts, intents for multiple activities, menus, fragments and dialogs, adapters, data persistence via shared preferences, SQLite, and web backends. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, UML design, development, testing, and presentation).

CSSE 484 iOS Application Development 3R-3L-4C W
Prerequisites: CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to programming mobile applications using the iOS stack. Topics include using X-Code for Swift and Objective-C app development, UI components, Storyboards, view controller actions and outlets, table views, navigation controllers, Core Data, and APIs for backend communication. Emphasis is on hands-on use of these components in application development. Includes a substantial team project (UI mockups, user stories, development, testing, and presentation).

CSSE 487 Senior Research Project I 4C
Prerequisites: RH 330 Technical & Professional Communication 4R-OL-4C F,W,S and senior standing
Corequisites: There are no corequisites for this course.

Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 488 Senior Research Project II 4C
Prerequisites: CSSE 487 Senior Research Project I 4C F,W,S
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 489 Senior Research Project III 4C
Prerequisites: CSSE 488 Senior Research Project II 4C F,W,S
Corequisites: There are no corequisites for this course.
Individual or group research on an unsolved technical problem. The problem is expected to be at an advanced level and have an appropriate client. A prototype system, a technical report, and a public presentation are required.

CSSE 490 Special Topics in Computer Science 4C
Prerequisites: Instructor consent
Corequisites: There are no corequisites for this course.
Selected topics of current interest. May be repeated for credit if topic is different.

CSSE 491 Directed Independent Studies 4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Independent study of an advanced subject not included in regularly offered courses. May be repeated for credit if topic or level is different.

CSSE 492 Undergraduate Research in Computer Science 4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Research under direction of a faculty member. Presentation of preliminary and final results to departmental seminar. Presentation of work at professional meetings or by publication in professional journals is strongly encouraged. May be repeated for credit if topic or level is different.

CSSE 493 Undergraduate Research in Software Engineering 4C
Prerequisites: Consent of instructor and department head
Corequisites: There are no corequisites for this course.
The Computer Science curriculum prepares students for careers in all areas of the computer industry as well as for graduate studies in computer science and computer related fields. Students have also found a computer science major to be excellent preparation for careers in law, medicine, business administration, industrial engineering, biomedical engineering, and other technical and non-technical fields.

CSSE 494 Senior Thesis I 4C
Prerequisites: RH 330 Technical & Professional Communication 4R-OL-4C F,W,S
Consent of instructor and department head
Corequisites: There are no corequisites for this course.

Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 495 Senior Thesis II 4C
Prerequisites: CSSE 494 Senior Thesis I 4C F,W,S Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 496 Senior Thesis III 4C
Prerequisites: CSSE 495 Senior Thesis II 4C F,W,S Consent of instructor and department head
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in computer science or software engineering. Topic is expected to be at an advanced level. Research paper and presentation to department seminar are required.

CSSE 497 Senior Capstone Project I 4C F
Prerequisites: CSSE 371 Software Requirements Engineering 3R-3L-4C F and senior standing
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 498 Senior Capstone Project II 4C W
Prerequisites: CSSE 374 Software Design 3R-3L-4C W, and CSSE 497 Senior Capstone Project I 4C F
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks

include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE 499 Senior Capstone Project III 4C S
Prerequisites: CSSE 498 Senior Capstone Project II 4C W
Corequisites: There are no corequisites for this course.
For a capstone experience, students work on a team to complete a three-term software engineering project for an approved client. Students choose from two approaches to complete their capstone: 1) Develop a substantive software product, using defensible software processes. The teams focus on delivering key software development, administrative, and user artifacts to the client. Tasks include project planning, risk analysis, use of standards, prototyping, configuration management, quality assurance, project reviews and reports, team management and organization, copyright, liability, and handling project failure. 2) Investigate a substantive software product or engineering process problem, using a defensible and documented research approach. Tasks include problem analysis, developing alternative solutions, evaluating the solutions via prototyping and iterative processes of investigation, comparing the potential solutions, recording the investigation experience in a research report, and delivering the research artifacts to the client.

CSSE CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Rose-Hulman Institute of Technology Course Catalog

Professors Berry, Chang, Doering, Estrada, Grigg, Herniter, Hong, Hudson, Kim, Miller, Moore, Padgett, Rostamkolai, Simoni, Song, Throne, Walter, Wheeler, and Yoder.

Electrical and Computer Engineering - Course Descriptions

ECE 160 Engineering Practice 0R-4L-2C F,W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to electrical and computer engineering, systems engineering design, programming, microcontrollers, soldering and circuit building. Students will work individually and on teams to complete projects and create a system for an end of term competition. Students will also learn about technical documentation and communication. Topics include functions, arrays, conditionals, loops, Boolean algebra, wireless communication, resistors, transistors, diodes motors, sensor, analog and digital inputs and outputs.

ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S, and ECE 160 Engineering Practice 0R-4L-2C F,W or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S or prior programming experience
Corequisites: There are no corequisites for this course.
An introduction to discrete-time signal processing applied to audio, images, and video. Topics include phasor representation of sinusoidal signals, complex arithmetic, sampling, signal spectra, linear time-invariant systems, frequency response, convolution, filter implementation, and MATLAB programming. Integral laboratory.

ECE 203 DC Circuits 3R-3L-4C S, F
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W, and PH 112 Physics II 3.5R-1.5L-4C W,S,F
Corequisites: There are no corequisites for this course.
A review of the definition of voltage, current, energy and power. An introduction to Ohm's Law, ideal DC independent and dependent voltage and current sources, resistors, inductors, capacitors, and operational amplifiers. Circuit analysis and simplification by using series, parallel, and Wye-Delta reduction, Kirchhoff's laws, mesh and nodal analysis, Thevenin, Norton and Maximum Power Theorems, superposition, and source transformations. An integral laboratory to build electric circuits and measure voltage, current, resistance and power.

ECE 204 AC Circuits 3R-3L-4C F,W
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and either ECE 203 DC Circuits 3R-3L-4C S, F* or ES 203 Electrical Systems 3R-3L-4C F,W,S* *with a grade of C or better
Corequisites: There are no corequisites for this course.
Capacitance, Self and Mutual Inductance. Root-mean-square values of waveforms. Application of phasors to sinusoidal steady-state. Impedance of circuit elements. Mesh and Nodal Analysis applied to ac circuits. Thevenin and Norton theorems applied to ac circuits. Single-phase ac power. Power factor correction. Voltage regulation and

efficiency of feeders. Balanced three-phase systems. Ideal and non-ideal transformer models. Integral laboratory.

ECE 205 Circuits & Systems 3R-3L-4C W,S
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and ECE 180 Introduction to Signal Processing 3R-3L-4C F,W,S, and RH 131 Rhetoric & Composition 4R-OL-4C F,W,S, and either ECE 203 DC Circuits 3R-3L-4C S, F* or ES 203 Electrical Systems 3R-3L-4C F,W,S* *with a grade of C or better
Corequisites: There are no corequisites for this course.
Introduction to 1st and 2nd order circuits and review of differential equations. Bode plots. System classification, impulse and step response, convolution. Laplace and inverse Laplace transforms, block and signal flow diagrams. Benefits of feedback. Modeling and simulating electrical systems. Matlab and Simulink. Integral laboratory.

ECE 206 Elements of Electrical Engineering 4R-0L-4C W,S
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
A course designed for engineers (other than electrical or computer) covering analysis of passive circuits, introduction to op-amps, instrumentation, sinusoidal steady-state, a-c power, and induction motors. EE and CPE majors may not take this course.

ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Prerequisites: ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and ECE 160 Engineering Practice 0R-4L-2C F,W
Corequisites: There are no corequisites for this course.
Sensors and actuators. Input and output devices. Microcontroller architecture. Standard communications protocols. Interrupt generation and processing. Data representation and storage. Memory management. The C programming language and programming styles. Integral laboratory and a term project.

ECE 233 Introduction to Digital Systems 3R-3L-4C F,W
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S or ECE 160 Engineering Practice 0R-4L-2C F,W
Corequisites: There are no corequisites for this course.
Number systems, Binary arithmetic, logic gates, forming logic circuits. Boolean algebra, Karnaugh maps. Propagation delay, hazards, common Combinational logic circuits, structures, and design. Contraction, latches, flip-flops, finite state machines, counters, Sequential circuit timing, and designing Sequential circuits. Register design, control and datapath design. Basic computer architecture, including memory. Integral laboratory.

ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W or ECE 205 Circuits & Systems 3R-3L-4C W,S, ES 203 Electrical Systems 3R-3L-4C F,W,S * For non-EE and non-Cpe majors with B or better
Corequisites: There are no corequisites for this course.
Modeling, analysis, and simulation of electronic circuits that contain two-terminal and threeterminal semiconductor devices. Large-signal, biasing, and small-signal analysis models. Introduction to wave shaping circuits, switching circuits, and amplifiers. Integral laboratory.

ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S

Prerequisites: ECE 205 Circuits & Systems 3R-3L-4C W,S, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Signal modeling. Fourier series and Fourier transforms. Response of systems to periodic and aperiodic signals. Filter characterization and design. Ideal and practical sampling. Use of numerical analysis software. Integral laboratory

ECE 310 Communication Systems 3R-3L-4C F, S
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Transmission of information over bandlimited, noisy communication channels. Line codes, probability of error, intersymbol interference. Modulation techniques, synchronization and frequency conversion. Integral laboratory.

ECE 312 Communication Networks 4R-0L-4C W
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S, and CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Layered architectures. Circuit and packet switching. The ISO Reference Model. Point-to-point protocols, error control, framing. Accessing shared media, local area networks. Virtual circuits, datagrams, routing, congestion control. Queuing theory. Reliable message transport, internetworking.

ECE 320 Linear Control Systems 3R-3L-4C F,W
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S, and ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S or ME 430 Mechatronic Systems 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
Analysis of linear control systems using classical and modern control theories in both continuous and discrete time. Plant representation, closed loop system representation, time response, frequency response, concept of stability. Root locus, Bode, and Nyquist methods. Computer modeling and simulation of feedback systems, implementation of discrete-time algorithims on microcontrollers.

ECE 331 Embedded System Design 3R-3L-4C W,S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Microcontroller architecture. Software development in both assembly language and the C programming language. Real-time event measurement and generation. Interrupt design and applications. Interfacing with peripheral digital and analog devices. Integrated development and debugging environment. Design and implementation of embedded systems for control, measurement, and display, etc. Integral laboratory. Credit cannot be obtained for both ECE 331 and ECE 430.

ECE 332 Computer Architecture II 4R-0L-4C S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.

Instruction-Level Parallelism. Pipelining. Data Hazards. Exceptions. Branch Prediction. Multilength Instructions. Loop Unrolling. TI C6000 Digital Signal Processor. Cache. Memory. MSP430 Microcontroller. PIC Microcontroller. Intel Itanium. Multiprocessors. Hardware Multithreading. Graphics Processors. Supercomputers.

ECE 340 Electromagnetic Fields 4R-0L-4C F,W
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Static and dynamic fields. Electric and magnetic properties of materials. Energy, force and power. Resistors, capacitors, and inductors. Application in sensing and actuation. Maxwell's equations. Introduction to electromagnetic waves. Use of vector calculus and numeric approximation. Technical reports and/or term papers.

ECE 341 Electromagnetic Waves 4R-0L-4C W,S
Prerequisites: ECE 340 Electromagnetic Fields 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Wave propagation and reflection. Power and lossy materials. Quasistatic analysis. Steady-state and transient analysis of transmission lines. Application in high-speed systems. Introduction to antennas. Technical reports and/or term papers.

ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Electromagnetic compatibility (EMC) regulations and measurement. Frequency behavior of passive components. Electromagnetic fields and waves. Transient behavior of transmission lines. Dipole and monopole antennas. Four coupling mechanisms: electrical and magnetic fields, common impedance, and electromagnetic wave. Conducted emissions. Radiated emissions. Electromagnetic shielding and grounding.

ECE 343 High-Speed Digital Design 3R-3L-4C F,S
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S and Computer Engineering Major
Corequisites: There are no corequisites for this course.
Signal path modeling through connecting lengths of transmission lines with lumped element models of discontinuities. Circuit parameters from geometries and material properties for resistance, capacitance, inductance and transmission line segments. Lossless and lossy transmission line circuit modeling. High-frequency and high-speed behavior of passive components. Frequency spectrum of digital signals. Digital device driver and receiver modeling. Transmission line impedance discontinuity and termination techniques. Electric and magnetic field coupling mechanisms for capacitive and inductive crosstalk. Ground noise, power plane noise and resonance. Signal and power integrity issues in high-speed digital systems at both the printed-circuit board and chip levels.

ECE 351 Analog Electronics 3R-3L-4C F,W
Prerequisites: ECE 205 Circuits & Systems 3R-3L-4C W,S, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.

Amplifier design and analysis including discrete and integrated circuit topologies. Cascaded amplifier, input and output stages, frequency response. Linear and non-linear op-amp circuits. Introduction to the non-ideal properties of op-amps. Integral laboratory.

ECE 362 Principles of Design 3R-0L-3C F,S
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W, and ECE 205 Circuits & Systems 3R-3L-4C W,S, ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F, and ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
A formal design course that emphasizes the design process. Project management, project reporting and decision-making are learned by student teams as they carry a project through several stages of a formal design process.

ECE 370 Power & Energy Systems 3R-1L-4C F,S
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
Analysis of generation systems consisting of: modeling of synchronous and induction generators, examination of fossil, nuclear, hydroelectric, solar, and wind technologies. Analysis of transmission and distribution systems consisting of modeling: power transformers, transmission lines, switchgear, and protection systems. Analysis of customer systems consisting of modeling: induction motors, linear and non-linear loads.

ECE 371 Sustainable Energy Systems 3R-3L-4C W,S
Prerequisites: ECE 204 AC Circuits 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
Conventional and modern sources of energy for power generation in electric power industry with the imposed economic, regulatory, and environmental constraints. Wind, solar-photovoltaic, micro-hydropower, and fuel cell systems. Integral laboratory.

ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
System properties: linearity and time-invariance. Sampling and reconstruction. Convolution in discrete-time systems. Z-transform, FIR and IIR filters. Discrete-time filter design. Discrete Fourier transform. Random Variables and Random Processes.

ECE 398 Undergraduate Projects 1-4C
Prerequisites: Arranged Prereq: Consent of instructor
Corequisites: There are no corequisites for this course.
Special design or research projects.

ECE 412 Software Defined Radio 3R-3L-4C S
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and ECE 310 Communication Systems 3R-3L-4C F, S consent of instructor
Corequisites: There are no corequisites for this course.
A software-defined radio (SDR) is characterized by its flexibility: Simply modifying software can completely change the radio’s functionality. This course addresses many of the choices an SDR designer must make to build a complete digital radio. Topics could include: modeling corruption, (de)modulation, AGC, filtering, bits to symbols,

carrier and timing recovery, pulse shaping, equalization, coding, noise figure for the RF front end, and clock-jitter of the A/D. In the integral laboratory students will use LabVIEW to create a complete digital radio using the NI USRP 2920 platform.

ECE 414 Wireless Systems 4R-0L-4C W
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S
Corequisites: There are no corequisites for this course.
Introduction to wireless communications and networks. Wireless channel models, vector space, modulation and demodulation, optimal receiver design, equalization, channel capacity, multipleaccess techniques, spread spectrum, and multiple-antenna systems. Additional recommended prerequisite: MA371 or MA373 with a grade of B or higher.

ECE 415 Wireless Electronics 2R-6L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Design, fabrication, and testing of a high frequency transmitter-receiver system including but not limited to oscillators, mixers, filters, amplifiers, and matching networks. Integral laboratory.

ECE 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with CHE 405, EP 410, and ME 416.

ECE 418 Fiber Optic Systems 4R-0L-4C S
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S Consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of common photonic systems such as fiber optic communication links, optical sensing systems, and optical networks. Topics include basic architectures, component overview, system design, and expected degradations along with mitigation techniques. An oral presentation of a technical paper is required.

ECE 419 Advanced MEMS: Modeling and Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with EP 411, and CHE 419.

ECE 420 Discrete-Time Control Systems 4R-0L-4C F
Prerequisites: ECE 320 Linear Control Systems 3R-3L-4C F,W or ME 406 Control Systems 3R-3L-4C F
Corequisites: There are no corequisites for this course.

Sampled systems and z-transforms. Transfer function and state-variable models of systems. Discrete-time control of systems including state variable feedback and observer construction.

ECE 425 Introduction to Mobile Robotics 3R-3L-4C W
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and ECE 320 Linear Control Systems 3R-3L-4C F,W or ME 406 Control Systems 3R-3L-4C F or BE 350 Biocontrol Systems 4R-0L-4C F or CHE 440 Process Control 4R-0L-4C W
Corequisites: There are no corequisites for this course.
This course will introduce the basic principles of mobile robotics history, theory, hardware and control. Topics will include robot components, effectors and actuators, locomotion, sensors, feedback control, control architectures, representation, localization and navigation. This is a project-oriented course and the student will have hands-on experience with a real mobile robot. The student will be required to complete several laboratory assignments and a multidisciplinary team design project.

ECE 430 Microcontroller-Based Systems 3R-3L-4C F
Prerequisites: ECE 250 Electronic Device Modeling 3R-3L-4C S,F* *For ECE students, consent of instructor for other students.
Corequisites: There are no corequisites for this course.
Microcontroller register set, addressing modes and instruction set. Microcontroller peripheral support modules. Assembly language and C programming. Fundamental data structures. Interrupts. Real time programming. Data communications. Microcontroller interface to displays, digital and analog devices, sensors, and actuators. Embedded system design, implementation and applications. Integrated development environment. Formal final report and oral presentation. Integral laboratory. Credit cannot be obtained for both ECE 331 and ECE 430.

ECE 452 Power Electronics 3R-3L-4C F
Prerequisites: ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Analysis and design of networks that use electronic devices as power switches. Silicon-controlled rectifiers, power transistors, and power MOSFETS are used to form phase-controlled rectifiers, AC voltage controllers, choppers, and inverters. Integral laboratory.

ECE 454 System Level Analog Electronics 3R-3L-4C W
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W
Corequisites: There are no corequisites for this course.
Analysis and design of Op-Amp circuits: wave shaping circuits, Schmitt triggers, power amplifiers, high power buffers, controlled current sources, peak detectors, sample and hold circuits. Precision Op-Amp Circuits. Non-ideal properties of Op-Amps. Integral laboratory.

ECE 460 Engineering Design I 1R-6L-3C F,W
Prerequisites: ECE 362 Principles of Design 3R-0L-3C F,S, and either ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S*, and ECE 310 Communication Systems 3R-3L-4C F, S*, and ECE 320 Linear Control Systems 3R-3L-4C F,W*, and ECE 341 Electromagnetic Waves 4R-0L-4C W,S*, and ECE 351 Analog Electronics 3R-3L-4C F,W*, and ECE 370 Power & Energy Systems 3R-1L-4C F,S*, and ECE 371 Sustainable Energy Systems 3R-3L-4C W,S*, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W* or CSSE 332 Operating Systems 3R-3L-4C W,S**, and CSSE

230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S**, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F**, and ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S**, and ECE 312 Communication Networks 4R-0L-4C W**, and ECE 332 Computer Architecture II 4R-0L-4C S**, and ECE 343 High-Speed Digital Design 3R-3L-4C F,S**, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W**, and ECE 320 Linear Control Systems 3R-3L-4C F,W** *For EE: Prereq or concurrent registration in the remainder of course. **For CPE: Prereq or concurrent registration in the remainder of course.
Corequisites: There are no corequisites for this course.
A continuation of a sequence of formal design courses that emphasizes completion of a client-driven project using a formal design process. Student teams carry a project from inception to completion to satisfy the need of a client. Integral laboratory.

ECE 461 Engineering Design II 1R-9L-4C F,W
Prerequisites: ECE 460 Engineering Design I 1R-6L-3C F,W
Corequisites: There are no corequisites for this course.
Continuation of the design project from ECE460. Integral laboratory.

ECE 462 Engineering Design III 1R-3L-2C W,S
Prerequisites: ECE 461 Engineering Design II 1R-9L-4C F,W
Corequisites: There are no corequisites for this course.
Completion of the design project from ECE 460 and ECE 461. Integral laboratory.

ECE 466 Consulting Engineering Seminar 2R-0L-2C
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Discussion problems in the field of consulting engineering; seminars presented by practicing consulting engineers. Cross-listed with BE 400, ME 420, CHE 420, and CE 420.

ECE 470 Power Systems I 3R-3L-4C F
Prerequisites: ECE 370 Power & Energy Systems 3R-1L-4C F,S
Corequisites: There are no corequisites for this course.
Per-unit concepts. Modeling and analysis of synchronous machines. Configuration of transmission and distribution lines. Modeling of power system components. Formulation of power flow equations. Computer solutions of the load-flow problem. Fault-level evaluation by symmetrical components. Principles of grounding. Integral laboratory.

ECE 471 Industrial Power Systems 4R-0L-4C W
Prerequisites: ECE 370 Power & Energy Systems 3R-1L-4C F,S
Corequisites: There are no corequisites for this course.
Design and analysis techniques for low and medium voltage power distribution systems. Harmonics, transients, system coordination, reliability and economics. A design project is carried throughout the course.

ECE 472 Power Systems II 3R-3L-4C S
Prerequisites: ECE 470 Power Systems I 3R-3L-4C F
Corequisites: There are no corequisites for this course.
Power system protection and stability. Design and application of relaying schemes for protection of transformers, buses, distribution lines, transmission lines, generators, motors, capacitors, and reactors. Power system stability and generator rotor dynamics phenomenon with use of the equal-area criterion. Integral laboratory.

ECE 473 Control of Power Systems 3R-3L-4C W
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
Principles of interconnected operation of power systems. Optimum scheduling of generation using economic dispatch and unit commitment. Primary and secondary load-frequency control. Voltage and reactive-power flow control. Principles of state estimation. Integral laboratory.

ECE 480 Introduction to Image Processing 3R-3L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

ECE 481 Electronic Music Synthesis 4R-0L-4C S
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Analog synthesis techniques. Instrument control using MIDI. FM, additive and subtractive synthesis. Physical modeling and sound spatialization. Course project.

ECE 483 DSP System Design 3R-3L-4C F
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Study of finite word length effects in DSP systems. Cascaded filter structures. Coefficient quantization, roundoff noise, scaling for overflow prevention. Discrete-time noise, filtering noise, power spectral density. Polyphase filtering, interpolation and decimation. Implementation and system design and test issues for a SSB communication system. Integral laboratory based on a fixed point programming project.

ECE 497 Special Topics in Electrical Engineering 1-4C
Prerequisites: Arranged prerequisite consent of instructor and department head
Corequisites: There are no corequisites for this course.
Topics of current interest to undergraduate students.

ECE 498 Undergraduate Projects 1-4C
Prerequisites: Arranged prerequisite consent of instructor
Corequisites: There are no corequisites for this course.
Special design or research projects.

ECE 510 Error Correcting Codes 4R-0L-4C F (odd years)
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S* *Graduate standing or with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Coding for reliable digital communication. Topics to be chosen from: Hamming and BCH codes, Reed-Solomon codes, convolutional codes, Viterbi decoding, turbo codes,

and recent developments, depending on interests of class and instructor. Mathematical background will be developed as needed.

ECE 511 Data Communications 4R-0L-4C F (even years)
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S*, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S* or ECE 310 Communication Systems 3R-3L-4C F, S**, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S** *Graduate standing **with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Design of digital communication systems. Autocorrelation function and power spectrum, vector space models of signals and noise, optimal receiver structures and performance, bandlimited channels and equalization, convolutional coding.

ECE 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with BE 516, CHE 505, EP 510, and ME 516.

ECE 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ME 519, EP 511, and CHE 519.

ECE 530 Advanced Microcomputers 3R-3L-4C S
Prerequisites: ECE 331 Embedded System Design 3R-3L-4C W,S* or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S* *Graduate standing; or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
32-bit microcontroller architecture. Software development in both assembly language and C language. Hardware interfacing. Use of a real-time-operating system (RTOS). System-on-a-chip (SOC) hardware/software design using a field programmable gate array (FPGA) chip containing an embedded microcontroller cores. Software debugging tools. Integral laboratory.

ECE 531 Digital Test & Product Engineering 3R-3L-4C S
Prerequisites: ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S*, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W*, and ECE 250 Electronic Device Modeling 3R-3L-4C S,F* *Graduate standing; or with grades of B or better in all three courses; or consent of instructor.
Corequisites: There are no corequisites for this course.

Industrial testing techniques for microcontrollers and other digital integrated circuits. Includes common digital system fault modeling, test generation, and design for testability in addition to memory testing strategies. Integral labs using an industrial grade automatic test environment (ATE).

ECE 534 Advanced Signal & Power Integrity 4R-0L-4C W
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S*, and ECE 342 Introduction to Electromagnetic Compatibility 3R-3L-4C F,S* or ECE 343 High-Speed Digital Design 3R-3L-4C F,S* *Graduate standing; or all courses with a grade of B or better; or ECE342 with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Signal and power integrity modeling and measurement in high-speed digital systems at IC, PCB, and chassis levels. High-frequency behavior of passive components and packages. Behavior and SPICE models of drivers and receivers. Lossy transmission lines and discontinuity characterization. Mixedmode s-parameters and other network parameters. Frequency and time-domain modeling of capacitive and inductive crosstalk. Differential signaling techniques; timing conventions. Synchronization. Signal equalization. Power plane noise and resonance. High-speed PCB design guidelines. Measurement techniques including time-domain reflectometry, vector network analyzer and impedance analyzer. PCB simulation. Full-wave simulations.

ECE 535 Design of Fault-Tolerant Systems 3R-3L-4C S
Prerequisites: CSSE 232 Computer Architecture I 3R-3L-4C F,W or CSSE 232 Computer Architecture I 3R-3L-4C F,W *Graduate standing; or with a grade of B or better; or ECE342 with a grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Methods of designing dependable electronic systems using fault-tolerance techniques. Dependability attributes: reliability, availability, safety, fault modeling. Techniques to evaluate electronic systems' dependability such as reliability block diagrams, Markov processes, FMECA (failure mode effects and critically analysis), and FTA (fault tree analysis). Design and analysis of fault-tolerant systems using hardware or information or time or software redundancy.

ECE 540 Antenna Engineering 3R-3L-4C W
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S* Graduate standing (course not required); *or with a grade of B or better; or consent of instructor.
Corequisites: There are no corequisites for this course.
Electromagnetic radiation, antenna terminology and characteristics, dipole antennas, arrays, aperture antennas, measurements, computer-aided analysis, design projects and reports.

ECE 541 Microwave/Millimeter-Wave Engineering 4R-0L-4C S
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S Graduate standing; or with grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Wave-guiding structures, microwave network analysis, scattering parameters, Z, Y and ABCD parameters, passive devices and components, design, fabrication, simulation and measurement of microwave devices and components, matching strategies, multi-conductor transmission lines and crosstalk.

ECE 542 Advanced Electromagnetics 4R-0L-4C F

Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S and Graduate standing; or with grade of B or better, or consent of instructor
Corequisites: There are no corequisites for this course.
Maxwell’s equations, EM field theorems, potential functions, power and energy, material properties, wave propagation, reflection and transmission, radiation, scattering, Green's functions, metamaterials and metamaterial-inspired structures, modeling & simulation, measurement technique.

ECE 543 Electromagnetic Metamaterials 4R-0L-4C
Prerequisites: ECE 341 Electromagnetic Waves 4R-0L-4C W,S* Graduate standing (course not required) *or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Electromagnetic fundamentals, control of permittivity and permeability, dispersion, causality, double-negative materials, epsilon near-zero materials, transmission line-based metamaterials, composite right/left handed wave-guiding structures, even/odd mode analysis, differential signaling, electromagnetic bandgap structures, phase control, dual band devices, enhanced bandwidth devices, zeroth-order resonators, full wave simulation, device fabrication and laboratory measurement.

ECE 551 Digital Integrated Circuit Design 3R-3L-4C F
Prerequisites: Graduate standing (course not required); or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Design, performance analysis, and physical layout of CMOS logic. Custom and standard cell methodologies. Use of commercial CAD tools. Design issues such as interconnect, timing, and testing methods. Integral laboratory and project.

ECE 552 Analog Integrated Circuit Design 3R-3L-4C W
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W, and ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W Graduate standing; or with a grade of B or better in both courses; or consent of instructor
Corequisites: There are no corequisites for this course.
Design, performance analysis, and physical layout of analog integrated circuits. Focus on operational amplifier design and op-amp circuits. Introduction to mixed-signal circuit design such as switch-capacitors, A/D, or D/A systems. Integral laboratory and design project.

ECE 553 Radio-Frequency Integrated Circuit Design 3R-3L-4C S
Prerequisites: ECE 310 Communication Systems 3R-3L-4C F, S, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing (courses not required); or with a grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Design, analysis, and physical layout of high-frequency analog integrated-circuits for modern RF transceivers. Circuit design for each primary transceiver component. General issues such as impedance matching and design of inductors on integrated circuits. Integral laboratory and design project.

ECE 554 Instrumentation 4R-0L-4C S
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.

Transducers and their applications. Analog signal processing techniques using operational amplifiers. A/D and D/A converters. Protection from electric shock. Measurement of biological potential waveforms (ECG, EMG, EEG, ENG, EOG, ERG). Ultrasound techniques and instrumentation. X-ray CAT techniques. No laboratory, but many in-class demonstrations and emphasis on circuit simulation.

ECE 556 Power Electronics: DC Power Supplies 3R-3L-4C S
Prerequisites: ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of AC-DC and DC-DC converters. Linear, basic switching, charge-pump, and fly-back topologies. Introduction to devices used in a power switching supplies. Thermal management. Integral laboratory.

ECE 557 Analog Test & Product Engineering 3R-3L-4C F
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with a grade of B or better in both courses, or consent of instructor
Corequisites: There are no corequisites for this course.
Fundamental skills necessary to be an industrial integrated circuit test engineer or product engineer. Includes the economics associated with testing, impact of fabrication variation on devices, instrumentation associated with industrial testing, turning a data sheet into a test plan, industrial testing techniques for analog circuits, trade-offs between test time and test accuracy, statistical analysis of the data and statistical process control, the use of device interface boards necessary to control device loading for different tests. Integral labs with an industrial grade automatic tester (ATE).

ECE 558 Mixed-Signal Test & Product Engineering 3R-3L-4C W
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S, and ECE 233 Introduction to Digital Systems 3R-3L-4C F,W, and ECE 351 Analog Electronics 3R-3L-4C F,W Graduate standing; or with grades of B or better in all three courses; or consent of instructor.
Corequisites: There are no corequisites for this course.
Industrial testing techniques for AC and DC tests of mixed-signal integrated circuits using an automatic test environment (ATE). Includes the structure and operation of comparators and standard data converters (DACs, ADCs), common data converter datasheet specifications, impact of data converter design on testing strategies, and statistical analysis of accuracy-time trade-offs. Integral labs using an industrial grade ATE.

ECE 580 Digital Signal Processing 4R-0L-4C W
Prerequisites: ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W, and MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S *Graduate standing (courses not required); or with grade of B or better in both courses; or consent of instructor. MA367 with a grade of B or higher recommended.
Corequisites: There are no corequisites for this course.
Digital filters. Fundamental concepts of digital signal processing. Analysis of discrete-time systems. Sampling and reconstruction. Theory and application of z-transforms. Design of recursive and nonrecursive digital filters. Window functions. Discrete Fourier transforms and FFT algorithm.

ECE 581 Digital Signal Processing Projects 2R-2L-2 or 4C
Prerequisites: ECE 580 Digital Signal Processing 4R-0L-4C W concurrent registration
Corequisites: There are no corequisites for this course.
Computer-aided design of digital filters and other DSP modules. Software and hardware realization using modern DSP chips. DSP chip architectures, C-language programming, and interfacing techniques. Optional advanced project may be done to earn four credit hours; otherwise two credit hours are given. Integral laboratory.

ECE 582 Advanced Image Processing 3R-3L-4C S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S Senior standing or Graduate standing
Corequisites: There are no corequisites for this course.
Introduction to image segmentation and recognition. Use of neural networks, fuzzy logic and morphological methods for feature extraction. Advanced segmentation, detection, recognition and interpretation. Relevant laboratory experiments and required project. Cross-listed with OE 537.

ECE 583 Pattern Recognition 3R-3L-4C S
Prerequisites: with a grade of B or better, or consent of instructor, or graduate standing
Corequisites: There are no corequisites for this course.
Bayesian decision theory, parameter estimation, non-parametric techniques, linear discriminant functions, supervised learning, unsupervised learning and clustering, artificial neural networks, ensemble classifiers.

ECE 584 Medical Imaging Systems 4R-0L-4C
Prerequisites: ECE 300 Continuous-Time Signals Systems 3R-3L-4C F,W,S Graduate standing; or with grade of B or better; or consent of instructor
Corequisites: There are no corequisites for this course.
Engineering principles of major imaging techniques/modalities for biomedical applications and health care including diagnostic x-ray, computed tomography, nuclear techniques, ultrasound, and magnetic resonance imaging. Topics include general characteristics of medical images; physical principles, signal processing to generate an image, and instrumentation of imaging modalities. Clinical applications of these technologies are also discussed. Same as BE541.

ECE 597 Special Topics in Electrical Engineering 4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Special topics of current interest to graduate students and senior undergraduates.

ECE 598 Thesis Research 1-4C
Prerequisites: Arranged
Corequisites: There are no corequisites for this course.
Thesis topic selected in consultation with adviser. Graduate students only.

ECE CPT Curricular Practical Training (CPT) 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment

from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

Last updated: 07/20/2017

Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511

Rose-Hulman Institute of Technology Course Catalog

Engineering Design - Course Descriptions

ENGD 100 Engineering Design Studio I 6R-10L-8C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Integrates rhetorical analysis, research methods, and the conventions of academic writing into the design process. Includes problem definition, analysis, alternate solutions, and specifications of final solutions. Uses sketching, computer-aided drawings, and traditional orthographic drawings to communicate design decisions. Introduces teamwork through group design efforts and instruction. Successful completion of this studio satisfies the requirements of RH131, EM103, and EM104. Students may not receive credit towards graduation for both ENGD100 and RH131, EM103, and EM104.

ENGD 110 Engineering Design Studio II 4R-12L-6C W
Prerequisites: ENGD 100 Engineering Design Studio I 6R-10L-8C F or RH 131 Rhetoric & Composition 4R-OL-4C F, and EM 103 Introduction to Design 1R-3L-2C S, and EM 104 Graphical Communications 1R-2L-2C F
Corequisites: There are no corequisites for this course.
Extends the design process to include the development of software, the use of instrumentation and measurement techniques, and the consideration of scientific research and technological development within cultural, historical, and social contexts and values. Introduces fundamental principles and techniques of programming, including classes, objects, and methods. Surveys types of sensors and basic principles of circuit design (including Ohm’s Law, Kirchoff’s Laws). Supplies context in ideas about technical progress and scientific facts, the role of design in social institutions, and issues of gender facing technical professionals and knowledge domains.

ENGD 120 Engineering Design Studio III 4R-12L-6C S
Prerequisites: ENGD 110 Engineering Design Studio II 4R-12L-6C W
Corequisites: There are no corequisites for this course.
Continues the design process with software development, instrumentation and measurement techniques, and cultural, historical, and social contexts and values surrounding scientific and technological development work. Adds more advanced programming concepts (implicit loops and conditionals) and tasks of software development (such as development of user interfaces). Includes use of electronic components (op amps, capacitors, inductors) and signal processing (amplifiers and filters). Social contexts for analysis of technology and its history include gender and work, with particular attention to the social implications of biotechnology. Students may not receive credit towards graduation for both ENGD120 and CSSE120, BE201, or IA239. Successful completion of ENGD110 and ENGD120 satisfies the requirements of an Engineering Topics elective (4 hr. elective), CSSE120, and IA239.

ENGD200 Systems Accounting and Modeling I 2R-0L-2C W
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W or MA 101 Introduction to Engineering Mathematics 4R-1L-4C F
Corequisites: There are no corequisites for this course.

Covers systems accounting and modeling approach to engineering science, conservation of mass, linear and angular momentum. 2D and 3D vectors will be introduced and reinforced with examples.

ENGD 210 Systems Accounting and Modeling II 4R-0L-4C S
Prerequisites: ENGD200 Systems Accounting and Modeling I 2R-0L-2C W or EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S equivalent
Corequisites: There are no corequisites for this course.
A common framework for engineering analysis is extended using the concepts of a system, accounting and conservation of extensive properties, constitutive relations, constraints, and modeling assumptions. Stress, strain, and deformation under axial loading are defined. Equilibrium is defined. Conservation equations for mass, charge, momentum and energy, and an entropy accounting equation are developed. Applications are developed from multiple engineering disciplines. Students may not receive credit towards graduation for both ENGD210 and ES201.

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Rose-Hulman
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Professors Andrijcic, Downing, Evans, James, Kline and Schumacher

Engineering Management - Course Descriptions

EMGT 100 Introduction to Entrepreneurship 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course provides an overview of the principles of entrepreneurship and becoming an entrepreneur in today's society. Topics include opportunity identification, market investigation, product development, developing marketing and business plans, and understanding business, financial, and legal matters related to venture creation. Concepts from the lean startup and canvas tools will be applied.

EMGT 152 Economic Thinking for Entrepreneurs 1R-0L-1C
Prerequisites: There are no prerequisites for this course.
Corequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S or consent of instructor
During this course students discuss the economic implications of entrepreneurial actions.

EMGT 330 Introduction to Engineering Management 4R-0L-4C Undergraduate Only
Prerequisites: Junior standing
Corequisites: There are no corequisites for this course.
Surveys issues important to the management of engineering activities and technological organizations. Topics include such things as the relationship of engineering and technology to management disciplines, the functions of a technical manager, principles and techniques for quality processes, project management, process management, logistics, legal issues, ethics, human resources, communication and organizational behavior.

EMGT 335 Design and Value Creation 4R-0L-4C
Prerequisites: Junior standing
Corequisites: There are no corequisites for this course.
This new course examines the design process in a unique multidisciplinary, entrepreneurial way focused on performing design in a market/social context and creating value for the stakeholders involved. Course concepts are applied to examining case examples and to developing new designs and systems. Grand Challenges themes will serve as the focus of the class for many of the design examples and student selected project topics. The NAE Grand Challenges identify fourteen major challenges facing the world including energy, health, sustainability, and security.

EMGT 427 Project Management 4R-0L-4C Undergraduate Only
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Presents the major issues and techniques of project management. Topics include: project evaluation and selection, scope management, team building, stakeholder management, risk assessment, scheduling, task partitioning & communication, rework, and negotiation. Provides application experiences with these concepts through

case analyses. Emphasizes typical problems and issues related to project management choices

EMGT 461 Multidisciplinary, Entrepreneurial Design I: Capture the Vision 3R-XL-4C
Prerequisites: Junior, Senior, or consent of instructor
Corequisites: There are no corequisites for this course.
Explores design processes characterized by interdisciplinary activity and focus on commercial success. Includes basic design processes with emphasis on data collection and specification, with special attention to the voice of the customer. Develops at least three creativity techniques and identifies sources of ideas for successful innovation. Demonstrates procedures for assessing markets and establishing conceptual business models and describes the fundamentals of project planning and management. Addresses aspects of professional practice -- -- ethics, communication, contemporary issues, social impacts, global context and team work in the design process. Uses a team project on reverse engineering to tie together course objectives, and identifies an entrepreneurial or appropriate externally sponsored project topic for later courses. Prerequisite: Junior standing or consent of instructor. (Students completing MG 461 may not receive credit for ME 470.)

EMGT 462 Multidisciplinary, Entrepreneurial Design II: Expand the Concept 2R-XL-XC
Prerequisites: EMGT 461 Multidisciplinary, Entrepreneurial Design I: Capture the Vision 3R-XL-4C or consent of instructor
Corequisites: There are no corequisites for this course.
Expands on the basic design process issues such as solution identification and selection and the assessment of trade-offs and impacts on health, safety, quality, environment, sustainability, and manufacturability. Applies design disciplines to a specific project by using creativity techniques, identifying sustainable competitive advantages and appropriate intellectual property protection procedures. Uses project planning methods to estimate project size and assess risks, as well as other techniques to facilitate rapid product development. Provides experiences in communication, project retrospectives and design reviews. Completes the early stages of a team selected and conducted project in entrepreneurial design that has the approval of students' home department. Prerequisite: EMGT461 or consent of instructor.

EMGT 463 Multidisciplinary, Entrepreneurial Design III: Deliver the Product 2R-XL-XC
Prerequisites: EMGT 462 Multidisciplinary, Entrepreneurial Design II: Expand the Concept 2R-XL-XC or consent of instructor
Corequisites: There are no corequisites for this course.
Further examines and applies design process disciplines, including techniques such as system modeling, optimization, statistical analysis, design of experiments, FMEA (Failure Modes and Effects Analysis), robust design, simulation and process improvement. Describes key business concepts needed for a business plan and applies them to the team projects. Uses professional project approaches such as metrics, retrospectives, design reviews and proper documentation. Emphasizes team project work with home department approval of specific discipline related design activities and with practical applications of concepts in the realization of functional prototypes or systems. Concludes with written and oral presentations of team project reports.

EMGT 486 Introduction to Supply Chain Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces and discusses traditional operations within supply chains including changes due to evolving technologies and globalization. Demonstrates relationships between suppliers, customers, and competitors and how they affect the entire manner in which organizations can efficiently globally integrate and optimize their manufacturing and business operations. Cross-listed with EMGT 586.

EMGT 497 Special Topics in Engineering Management (1-4)R-0L-(1-4)C
Prerequisites: May require consent of instructor or specific prerequisites.
Corequisites: There are no corequisites for this course.
Examines particular engineering management topics of current interest and/or new courses for engineering management and other students. May require consent of instructor or specific prerequisites.

EMGT 511 Graduate Seminar I 1R-0L-1C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 512 Graduate Seminar II 1R-0L-1C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 513 Graduate Seminar III 1R-0L-1C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 514 Graduate Seminar IV 1R-0L-1C Summer
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected topics relevant to Engineering management are discussed by graduate students, faculty, and guest speakers.

EMGT 520 Accounting for Technical Managers 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
An introduction to accounting principles and practices as related to financial and managerial accounting. The uses of accounting information and the means by which pertinent accounting data are gathered and analyzed for internal purposes and management decisions.

EMGT 521 Financial Management in a Technical Environment 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

A comprehensive survey of financial concepts, techniques, instruments, and procedures which are related to the financial structure, assets management, dividend policy, and the capital budgeting decisions of a firm. Basic skills in financial analysis are developed. Operations of domestic and international financial markets are covered.

EMGT 522 Leadership & Organizational Culture 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course reviews the management literatures on leadership and organizational culture. It explores that interaction and the range of differences found in practice. Additional topics include: Organizational Change, Vision & Strategy, Business Ethics, and Senge’s Learning Organization. Course activities include the ‘Winning At Design Automation’ simulation that demonstrates cultural issues surrounding rapid growth in a high-tech, high-commitment company, and The Ethics Challenge game. Students select a company as the topic of their term paper, describing its culture (Schein’s approach) and a plan to promote change (Conger’s Charismatic Leadership). Students make a ‘call to action’ speech to convey their leadership plan.

EMGT 523 Marketing in New Product Development 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course explores marketing concepts and marketing strategy within the context of new product development. Topics addressed include: market research methods, market segmentation, product positioning (4 Ps), pricing strategies, alliances, elasticity, advertising & brands, and the champion role. Student projects define a new product idea, apply course concepts to the development of that idea (segmentation, pricing, etc.) and present their analysis to the class. The course includes the ‘NPDChallenge’simulation that demonstrates marketing issues an entrepreneur faces in developing a new product.

EMGT 524 Production/Operations Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
To provide an introduction to operations management for the technical manager including contemporary management principles and technical methods. Key focus topics include development of strategy in operations activities and the use of a business simulation exercise and project to illustrate class concepts.

EMGT 525 Human Resources Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines Human Resource Management for engineers who may or may not have direct reports (subordinates). Key focus topics include systematic changes that influence employees' behavior, attitudes, and performance throughout the employment lifecycle. Furthermore, we explore value-added HRM practices related to analyzing/designing work, recruiting and selection, training and development, evaluating performance, and the creation of positive employee relations in today's workplace.

EMGT 526 Innovation Management & Forecasting 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

This course introduces the concepts of innovation types (radical, incremental, disruptive, open), invention, and diffusion to identify patterns of technology change. Technology management strategies are suggested by an even blend of theory and case analysis. The course explores the impact of innovation on society, including long term trends in productivity, energy, and information technologies. Techniques used in technology forecasting (monitoring, growth curves, scenarios, analogy, Delphi, roadmapping, and simulation) are described & example forecasts are examined.

EMGT 527 Project Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course presents the major issues and techniques of project management. Topics include: project evaluation and selection, scope management, team building, stakeholder management, risk assessment, estimating, scheduling, Mythical Man Month, Critical Path & Critical Chain, task partitioning & communication, rework, and negotiation. Students apply these concepts in writing case analyses. Typical problems and success factors are discussed in relation to project management choices. Special issues encountered in virtual teams are discussed.

EMGT 529 Organizational Behavior 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course will introduce students to principles and theories related to management and organizational behavior. The goal is to transfer or develop knowledge and skills for high performance in a complex technical business environment requiring engineers to make and communicate sound decisions, and react appropriately to unanticipated events. The concepts and techniques for maximizing the effectiveness of engineers in the achievement of organizational and project goals are also emphasized. Topics include power, teaming, motivation, selection, and development while understanding individual characteristics, attitudes, and behaviors. Additionally, we will examine how the use of Emotional Intelligence (EI) will be useful to the advancement of organizations that are culturally diverse.

EMGT 531 Economics for Technical Managers 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Applies economic analysis to the solutions of business problems. Emphasizes the economics of market and organizational structure, demand determinates, cost analysis, investment and strategy decisions, agency problems and ethics. Special reference is made to technology based organizations.

EMGT 532 Technical Entrepreneurship 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the principles and tools for innovation and entrepreneurship in technologically based businesses. Includes perspectives for both independent entrepreneurs and intrapreneurs. Develops basic concepts of business planning. Emphasizes a major group business plan based upon a technological innovation. May be used as a management core class.

EMGT 533 Intercultural Communication 4R-0L-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course presents the Constructivist theory of communication and its application. The culture concept is applied at ethnic (~70%) organizational and interpersonal levels. The course balances theory and application and students write analysis of videos to apply course concepts. Students use Spradley's Ethnoscience approach to conduct interviews and write an ethnography for their term paper. The course helps students to better: develop interpersonal relations, improve their interviewing skills, analyze cultures, and understand diversity across ethnic & gender differences. Concepts include: Culture Shock, Empathy, The Social Construction of Reality, Non-Verbal Communication, High & Low Context cultures, M-time & P-time cultures.

EMGT 534 Management Science 4R-OL-4C F

Prerequisites: Senior or graduate standing
Corequisites: There are no corequisites for this course.
A study of the development and analysis of various mathematical models useful in managerial decision-making. This includes discussions of what models are, how to create them, how they are used, and what insights they provide. Spreadsheets will be used to do much of the computational work. Topics considered include linear, integer, and nonlinear programming, network models, inventory management, project management, and simulation models. Examples from all areas of business and industry will be investigated. We will also investigate how companies are using these techniques to solve current problems. Same as MA 534.

EMGT 535 Strategy and Globalization 4R-0L-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course samples the strategy literature and distinguishes economic and managerial (resource-based view) perspectives. Strategy issues encountered in transnational management are addressed in cases. Scenario planning is described. Trends and implications of globalization are explored (off-shoring, 'rise of the rest', resource use & climate change, BOP, Business Model change) and the 'great recession' is discussed from a long-wave perspective. Strategy implementation issues are addressed. Students develop strategies for an organization of their choice and evaluate those strategies using the 'Scenariosto-Strategies' approach in their term paper.

EMGT 536 Leadership and Global Challenges 4R-0L-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course examines the art of leadership and its development in our increasingly globalized society. In this course students will apply their general education and use their knowledge, experience, and perspectives learned in a variety of disciplines to investigate the nature and dynamics of leadership. Examining general theoretical approaches, with close attention to the unique challenges which globalization and cross-cultural interactions impose upon leaders, the class will work on three case studies. The first case study focuses on an individual in order to illustrate leadership development. The second will focus on a corporation in order to illustrate mutual influence of leaders, constituents, and organizations. The third will be about an event or a situation which exemplifies the challenges and creativity of leadership in global/transnational/multicultural operations.

EMGT 537 Facilities Management 4R-0L-4C
Prerequisites: SR or GR Class standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course provides comprehensive analysis of the major issues in facilities management and planning of production and service facilities. The course emphasizes the use of quantitative and qualitative analysis in the design process. Topics include facility location, plant layout, space requirements, materials handling, personal requirements, system flow analysis, facility design, design algorithms, and distribution systems.

EMGT 538 Product Realization 4R-0L-4C
Prerequisites: SR or GR Class standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on new product realization process. It provides fundamental methods and complimentary strategies for product realization. The major focus is on product development teams, idea and concept generation, concept evaluation and selection, customer needs, product function and architecture, design for manufacture and assembly, design for environment and safety, prototyping, product development, product evaluation for cost and performance, and product launch and support.

EMGT 540 Fundamentals of Engineering Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys issues important to the management of engineering activities and technological organizations. Topics include such things as the relationship of engineering and technology to management disciplines, the functions of a technical manager, principles and techniques for quality processes, project management, process management, logistics, legal issues, ethics, human resources, communication and organizational behavior. Case studies, projects and role playing activities demonstrate the importance of the concepts.

EMGT 545 Quality Methods 4R-0L-4C
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S, MA 382 Introduction to Statistics with Probability 4R-0L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to various aspects of quality control and statistical process control (SPC) to include the following topics: history of quality control, Deming and his management philosophies, review and development of statistical tools and probability methods associated with quality control and SPC, development and application of control charts for continuous and discrete data, time-weighted control charts, identification of common cause variation in a process, identification and removal of special cause variation in a process, data transformations and distribution modeling, rational subgrouping, process capability analysis, and the use of statistical software for data analysis and SPC. The use of real-world data in exercises will be emphasized. Other topics to be included as time allows: Six Sigma methodology and language, general measurement system analysis, gage repeatability and reproducibility.

EMGT 546 Statistical Methods in Six Sigma 4R-0L-4C
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S, MA 382 Introduction to Statistics with Probability 4R-0L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.

A course on statistical methods used in the Six Sigma to include the following topics: the history of Six Sigma, certification and belts, the Define-Measure-Analyze-Improve-Control (DMAIC) methodology, review of statistical tools associated Six Sigma (e.g., the “Magnificent Seven,” inference, graphics), project selection tools (e.g., Voice of Customer, Affinity Diagram, Critical to Quality Diagram), Define phase tools (e.g., Spaghetti Diagram, Kano Model, Root Cause Analysis, Cause and Effect Diagram), computation of Sigma Levels and Defects per Million, Measure phase tools (e.g., Gage Repeatability and Reproducibility, Attribute Agreement Analysis, descriptive and inferential statistics), Analyze phase tools (e.g., Cause and Effect Matrix, Failure Modes and Effects Analysis, Design of Experiments), Improve phase tools (e.g., practical applications to improve a real-world process), Control phase tools (e.g., control charts, capability analysis), cost of poor quality, and the use of statistical software for data analysis. The use of real-world data in exercises will be emphasized. Other topics to be included as time allows: lean methodologies, team formations, Taguchi’s loss function, regression, process tampering.

EMGT 547 Six Sigma in Practice 4R-0L-4C
Prerequisites: EMGT 546 Statistical Methods in Six Sigma 4R-0L-4C F, MA 387 Statistical Methods in Six Sigma 4R-0L-4C F or experience in Six Sigma through an internship or co-op with consent of instructor.
Corequisites: There are no corequisites for this course.
This course is devoted to selecting and completing a real-world Six Sigma Green or Black Belt project either on-campus or in the community. It assumes knowledge of the statistical and managerial methods in Six Sigma and the DMAIC process, including those in the EMGT546 course description (e.g., CTQ Diagram, Gage R&R, FMEA).

EMGT 551 Intellectual Property for Engineers and Scientists 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the influence intellectual property law has on the professional practice of engineers, scientists and engineering managers. Topics to be considered include: extracting value from intellectual property; patentable subject matter; novelty and loss of right; non-obviousness requirement; utility requirement; patent prosecution; patent litigation; designing around valid US patents; international patent rights; copyrights; trade secrets; and trademarks.

EMGT 552 Business Law for Technical Managers 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the legal issues that will likely arise during a lifetime of employment at the management level. Topics to be considered include: business ethics; dispute resolution; intentional torts; negligence and strict liability; criminal law and procedure; contracts, sales, warranties, and products liability; negotiable instruments; bankruptcy; employment law; labor law; business organizations; consumer law; and real property law.

EMGT 561 Failures of Engineered Systems 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Reviews past failures of engineered systems in order to improve an engineering manager's ability to anticipate, prevent, and respond to failures. The technical, human

factor, and organizational root causes of the failures of engineered systems are examined. Case studies are used to illustrate the techniques that have been developed to analyze, investigate and prevent failures. Additionally, regulatory and legal responses to failures are also explored.

EMGT 562 Risk Analysis and Management 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course will introduce students to principles and methods of risk analysis and risk management, as related to diverse engineering and socio-technical systems. Students will learn how to: identify, prioritize and quantify risks; perform qualitative and quantitative risk assessments and develop risk models; assess uncertainty; identify, evaluate, and prioritize risk management alternatives; and communicate risk to stakeholders. Through the use of varied example problems and case studies, students will develop an understanding of the appropriate use of risk analysis and management methods for engineering and policy decision making under uncertainty.

EMGT 564 Systems Architecture 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This class will introduce students to the art and science of systems architecting, where systems architecting refers to uncovering the fundamental structure of a system (functional, physical, logical, operational) defined in terms of system's elements, interfaces, processes, constraints, and behaviors that must operate under specific requirements and constraints. Focus will be placed on investigating the broader meaning of architectures, as they relate to organizations and businesses, in addition to engineered systems and products. Students will be introduced to heuristic and model-based approaches for systems architecting. Through case-studies and example problems in areas of production and manufacturing systems, intelligent transportation systems, social systems, and others, students will be able to apply the principles, processes and tools of systems architecting in order to structure and support the system development process of a balanced, well-integrated and socially and financially acceptable system.

EMGT 567 Economic Analysis of Engineering Projects 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This class will introduce students to critical principles of economic analysis of engineering projects. In particular, students will explore the process of making economic decisions under the influence of possibly uncertain future conditions and events. These economic decisions might involve investing in new facilities, improving existing production processes, or developing and marketing new products or services in the private and public sectors. Deterministic and multi-attribute evaluation approaches will be discussed. Students will be introduced to methodologies including capital budgeting, cost estimating, various alternative comparison methods, and life cycle costing. Additionally, students will be introduced to the concept of welfare economics through which they will explore economic impacts of infrastructure projects in the public sector. Emphasis will be placed on systems thinking and a systems approach to defining and solving economic problems.

EMGT 570 Lean Six Sigma 4R-0L-4C

Prerequisites: SR or GR Class standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course focuses on the current lean six sigma engineering and technology techniques, principles, and philosophies relevant to manufacturing and service sectors. The course content emphasizes the DMAIC (Define, Measure, Analyze, Improve and Control) methodology in combined with the Lean techniques and practices through analytical and quantitative tools. Students will practice lean six sigma tools and methods by applying the DMAIC framework on practical problems in order to improve processes, increase efficiency, reduce or eliminate wastes and variation, and/or save money.

EMGT 571 Operations Research for Technical Managers 4R-0L-4C
Prerequisites: SR or GR Class standing or consent of instructor
Corequisites: There are no corequisites for this course.
This is a general operations research course structured for technical managers. It covers the application of scientific methods to business management, providing a quantitative basis for complex decisions. The focus is on complementary concepts and methods of decision and risk Analysis, inventory models, stochastic models, queuing systems, simulation modeling, and solving practical operations research problems using linear, non-linear, and integer models.

EMGT 572 Reliability Engineering 4R-0L-4C
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
A course that introduces probabilistic models and statistical methods used in the analysis of reliability problems. Topics include: a general review of necessary topics from probability and statistics, the definition of reliability in an engineering setting, reliability's history and development, case studies that identify reliability as an essential field of study in today's world, exploration of the common distributions used to model failure and survival times, as well as hazard rates, the determination of lifetime characteristics of a product using graphical and quantitative methods, estimation of parameters for lifetime models, examination of the types of data, censored and uncensored, commonly found in reliability studies, the practice of fitting appropriate models to data, assessing the fit and adequacy of a model with parameter estimates to reliability data, and the use of Minitab to aid in the investigation of parameter estimation and model adequacy for reliability data.

EMGT 581 Multi-objective Optimization 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course will consider how humans make optimal decisions in an uncertain environment, when they have to simultaneously satisfy multiple objectives/goals under limited resources. Specifically we will consider: how to structure multi-objective problems, different methods and theories of quantifying preferences over multiple objectives a priori or a posteriori, multi-objective optimization methods without preference specification, multi-attribute utility theory, value trade-offs, risk attitudes, and other topics like fuzzy methods. We will also consider the applications of these theories and methods to various problems, including managerial and operational business issues, public policy issues, development of new businesses, etc.

EMGT 584 Systems Thinking and Evaluation 4R-0L-4C

Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
This course will focus on applying systems thinking and methodologies, as well as parametric and nonparametric statistical methods to evaluate alternative system designs and design performance measures. Students will learn how to: identify and evaluate system goals, requirements and performance measures; design experiments to assess system performance; apply decision analysis techniques to diverse trade studies; and generate a business case for presenting technical analysis results.

EMGT 585 Statistics for Technical Managers 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines basic statistics and probability while focusing on concepts most relevant to becoming an effective Engineering Manager. Students will learn to collect and analyze data to make statistically sound managerial decisions. Discussions related to descriptive statistics, hypothesis testing, confidence intervals, power calculations, correlation, linear/multiple regression, and analysis of variance (ANOVA). Students will complete a graduate-level project utilizing course concepts.

EMGT 586 Supply Chain Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines disruptions to traditional operations within supply chains due to changes in both technology and globalization. Shows how relationships between suppliers, customers, and competitors have changed dramatically to affect the entire manner in which organizations perform their manufacturing and business operations. Describes product supply chain complexity and the implications of expanding global customer bases, increasing supplier dependence, and larger ranges of locations and customers. Outcomes include the abilities to identify and define the critical components of supply chains, apply best practices in the buyer-seller relationship and understand why managing a supply chain is an important strategic capability for an organization. Cross-listed with EMGT 486.

EMGT 587 Systems Engineering 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces system engineering and analysis techniques, including the systems life cycle, system design procedures, risk analysis, analysis methods including reliability and maintainability. Provides applications for mechanical, electrical and a wide variety of other systems. Uses Visio or CORE software to create IDEFO drawings and other documentation for system design.

EMGT 588 Quality Management 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduction to quality for the technical manager including management principles and technical methods. Balance will be approximately 65% technical methods and 35% management concepts. Management topics focus on the concept of total quality (TQ) as it applies to technology based businesses including design, manufacturing and service activities. Contemporary quality philosophies are reviewed including Deming and Taguchi. Technical tools and methods are presented including basic statistical

concepts, control charts for variable and attributes, process capability studies, six sigma, and tools for design and process improvement. Case studies and class labs will be used to highlight key topics.

EMGT 589 Manufacturing Systems 4R-0L-4C
Prerequisites: Senior standing or consent of instructor
Corequisites: There are no corequisites for this course.
Provides a comprehensive introduction to manufacturing systems covering the behavior laws at work in batch production or assembly lines. Includes production strategy, scheduling, and control methods and detailed analysis of fundamental manufacturing measures such as cycle time, throughput, capacity, work-in-process, inventory, and variability. Explores historical practices and the natural behaviors that are described in laws for manufacturing that help managers understand basic factory physics.

EMGT 590 Integrated Project as assigned; however, not more than 8 credits can be applied to MS degree requirements
Prerequisites: Completion of technical component and business core or permission of instructor
Corequisites: There are no corequisites for this course.
The integration of business and technical considerations in new product development. The identification of managerial and engineering challenges faced in developing a commercially viable new product within the context of a rapidly changing and highly competitive business environment. Readings, case studies and individual projects dealing with strategic planning, entrepreneurship, new product development, and related topics. The focus is on a major team project. This integrated project must include the identification of a new product including all relevant business and technical issues and the development of a detailed plan for profitably bringing this new product to market. A final report with oral presentations is required.

EMGT 597 Special Management Topics in Engineering Management (1-4)R-0L-(1-4)C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines particular management topics of current interest and/or new courses for engineering management and other graduate students and upper level undergraduates. May require consent of instructor or specific prerequisites.

EMGT 598 Special Technical Topics in Engineering Management (1-4)R-0L-(1-4)C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines particular technical topics of current interest and/or new courses for engineering management and other graduate students and upper level undergraduates. May require consent of instructor or specific prerequisites.

EMGT CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of Department Head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment

from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

EMGT ESC Escalate Program Participant 0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Students participating in the Escalate entrepreneurship program will be enrolled in this zero credit section each quarter. The course will be graded S or U. A grade of S will be given for completing the required Escalate courses, attending required professional development activities, and completing required project activities. Only students in the Escalate cohort may enroll in this section.

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Engineering Mechanics - Course Descriptions

EM 102 Graphical Communications for Civil Engineers 1R-2L-2C S
Prerequisites: CE major only or consent of instructor
Corequisites: There are no corequisites for this course.
Introduces the basic techniques used in engineering and scientific communication. Topics will include sketching of pictorials, computer-aided drawing, orthographic drawings, auxiliary views, reading engineering drawings and using electronic forms of communication. Focus on civil engineering applications.

EM 103 Introduction to Design 1R-3L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the engineering design process including problem definition, analysis, alternate solutions, specifications of final solution, and techniques of oral and written communications. Stresses the importance of teamwork through group design efforts.

EM 104 Graphical Communications 1R-2L-2C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the basic techniques used in engineering and scientific communication. Topics will include sketching of pictorials, computer-aided drawing, orthographic drawings, auxiliary views, reading engineering drawings and using electronic forms of communication.

EM 120 Engineering Statics 4R-0L-4C F, S
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W
Corequisites: There are no corequisites for this course.
Covers two- and three-dimensional force systems, equilibrium, structures, distributed forces, shear and bending moment diagrams, friction, and area moments of inertia. Emphasizes free-body diagrams.

EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W
Corequisites: There are no corequisites for this course.
Covers two- and three-dimensional force systems, equilibrium, structures, distributed forces, and strength and elastic deflection of engineering materials due to loads applied axially. Emphasizes free-body diagrams.

EM 202 Dynamics 4R-0L-4C S
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S, and EM 120 Engineering Statics 4R-0L-4C F, S or PH 111 Physics I 3.5R-1.5L-4C F,W
Corequisites: There are no corequisites for this course.
Kinematics and kinetics of particles in space and rigid bodies in plane motion. Applications of the principles of Newton's laws, work-energy, impulse-momentum, and conservation laws to solutions of simple two-dimensional dynamics problems.

EM 203 Mechanics of Materials 4R-0L-4C W
Prerequisites: EM 120 Engineering Statics 4R-0L-4C F, S

Corequisites: There are no corequisites for this course.
Strength and elastic deflection of engineering materials due to loads applied axially, in torsion, in bending, and in shear. Combined stresses and principal stresses. Applications to design of beams and shafts.

EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Prerequisites: EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S
Corequisites: There are no corequisites for this course.
Strength and elastic deflection of engineering materials due to loads applied in torsion, in bending, and in shear. Shear diagrams, bending moment diagrams, and area moments of inertia. Combined stresses and principal stresses. Applications to design of beams and shafts.

EM 301 Fluid Mechanics 4R-0L-4C S
Prerequisites: EM 202 Dynamics 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Covers fluid properties, fluid statics, fluid dynamics, including pipe flow, and turbomachinery. Stresses the control volume approach, Eulerian description of flow, and conservation principles (mass, momentum, and energy).

EM 402 Three-Dimensional Dynamics 4R-0L-4C F
Prerequisites: ES 204 Mechanical Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduces the kinematics and dynamics of particles and rigid bodies undergoing three-dimensional motion. Topics include the application of linear and angular momenta conservation, energy, Euler angles and other representations of a rotation, and numerical simulation of equations of motion. Additional topics may be added as needed.

EM 403 Advanced Mechanics of Materials 4R-0L-4C S
Prerequisites: EM 203 Mechanics of Materials 4R-0L-4C W or EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Covers advanced topics in mechanics of deformable bodies and theories of failure. Introduces the theory of elasticity.

EM 406 Vibration Analysis 4R-0L-4C F
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Dynamic analysis of vibrating mechanical systems. Includes studies of single- and multiple-degrees-of-freedom, damped and undamped systems in both free and forced motion. Applications to vibration isolation and absorption, design of vibration measurement instrumentation, rotating unbalance, and torsional vibration of rotors.

EM 493 Selected Topics in Engineering & Technology As assigned
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics arranged by instructor.

EM 501 Topics in Fluid Mechanics Arranged
Prerequisites: ME 401 Foundations of Fluid Mechanics 3R-3L-4C S,F or consent of instructor
Corequisites: There are no corequisites for this course.

Course may be repeated for different topics in fluid mechanics.

EM 502 Advanced Dynamics 4R-0L-4C
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Kinematics and dynamics of particles and rigid bodies in two- and three-dimensional motion. Includes Lagrangian and Hamiltonian formulation of equations of motion. Applications to conservative, nonconservative, holonomic and non-holonomic systems.

EM 503 Advanced Vibration Analysis 4R-0L-4C W
Prerequisites: EM 406 Vibration Analysis 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Dynamic analysis of multiple-degree-of-freedom lumped parameter vibrating systems as well as continuous systems. Lagrange's equations of motion. Applications include numerical methods and matrix formulation. Introduction to nonlinear and random vibration analysis. Methods of Rayleigh and Rayleigh-Ritz.

EM 505 Theory of Elasticity 4R-0L-4C
Prerequisites: EM 203 Mechanics of Materials 4R-0L-4C W or EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Introduces the classical formulation of problems in elasticity. Emphasizes the derivation and the applications of the basic constitutive equations of elasticity such as strain-displacement, equilibrium, compatibility, and stress-strain. Covers St. Venant's problems, energy principles, and variational methods.

EM 508 Energy Methods in Engineering Mechanics 4R-0L-4C
Prerequisites: EM 403 Advanced Mechanics of Materials 4R-0L-4C S, and MA 330 Vector Calculus 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
General concepts and principles in mechanics, conservative mechanical systems, and variational methods. Applications to deformable bodies.

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Professors Bunch, Ditteon, Duree, Granieri, Joenathan, E. Kirkpatrick, S. Kirkpatrick, Kirtley, Leisher,Letfullin, Liptak, McInerney, Moloney, Siahmakoun, Syed, and Wagner.

NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

EP Electives:
Courses from any science or engineering department which are of relevant level to the area concentration. If not in the area concentration, courses should be 300 level or above. It is recommended that students take a sequence of classes from the area concentration. This will fulfill engineering science elective in their engineering curriculum.

Engineering Physics - Course Descriptions

EP 180 Engineering at Nanoscale 2R-0L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduction to nanoscience and engineering: properties and behavior of materials, devices, and systems (natural and artificial) at nanoscale, applications of nanoscience. Characterization techniques: Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM), and thin film measurements. Basic cleanroom safety and experience, microfabrication processing techniques: photolithography, thin film deposition. Intro to design and data analysis software.

EP 280 Introduction to Nano-engineering 3.5R-1.5L-4C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Scaling laws in small systems; electronics and photonics devices and systems, basics of quantum and statistical mechanics, nanomaterials and fabrication: examples of zero, one, two, and three dimensional nanostructures, carbon nanotubes, Nanoelectronics: basics of solid state physics; electron energy band, semiconductors, tunneling and quantum structures, molecular electronics, Nanophotonics in metals and semiconductors, surface plasmon resonance and applications, photonic bandgap crystals.

EP 290 Directed Study 1-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for freshmen and sophomore students under the direction of a physics or optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

EP 330 Material Failure 3R-3L-4C W
Prerequisites: PH 112 Physics II 3.5R-1.5L-4C W,S,F
Corequisites: There are no corequisites for this course.
Principles of material failure; appearance, physical cause and mathematical description with emphasis on the materials used for micro-scale devices and assemblies. Failure types considered include Rupture, Fatigue, Creep, Corrosion, Electromigration,

Electrical Overstress, Electrical Discharge and Thermal. Experiments illustrate the failure type and the machines used to study them. These include Electron, Optical and X-ray microscopes, Spectroscopy and Tension machines. A brief description of the working of each machine will be given.

EP 380 Nanotechnology, Entrepreneurship & Ethics 3.5R-1.5L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Scaling laws in small systems; mechanical, biological, fluidics, and thermal systems. Nanomaterials and nanofabrication. Nanomechanics: cantilever oscillation, atomic-force microscopy (AFM) and its applications, nano-biotechnology, machinery of cell, and molecular motors. Nanoscale optics, Nanoscale heat: conduction, convection, and blackbody radiation. Basics of fluidics, nanoscale fluidics and applications, entrepreneurship and ethics, concepts and tools in innovation and social impacts of nanotechnology.

EP 406 Semiconductor Devices & Fabrication 3R-3L-4C W
Prerequisites: PH 405 Semiconductor Materials & Applications 3R-3L-4C F or ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Physical properties and applications of semiconductor devices including bipolar junction transistors (BJT), metal-semiconductor contacts (Schottky and ohmic), junction field effect transistors (JFET and MESFET), metal-oxidesemiconductor (MOS) interfaces and field effect transistors (MOSFET and CMOS), photoconductors, photodetectors (PIN and APD), solar cells, light emitting diodes (LED), and laser diodes. Laboratory experiments will cover the following topics: characterization of semiconductor devices, op-amps, CMOS, NAND and other logic and analog components. Cross-listed with EP 506.

EP 407 Semiconductor Fabrication & Characterization 2R-6L-4C F
Prerequisites: PH 405 Semiconductor Materials & Applications 3R-3L-4C F or Junior or Senior standing & consent of instructor
Corequisites: There are no corequisites for this course.
Fabrication and characterization of micro/nanoelectronic devices; Semiconductor devices; Oxidation, ion implantation, etching, deposition, lithography, and back-end processing; Process integration of various technologies, including CMOS, double poly bipolar junction transistor, and GaAs MESFET. Process and device simulators illustrate concepts introduced in class. Modern tools/techniques for both bulk- and thin-film characterization; Laboratory is an integral component of this class. Students work in teams to fabricate a multi-junction semiconductor device, using various techniques which include photolithography, diffusion, oxidation, and etching. In-process measurement results are compared with final electrical test results. Circuits are used to carry out performance evaluation.

EP 408 Microsensors and Actuators 3R-3L-4C S
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S Junior or Senior standing, and consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to solid state materials and conventional silicon processing. Measurement of signals from resistance- and capacitance-based transducers; sensor characteristics,

calibration and reliability. Examples of microsensors: thermal, radiation, mechanical, chemical, optical fibers, and biological. Cross-listed with EP 508.

EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers, wafer-level processes, vacuum systems, thin-film deposition via PVD, dry and wet etching, photolithography, surface and bulk micromachining, process integration, MEMS applications: heat actuators, capacitive accelerometer, DLP, bio-sensor, and pressure sensor. Cross-listed with ME 416, ECE 416, and CHE405.

EP 411 Advanced topics in MEMS 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent course
Corequisites: There are no corequisites for this course.
Topics such as: Microlithography, design process, modeling; analytical and numerical. Use of software for layout design and device simulation. Characterization and reliability of MEMS devices. MEMS and microelectronic packaging. Introduction to microfluidic systems. Applications in engineering, biomedicine, and chemistry. Cross-listed with ECE 419, and CHE 419.

EP 415 Engineering Physics Design I 2R-6L-4C S
Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W or EP 280 Introduction to Nano-engineering 3.5R-1.5L-4C W and Junior or Senior standing
Corequisites: RH 330 Technical & Professional Communication 4R-OL-4C
Principles of design. Codes of ethics appropriate to engineers. Case studies related to optical engineering and engineering physics professional practice, teamwork, contemporary issues, patents and intellectual property. Team-oriented design project work on selected topics in optical engineering and engineering physics. Introduction to product development practices, product research, planning and project management. Preliminary design of a product and product specifications. Deliver a design document specific to customer needs and constraints. Cross-listed with OE 415.

EP 416 Engineering Physics Design II 2R-6L-4C F
Prerequisites: EP 415 Engineering Physics Design I 2R-6L-4C S
Corequisites: There are no corequisites for this course.
Team-based capstone design project following structured design processes and utilizing knowledge gained from prior coursework. Project planning and budgeting, development of product/process specifications, application of engineering standards, system design and prototyping subject to multiple realistic constraints (cost, schedule, and performance). Formal midterm design review. Deliver initial statement of work and interim technical report. Laboratory activities supporting the formal design process. Cross-listed with OE 416.

EP 417 Engineering Physics Design III 2R-6L-4C W
Prerequisites: EP 416 Engineering Physics Design II 2R-6L-4C F
Corequisites: There are no corequisites for this course.
Continuation of EP 416. System design and prototyping, performance testing, and data analysis. Formal midterm design review. Demonstration of a functional prototype. Deliver oral presentation and final technical report. Cross-listed with OE 417.

EP 450 Nanomedicine 4R-0L-4C
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W or Junior or Senior standing and consent of instructor
Corequisites: There are no corequisites for this course.
Material presented includes the functions and properties of medical nanodevices, the design and fabrication of nanorobots and nanoparticles, the current and potential applications of nanomedicine. Introduction to cancer cell biology and techniques for selective targeting of cancer cells, simulations of the optical and thermal properties of normal and cancerous cell organelles. Nanoplasmonics: Lorentz-Mie simulations of optical properties of nanoparticles, the use of plasmonic nanoparticles in diagnosis and therapy. Introduction to the nanophotodynamic therapies and the new dynamic modes in selective nanophotothermolysis of cancer, the design and methods of activation of nanodrugs. Time and space evolutions of thermal fields in and around the nano- bio-particles and nanoclusters. Ablation of the soft and hard biological tissues by activated nanoparticles.

EP 470 Special Topics in Engineering Physics 2-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in engineering physics.

EP 490 Directed Study 1-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

EP 506 Semiconductor Devices & Fabrication 3R-3L-4C W
Prerequisites: PH 405 Semiconductor Materials & Applications 3R-3L-4C F or ECE 250 Electronic Device Modeling 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Physical properties and applications of semiconductor devices including bipolar junction transistors (BJT), metal-semiconductor contacts (Schottky and ohmic), junction field effect transistors (JFET and MESFET), metal-oxidesemiconductor (MOS) interfaces and field effect transistors (MOSFET and CMOS), photoconductors, photodetectors (PIN and APD), solar cells, light emitting diodes (LED), and laser diodes. Laboratory experiments will cover the following topics: characterization of semiconductor devices, op-amps, CMOS, NAND and other logic and analog components. Graduate credit requires a more advanced project. Cross-listed with EP 406.

EP 507 Semiconductor Fabrication & Characterization 2R-6L-4C F
Prerequisites: PH 405 Semiconductor Materials & Applications 3R-3L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
Fabrication and characterization of micro/nanoelectronic devices; Semiconductor devices; Oxidation, ion implantation, etching, deposition, lithography, and back-end processing; Process integration of various technologies, including CMOS, double poly bipolar junction transistor, and GaAs MESFET. Process and device simulators illustrate concepts introduced in class. Modern tools/techniques for both bulk- and

thin-film characterization; Laboratory is an integral component of this class. Students work in teams to fabricate a multi-junction semiconductor device, using various techniques which include photolithography, diffusion, oxidation, and etching. In-process measurement results are compared with final electrical test results. Circuits are used to carry out performance evaluation. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both EP 407 and EP 507.

EP 508 Microsensors and Actuators 3R-3L-4C S
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S Junior or Senior standing and consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to solid state materials and conventional silicon processing. Measurement of signals from resistance- and capacitance-based transducers; sensor characteristics, calibration and reliability. Examples of microsensors: thermal, radiation, mechanical, chemical, optical fibers, and biological. Students must do additional project work on a topic selected by the instructor. Cross-listed with EP 408.

EP 510 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers, wafer-level processes, vacuum systems, thin-film deposition via PVD, dry and wet etching, photolithography, surface and bulk micromachining, process integration, MEMS applications: heat actuators, capacitive accelerometer, DLP, bio-sensor, and pressure sensor. Students must do additional project work on a topic selected by the instructor. Cross-listed with BE 516, CHE 505, ECE 516, and ME 516.

EP 511 Advanced topics in MEMS 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or EP 510 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or consent of instructor
Corequisites: There are no corequisites for this course.
Topics such as: Microlithography. Design process, modeling; analytical and numerical. Use of software for layout design and device simulation. Characterization and reliability of MEMS devices. MEMS and microelectronic packaging. Introduction to microfluidic systems. Applications in engineering, biomedicine, and chemistry. Students must do additional project work on a topic selected by the instructor. Cross-listed with ME 519, ECE 519, and CHE 519.

EP CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of Department Head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511

Rose-Hulman Institute of Technology Course Catalog

Curriculum Structure

The Rose-Hulman / Foundation Coalition Sophomore Engineering Curriculum consists of eight courses (30 credit hours) taken over the three quarters of the sophomore year. As shown below the courses are listed as either mathematics (MA) or engineering science (ES) courses:

FALL QUARTER . . . . 12 Credit Hours

MA 211 Differential Equations (4)
ES 201 Conservation & Accounting Principles (4)
ES 203 Electrical Systems (4)

WINTER QUARTER . . . . 10 Credit Hours

MA 212 Matrix Algebra & Systems of Differential Equations (4)
ES 202 Fluid & Thermal Systems (3)
ES 204 Mechanical Systems (3)

SPRING QUARTER . . . . 8 Credit Hours

MA 223 Statistics for Engineers (4)
ES 205 Analysis & Design of Engineering Systems (4)

TOTAL . . . . 30 Credit Hours

Curriculum Goals

This set of courses has been designed so that students who participate in this program should

- develop a strong background in engineering science,
- develop an understanding of modeling,
- be able to apply a common problem-solving approach built around the application of conservation and accounting principles and constitutive relations,
- continue to develop effective communication skills,
- be proficient in applying standard statistical procedures and quality control concepts,
- develop a strong background in mathematics,
- be encouraged to be inquisitive and self-motivated learners,
- develop an appreciation for engineering as a profession and begin to develop an identity as an engineer,
- be able to work effectively in teams and recognize the importance of individual responsibility in team efforts,
- be able to apply computer tools appropriately,
- be comfortable working with ambiguity,
- be familiar with the overall design process,
- be able to locate and retrieve both technical and non-technical information,
- be introduced to safe and effective use of instruments,
- appreciate the role of creativity in engineering,
- develop a recognition of the benefits of the new curriculum, and
- be encouraged to have fun learning.

Each course in the curriculum has been developed around a set of course goals and objectives that support these seventeen curriculum goals.

Engineering Science - Course Descriptions

ES 201 Conservation & Accounting Principles 4R-0L-4C F,W
Prerequisites: EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S, and MA 113 Calculus III 5R-0L-5C F,W,S, and PH 111 Physics I 3.5R-1.5L-4C F,W
Corequisites: There are no corequisites for this course.
A common framework for engineering analysis is developed using the concepts of a system, accounting and conservation of extensive properties, constitutive relations, constraints, and modeling assumptions. Conservation equations for mass, charge, momentum and energy, and an entropy accounting equation are developed. Applications taken from all engineering disciplines stress constructing solutions from basic principles.

ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Prerequisites: ES 201 Conservation & Accounting Principles 4R-0L-4C F,W with a grade of C or better
Corequisites: There are no corequisites for this course.
Extend the conservation and accounting framework to examine fluid motion. Topics include dimensional analysis, pressure variation in both stationary and moving fluids, viscous effects including boundary layers, laminar and turbulent flow. Applications include lift and drag, pipe flow, compressible flow. Fundamental concepts are enriched by laboratory experiences.

ES 203 Electrical Systems 3R-3L-4C F,W,S
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S, and PH 112 Physics II 3.5R-1.5L-4C W,S,F, and EM 121 Statics & Mechanics of Materials I 4R-0L-4C F, W, S or EM 120 Engineering Statics 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Circuit elements, Kirchhoff's laws, equivalent circuits, voltage and current dividers, and analysis techniques for both DC and the phasor domain. AC circuits and power. Operational amplifiers. Integral laboratory.

ES 204 Mechanical Systems 2 2/3R-1L-3C W,S
Prerequisites: ES 201 Conservation & Accounting Principles 4R-0L-4C F,W*, ME 123 Computer Programming 4R-0L-4C F,W,S** or BE 100 Problem Solving in the Biological Sciences & Engineering 3R-3L-4C S** or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S** *ES 201 with a grade of C or better ** or equivalent
Corequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Conservation and accounting equations applied to mechanical systems. Kinematics and kinetics of particles in space and of rigid bodies in plane motion.

ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F
Prerequisites: ES 203 Electrical Systems 3R-3L-4C F,W,S* or ECE 203 DC Circuits 3R-3L-4C S, F*, and ES 204 Mechanical Systems 2 2/3R-1L-3C W,S, and MA 211 Differential Equations 4R-0L-4C F,W,S *with a grade of C or better
Corequisites: There are no corequisites for this course.
Conservation and accounting principles are used to model engineering systems comprising mechanical, electrical, fluid, and thermal elements. Dynamic behavior and performance criteria are characterized in the time and frequency domains. Topics include block diagrams, deriving and solving differential equations of motion,

experimental parameter identification and model validation, teaming, and reporting engineering results.

ES 212 Fluid Systems 3R-3L-4C W,S
Prerequisites: ES 201 Conservation & Accounting Principles 4R-0L-4C F,W With a grade of C or higher
Corequisites: There are no corequisites for this course.
Extend the conservation and accounting framework to examine fluid motion. Topics include dimensional analysis, pressure variation in both stationary and moving fluids, viscous effects including boundary layers, laminar and turbulent flow, and compressibility effects. Applications include similitude, lift and drag, pipe flow, nozzle and diffuser flow. Fundamental concepts are enriched by laboratory experiences.

ES 214 Mechanical Systems 3R-1L-4C W,S
Prerequisites: ES 201 Conservation & Accounting Principles 4R-0L-4C F,W*, ME 123 Computer Programming 4R-0L-4C F,W,S or BE 100 Problem Solving in the Biological Sciences & Engineering 3R-3L-4C S or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S *ES 201 with a grade of C or higher
Corequisites: ES 212 Fluid Systems 3R-3L-4C W,S
Conservation and accounting equations applied to mechanical systems. Kinematics and kinetics of particles in space and of rigid bodies in plane motion.

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International students for whom English is not their native language will be required to take an assessment test to gauge their reading, writing, speaking and listening proficiency in English. The purpose of this testing is to ensure that all students have the proper communication skills to advance successfully through the challenging Rose-Hulman curriculum. Based on this assessment, some students will be required to take one or more English as a Second Language (ESL) courses. Those students must successfully complete ESL 102 prior to taking RH131 Rhetoric and Composition.

In addition:

- Students may not drop an ESL course.
- Students may not apply more than four credits of ESL coursework toward free elective credits in their major if applicable.
- Students must successfully complete all ESL course requirements within the first year of enrollment at Rose-Hulman or face dismissal from the Institute.

English Second Language - Course Descriptions

ESL 101 Reading and Writing 1 4R-0L-4C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Focuses on the basic patterns and conventions of U.S. academic prose. Familiarizes students with essential essay structures with particular emphasis on identifying, developing, and supporting a thesis. Deepens knowledge of grammar and academic vocabulary. Introduces the topic of academic integrity and appropriate use of outside source material. Students required to take ESL 101 must complete the course with a grade of C or higher prior to taking ESL 102.

ESL 102 Reading and Writing 2 4R-0L-4C F,W,S
Prerequisites: ESL 101 Reading and Writing 1 4R-0L-4C F (Completion of ESL 101 with a grade of C or higher) or placement via ESL exam
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Reviews the basic patterns and conventions of U.S. academic reading and writing. Introduces students to formal research techniques and provides extensive practice with incorporating outside sources and using strategies for maintaining academic integrity. Guides students through readings in academic journals and articles. Students required to take ESL102 must successfully complete the course prior to taking RH 131.

ESL 111 Listening and Speaking 3R-1L-4C F,W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Develops spoken fluency with emphasis on the basic pronunciation, rhythm, and intonation patterns of English. Prepares students for academic presentations with a particular focus on STEM vocabulary. Develops students' academic listening and note-taking skills.

ESL 399 Special Topics (1-4 credits) 4R-OL-4C Arranged
Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
For non-native speakers of English. Examines a selected ESL topic in depth. A particular offering may require a prerequisite or consent of the instructor.

ESL 499 Directed Study (1-4 credits) 4R-OL-4C Arranged
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
For non-native speakers of English. Allows for individual study of an ESL topic selected by the instructor and the student(s). A plan of study, regular meetings with the instructor, and a major term project are required.

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Geology - Course Descriptions

GEOL 270 Geology for Engineers & Environmental Scientists 4R-0L-4C
Prerequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Corequisites: There are no corequisites for this course.
Physical, historical, chemical, structural and environmental aspects of earth science addressed from an engineer's or environmental scientist's perspective. The course includes study of minerals and rocks, investigation of geologic hazards, an introduction to rock and soil mechanics, case studies, and interpretation of topographic maps, geologic maps and aerial photographs.

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Rose-Hulman
Institute of Technology
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AREAS OF STUDY

- See Thematic Categories, below.

MAJORS

- Economics
- International Studies (second major only)

Certificates

- German Technical Translator

MINORS

- Anthropology
- Art
- Cognitive Science
- East Asian Studies
- Economics
- European Studies
- Geography
- German
- History
- Japanese
- Language and Literature
- Latin American Studies
- Music
- Political Science
- Philosophy and Religion
- Psychology
- Spanish
- Theatre and Drama

Professors Abas, Bremmer, Carlson, Carvill, Casey, Chapman, Christ, Christensen, Dyer, Garcia, Gardner, Grose, Hartner, Hartnett, Hirotani, House, Jensen, Jern, Kim, Kukral, Livingston, Martland, Michel, Minster, Smith Roads, Summers, Taylor, Watt, and Williams.

MISSION STATEMENT

To enable our students to become creative, sophisticated thinkers, active citizens, and effective leaders in the global community, the department contributes to a broad liberal education, introducing students to a wide array of disciplines and traditions in the humanities and social sciences. In doing so, it provides learning experiences that, in addition to their intrinsic value, enrich a scientific and technical education.

Educational Objectives

Within the context of a liberal education, the department fosters in its students the desire and the ability to:

1. **think critically**, forming cogent, informed opinions, defining and solving problems with an awareness that societal processes are complex and interactive;
2. **communicate effectively** to diverse audiences, including those from other cultures and communities;
3. **succeed in a global context** by understanding and adapting to diverse cultures, alternative points of view, and the challenges of globalization;
4. **exhibit ethical and responsible leadership** as individuals, citizens, and professionals, committed to lifelong learning and achievement.

Disciplines

The HUMANITIES study what it means to be human within a contemporary or historical context. These disciplines analyze the ideas and expressive artifacts of individuals or groups emphasizing qualitative rather than quantitative methods. The Humanities provide us with the broad frameworks within which enduring questions of existence, relationships, values, and aesthetics can be examined from multiple perspectives.

The SOCIAL SCIENCES study human interactions and the social institutions in which these occur. These disciplines tend to adopt scientific methods, emphasizing quantitative rather than qualitative approaches. The Social Sciences provide us with the broad frameworks within which to analyze the nature of social systems, processes, and outcomes.

The following disciplines are represented within the department:

HUMANITIES	SOCIAL SCIENCES
Art and Art History	Anthropology
English and Literature	Archaeology
Foreign Languages(German, Japanese, and Spanish)	Economics
History	Geography
Music	Political Science
Philosophy and Religion	Psychology
Theater	Sociology

Thematic Categories

The majority of courses offered by the department are distributed across three thematic categories. These are:

- **Global Studies (GS prefix):** Courses whose primary focus is on the examination of other societies, or on the interrelationships among multiple societies.
- **Ideas and Arts (IA prefix):** Courses whose primary focus is on theories and debates within disciplines, the development of ideas, or arts and aesthetics.

- **Society and Values (SV prefix):** Courses whose primary focus is on the dynamics, patterns, and values of human interaction and social institutions.

In addition, courses related to communication skills and foreign languages have their own designations:

- Rhetoric and Composition (required of all students, with the exception noted below) and Technical Communication are designated with an RH prefix. Rhetoric and Composition is RH 131 and Technical Communication is RH 330
- Foreign language courses are identified by prefixes which identify the language: GE for German, JP for Japanese, and SP for Spanish

Course Levels in the Humanities and Social Sciences

The courses in the Humanities and Social Sciences Department are intended to contribute to our students' broad liberal education. Given this, they frequently do not follow a sequence or require prerequisites. This does not mean, however, that there is no distinction between upper and lower level courses. In general **lower level courses (100 and 200 level)** tend to be broad surveys of particular subject areas within disciplines. **Upper level courses (300 and 400 level)** are often more focused in terms of subject matter and may go into greater depth of content.

Graduation Requirements

1. General

- All students must take a minimum of nine courses (36 credits) in Humanities and Social Sciences (HSS). These courses may be chosen from the HSS offerings, within the restrictions below. (A student taking an area minor in HSS must take a minimum of ten to eleven courses; see below.)

2. Rhetoric and Composition

- All students, with the exception noted below, are required to take RH 131, Rhetoric and Composition, on campus. Freshmen, unless exempted or taking a foreign language, are normally enrolled automatically in the course in either the Fall or Winter Quarter. Students who have taken a writing course at another college will be granted free elective transfer credit, but are not exempted from RH 131.
- **EXEMPTION**: An entering student (freshman or transfer) who meets both of the following requirements may be exempt from the RH 131 requirement. The student will not, however, be awarded credit for RH 131. Any HSS course may be substituted for RH 131 for exempted students.
  1. A combined score of 1500 or above on the Writing and Critical Reading sections of the Scholastic Aptitude Test (SAT) or of 34 or above on the English section of the ACT exam.
  2. Has received grades of B or higher in all high school English courses.
- **INTERNATIONAL STUDENTS**:

  International students for whom English is not their native language will be required to take an assessment test to gauge their reading, writing, speaking and listening proficiency in English and may be required to take one or more English as a Second Language (ESL) courses prior to taking RH131 Rhetoric and Composition.

3. Technical and Professional Communication

- Technical and Professional Communication is a requirement for most majors. Students are required to take RH 330 on campus. Students who have taken a technical writing course at another college will be granted free elective transfer credit, but are not exempted from RH 330.

4. Distribution Requirements

- All students will take two courses in each of the three thematic categories: Global Studies, Ideas and Arts, and Society and Values. The section of course descriptions lists courses currently available in each category. Students are also required to take one additional course in any category OR two additional courses in any category IF Technical Communication is not required of any of the student's majors. Technical communication may be taken as one of the additional courses if not required by the student's major(s).

5. Foreign Language

- Students who elect to take a foreign language should note the following special requirements.
    1. A minimum of two terms of the same language (or the equivalent thereof) must be completed in order to apply foreign language credits toward Humanities and Social Sciences requirements. If only SP111, JP111 or GE111 is completed, that course will not be allowed to satisfy an HSS requirement. For transfer credit, a single foreign language course at 4 credit hours may be used to satisfy an HSS requirement if it is higher than the entry level course (xx111) in that language. Example: Transfer credit awarded for SP113 could be used to satisfy one HSS course requirement.
    2. HSS credit will not be awarded for a lower-level language course until the student takes and passes the following course in the language sequence with a grade of C or better.
    3. Students who take 2-3 courses in a foreign language sequence may allocate those language courses in any of the three thematic categories as they choose, but may have no more than one language course in any category. In other words, the student must still take at least one course in each thematic category in a discipline other than foreign language and must also take RH 131. If a fourth foreign language course is counted toward the general HSS requirements, it will count as the one additional course noted under the Distribution Requirements.
    4. Students who take twelve courses (four years) in a single language are exempted from RH 131 and from both courses in Global Studies.
    5. Students may not earn foreign language credit in their native languages.
    6. Note: Students planning to study abroad should be sure to have their program approved ahead of time by the head of the HSS Department and by the head of the Department in which they are majoring.

6. Minors

- Students may elect a minor in most of the HSS Department's disciplines. In addition, several interdisciplinary minors are available. (See below.)

7. Transfer Credit

- Of the 9 required Humanities and Social Science courses (36 credit hours), a student must fulfill at least 6 of them (24 credit hours) through completion of Rose-Hulman coursework. Accordingly, a student may not fulfill more than 3 of them (12 credit hours) through transfer, AP, or IB credits. Exceptions will generally be made for (1) transfer students who matriculate with credit previously earned while enrolled at another college or university in pursuit of a post-secondary degree or (2) students who participate in an approved study abroad program. Exceptions may also be made for students pursuing additional coursework beyond the requirements of their major, such as double-major programs, or unique professional opportunities. All exceptions are subject to review and approval by the Head of the Humanities and Social Sciences Department. There is no limit on the number of HSS courses that can be transferred to Rose-Hulman, only the number counted towards required HSS credits. ***This rule will come into effect as of August 2018.***

8. Dual Credit Courses

- Credits accrued through dual credit courses taken while in high school and taught in high schools are generally not eligible for transfer to Rose-Hulman. Dual credit refers to courses taught to high school students for which the students receive both high school credit and college credit. Exceptions can be made by the relevant department head. In these cases, full documentation of the course will be required and a personal interview with the Department Head may be required. ***This rule will come into effect as of August 2018.***

HELP WITH REQUIREMENTS

Students having questions concerning these requirements should consult their advisers or the head of the HSS Department. A check sheet summarizing HSS graduation requirements is available in the HSS Department Office.

Minor

A student may elect to take an Minor in Anthropology, East Asian Studies, Economics, European Studies, Geography, German, History, Japanese, Language and Literature, Latin American Studies Philosophy and Religion, Political Science, Psychology, Spanish or Theatre and Drama by concentrating 5 to 7 HSS courses in that area. NOTE: All Minors require taking one additional HSS course, for a minimum of 40 HSS credits (44 in the case of foreign languages). See the specific requirements listed under each Minor. Successful completion of the Minor is indicated on the student's grade transcript. A student interested in pursuing a Minor should consult with the appropriate Minor Adviser, listed below, for aid in planning a course schedule. No courses counted toward fulfilling the requirements for one minor may be counted in fulfilling the requirements of another minor.

Minor	***Advisor***

Anthropology	Paul Christensen
Art	Steve Letsinger
Cognitive Science	Alan Jern
East Asian Studies	Tim Grose
Economics	Dale S. Bremmer Kevin Christ Jong Hun Kim
European Studies	Andreas Michel
German	Heidemarie Heeter
Geography	Michael Kukral
History	Samuel Martland
Japanese	Maki Hirotani
Language and Literature	Caroline Carvill
Music	David Chapman
Latin American Studies	Gustavo Garcia
Philosophy and Religion	Dan Hartner
Political Science	Terrence Casey
Psychology	Alan Jern
Spanish	John Gardner
Theatre and Drama	Terence Hartnett

HSS MAJORS

International Studies Major (IS) (second major only)

In the 21st century, technical work occurs increasingly in an international and multi-lingual arena. The International Studies major provides Rose-Hulman students with the opportunity to complement their primary major with a second major that prepares them for an interdependent, multicultural, and transnational world. Courses in the major focus on economic, cultural, and social processes that take place among nations and world regions. Topics may include globalization, post-colonialism, communication, migration, and environmental change.

The IS major promotes the critical understanding of the historical and contemporary entanglements of diverse cultures around the world. It offers theoretical tools and models practical steps with which to assess competing claims about the world. Students will participate in the analysis of complex situations in which the evidence may be ambiguous and in which there may be no one clear answer. They will learn to devise questions that guide productive research into such situations.

Learning Outcomes:

1. Recognition of cultural diversity requires the comparison and analysis of historical, cultural, political, social, or regional differences.
   a. Analyze a socio-cultural artifact, event, or system of a society different from your own.

   b. Compare socio-cultural artifacts or systems in two or more cultures/world regions/civilizations
   c. Carry out a project involving meaningful contact with students, colleagues, clients, or sponsors abroad.
2. Transnational and global awareness requires an understanding of the ideas, systems, processes, or trends that have created a globally interdependent world.
   a. Explain the global causes or effects of an action or decision by nation-states, corporations, groups of people, or other actors
   b. Argue for a course of action—political, economic, or otherwise—when given an international situation/case study
3. Independent Study of global issues requires the application of appropriate analytic vocabulary, methodologies, or critical frameworks from the Humanities or the Social Sciences
   a. Assemble and evaluate resources for research in international studies.
   b. Design and carry out a research project analyzing a significant international or global issue, system, process, or event.

Requirements for a second major in International Studies (60 cred.)

- Students double majoring in International Studies may use their International Studies courses to satisfy HSS graduation requirements.
- Courses counted for the International Studies major may not be counted for HSS minors—except that foreign language courses may be used to fulfill foreign language requirements in one additional minor.
- Students wishing to pursue a double major in Economics and International Studies may not choose the IPE area of concentration.
- All International Studies majors are subject to approval by HSS Department Head and the Institute Curriculum Committee.

1.**Disciplinary Distribution** (4 courses, 16 credit hours that introduce students to key concepts, disciplines, and analytical approaches in international studies).

Students choose one course each from **FOUR** of the following six disciplines. The courses have international processes, comparisons, or other connections as a central focus. They may be substituted with other courses with same focus with consent of IS major director.

Economics
SV 150 Introduction to Microeconomics
SV 152 Introduction to Macroeconomics

Geography
GS 291 World Geography
GS 491 Geography of Europe
GS 492 Geography of Africa

Political Science
GS 163 International Relations
GS 161 Comparative Politics

Literature
IA 233 World Literature
IA 311 German Colonialism

IA 380 Literature and Human Rights in Latin America

History
GS 223 World History
GS 422 Industrial Revolution in Global Context
GS 221Colonial Latin America

Anthropology
GS 185 Introduction to Anthropology
GS 128 Introduction to East Asia
IA 328 Ethnicity and the State in China

2. **Concentration** (7 courses, 28 credit hours)
Each student must take seven courses that allow the student to develop advanced area or topic
knowledge and disciplinary analytical skills in a coherent field of concentration. The student must choose these courses in consultation with the IS major director and other faculty, write a statement explaining how those courses fit together, and get it approved by a committee designated by the IS major director by the fall quarter of junior year.

3. **Language** (3 courses, 12 credit hours) One full year of a foreign language (e.g., German, Japanese, Spanish)

4. GS 496 and GS 497 **Senior Project** in International Studies (2 credits each; 4 credit hours total)

Guided study, research, and analytical writing on a topic in international studies, integrating knowledge gained from international experience and/or from course work in the major.

Senior project proposals will be approved by a committee designated by the International Studies Major Director.

HSS MINORS

MINOR IN ANTHROPOLOGY

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Anthropology has the following requirements:

1. Five Courses in Anthropology
2. The following course is required:
    - GS 185 Introduction to Anthropology
3. Four additional courses from the list below:
    - GS 128 Introduction to East Asia
    - GS 368 Tokyo
    - GS 379 Japanese Culture
    - GS 384 Japanese Society
    - GS 385 Japanese Society Seminar
    - IA 388 Food, Culture, and the Self
    - IA 389 Anthropology of Addiction

- SV 386 Human Evolution
- SV 389 Anthropology of Sports
- XX 399 Special Topics
- XX 499 Directed Study

4. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
5. Substitutions may be made with the approval of the Minor Advisor

MINOR IN ART

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Area Minor in Art has the following requirements:

1. Five Courses in Art
2. The following three courses are required:
   - IA142 Drawing
   - IA148 Beginning Photography
   - SV242 Visual Arts in Civilization
3. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
4. Substitutions may be made with the approval of the Minor Advisor
   Courses
   - GS442 Art History: Renaissance to Modern
   - IA142 Drawing
   - IA148 Beginning Photography
   - IA244 Design and Color
   - SV242 Visual Arts in Civilization

MINOR IN EAST ASIAN STUDIES

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in East Asian Studies has the following requirements:

1. Three courses (or proficiency) in Japanese Language. (Language courses may be allocated in any of the three thematic categories, but there may be no more than one language course in any category.)
2. Four courses selected from the following:
   - GS128 Introduction to East Asian History
   - GS207 Asian Religions and Philosophy
   - GS327 Modern China
   - GS379 Japanese Culture
   - GS368 Tokyo
   - GS380 Pop Culture in China
   - GS384 Japanese Society
   - GS385 Japanese Society Seminar
   - IA325 Islam and Muslim Groups in China
   - IA328 Ethnicity and State in China
3. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
4. Substitutions may be made with the approval of the minor advisor.

MINOR IN ECONOMICS

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Economics has the following requirements:

1. Five courses in Economics, distributed as follows:
    - Introduction to Microeconomics (SV 150)
    - Introduction to Macroeconomics (SV 152)
    - Intermediate Microeconomics (IA 350) or Intermediate Macroeconomics (IA 351)
    - Two additional Economics courses chosen by the student and approved by an Economics Minor Advisor. These shall be selected to provide some depth in the student's understanding of economic analysis and its applications;
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor
   Courses
    - GS350 International Trade and Globalization
    - GS351 International Finance
    - GS352 Economic Growth and Development
    - IA350 Intermediate Microeconomics
    - IA351 Intermediate Macroeconomics
    - IA352 Game Theory
    - IA353 History of Economic Thought
    - IA450 Mathematical Economics
    - SV150 Introduction to Microeconomics
    - SV152 Introduction to Macroeconomics
    - SV351 Managerial Economics
    - SV352 Money and Banking
    - SV353 Industrial Organization
    - SV354 Environmental Economics
    - SV355 Health Economics
    - SV356 Corporate Finance
    - SV357 Labor Economics
    - SV450 Econometrics
    - XX399 Special Topics
    - XX456/457 Senior Project

MINOR IN EUROPEAN STUDIES

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in European Studies has the following requirements:

1. Three courses (or proficiency) in either German or Spanish. (Language courses may be allocated in any of the four thematic categories, but there may be no more than one language course in any category.)
2. Four courses selected from the following:
    - GS313 Contemporary Spain

- GS337 Shakespeare's Europe
- GS363 European Politics and Government
- GS366 The European Union
- GS431 Literary London
- GS469 Contemporary British Fiction and Film
- GS491 Geography of Europe
- IA311 Topics in German Culture I
- IA337 European Romanticism
- SV222 Western Civilization to 1500
- SV223 Western Civilization from 1500 to the Present
- SV291 Medieval Europe
- SV413 Contemporary Germany
- XX399 Special Topics
- XX499 Directed Study

3. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
4. Substitutions may be made with the approval of the Minor Adviser.

MINOR IN GEOGRAPHY

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Geography has the following requirements:

1. Five courses in Geography, one of which must be either World Regional Geography (GS291) or Cultural Geography (SV191).
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor.
   Courses
   - GS191 Geography of Middle East
   - GS222 Modern Latin America
   - GS291 World Geography
   - GS327 Modern China
   - GS391 Contemporary Europe
   - GS491 Geography of Europe
   - GS492 Geography of Africa
   - SV191 Cultural Geography
   - SV291 Medieval Europe
   - XX399 Special Topics
   - XX499 Directed Study

MINOR IN HISTORY

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in History has the following requirements:

1. Five courses in History

    - Must include at least one of the following research-based courses: GS325, GS422, SV322.
    - May include one of the “approved courses in related disciplines”
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor

History Courses

- GS221 Colonial Latin America
- GS222 Modern Latin America
- GS223 World History since 1400
- GS324 Brazil Since 1500
- GS325 Cities and Technology
- GS422 Industrial Revolution in Global Context
- SV322 Disasters and Modern Society since 1700
- XX399 Special Topics
- XX499 Directed Readings

Approved courses in related disciplines (One of these can count towards the History minor without special permission.)

- GS 327 Modern China 4R-OL-4C
- GS413 Nazi Germany: Fact and Fiction
- IA311 German Colonialism
- SV291 Medieval Europe
- IA353 History of Economic Thought

MINOR IN LANGUAGE AND LITERATURE

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Language and Literature has the following requirements:

1. In addition to RH 131 and RH 330, five courses in Language and Literature.
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor.
   Courses
    - GS237 Science Fiction
    - GS334 Travel in World Literature
    - GS335 The Global Novel in the Twentieth Century
    - GS336 Literature of War
    - GS337 Shakespeare's Europe
    - GS338 Contemporary Arabic Literature in Translation
    - GS339 Contemporary Global Film
    - GS412 Topics in German Culture II
    - GS431 Literary London
    - GS432 Literature and Film of the Global Economy
    - GS462 Postcolonial Literature
    - GS469 Contemporary British Fiction and Film
    - IA230 Fundamentals of Public Speaking

- IA231 Introduction to Poetry
- IA232 African American Music in American Literature
- IA233 World Literature
- IA234 Major American Writers
- IA235 Major British Writers
- IA237 Introduction to Drama
- IA238 African American Literature
- IA239 Rhetoric of Science
- IA240 Introduction to Shakespeare
- IA241 Introduction to Film Studies
- IA330 Documentary Film
- IA331 American Modernism
- IA333 Representations and Redefinitions of Reality
- IA334 Creative Writing
- IA335 Bible as Literature
- IA336 Mystery & Horror Literature
- IA337 European Romanticism
- IA338 Medicine in Literature
- IA339 Rebellion in American Literature
- IA341 Steinbeck and American Society
- IA342 Modern Southern Fiction
- IA431 History of the American Novel
- IA436 Reinterpretations of Literary Themes
- SV134 Popular Literature
- SV231 Introduction to Short Fiction
- SV232 Introduction to Non-Fiction
- SV233 Survey of American Literature
- SV332 Gender, Work & Popular Culture
- SV334 Utopian Thought and Literature
- SV336 Contemporary American Fiction
- SV337 20th century American Novel
- SV339 Literature and the Environment
- SV234 The American Dream
- XX399 Special Topics
- XX499 Directed Study

MINOR IN LATIN AMERICAN STUDIES

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Latin American Studies has the following requirements:

1. Three courses (or proficiency) in Spanish Language. (Language courses may be allocated in any of the three thematic categories, but there may be no more than one language course in any category.)
2. Four courses selected from the following:
    - GS221 Colonial Latin America
    - GS222 Modern Latin America
    - GS313 Contemporary Spain

- GS324 Brazil Since 1500
- IA332 Don Quixote
- SV338 Latin American Fiction: The Boom and Beyond
- XX399 Special Topics
- XX499 Directed Topics

3. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
4. Substitutions may be made with the approval of the Minor Adviser.

MINOR IN MODERN LANGUAGES (GERMAN, JAPANESE, AND SPANISH)

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Modern Languages has the following requirements:

1. Six successive courses, or the equivalent, in German, Japanese or Spanish.
2. RH 131 and 3 HSS courses, one in each category.
3. This means a minimum of 44 credits in HSS courses must be earned.
4. Students may not earn foreign language credit in their native languages.

First Year Courses
GE 111/112/113 German Language and Culture I/II/III JP 111/112/113 Japanese Language and Culture I/II/III SP 111/112/113 Spanish Language and Culture I/II/III
Second Year Courses
GE 211/212/213 German Language and Culture IV/V/VI JP 211/212/213 Japanese Language and Culture IV/V/VI SP 211/212/213 Spanish Language and Culture IV/V/VI
Third Year Courses
GE 311 Topics in German Culture I/ GE312 Reading German Texts/313 Advanced Grammar and Translation Methods/ JP 311/312/313 Japanese Language and Culture VII/VIII/IX
Fourth Year Courses
GE 411 Technical Translation/412 Topics in German Culture II/413 Contemporary Germany/ JP 411/412/413 Japanese Language and Culture X/XI/XII
XX 399 Special Topics
XX 499 Directed Study

NOTES:
Credits earned in a first-year, first-term language do not count in satisfying HSS graduation requirements unless the second course in the sequence is also completed successfully.
Students who have completed high school courses in German, Japanese or Spanish can get credit-by-examination for their knowledge by completing subsequent advanced level courses.

MINOR IN MUSIC

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the Minor Advisor.

The Minor in Music has the following requirements:

1. Twenty credits (the equivalent of five courses) in Music. IA246, IA346, SV244, and four credits of IA348 are required.
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor.

Music Theory courses *(both required):*

- IA246 Music Theory I: Fundamentals of Tonal Music
- IA346 Music Theory II: Basic Form and Composition *(pre-requisite: IA246)*

Students who have taken music theory before attending Rose#Hulman may choose to take a Theory I placement test in order to be granted admittance to Music Theory II. Students who successfully pursue this option must then substitute for Music Theory I another music#related course, as approved by the Music Advisor.

Music History and Culture courses *(one required; student may chose the other):*

- GS243 Early European Music (Before 1650)
- SV244 Western Music of the Baroque, Classical, and Romantic Eras *(required)*
- SV245 Western Music in the 20th Century
- SV246 Popular Music in the Era of Recorded Sound
- GS343 Musics of the World

Music Performance *(four credits required):*

- IA348 Music Performance *(pre#requisite: consent of the ensemble director[s])*

One credit represents one academic term of satisfactory participation in one accredited Performing Groups (Concert Band, Jazz Ensemble, String Ensemble/Orchestra, and Chorus). Maximum of two credits (that is, participation in two ensembles) per term. The four required credits need not be completed consecutively, nor must they all be completed in the same performing group. The specific criteria for "satisfactory participation" will be provided to the candidate by the ensemble directors.

MINOR IN PHILOSOPHY

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Philosophy has the following requirements:

1. Five courses in Philosophy, one of which must be Introduction to Philosophy (IA 101).
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor.

Philosophy Courses:

- IA101 – Introduction to Philosophy
- IA102 – Critical Thinking & Introduction to Logic
- IA401 – Philosophy of Science

- IA302 – Philosophy of Religion
- IA301 – Philosophy of Mind
- IA303 – Political Philosophy
- SV402– Human Nature
- SV303 – Business & Engineering Ethics
- SV304 – Bioethics
- XX399 – Special Topics
- XX499 – Directed Study

Minor in Political Science

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Political Science has the following requirements:

1. Five courses in Political Science, one of which must be Comparative Politics (GS 161), International Relations (GS 163), or American Politics and Government (SV 166)
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the Minor Advisor.
   Courses
   - GS161 Comparative Politics
   - GS163 International Relations
   - GS361 Politics of the Global Economy
   - GS366 The European Union
   - SV166 American Politics and Government
   - SV 345 Presidential Election Rhetoric
   - SV369 British Politics and Government
   - IA303 Political Philosophy
   - IA463 Seminar on America's Future
   - XX399 Special Topics
   - XX499 Directed Study

Minor in Psychology

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

The Minor in Psychology has the following requirements:

1. Principles of Psychology (SV 171).
2. Four other psychology courses.
3. Engineering Statistics I (MA 223) or Introduction to Probability and Statistics with Applications (MA 381).
4. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
5. Substitutions may be made with the approval of the Minor Advisor.

Courses:

- SV 171 Principles of Psychology

- SV 372 Social Psychology
- SV 472 Studying Human Behavior
- SV 373 Abnormal Psychology
- IA 371 Cognitive Psychology
- IA 471 Computational Psychology
- IA 301 Philosophy of Mind

Minor in Theater and Drama

Students may apply only one (1) transfer course toward a minor. Exceptions may be made with the approval of the minor advisor.

Requirements:

1. Five courses (20 credits) in Theater and Drama.
2. A minimum of 40 credits in HSS courses must be earned to obtain the minor.
3. Substitutions may be made with the approval of the minor advisor.

Courses:

- IA 299 Introduction to Theater Arts
- IA 237 Introduction to Drama
- IA 240 Introduction to Shakespeare
- SV 340 American Drama
- SV 341 African American Drama
- SV 342 Modern European Drama
- GS 337 Shakespeare’s Europe
- GS 429 Greek and Roman Drama
- GS 430 World Drama

GERMAN TECHNICAL TRANSLATOR’S CERTIFICATE PROGRAM

A student may earn, in addition to one of the regular degree programs in science or engineering, a certificate of proficiency in German technical translation. Successful completion of this non-degree program partially fulfills the graduation requirements in humanities and social sciences.

Certificate Requirements

A student must have a 3.0 in the first two years of German and in his/her major, as well as permission of the instructor, to enter the third year language courses. Exceptions may be made by the instructor in charge of the program.

1. A student must complete all the technical courses required by one of the Institute’s degree-granting programs.
2. A student must successfully complete the third and fourth year courses of the German Studies program (GE 311/312/313 and GE 411/412/413).
3. A student who successfully completes the four-year language program is exempted from RH 131 Rhetoric and Composition, and from both courses in Global Studies (GS). This generally means that the student will only need to take three

HSS courses other than German (one IA, one SV, and RH330 Technical and Professional Communication).

Commentary

A student who qualifies through the Foreign Language Examination administered at Rose-Hulman during Freshman orientation week, will be permitted to enroll in the appropriate level of German as determined by the foreign language faculty. A student who successfully completes a quarter of more advanced language at Rose-Hulman with a grade of C or better will be granted 4 hours of Credit by Examination for each quarter of language by-passed. (Note: a minimum of two terms of college language must be completed in order to receive HSS graduation credit.)

1. A student who is in the German Studies Program in Culture and Technology is not required to take RH 131, Rhetoric and Composition.
2. In order to obtain the Translator's Certificate, some students in some curricula may have to take more than the minimum number of credits required for graduation.
3. Due to scheduling requirements of some regular degree programs, a student may also have to carry an overload in some terms. This means that the student will have to maintain a better-than-average grade point average to meet the Institute requirements permitting an overload. See the Student Handbook for details.
4. A student is strongly urged, but not required, to spend at least one summer studying in an approved program for foreigners in Germany. Some small grants may be available to help defray expenses.

Summary	**Credits**
First Year German (GE 111, 112, and 113 or approved equivalent)	12
Second Year German (GE211, 212, 213 or approved equivalent)	12
Third Year German (GE311 Topics in German Culture I; GE312 Reading German Texts; and GE313 Advanced Grammar and Translation Methods	12
Fourth Year German (GE411 Technical Translation; GE412 Topics in German Culture II; and GE413 Contemporary Germany)	12
One IA course (any)	4
One SV course (any)	4
RH330 (required for most majors)	4

TOTAL	**60**

Humanities & Social Sciences - Course Descriptions

FL 299 Summer Language Study Abroad 12C Max S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Maximum Credit per Summer: 12. May be repeated. Credit for approved summer foreign language study abroad. May count towards a departmental minor, with the exception of a foreign language minor. Prior approval by the HSS Department Head and evidence of satisfactory completion required

GE 111 German Language and Culture I (GE 111) 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary training in hearing, speaking, reading, and writing German. Uses reading exercises to show the relationship between language and culture. Required language laboratory.

GE 112 German Language and Culture II (GE 112) 4R-OL-4C W
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary training in hearing, speaking, reading, and writing German. Uses reading exercises to show the relationship between language and culture. Required language laboratory.

GE 113 German Language and Culture III (GE 113) 4R-OL-4C S
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary training in hearing, speaking, reading, and writing German. Uses reading exercises to show the relationship between language and culture. Required language laboratory.

GE 211 German Language and Culture IV 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Reviews German grammar, emphasizing its logical sub-structure. Stresses analysis of complex sentences of scholarly German. Introduces the student to selected topics dealing with life in Germany as contrasted with life in the U.S. Provides continued practice in reading and speaking. Required language laboratory.

GE 212 German Language and Culture V 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Reviews German grammar, emphasizing its logical sub-structure. Stresses analysis of complex sentences of scholarly German. Introduces the student to selected topics dealing with life in Germany as contrasted with life in the U.S. Provides continued practice in reading and speaking. Required language laboratory.

GE 213 German Language and Culture VI 4R-OL-4C S
Prerequisites: Preceding course or placement by examination.

Corequisites: There are no corequisites for this course.
Reviews German grammar, emphasizing its logical sub-structure. Stresses analysis of complex sentences of scholarly German. Introduces the student to selected topics dealing with life in Germany as contrasted with life in the U.S. Provides continued practice in reading and speaking. Required language laboratory.

GE 311 Issues in German Culture I 4R-OL-4C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a variety of historical and contemporary issues in German popular and high culture. Same as IA 311.

GE 312 Reading German Texts 4R-OL-4C W
Prerequisites: GE 213 German Language and Culture VI 4R-OL-4C S
Corequisites: There are no corequisites for this course.
Studies and practices effective reading of German texts. Analyzes and evaluates their contents in discussions and the writings of short German essays.

GE 313 Advanced Grammar & Translation Methods 4R-OL-4C S
Prerequisites: GE 312 Reading German Texts 4R-OL-4C W
Corequisites: There are no corequisites for this course.
Introduces advanced grammar concepts targeted for translation of German texts. Familiarizes students with translation techniques for a variety of text types.

GE 411 Technical Translation 4R-OL-4C F
Prerequisites: GE 313 Advanced Grammar & Translation Methods 4R-OL-4C S
Corequisites: There are no corequisites for this course.
Introduces scientific and technological vocabulary; continues working with complex grammatical structures; applies methods of translation using scientific and technical texts. Requires the writing of a major technical translation project.

GE 412 Topics in German Culture II 4R-OL-4C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores topics in German and European intellectual history as represented in literature, essay, and film. Same as GS 412.

GE 413 Contemporary Germany 4R-0L-4C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces historical, political, and cultural issues in German society from 1945 to the present. Compares German to European developments. Taught in English and open to all students. Same as SV 413.

GS 128 Intro to East Asia 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the changing political, economic, and cultural orders in East Asia. (NOTE: formerly Intro to East Asian History)

GS 130 Introduction to Sustainability 4R#OL#4C
Prerequisites: Admission to HERE program or consent of Instructor

Corequisites: There are no corequisites for this course.
Surveys the fundamentals of sustainability in scientific, technical, and social contexts. Introduces students to the history of environmentalism and sustainability, along with the basics of ecology, climate assessment, natural cycles, life-cycle analysis, environmental economics, and other concepts.

GS 161 Comparative Politics 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the politics and government of numerous countries around the world. Explores the concepts and principles of comparative political analysis.

GS 163 International Relations 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes the structures, actors, and major problems of the international political system.

GS 185 Introduction to Anthropology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines human adaptation and diversity as well as the development and variety of economic, political, religious, family, gender and expressive institutions.

GS 191 Geography of Middle East 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the culture, landscape, and peoples of the Middle East and North Africa through discussion, maps, regional analysis, and visual presentations. Includes social issues and contemporary problems facing this area, from Afghanistan to Mauritania and all points between.

GS 207 Religion in China 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces students to China's "official" religions (Buddhism, Taoism, Islam, Protestantism, and Catholicism) and the rich faith-based belief systems that are prominent in contemporary China (Shamanism, local deities, etc.). (NOTE: Formerly Asian Religions and Philosophy)

GS 221 Colonial Latin America 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the history of Latin America from before the conquest to independence, with particular emphasis on social, economic, political, and cultural developments between 1492 and 1800.

GS 222 Modern Latin America 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the history of Latin America from independence (about 1810) to the present, with particular emphasis on the social, economic, political, and cultural developments of the past hundred years. Introduces major problems facing contemporary Latin

America, including the search for stable government, political violence, environmental degradation, and extreme poverty and inequality.

GS 223 World History since 1400 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the history and interaction of major world regions since about 1400, with particular emphasis on the development of global economic, political, and cultural networks in recent centuries.

GS 231 Global Writing & Intercultural Communication 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes rhetorical traditions and communication styles within and across diverse cultures as well as global uses of English. Introduces students to theories and practices for communicating and collaborating across languages and cultures.

GS 237 Science Fiction 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes literary techniques used for displacing historical reality into a cross-cultural perspective to create science fiction. Emphasizes science fiction's humanistic usefulness in examining human values from an "extra-species, extra-terrestrial" perspective and in assessing the effects of technology on varieties of belief structures and social institutions.

GS 243 Early European Music 4R#OL#4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys the early music of Europe in the Medieval, Renaissance, and early Baroque periods and explores problems of accessing musical practices distant and distinct from our own.

GS 291 World Geography 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the people and lands of the world through studies and concepts from human geography with emphasis on cultural landscape,, maps, and visual interpretation. Emphasis is placed on the culture regions of Africa, Europe, Asia, the Middle East, and the South Pacific.

GS 313 Contemporary Spain 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces historical, political, and above all cultural issues in Spanish society, beginning with an overview of Spain prior to the twentieth century, but concentrating on the period from 1975 to the present. Special emphasis on the unique characteristics of Catalonia, Galicia and the Basque Country. Taught in English.

GS 324 Brazil Since 1500 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Provides a basic understanding of Brazilian history, major political parties and issues, geography, economy, and major social and cultural phenomena. Explores the creation of a multicultural society, Brazil’s place in global systems, and other issues.

GS 327 Modern China 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores modern Chinese history from the Qing dynasty (1644-1911) to the present day.

GS 328 Pop Culture in China 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the production and consumption of pop culture in China including literature, music, film, and print media.

GS 330 Contemporary Global Film 3R-3L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines films outside of the Hollywood tradition with a consideration of the cultural, political, and economic influences that shape film.

GS 331 Irish Drama 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys Irish drama from about 1900 to the present.

GS 334 Travel in World Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a wide variety of literature—including some in translation—and emphasizes works that comment on travel, tourism, and the effects of colonialism.

GS 335 The Global Novel in the Twentieth Century 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores novels, written in or translated into English, by non-American authors. Provides students with multiple perspectives on different global cultures.

GS 336 Literature of War 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the influence of military engagements on individual writers. Analyzes literary works as responses to the cultural, psychological, and social impacts of war.

GS 337 Shakespeare's Europe 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies Shakespeare's representations of cultures outside of Britain, with attention to his source texts in other national literatures and historians' perspectives on the cities where the plays are set.

GS 338 Contemporary Arabic Literature in Translation 4R-OL-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers a range of literature and film by writers and filmmakers from North Africa, the Middle East, and the Arabic-speaking diaspora. Includes literature in translation by major authors of this genre and critical works by a number of scholars of Arabic literature.

GS 339 Contemporary Global Film 4R#OL#4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys world cinema, emphasizing the importance of situating films within their historical and cultural background as well as recognizing the tensions between art and business in the film industry and how that shapes the medium.

GS 343 Musics of the World 4R#OL#4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys the role of music in human cultures around the world and explores problems of accessing musical practices distant and distinct from our own, as well as thinking critically about those most familiar to us.

GS 350 International Trade & Globalization 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes the theory of international trade, trade policy, foreign exchange and the payments adjustment process, adjustment policies and multinational corporations.

GS 351 International Finance 4R-OL-4C
Prerequisites: SV 151 Principles of Economics 4R-OL-4C F,W,S or SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Studies the workings of international financial markets, the role of exchange rates in international trade and capital movement, and the effects of exchange rate volatility. Topics include exchange rates and the foreign exchange market, the balance of payments, parity conditions, the international monetary system, and international interdependence.

GS 352 Economic Growth & Development 4R-OL-4C
Prerequisites: SV 151 Principles of Economics 4R-OL-4C F,W,S or SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes the determinants of economic growth. Pays special attention to problems faced by developing nations and discusses the impact of globalization.

GS 361 Politics of the Global Economy 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes the political aspects of the global economy. Reviews the dominant theoretical approaches, concepts, and major issues in the international political economy.

GS 363 European Politics & Government 4R-OL-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the ideology, culture, political processes, institutions, and public policy of selected European political systems.

GS 366 The European Union 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the historical development of European integration and current EU institutions, politics, and policy.

GS 368 Tokyo (Travel Course) 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores Tokyo from its origins to contemporary place as a "global capital" through history, geography, and culture.

GS 379 Japanese Culture 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examine Japanese culture in various aspects (e.g., society, arts, history, education, media, and pop culture).

GS 380 Pop Culture in China 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the production and consumption of pop culture in China including literature, music, film, and print media.

GS 384 Japanese Society 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces contemporary Japan from an anthropological perspective with an emphasis on the contradictions between hyper-modernity and traditionalism.

GS 386 Hispanic Culture and Civilization (Latin America) 4R-OL-4C
Prerequisites: SP 213 Spanish for Engineers 4R-OL-4C S permission of instructor.
Corequisites: There are no corequisites for this course.
Introduces Hispanic culture and civilization from its origins to the present. Examines Hispanic Latin American societies through cultural expression, including literature, visual arts, music and film. Analyzes the diversity of cultural aspects of Spanish Latin America. Taught in Spanish.

GS 387 Hispanic Culture and Civilization (Spain) 4R-OL-4C
Prerequisites: SP 213 Spanish for Engineers 4R-OL-4C S permission of instructor.
Corequisites: There are no corequisites for this course.
Introduces Hispanic culture and civilization from its origins to the present. Examines Spanish society through cultural expression, including literature, visual arts, music and film. Analyzes the diversity of cultural aspects of Spain. Taught in Spanish.

GS 391 Contemporary Europe 4R-OL-4C
Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
Surveys the changes and dynamics confronting Europe in the 20th Century. The dissolution of empires and communism to the expanding European Union will be examined with maps, theories and concepts from political geography. Ethics and values related to territoriality, place, and culture will be examined.

GS 399 Special Topics 4R-OL-4C Arranged
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a selected topic in one of the HSS disciplines in depth. A particular offering may require a prerequisite or consent of the instructor.

GS 412 Topics in German Culture II 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores topics in German and European intellectual history as represented in literature, essay, and film. Same as GE412.

GS 422 Industrial Revolution in Global Context 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the changes in production, distribution, and consumption commonly known as the Industrial Revolution of the 18th and 19th centuries. Explores technological, economic, social, and cultural aspects of these changes, both in industrialized countries and in other parts of the world.

GS 425 Cities & Technology in the Industrial Age 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores development of cities and the machines and systems that make them possible as human life became more and more urban and industrial from 1700 to the present. Compares urban growth and city life in different parts of the world.

GS 429 Greek and Roman Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines drama in the classical world with special emphasis on the ways it was produced, staged, and acted. Close reading of plays by the Greek and Roman dramatists in translation.

GS 430 World Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines drama from multiple cultures and time periods through a thematic lens.

GS 431 Literary London 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Considers literary depictions of London, a highly symbolic and frequently used setting in 19th, 20th, and 21st century British literature. Covers a broad range of literary texts set in the city, including works by major authors of this genre and a number of recent works by ethnic minority writers.

GS 432 Literature & Film of the Global Economy 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Focuses on contemporary fictional and non-fictional narratives that address economic interdependence between nation states. Employs an interdisciplinary approach to contextualize these narratives.

GS 442 Art History: Renaissance to Modern 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the creation and uses of visual art by world civilizations from the Renaissance to the present. Studies the cultural evolution brought about by scientific and technological changes which culminate in the Modern and Post-Modern eras.

GS 462 Transnational and Postcolonial Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines works by transnational and postcolonial writers and theorists, and covers contemporary human rights and anti-colonial/anti-globalization movements.

GS 469 Contemporary British Fiction & Film 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers fiction and film produced in the British Isles during the last half of the 20th and the beginning of the 21st century, including works by both canonical and non-canonical authors. Includes readings about a number of pressing issues in contemporary Britain, and focuses on literary responses to race and class concerns.

GS 470 Japanese Media 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores historical and contemporary media-related Japanese culture, both in visual and text communications.

GS 485 Seminar on Japanese Society 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Provides students a firm grounding in Western intellectual engagement with Japan, particularly from an anthropological perspective. Considers how Japan has been created and framed as a site of study through close readings of relevant ethnographic literature.

GS 491 Geography of Europe 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the culture, landscape, and peoples of Europe through discussion, maps, regional analysis, and visual presentations. Includes social issues and contemporary problems facing the Europeans, from Russia to Ireland and all points between.

GS 492 Geography of Africa 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Introduces the culture, landscape, and peoples of Africa south of the Sahara Desert through discussion, maps, regional analysis, and visual presentations. Includes social issues and contemporary problems facing this area, from South Africa to Senegal and all points between.

GS 496 Senior Project in International Studies 2C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Guided study, research, and analytical writing on a topic in international studies, integrating knowledge gained from international experience and/or from course work in the major.

GS497 Senior Project in International Studies 2C
Prerequisites: GS 496 Senior Project in International Studies 2C S
Corequisites: There are no corequisites for this course.
Guided study, research, and analytical writing on a topic in international studies, integrating knowledge gained from international experience and/or from course work in the major.

GS 499 Directed Study 4R-OL-4C Arranged
Prerequisites: Consent of the Instructor and HSS Department Head
Corequisites: There are no corequisites for this course.
Allows for individual study of an HSS topic selected by the instructor and the student(s). A plan of study, regular meetings with the instructor, and a major term project are required.

GS CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complementary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

IA 101 Introduction to Philosophy 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the student to the methods and subject matter of philosophy through a selective consideration of fundamental philosophical problems such as the nature of reality, the existence of God, the criteria of knowing, and the basis of morality.

IA 142 Drawing 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the student to drawing as a basis of personal expression. Exposes the student to a range of tools, techniques, and attitudes.

IA 148 Beginning Photography 4R-OL-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the student to historical aspects of photography, the impact of the visual image in modern culture, and photography as a medium of individual expression.

IA 180 Introduction to Islam 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the major figures, tenets, and cultural adaptions of Islam from Muhammad to the present day.

IA 230 Fundamentals of Public Speaking 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the thought processes necessary to organize speech content. Analyzes components of effective delivery and language. Provides practice in a variety of speech types, such as special occasion speeches, informative presentations, and persuasive speeches, as well as impromptu speaking.

IA 231 Introduction to Poetry 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Provides students with the means for understanding and appreciating poetry. Focuses on tone, speaker, figurative language, verse forms, and structure in poems from a variety of historical periods.

IA 232 African American Music in American Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys the history of African-American music, from slavery to the present, and considers the ways in which writers have adapted different musical styles into their work. Includes--but is not limited to--readings on spirituals, blues, jazz, funk, and hip-hop; written works will include nonfiction, novels, poetry, short stories, and drama.

IA 233 World Literatures 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines literary texts and their historical contexts across boundaries of language, culture, and ethnicity.

IA 234 Major American Writers 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers a broad range of American novelists and poets, with special attention to their roles in major literary movements such as romanticism, naturalism, and modernism.

IA 235 Major British Writers 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines well-known British writers, placed against the historical backgrounds of their times. Poetry, drama, fiction, and non-fiction from such famous writers as Chaucer,

Spenser, Shakespeare, Milton, Swift, Pope, Johnson, Wordsworth, Bronte, Browning, Joyce, Lawrence, Auden, and Beckett will be studied.

IA 236 Communicating STEM to a Public Audience 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the role of scientists and engineers as public intellectuals who can influence policy and public understanding. Emphasizes strategies for communicating technical knowledge to public audiences through popular media.

IA 237 Introduction to Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Traces the development of drama by analyzing representative plays from historical periods and from different cultures. Analyzes how, and why, drama has changed over time and how individual plays mirror their times and cultures.

IA 238 African American Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys African-American literature, history, and culture from the Colonial era to the present day.

IA 239 Introduction to Science, Technology and Society 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Investigates the relationships of scientific research and technological development to cultural, historical, and social contexts and values.

IA 240 Introduction to Shakespeare 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies Shakespeare’s histories, comedies, tragedies, and romances. Focuses on close textual reading of selected plays within the intellectual framework of his era.

IA 241 IIntroduction to Film Studies 3R-3L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers the formal elements of film and provides a vocabulary for analyzing film. Introduces film theory and criticism.

IA 244 Design & Color 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores visual design and communication, creative problem solving, color theory and aesthetics. Students engage in problem-solving to create projects using a variety of materials.

IA 246 Music Theory I: Fundamentals of Tonal Music 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Teaches basic techniques of music notation and analysis of melody, harmony, rhythm, form, and style. Includes a comprehensive Analysis Project.

IA 299 Introduction to Theater Arts 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the whole mechanism of the modern theater and how it works, including principles and theories of theatrical art: production, direction, acting, scenic design, costume design, lighting design, makeup, sound and multimedia, and theater architecture.

IA 302 Philosophy of Religion 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the basic philosophical problems found in religion. Deals specifically with the nature of religion, the nature and existence of God, religious language, and the religious life.

IA 311 Topics in German Culture I 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a variety of historical and contemporary issues in German popular and high culture. Same as GE311.

IA 325 Islam and Muslim Groups in China 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the localization of Islam among China's ten officially recognized Muslim ethno-national groups.

IA 328 Ethnicity & the State in China 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces students to the concepts of ethnic group, ethnicity, and nationalism and explores how ethnonational identity is institutionalized, constructed, and negotiated in contemporary China.

IA 330 Documentary Film 3R-3L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the development, contexts, generic conventions, and social functions of documentary film

IA 331 American Modernism 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores texts published in the first half of the twentieth century, what is commonly called the "Modernist" era. Focuses primarily on written works in different genres, but also covers music, film, visual arts, and other media.

IA 332 Don Quixote 4R-OL-4C
Prerequisites: There are no prerequisites for this course.

Corequisites: There are no corequisites for this course.
Studies Cervantes’ masterwork in translation and its relationship to the society and literature of its day as well as its relevance to our own. Taught in English.

IA 333 Representations & Redefinitions of Reality 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines representative pieces of philosophy, literature, and popular culture that all seek to represent and--in some cases--redefine the notion of "reality."

IA 334 Creative Writing 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces students to writing in genres such as poetry, short fiction, literary nonfiction, and drama. Employs a variety of writing and revision techniques to assist students in producing a portfolio of their work.

IA 335 Bible as Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the Hebrew Bible and the New Testament as literary texts. Emphasizes the variety of genres employed in biblical literature and introduces students to different approaches appropriate to literary interpretation.

IA 336 Mystery & Horror Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the development, contexts, generic conventions, and social functions of modern horror and detective fiction from their roots in European Gothic traditions to the present.

IA 337 European Romanticism 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covers major authors and themes in European Romantic literature from 1770-1830, as well as its repercussions and transformations.

IA 338 Medicine in Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines images of patients, doctors, and other medical professionals as constructed in literary works. Explores medical and ethical issues as represented in both classic and current fiction.

IA 339 Rebellion in American Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines American literary and historical texts that use rebellion against different kinds of authority--governmental, social, cultural, artistic, personal--as their central subject, motif, and / or theme. Includes readings from the Colonial era to the present day.

IA 340 Ethics in Human Communication 4R-OL-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the interconnection between ethics and rhetoric by studying such topics as persuasion versus propaganda, manipulation and distortion through language, leadership and communication, manifestations of prejudice (racism and sexism), language of intimidation and oppression, dehumanizing communication, effects of advertisement, and the content and effectiveness of professional codes for ethical communication.

IA 342 Modern Southern Fiction 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the major writers of the American South (both the modern and contemporary periods). Emphasizes recurrent social themes and fictional methods.

IA 343 Visual Rhetoric and Graphic Novels 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the relationships between art and argument in comic books and graphic novels. Provides a vocabulary for students to discuss, analyze, and produce graphic communication, including the creation of their own minicomic. (No drawing skills required).

IA 344 Writing in a Digital Age 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the influence of digital technologies on the ways we read, produce texts, and interact. Emphasizes strategies for producing new media texts, such as podcasts, blogs, infographics, and “viral” videos.

IA 346 Music Theory II: Basic Form and Composition 4R-OL-4C
Prerequisites: IA 246 Music Theory I: Fundamentals of Tonal Music 4R-OL-4C S or consent of instructor
Corequisites: There are no corequisites for this course.
Applies notational and analytical techniques to arranging/composing tasks, using music notation software.

IA 348 Music Performance 1R-0L-1R
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Applies music skills in performance groups for music minors. May be repeated up to 4 hours.

IA 350 Intermediate Microeconomics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes optimal choice, and the conditions required for efficient exchange in market economies. Emphasizes rational choice theory as it applies to consumers and businesses, with complementary examination of uncertainty, anomalous features of actual market behavior.

IA 351 Intermediate Macroeconomics 4R-OL-4C
Prerequisites: SV 151 Principles of Economics 4R-OL-4C F,W,S or SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Studies the economy as a whole, including factors affecting economic growth, unemployment and inflation. Explains economic events and considers how policies affect economic performance.

IA 352 Game Theory IA 352 Game Theory 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduces techniques used to solve strategic games encountered in business and economics. Analyzes behavior of economic agents in various situations including single and repeated games with perfect and imperfect information.

IA 353 History of Economic Thought 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S, SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Surveys the history of economic thought and examines the literature of economics from rhetorical, historical, and methodological perspectives using original sources.

IA 371 Cognitive Psychology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores how the mind works using experimental findings and psychological models. Topics include perception, attention, memory, reasoning, decision-making and language.

IA 380 Literature and Human Rights in Latin America 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores testimonial narratives, which give a “voice to the voiceless,” allowing marginalized peoples to bear witness to human rights abuses. Examines testimonial narratives in terms of historical context, structure, narrative voice, and effectiveness in addressing situations of oppression and violence. Taught in English.

IA 388 Food, Culture, and the Self 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines food as a focus for deeper inquiry into culture, identity, national development, globalization and social change.

IA 389 Anthropology of Addiction 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the concept of addiction – a frequently used yet rather imprecise term -- from a variety of perspectives to better understand this complex term and cultural concept.

IA 399 Special Topics 4R-OL-4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a selected topic in one of the HSS disciplines in depth. A particular offering may require a prerequisite or consent of the instructor.

IA 401 Philosophy of Science 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a range of philosophical questions about the methods, foundations, assumptions, and scope of science, including: How does science work? Can science reveal truths about the structure of the world? What is the scientific method and how is it different from other forms of knowledge acquisition, such as philosophy? What is a scientific explanation? What counts as evidence for a theory? What are scientific laws? These and other questions will be explored by engaging with a variety of classical and contemporary philosophical texts and arguments

IA 431 History of the American Novel 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies the novel in America from its early examples into the present. Emphasizes influential novels with historical and societal impact, placing more recent novels into historical context.

IA 433 Film Adaptations: From Text to Screen 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines decisions made by screenwriters and filmmakers when adapting works of fiction or autobiography for the screen. Considers how the original texts (primarily classics of American and British literature) are transformed into a medium relying on images and sound as well as language.

IA 436 Reinterpretations of Literary Themes 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines pieces of literature which rework the themes, characters and/or plots of other works to show how different authors from different times and cultures reinterpret earlier works in their own way.

IA 450 Mathematical Economics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S, SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Illustrates the use of mathematics in economic analysis. Includes discussion of mathematical programming, decision theory, the applications of differential and integral calculus, differential and difference equations.

IA 463 Seminar on America's Future 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the key political, economic, and security challenges facing the United States in a changing global environment.

IA 471 Computational Psychology 4R-OL-4C
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
Explores computational principles that can be used to explain human learning and develop intelligent machines. Includes programming assignments.

IA 499 Directed Study 4R-OL-4C Arranged
Prerequisites: Consent of the Instructor and HSS Department Head
Corequisites: There are no corequisites for this course.
Allows for individual study of an HSS topic selected by the instructor and the student(s). A plan of study, regular meetings with the instructor, and a major term project are required.

IA CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complementary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

JP 111 Japanese Language and Culture I 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provide elementary training in speaking, listening, reading and writing Japanese. Three types of characters, Hiragana, Katakana, and Kanji will be introduced as well as fundamental linguistic forms and functions of modern Japanese.

JP 112 Japanese Language and Culture II 4R-OL-4C W
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provide elementary training in speaking, listening, reading and writing Japanese. Three types of characters, Hiragana, Katakana, and Kanji will be introduced as well as fundamental linguistic forms and functions of modern Japanese.

JP 113 Japanese Language and Culture III 4R-OL-4C S
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provide elementary training in speaking, listening, reading and writing Japanese. Three types of characters, Hiragana, Katakana, and Kanji will be introduced as well as fundamental linguistic forms and functions of modern Japanese.

JP 211 Japanese Language and Culture IV 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.

Provides further training in speaking, listening, reading and writing Japanese. More advanced aspects of modern Japanese such as honorific and humble forms, empathic expressions, casual speech, and male and female speech are examined.

JP 212 Japanese Language and Culture V 4R-OL-4C W
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides further training in speaking, listening, reading and writing Japanese. More advanced aspects of modern Japanese such as honorific and humble forms, empathic expressions, casual speech, and male and female speech are examined.

JP 213 Japanese Language and Culture VI 4R-OL-4C S
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides further training in speaking, listening, reading and writing Japanese. More advanced aspects of modern Japanese such as honorific and humble forms, empathic expressions, casual speech, and male and female speech are examined.

JP 311 Japanese Language and Culture VII 4R-XL-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Further develops reading, writing, and speaking skills. Students learn technical terms by participating in engineering laboratory with Japanese students. Includes cultural field trips and company visits. [This course is offered as a summer program at Kanazawa Institute of Technology.]

JP 312 Japanese Language and Culture VIII 4R-XL-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Further develops reading, writing, and speaking skills. Students learn technical terms by participating in engineering laboratory with Japanese students. Includes cultural field trips and company visits. [This course is offered as a summer program at Kanazawa Institute of Technology.]

JP 313 Japanese Language and Culture IX 4R-XL-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Further develops reading, writing, and speaking skills. Students learn technical terms by participating in engineering laboratory with Japanese students. Includes cultural field trips and company visits. [This course is offered as a summer program at Kanazawa Institute of Technology.]

JP 411 Japanese Language and Culture X 4R-0L-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Develops advanced language communications skills. Presents further cultural aspects of contemporary Japanese. Introduces reading and writing of scientific Japanese. [This course is offered as a summer program at Kanazawa Institute of Technology.]

JP 412 Japanese Language and Culture XI 4R-0L-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Develops advanced language communications skills. Presents further cultural aspects of contemporary Japanese. Introduces reading and writing of scientific Japanese. [This course is offered as a summer program at Kanazawa Institute of Technology.]

JP 413 Japanese Language and Culture XII 4R-0L-4C S (Through Study Abroad Program)
Prerequisites: Preceding course
Corequisites: There are no corequisites for this course.
Develops advanced language communications skills. Presents further cultural aspects of contemporary Japanese. Introduces reading and writing of scientific Japanese. [This course is offered as a summer program at Kanazawa Institute of Technology.]

RH 131 Rhetoric & Composition 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Emphasizes rhetorical analysis oftexts and images,research methods, and theconventions of academic writing, including argumentation.

RH 330 Technical & Professional Communication 4R-OL-4C
Prerequisites: RH 131 Rhetoric & Composition 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Provides students with instruction and practice in analyzing contexts, audiences, and genres; crafting documents to meet the demands and constraints of professional situations; integrating all stages of the writing process; and collaborating effectively within and across teams.

SP 111 Spanish Language and Culture I 4R-OL-4C F
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary and intermediate training in oral/aural skills, reading, and writing Spanish. Enhances grammar presentations by means of appropriate readings that show the relationship between language and culture.

SP 112 Spanish Language and Culture II 4R-OL-4C W
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary and intermediate training in oral/aural skills, reading, and writing Spanish. Enhances grammar presentations by means of appropriate readings that show the relationship between language and culture.

SP 113 Spanish Language and Culture III 4R-OL-4C S
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Provides elementary and intermediate training in oral/aural skills, reading, and writing Spanish. Enhances grammar presentations by means of appropriate readings that show the relationship between language and culture.

SP 211 Spanish Language and Culture IV 4R-OL-4C F

Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Stresses conversational skills and intensive first year grammar review. Intermediate reading and discussion of texts on contemporary issues and cultural topics from Latin America and Spain.

SP 212 Spanish Language and Culture V 4R-OL-4C W
Prerequisites: Preceding course or placement by examination.
Corequisites: There are no corequisites for this course.
Stresses conversational skills and intensive first year grammar review. Intermediate reading and discussion of texts on contemporary issues and cultural topics from Latin America and Spain.

SP 213 Spanish for Engineers 4R-OL-4C S
Prerequisites: SP 212 Spanish Language and Culture V 4R-OL-4C W or placement by examination
Corequisites: There are no corequisites for this course.
Stresses language skills useful for the engineering profession. Provides training in advanced reading, writing and conversation with emphasis on the use of language in a professional context.

SV 130 Introduction to Disability Studies 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces disability studies, a multi-disciplinary field that identifies, challenges, and re-conceptualizes representations of disability. Topics may include disability history and policy, activism, bioethics, and the role of technology and engineering in our perceptions of disability.

SV 134 Popular Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes texts written for mass consumption, such as detective novels, horror stories, fantasy fiction, and contemporary thrillers. Explores these literary genres' conventions, traditions, and sociohistorical contexts.

SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes the market behavior of buyers and sellers. Topics include demand and supply, costs, competition, oligopoly, monopoly, economic efficiency and resource allocation, the effects of government intervention, and international trade. A student cannot take both SV 150 and SV 151, Principles of Economics, for credit.

SV 151 Principles of Economics 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Includes both microeconomics and macroeconomics. Analyzes market behavior. Considers production and pricing decisions under alternative industrial structures. Examines the determinants of economic growth, unemployment and inflation, including fiscal and monetary policy.

SV 152 Introduction to Macroeconomics 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes the performance of the entire economy. Topics include demand and supply, GDP, unemployment and inflation, the impact of monetary and fiscal policy, business cycles, determinants of economic growth, and international finance. A student cannot take both SV 152 and SV 151, Principles of Economics, for credit.

SV 166 American Politics and Government 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the ideology, culture, political processes, institutions, and public policy of the American democratic system.

SV 171 Introduction to Psychology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
A broad survey of the scientific study of mind and behavior. Topics include learning, perception, emotion, motivation, memory, childhood development, personality, social behavior, and psychological disorders.

SV 188 Introduction to Sociology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the foundations of sociology, paying particular attention to how humans shape and give meaning to the world in which we live.

SV 191 Cultural Geography 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores themes, topics, and concepts in cultural geography studies with examples from a diversity of world areas. Included are studies and examples from language, religion, settlement, ethnicity, agriculture, urbanization, population, and popular culture.

SV 201 Religion & Ecology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines religious and cultural beliefs, texts, and practices relating to the natural world, focusing primarily on historical transvaluations of the concept of nature.

SV 231 Introduction to Short Fiction 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Guides students in reading, appreciating, and analyzing a range of short fiction. Gives special attention to how reading such fiction can help us better understand ourselves and our relationships to the societies in which we live.

SV 232 Introduction to Non-Fiction 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Guides students in learning about human interactions by reading, appreciating, and analyzing contemporary non-fiction works. Includes both general essays and science and nature writing.

SV 233 Survey of American Lit 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies a broad range of American literature since the Civil War. Examines a variety of authors and genres (fiction, poetry, prose, nonfiction).

SV 234 The American Dream 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes representations of the American Dream in fictional and non-fictional narratives through a cultural studies approach.

SV 242 Visual Arts in Civilization 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Investigates the purposes and uses of art in civilizations with an emphasis on art appreciation. Aesthetic and historical issues are explored to reveal how art makes worldviews tangible.

SV 244 Western Music in the Baroque, Classical, Romantic Eras 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys composers, events, and genres of western art music in the “common practice period” and their contexts in world history.

SV 245 Western Music in the 20th Century 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys composers, events, and genres in the Modern and Postmodern periods and their contexts in world history.

SV 246 Popular Music in the Era of Recorded Sound 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys the impact of audio recording revolutions of the 20th century on American popular music and explores relationships between technology and its competing and complementary human interests, such as aesthetics, politics, tradition, commerce, law, ethics, among many others.

SV 291 Medieval Europe 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the settlement, state and nation building, trade, innovation, and peopling of Europe from the age of Vandals, Goths, and Vikings to the Renaissance. Emphasizes wars, revolts, power and society in transforming the map of Europe through studies of historical geography.

SV 303 Business & Engineering Ethics 4R#OL#4C

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the ethical issues faced by professional businesspeople and engineers working in a global corporate context. Issues include the development and use of codes of professional ethics, the social responsibilities of corporations, the autonomy of professionals, whistleblowing and corporate loyalty, environmental obligations of corporations and professionals, standards of conduct in international business, and the impact of technology on our world.

SV 304 Bioethics 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines the major moral issues in the development and practice of biomedicine and biomedical research through the analysis of philosophical and ethical theory as well as analysis of real cases of morally questionable practice in biomedicine. Topics include the autonomy and rights of patients, physicians, and researchers, informed consent and experimentation with humans and animals, the moral status of genetic and reproductive controls and interventions, the extension and termination of life, and the allocation of scarce medical resources.

SV 322 Disasters & Modern Society 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines how people at different times and places have tried to explain and prevent natural and technological disasters, and how those disasters have influenced the development of modern society. Explores how societies have thought about nature and technology, measured costs in lives and property, and perceived obligations between rich and poor.

SV 332 Gender, Work & Popular Culture 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines popular culture representations of masculinity and femininity in the workplace. Employs an interdisciplinary cultural studies approach for analyzing gendered representations of work and how they intersect with topics such as technology, race, and class.

SV 334 Utopian Thought & Literature 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies varieties of utopian thought from a cross-cultural perspective.

SV 336 Contemporary American Fiction 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Analyzes the evolution of the American novel since 1945, with an emphasis on the historical context of late 20th-century American culture.

SV 337 20th-Century American Novel 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Examines the American novel with representatives of the major 20th century literary periods: realism, modernism, postmodernism. Examines the themes and issues addressed in different decades and from different perspectives.

SV 338 Latin American Fiction: The Boom & Beyond 0 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Studies writers associated with the “Boom” in Latin American fiction (the expanded popularity beginning in the 1960’s), along with their literary predecessors and descendents. Examines the relationship between literature and cultural context.

SV 339 Literature and the Environment 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Considers the relationship between art and the natural world. Readings may include myths and poems, travel and adventure narratives, activist projects and manifestoes, and scientific and philosophical essays, drawn from a variety of cultural traditions.

SV 340 American Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys American drama from the colonial period to the present.

SV 341 African-American Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys African-American drama from the early 19th century to the present.

SV 342 Modern European Drama 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Surveys modern European drama from about 1870 to the present.

SV 345 Presidential Election Rhetoric 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Increases students’ awareness and understanding of the U.S. Presidential election process, candidates, campaign issues, campaign advertising, debates, and the role of the news media. Focuses on analyzing and producing rhetoric associated with presidential campaigns.

SV 351 Managerial Economics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Applies economic analysis to the management of modern business enterprise. Emphasizes demand estimation, business forecasting, uncertainty, investment decisions, capital budgeting, and pricing strategies. Students should have some knowledge of business statistics.

SV 352 Money & Banking 4R-OL-4C

Prerequisites: SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Examines the nature and functions of financial markets and institutions. Analyzes the determination of interest rates and the processing of information. Considers the relationship between the financial system and the macroeconomy.

SV 353 Industrial Organization 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Examines the influence of market structure and competition policy on business firms' decisions. Discusses modern theories of the firm, implications of market power, strategic interaction, merger and acquisition activity, antitrust policy and regulation.

SV 354 Environmental Economics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes the consequences of pollution and discusses possible solutions to reduce pollution. Introduces analytical tools used in environmental planning. Performs benefit-cost analyses of regulations dealing with air, water, and solid waste pollution.

SV 355 Health Economics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes demand and supply of health care and the roles of medical technology and health insurance. Studies the behavior of physicians, the use of paramedics, preventive care, and outpatient care. Examines the rising cost of health care and analyzes appropriate public policy responses.

SV 356 Corporate Finance 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S, SV 151 Principles of Economics 4R-OL-4C F,W,S or SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduces managerial finance. Examines the valuation of assets, the cost of capital, capital structure, working capital management, planning and budgeting, and long-term financing.

SV 357 Labor Economics 4R-OL-4C
Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Analyzes labor markets with theoretical, empirical, and policy applications. Explains the determination of employment and wages. Studies compensating wage differentials, labor market discrimination, labor unions and theories of unemployment.

SV 369 British Politics & Government 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.

Examines the historical development, ideology, culture, political processes, institutions, and public policy of the political system of the United Kingdom.

SV 371 Social Psychology 4R#OL#4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores how people's behavior, feelings, and thoughts are influenced by their social environments. Topics include attitude formation, prejudice, relationships, group behavior, conformity, altruism, and aggression.

SV 373 Abnormal Psychology 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Explores the diagnosis, causes, and treatments of psychological disorders.

SV 386 Human Evolution 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines human origins and evolution, the fossil record, and genetics; compares human behavior with other primates; and explores the extent and causes of human physical diversity.

SV 389 Anthropology of Sports 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces the study of sport through a critical anthropological lens. Sport is used to contextualize gender, health, technology, ethnic difference, nationalism, sexuality, and socioeconomic class.

SV 399 Special Topics 4R-OL-4C Arranged
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines a selected topic in one of the HSS disciplines in depth. A particular offering may require a prerequisite or consent of the instructor.

SV 402 Human Nature 4R#OL#4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Examines what it means to be human by examining major philosophical texts in the Western tradition in conjunction with recent developments in psychology and cognitive science. The central issues include happiness and the good life, morality, justice, and the structure of human social institutions.

SV 413 Contemporary Germany 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces historical, political, and cultural issues in German society from 1945 to the present. Compares German to European developments. Same as GE413.

SV 450 Econometrics 4R-OL-4C F (odd years)

Prerequisites: SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S, SV 152 Introduction to Macroeconomics 4R-0L-4C F,W,S or SV 151 Principles of Economics 4R-OL-4C F,W,S
Corequisites: There are no corequisites for this course.
Applies statistical methods to problems of economic analysis. Stresses the use of regression analysis in economic research and discusses the special problems encountered in empirical investigation of economic phenomena. In addition to SL 151, the student should have some knowledge of statistics.

SV 472 Studying Human Behavior 4R-OL-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduces students to the methods of behavioral science by having them design, run, and analyze actual psychology experiments.

SV 499 Directed Study 4R-OL-4C Arranged
Prerequisites: Consent of the Instructor and HSS Department Head
Corequisites: There are no corequisites for this course.
Allows for individual study of an HSS topic selected by the instructor and the student(s). A plan of study, regular meetings with the instructor, and a major term project are required.

SV CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

XX 456 Seminar for HSS Senior Project 2R-OL-2C F
Prerequisites: Economics or International Studies major and Junior or Senior standing, or permission of instructor
Corequisites: There are no corequisites for this course.
Reviews methodologies employed in Economics and/or International Studies, and directs students toward approval of a senior project proposal. Required of all Economics and International Studies majors and double majors.

XX 457 Directed Study for HSS Senior Project 2R-OL-2C Arranged W.S
Prerequisites: XX 456 Seminar for HSS Senior Project 2R-OL-2C F
Corequisites: There are no corequisites for this course.
Directed study leading to completion of a senior project that demonstrates the ability to pursue independent intellectual inquiry. Required of all Economics and International Studies majors and double majors.

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Professors All, Bryan, Butske, Carlisle, Eichholz, Finn, Goulet, Green, Grimaldi, Heyman, Holden, A. Holder, L. Holder, Inlow, Kozai, Langley, Leader, McSweeney, Minevich, Rader, Reyes, Rickert, Riehl, Shibberu, Tarrant, Weyand and Williams.

Mathematics - Course Descriptions

MA 101 Introduction to Engineering Mathematics 4R-1L-4C F
Prerequisites: Permission of department head
Corequisites: There are no corequisites for this course.
Introductory differential calculus with an emphasis on applications and modeling. Limits, continuity, differentiation, and antidifferentiation, culminating in definite integration and the Fundamental Theorem of Calculus. Parametric curves. L'Hopital's Rule. Newton's Method. Class will meet for a two-period session once per week, alternating laboratory work with a recitation period. Students may not receive credit towards graduation for both MA101 and MA111.

MA 102 Introduction to Engineering Mathematics II 4R-1L-4C W
Prerequisites: MA 101 Introduction to Engineering Mathematics 4R-1L-4C F
Corequisites: There are no corequisites for this course.
Integral calculus techniques with an emphasis on their use in compartment, conservation, and circuit models. Separable and linear first order differential equations. Improper integrals. Infinite series, including power and Taylor series. Numerical integration. Class will meet for a two-period session once per week, alternating laboratory work with a recitation period. Students may not receive credit towards graduation for both MA102 and MA112.

MA 103 Applied Multivariate Calculus 4R-1L-4C S
Prerequisites: MA 102 Introduction to Engineering Mathematics II 4R-1L-4C W, and ENGD 100 Engineering Design Studio I 6R-10L-8C F
Corequisites: There are no corequisites for this course.
Matrices and vectors. Projectile motion. Scalar fields and vector fields. Multiple integrals. Partial derivatives, the gradient, extrema of functions of several variables. Arclength. Cylindrical and spherical coordinate systems. Class will meet for a two-period session once per week, alternating laboratory work with a recitation period. Students may not receive credit towards graduation for both MA103 and MA113.

MA 111 Calculus I 5R-0L-5C F,W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Calculus and analytic geometry in the plane. Algebraic and transcendental functions. Limits and continuity. Differentiation, geometric and physical interpretations of the derivative, Newton's method. Introduction to integration and the Fundamental Theorem of Calculus.

MA 112 Calculus II 5R-0L-5C F,W,S
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W
Corequisites: There are no corequisites for this course.
Techniques of integration, numerical integration, applications of integration. L'Hopital's rule and improper integrals. Separable first order differential equations, applications of

separable first order differential equations. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series.

MA 113 Calculus III 5R-0L-5C F,W,S
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Vectors and parametric equations in three dimensions. Functions of several variables, partial derivatives, maxima and minima of functions of several variables, multiple integrals, and other coordinate systems. Applications of partial derivatives and multiple integrals.

MA 190 Contemporary Mathematical Problems 2R-0L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: MA 113 Calculus III 5R-0L-5C F,W,S
A seminar-style course consisting of an overview of selected contemporary problems and areas in the mathematical sciences. Problems to be discussed will be selected from recent publications in research and applications, famous problems, and outstanding problems of great significance.

MA 200 Career Preparation 1R-0L-1C W
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for mathematics majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. Cross-listed with CHEM 200 and PH200.

MA 201 Applied Dynamical Systems I 4R-1L-4C F
Prerequisites: MA 103 Applied Multivariate Calculus 4R-1L-4C S
Corequisites: There are no corequisites for this course.
Scalar linear differential equations; characteristic equation, undetermined coefficients, variation of parameters. Power series solutions. Gaussian elimination and properties of matrices. Euler’s formula. Systems of linear differential equations; eigenvalues and eigenvectors, undetermined coefficients. Applications to compartment models and electrical circuits. Class will meet for a two-period session once per week, alternating laboratory work with a recitation period. Students may not receive credit towards graduation for both MA201 and MA211.

MA 202 Applied Dynamical Systems II 4R-1L-4C W
Prerequisites: MA 201 Applied Dynamical Systems I 4R-1L-4C F
Corequisites: There are no corequisites for this course.
Diagonalization and the matrix exponential. Stability of linear and nonlinear systems. Phase portraits. Numerical methods. Fourier series, with applications to solving differential equations. Class will meet for a two-period session once per week, alternating laboratory work with a recitation period. Students may not receive credit towards graduation for both MA202 and MA212.

MA 211 Differential Equations 4R-0L-4C F,W,S
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
First order differential equations including basic solution techniques and numerical methods. Second order linear, constant coefficient differential equations, including both

the homogeneous and non-homogeneous cases. Laplace transforms, Introduction to complex arithmetic, as needed. Applications to problems in science and engineering.

MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Basic matrix algebra with emphasis on understanding systems of linear equations from algebraic and geometric viewpoints, and eigenvalues and eigenvectors. Solution of systems of first order linear differential equations by eigensystems and investigation of their solution structure determined by eigensystems. Phase portrait analysis and classification of the nature of the stability of critical points for linear and nonlinear systems. Fourier series. Introduction to complex arithmetic, as needed. Applications to problems in science and engineering.

MA 223 Engineering Statistics I 4R-0L-4C F,W,S
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
This is an introductory course in statistical data analysis. Topics covered include descriptive statistics, introduction to probability concepts, and random variables. A Central Limit Theorem will be presented. Inference (hypothesis testing and confidence intervals) for one mean, two independent means, and two means from a paired sample will be covered. An introduction to one factor analysis of variance and simple linear regression will be presented. Time permitting, inference for a one proportion and one standard deviation/variance are discussed. Both classical methods for inference as well as modern resampling methods are presented. A computer package will be used for statistical analysis and simulation. Experimental data from a variety of fields of interest to the science and engineering majors enrolled will also be used to illustrate statistical concepts and facilitate the development of the student’s statistical thinking. A student cannot take both MA 223 and MA 382 for credit.

MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Prerequisites: MA 112 Calculus II 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to enumeration and discrete structures. Permutations, combinations and the pigeonhole principle. Elementary mathematical logic and proof techniques, including mathematical induction. Properties of the integers. Set theory. Introduction to functions.

MA 323 Geometric Modeling 4R-0L-4C W (Even years)
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Covers some of the mathematical methods for describing physical or virtual objects in computer aided geometric design (CAGD) and computer graphics. Emphasizes methods for curve and surface modeling, and discusses both the underlying geometric concepts and the practical aspects of constructing geometric models of objects. Topics covered include Bezier curves, Hermite curves, B-splines, Bezier patches, subdivision surfaces. In discussing these, ideas from analytic geometry, differential geometry, affine geometry, combinatorial geometry, and projective geometry will be introduced.

MA 325 Fractals and Chaotic Dynamical Systems 4R-0L-4C Arranged

Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Emphasis on the mathematical and computer graphics foundations behind fractal images and the relationship between chaotic dynamics and fractal geometry. Self-similar fractals, random fractals with Brownian motion, and fractals generated from dynamical systems. Fractal dimensions. Iterated function systems. Chaos in one-dimensional maps. Controlling chaos. Mandelbrot and Julia sets. Computer graphics. Same as CSSE 325.

MA 327 Low Dimensional Topology 4R-0L-4C W (odd years)
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
An introduction to the topology of one-, two-, and three-dimensional manifolds and its application to other areas of mathematics and science. Topics may include, but are not restricted to, classification of curves and surfaces, Euler characteristic, tiling and coloring theorems, graph embeddings, vector fields, knots and links, and elementary algebraic topology. Intended for science and engineering majors as well as mathematics majors.

MA 330 Vector Calculus 4R-0L-4C F,S
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Calculus of vector- valued functions of one and several variables. Topics include differentiation (divergence, gradient and curl of a vector field) and integration (line integrals and surface integrals). Applications of Green’s theorem, Stokes’ theorem and the divergence theorem to potential theory and/or fluid mechanics will be provided.

MA 332 Introduction to Computational Science 4R-0L-4C F,W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to Computational Science using Matlab. Floating point arithmetic, Matlab programming, solution of nonlinear equations, interpolation, least squares problems, numerical differentiation and integration, solution of linear systems.

MA 335 Introduction to Parallel Computing 4R-0L-4C S (odd years)
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S and programming experience
Corequisites: There are no corequisites for this course.
Principles of scientific computation on parallel computers. Algorithms for the solution of linear systems and other scientific computing problems on parallel machines. Course includes a major project on RHIT's parallel cluster. Same as CSSE 335.

MA 336 Boundary Value Problems 4R-0L-4C F,S
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.

Introduction to boundary value problems and partial differential equations. Emphasis on boundary values problems that arise from the wave equation, diffusion equation, and Laplace's equation in one, two and three dimensions. Solutions to such boundary value problems will be discussed using Fourier series, numerical techniques, and integral transforms.

MA 341 Topics in Mathematical Modeling 4R-0L-4C W
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to techniques of mathematical modeling involved in the analysis of meaningful and practical problems arising in many disciplines including mathematical sciences, operations research, engineering, and the management and life sciences. Topics may include creative and empirical model construction, model fitting, models requiring optimization, and modeling dynamic behavior. Student participation in significant individual and group projects will be emphasized.

MA 342 Computational Modeling 4R-0L-4C S
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either CHE 310 Numerical Methods for Chemical Engineers 4R-0L-4C W or CE 310 Computer Applications in Civil Engineering 2R-0L-2C S or MA 332 Introduction to Computational Science 4R-0L-4C F,W or ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Corequisites: There are no corequisites for this course.
Computational modeling and simulation of scientific problems using Matlab. Students will create and utilize computer-based models to solve practical problems. Monte Carlo methods, linear systems, solution of ODEs.

MA 351-6 Problem Solving Seminar 1R-0L-1C F,W,S
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
An exposure to mathematical problems varying widely in both difficulty and content. Students will be expected to participate actively, not only in the solution process itself but also in the presentation of finished work, both orally and in writing. A student may earn a maximum of six credits in MA 351-6. Cannot count toward mathematics major core hours or the math minor.

MA 366 Functions of a Real Variable 4R-0L-4C W
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W, and MA 113 Calculus III 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Calculus of functions of a single variable. A more careful development of the basic concepts of analysis, including sequences, limits, continuity, differentiability, integration, infinite series, power series, Taylor's Theorem, and uniform convergence.

MA 367 Functions of a Complex Variable 4R-0L-4C S
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.

Elementary properties of analytic functions including Cauchy's theorem and its consequences, Laurent series, the Residue Theorem, and mapping properties of analytic functions.

MA 371 Linear Algebra I 4R-0L-4C F,S
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
Similar to MA373, but with an emphasis on the theory behind matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Introduction to vector spaces. Some proof writing will be required. Those interested in applications of matrices and vector spaces should take MA373. A student cannot take both MA 371 and MA 373 for credit.

MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S or consent of instructor
Corequisites: There are no corequisites for this course.
Similar to MA 371, but with emphasis on applications of matrices and vector spaces. Systems of linear equations, Gaussian elimination, and the LU decomposition of a matrix. Projections, least squares approximations, and the Gram-Schmidt process. Eigenvalues and eigenvectors of a matrix. The diagonalization theorem. The singular value decomposition of a matrix. Those interested in the theory behind matrices and vector spaces should take MA 371. A student cannot take both MA 371 and MA 373 for credit.

MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
A continuation of MA 275. Relations. An introduction to finite state machines. More advanced enumeration techniques including recurrence relations, generating functions and the principle of inclusion and exclusion.

MA 376 Abstract Algebra 4R-0L-4C S
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
An introduction to Group Theory. Topics include: matrix groups, groups of integers modulo a natural number, symmetric and dihedral groups, homomorphisms, subgroups, cosets, quotient groups and group actions. Applications, possibly including games and puzzles, cryptography, and coding theory. Other topics may also be introduced according to time and student interest.

MA 378 Number Theory 4R-0L-4C S
Prerequisites: consent of instructor
Corequisites: There are no corequisites for this course.
Divisibility, congruences, prime numbers, factorization algorithms, RSA encryption, solutions of equations in integers, quadratic residues, reciprocity, generating functions, multiplicative and other important functions of elementary number theory. Mathematical conjecture and proof, mathematical induction.

MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Prerequisites: MA 113 Calculus III 5R-0L-5C F,W,S
Corequisites: There are no corequisites for this course.
Introduction to probability theory; axioms of probability, sample spaces, and probability laws (including conditional probabilities). Univariate random variables (discrete and continuous) and their expectations including these distributions: binomial, Poisson, geometric, uniform, exponential, and normal. Introduction to moment generating functions. Introduction to jointly distributed random variables. Univariate and joint transformations of random variables. The distribution of linear combinations of random variables and an introduction to the Central Limit Theorem. Applications of probability to statistics.

MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
This is an introductory course in statistical data analysis and mathematical statistics. Topics covered include descriptive statistics, sampling distributions (including the Central Limit Theorem), point estimation, hypothesis testing and confidence intervals for both one and two populations, linear regression, and analysis of variance. Emphasis will be placed on both data analysis and mathematical derivations of statistical techniques. A computer package will be used for statistical analysis and simulation. Experimental data from a variety of fields of interest will also be used to illustrate statistical concepts and facilitate the development of the student's statistical thinking. A student cannot take both MA 223 and MA 382 for credit.

MA 383 Engineering Statistics II 4R-0L-4C F
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Hypothesis testing, confidence intervals, sample size determination, and power calculations for means and proportions; two factor analysis of variance (with and without interactions); analysis of several proportions; confidence and prediction intervals for estimated values using simple linear regression; Pearson (linear) correlation coefficient; introduction to multiple regression to include polynomial regression; review of fundamental prerequisite statistics will be included as necessary.

MA 384 Data Mining 4R–0L–4C
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and either MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
An introduction to data mining for large data sets, include data preparation, exploration, aggregation/reduction, and visualization. Elementary methods for classification, association, and cluster analysis are covered. Significant attention will be given to presenting and reporting data mining results. Same as CSSE 384.

MA 385 Quality Methods 4R-0L-4C
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F

Corequisites: There are no corequisites for this course.
Introduction to various aspects of statistical quality control and statistical process control to include the following topics: importance of variance reduction and probability concepts influencing product quality and reliability; development and application of control charts (P-charts, NP-charts, C-charts, U-charts, individual's charts, moving range charts, X-bar and R as well as X-bar and S charts); process capability indices (their use and misuse); introduction to acceptance sampling. Other topics to be included as time allows: 6 sigma thinking, gauge reproducibility and repeatability, and total quality management with the philosophies of Deming, Juran, and Crosby. Review of fundamental prerequisite statistics will be included as necessary. Same as BE 385

MA 386 Statistical Programming 4R-0L-4C
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F and previous programming course
Corequisites: There are no corequisites for this course.
Computational data analysis is an essential part of modern statistics. This course provides a practical foundation for students to compute with data. This course will introduce students to tools for data management, manipulation and analysis that are common in statistics and data science. The R computing language will be introduced. Topics will include data structures in R, writing functions, webscraping, data cleaning (both quantitative and textual data), processing unstructured data, static and interactive graphical presentations of data, and coding of modern algorithms for data analysis (bootstrapping and Monte Carlo methods).

MA 387 Statistical Methods in Six Sigma 4R-0L-4C
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Corequisites: There are no corequisites for this course.
A course on statistical methods used in the Six Sigma /DMAIC (Define, Measure, Analyze, Improve, Control) paradigm. Topics will include, but are not limited to, gauge repeatability and reproducibility, control charts, regression, design of experiments, and response surface optimization.

MA 390 Topics in the Mathematics of Engineering 1-2C Arranged
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
A succinct mathematical study that is supportive of the engineering curricula. Topics could be chosen from signal processing, fluid dynamics, thermodynamics, as well as others. A student may take the course for credit more than once provided the topics are different.

MA 421 Tensor Calculus & Riemannian Geometry 4R-0L-4C Arranged
Prerequisites: MA 330 Vector Calculus 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
An introduction to the calculus of tensor fields and the local geometry of manifolds.Topics covered include: manifolds, tangent space, cotangent spaces, vector fields, differential forms, tensor fields, Riemannian metrics, covariant derivative and connections, parallel transport and geodesics, Ricci tensor, Riemannian curvature tensor. Applications will be given in physics (general relativity, mechanics, string theory) and engineering (continuum mechanics).

MA 423 Topics in Geometry 4R-0L-4C Arranged
Prerequisites: MA 371 Linear Algebra I 4R-0L-4C F,S or MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
An advanced geometry course with topics possibly chosen from the areas of projective geometry, computational geometry, differential geometry algebraic geometry, Euclidean geometry or non-Euclidean geometry. A student may take the course for credit more than once provided the topics are different.

MA 430 Topics in Applied Mathematics 4R-0L-4C Arranged
Prerequisites: Instructor permission
Corequisites: There are no corequisites for this course.
A topics course in the general area of continuous applied mathematics. Topics may include mathematical physics, mathematical biology, mathematical finance, mathematics of vision, PDEs, image processing methods, continuum mechanics, dynamical systems, and mathematical modeling. A student may take the course for credit more than once provided the topics are different.

MA 431 Calculus of Variations 4R-0L-4C Arranged
Prerequisites: MA 330 Vector Calculus 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Euler-Lagrange and Hamiltonian equations, with possible applications in mechanics, electrostatics, optics, quantum mechanics and elasticity theory. An introduction to “direct methods.” Applications will be chosen in accordance with the interest of the students. Both classical and numerical methods have their place in this course.

MA 433 Numerical Analysis 4R-0L-4C W
Prerequisites: MA 332 Introduction to Computational Science 4R-0L-4C F,W or MA 366 Functions of a Real Variable 4R-0L-4C W or MA 371 Linear Algebra I 4R-0L-4C F,S or MA 435 Finite Difference Methods 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Root-finding, computational matrix algebra, nonlinear optimization, polynomial interpolation, splines, numerical integration, numerical solution of ordinary differential equations. Principles of error analysis and scientific computation. Selection of appropriate algorithms based on the numerical problem and on the software and hardware (such as parallel machines) available.

MA 434 Topics in Numerical Analysis 4R-0L-4C Arranged
Prerequisites: MA 433 Numerical Analysis 4R-0L-4C W
Corequisites: There are no corequisites for this course.
An extension of the material presented in MA433. Topics may include numerical problems, numerical solution of partial differential equations (finite differences, finite elements, spectral methods), sparse matrices, global optimization, approximation theory. A student may take the course for credit more than once provided the topics are different.

MA 435 Finite Difference Methods 4R-0L-4C W
Prerequisites: MA 332 Introduction to Computational Science 4R-0L-4C F,W or MA 371 Linear Algebra I 4R-0L-4C F,S or MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W or MA 433 Numerical Analysis 4R-0L-4C W
Corequisites: There are no corequisites for this course.

An introduction to finite difference methods for linear parabolic, hyperbolic, and elliptic partial differential equations. Consistency, stability, convergence, and the Lax Equivalence Theorem. Solution techniques for the resulting linear systems.

MA 436 Introduction to Partial Differential Equations 4R-0L-4C F (even years)
Prerequisites: MA 330 Vector Calculus 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Partial differential equations, elliptic, hyperbolic, and parabolic equations. Boundary and initial value problems. Separation of variables, special functions. Eigenfunction expansions. Existence and uniqueness of solutions. Sturm-Liouville theory, Green's function.

MA 438 Advanced Engineering Mathematics 4R-0L-4C W
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S senior standing
Corequisites: There are no corequisites for this course.
A fast-paced course in advanced applied mathematics for engineering and physics students that combines aspects of MA330, MA336, and MA373. Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix and the del operator in standard coordinate systems; and Fourier series with application to the solution of partial differential equation boundary value problems. Students who receive credit for MA438 may only receive credit for at most one of MA330, MA336, MA371, and MA373.

MA 439 Mathematical Methods of Image Processing 4R-0L-4C F
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Mathematical formulation and development of methods used in image processing, especially compression. Vector space models of signals and images, one- and two-dimensional discrete Fourier transforms, the discrete cosine transform, and block transforms. Frequency domain, basis waveforms, and frequency domain representation of signals and images. Convolution and filtering. Filter banks, wavelets and the discrete wavelet transform. Application to Fourier based and wavelet based compression such as the JPEG compression standard. Compression concepts such as scalar quantization and measures of performance.

MA 444 Deterministic Models in Operations Research 4R-0L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either MA 371 Linear Algebra I 4R-0L-4C F,S or MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Formulation of various deterministic problems as mathematical optimization models and the derivation of algorithms to solve them. Optimization models studied include linear programs, integer programs, and various network models. Emphasis on model formulation and algorithm development "from the ground up."

MA 445 Stochastic Models in Operations Research 4R-0L-4C S (even years)

Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduction to stochastic mathematical models and techniques that aid in the decision-making process. Topics covered include a review of conditional probability, discrete and continuous Markov chains, Poisson processes, queueing theory (waiting line problems), and reliability.

MA 446 Combinatorial Optimization 4R-0L-4C S (even years)
Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
An introduction to graph- and network-based optimization models, including spanning trees, network flow, and matching problems. Focus is on the development of both models for real-world applications and algorithms for their solution.

MA 450 Mathematics Seminar 1R-0L-1C F,W,S
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
A student must attend at least 10 mathematics seminars or colloquia and present at one of the seminars, based on material mutually agreed upon by the instructor and the student. A successful presentation is required for a passing grade. As seminars may not be offered every week during the quarter a student may extend the course over more than one quarter, but it must be completed within two consecutive quarters. A student may take this course a maximum of four times.

MA 460 Topics in Analysis 4R-0L-4C Arranged
Prerequisites: Instructor permission
Corequisites: There are no corequisites for this course.
An advanced topics course in analysis. Topic of the course could be advanced topics in real analysis, advanced topics in complex analysis, analysis on manifolds, measure theory or an advanced course in applied analysis (differential equations). May be taken more than once provided topics are different

MA 461 Topics in Topology 4R-0L-4C Arranged
Prerequisites: MA 366 Functions of a Real Variable 4R-0L-4C W or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to selected topics from point-set topology or algebraic topology from a rigorous point of view. Possible topics include metric spaces, general topological spaces, compactness, connectedness, separation axioms, compactification and metrization theorems, homotopy and homology, and covering spaces. Intended for mathematics majors planning to pursue graduate study in mathematics.

MA 466 Introduction to Functional Analysis 4R-0L-4C Arranged
Prerequisites: MA 366 Functions of a Real Variable 4R-0L-4C W
Corequisites: There are no corequisites for this course.
An introduction to the theory of Banach spaces emphasizing properties of Hilbert spaces and linear operators. Special attention will be given to compact operators and integral equations.

MA 470 Topics in Algebra 4R-0L-4C Arranged
Prerequisites: Instructor permission

Corequisites: There are no corequisites for this course.
An advanced topics course in algebra. Topic of the course could be commutative algebra, Galois theory, algebraic geometry, Lie groups and algebras, or other advanced topics in algebra. May be taken more than once provided topics are different.

MA 471 Linear Algebra II 4R-0L-4C S (even years)
Prerequisites: MA 371 Linear Algebra I 4R-0L-4C F,S or MA 373 Applied Linear Algebra for Engineers 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Continuation of Linear Algebra I. Properties of Hermitian and positive definite matrices and factorization theorems (LU, QR, spectral theorem, SVD). Linear transformations and vector spaces.

MA 473 Design & Analysis of Algorithms 4R-0L-4C W
Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S, and CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Students study techniques for designing algorithms and for analyzing the time and space efficiency of algorithms. The algorithm design techniques include divide-and-conquer, greedy algorithms, dynamic programming, randomized algorithms and parallel algorithms. The algorithm analysis includes computational models, best/average/ worst case analysis, and computational complexity (including lower bounds and NP-completeness). Same as CSSE 473.

MA 474 Theory of Computation 4R-0L-4C S
Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S, and CSSE 230 Data Structures and Algorithm Analysis 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Students study mathematical models by which to answer three questions: What is a computer? What limits exist on what problems computers can solve? What does it mean for a problem to be hard? Topics include models of computation (including Turing machines), undecidability (including the Halting Problem) and computational complexity (including NP-completeness). Same as CSSE 474.

MA 475 Topics in Discrete Mathematics 4R-0L-4C Arranged
Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S
Corequisites: There are no corequisites for this course.
An extension of the material presented in MA 275 and 375. Topics may include combinatorial design, Fibonacci numbers, or the Probabilistic Method, among others. A student may take the course for credit more than once provided the topics are different.

MA 476 Algebraic Codes 4R-0L-4C S (odd years)
Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S or consent of instructor
Corequisites: There are no corequisites for this course.
Construction and theory of linear and nonlinear error correcting codes. Generator matrices, parity check matrices, and the dual code. Cyclic codes, quadratic residue codes, BCH codes, Reed-Solomon codes, and derived codes. Weight enumeration and information rate of optimum codes.

MA 477 Graph Theory 4R-0L-4C S (even years)

Prerequisites: MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S or consent of instructor
Corequisites: There are no corequisites for this course.
An introduction to the theory and applications of directed and undirected graphs. Possible topics include the following: Connectivity, subgraphs, graph isomorphism, Euler trails and circuits, planarity and the theorems of Kuratowski and Euler, Hamilton paths and cycles, graph coloring and chromatic polynomials, matchings, trees with applications to searching and coding, and algorithms dealing with minimal spanning trees, articulation points, and transport networks

MA 478 Topics in Number Theory 4R-0L-4C Arranged
Prerequisites: MA 378 Number Theory 4R-0L-4C S or MA 375 Discrete & Combinatorial Algebra II 4R-0L-4C W, S or consent of the instructor
Corequisites: There are no corequisites for this course.
Advanced topics in Number Theory. Topics may include elliptic curve cryptography, the Fermat-Wiles Theorem, elliptic curves, modular forms, p-adic numbers, Galois theory, diophantine approximations, analytic number theory, algebraic number theory. A student may take the course for credit more than once provided the topics are different.

MA 479 Cryptography 4R-0L-4C S
Prerequisites: MA 275 Discrete & Combinatorial Algebra I 4R-0L-4C F,W, and CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S
Corequisites: There are no corequisites for this course.
Introduction to basic ideas of modern cryptography with emphasis on mathematical background and practical implementation. Topics include: the history of cryptography and cryptanalysis, public and private key cryptography, digital signatures, and limitations of modern cryptography. Touches upon some of the societal issues of cryptography (same as CSSE 479)

MA 480 Topics in Probability or Statistics 4R-0L-4C Arranged
Prerequisites: Instructor permission
Corequisites: There are no corequisites for this course.
An advanced course in probability or statistics. Possible topics include (but are not restricted to) reliability, discrete event simulation, multivariate statistics, Bayesian statistics, actuarial science, nonparametric statistics, categorical data analysis, and time series analysis. May be taken more than once provided topics are different.

MA 481 Mathematical Statistics 4R-0L-4C W (even years)
Prerequisites: MA 382 Introduction to Statistics with Probability 4R-0L-4C F or MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S and consent of instructor
Corequisites: There are no corequisites for this course.
An introduction to mathematical statistics. Review of distributions of functions of random variables. Moment generating functions. Limiting distributions. Point estimation and sufficient statistics. Fisher information and Rao-Cramer inequality. Theory of statistical tests.

MA 482 Bioengineering Statistics 4R-0L-4C S
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Corequisites: There are no corequisites for this course.

This course introduces statistical techniques for addressing the challenges that arise in the analysis of data from the biological sciences (including biology, biomedical engineering, and the medical community). Topics include linear regression modeling, nonlinear regression, repeated measures analysis (including mixed models), and survival/reliability analysis (analysis of time-to-event data). Flexible modeling strategies including relaxing linearity and distributional assumptions are discussed. Additional topics are introduced when discussing articles found in the literature, including properties of study design, power, meta-analysis, missing data, and causal inference. No prerequisite knowledge of biology is assumed. Review of fundamental prerequisite statistics will be included as necessary. Same as BE 482.

MA 485 Applied Regression Analysis & Introduction to Time Series 4R-0L-4C W (odd years)
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and either MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Review of simple linear regression; confidence and prediction intervals for estimated values using simple linear regression; introduction to such concepts as model fit, misspecification, multi-collinearity, heterogeneous variances and transformation of both independent and dependent variables; introduction to multiple regression to include polynomial regression; use of dummy variables and diagnostics based on residuals; sequential variable selection to include forward inclusion and backward exclusion of variables; best subset regression; introduction to time series; autocorrelation; moving averages and exponential smoothing.

MA 487 Design of Experiments 4R-0L-4C W (even years)
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 382 Introduction to Statistics with Probability 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Review of one factor analysis of variance; tests for homogeneity of variance and model assumptions; multiple comparisons, post hoc comparisons, and orthogonal contrasts; two factor analysis of variance (with and without interactions); three factor and higher full factorial designs; analysis of covariance and repeated measures designs; screening designs to include 2 to the k and 3 to the k design; fractional factorial designs; introduction to General Linear Models. Other topics that may be included as time allows: fixed, random, and mixed designs as well as nested designs. Review of fundamental prerequisite statistics will be included as necessary.

MA 490 Topics in Mathematics Variable credit
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
This course will cover advanced topics in mathematics not offered in listed courses.

MA 491 Introduction to Mathematical Modeling 2C F
Prerequisites: Senior Standing or permission of the instructor
Corequisites: There are no corequisites for this course.
An introduction to the process of mathematically modeling a problem, including data collection, defining the appropriate mathematical model and interpreting the results of the proposed model. Emphasis placed on the modeling process, using examples from both continuous and discrete mathematics.

MA 492 Senior Project I 2C F
Prerequisites: Senior Standing or permission of the instructor
Corequisites: There are no corequisites for this course.
Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content. Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one). Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one. A submitted written report and public presentation to department are required

MA 493 Senior Project II 2C F,W
Prerequisites: MA 492 Senior Project I 2C F or permission of the instructor
Corequisites: There are no corequisites for this course.
Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content. Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one). Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one. A submitted written report and public presentation to department are required

MA 494 Senior Project III 2C W,S
Prerequisites: MA 493 Senior Project II 2C F,W
Corequisites: There are no corequisites for this course.
Either participation in a sponsored project or investigation of a problem with a substantial mathematical application, modeling and/or computational content. Students either work individually or in a team typically of 2 or 3, under the supervision of the faculty adviser (course instructor), interacting with the sponsor (if there is one). Problems vary considerably, depending upon student interest, but normally require computer implementation and documentation. All work required for completion of the Senior Project must be completed in a form acceptable to the adviser and the sponsor if there is one. A submitted written report and public presentation to department are required

MA 495 Research Project in Mathematics Variable Credit
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
An undergraduate research project in mathematics or the application of mathematics to other areas. Students may work independently or in teams as determined by the instructor. Though the instructor will offer appropriate guidance in the conduct of the research, students will be expected to perform independent work and collaborative work if on a team. The course may be taken more than once provided that the research or project is different.

MA 496 Senior Thesis I 4C F
Prerequisites: Senior Standing or permission of the instructor

Corequisites: There are no corequisites for this course.
Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level. Research paper and public presentation to department are required.

MA 497 Senior Thesis II 2C F,W
Prerequisites: MA 496 Senior Thesis I 4C F or permission of instructor
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level. Research paper and public presentation to department are required.

MA 498 Senior Thesis III 2C W,S
Prerequisites: MA 497 Senior Thesis II 2C F,W
Corequisites: There are no corequisites for this course.
Individual study and research of a topic in mathematics. Topic is expected to be at an advanced level. Research paper and public presentation to department are required.

MA 534 Management Science 4R-0L-4C F (even years)
Prerequisites: Senior or graduate standing
Corequisites: There are no corequisites for this course.
A study of the development and analysis of various mathematical models useful in managerial decision-making. This includes discussions of what models are, how to create them, how they are used, and what insights they provide. Spreadsheets will be used to do much of the computational work. Topics considered include linear, integer, and nonlinear programming, network models, inventory management, project management, and simulation models. Examples from all areas of business and industry will be investigated. We will also investigate how companies are using these techniques to solve current problems. Same as EMGT 534.

MA 538 Advanced Engineering Mathematics 4R-0L-4C W
Prerequisites: Graduate standing
Corequisites: There are no corequisites for this course.
A fast-paced course in advanced applied mathematics for graduate-level engineering students. Applied linear algebra, including abstract vector spaces, linear operators, eigentheory, diagonalization, and the matrix exponential; review of partial differentiation and multiple integration, including Lagrange multipliers and other optimization topics; vector analysis, including the Jacobian matrix, the del operator in standard coordinate systems, and line integrals; and Fourier series with application to the solution of partial differential equation boundary value problems. Students may not receive credit for both MA438 and MA538. Students who receive credit for MA538 may only receive graduate credit for at most one of MA330, MA336, MA371, and MA373.

MA 580 Topics in Advanced Probability Theory & Its Applications 4R-0L-4C Arranged
Prerequisites: MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Advanced topics in probability theory as well as applications that are not offered in the listed courses.

MA 581 Topics in Advanced Statistics 4R-0L-4C Arranged
Prerequisites: MA 223 Engineering Statistics I 4R-0L-4C F,W,S or MA 381 Introduction to Probability with Applications to Statistics 4R-0L-4C F,W,S Consent of instructor

Corequisites: There are no corequisites for this course.
This course will cover advanced topics in mathematical statistics as well as applied statistics that are not offered in the listed courses.

MA 590 Graduate Topics in Mathematics Variable Credit
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
This course will cover graduate-level topics in mathematics not offered in listed courses.

MA CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

MAFTC Calculus I, Calculus II, Calculus III - Fast Track Calculus 15R-0L-15C
Prerequisites: At least one year of high school Calculus, at least a 700 Math Score or 680 math/700 critical reading or better on the SAT (31 Math or 30 Math/31 English ACT score), and approval by the Fast Track Selection Committee.
Corequisites: There are no corequisites for this course.
A 5-week fast paced course equivalent to Calculus I, II and III. Taught in the summer only to incoming freshmen. Review of differential calculus. Introduction to integration and the Fundamental Theorem of Calculus. Techniques of integration, numerical integration, applications of integration. L’Hopital’s rule (and improper integrals). Separable first order differential equations, applications of separable first order differential equation. Series of constants, power series, Taylor polynomials, Taylor and McLaurin series. Vectors and parametric equations in three dimensions. Functions of several variables, partial derivatives, maxima and minima of functions of several variables, multiple integrals, and other coordinate systems. Applications of partial derivatives and multiple integrals. This course may be taken as Pass/Fail only.

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Professors Adams, Bernal, Bercich, Brackin, Burchett, Cantwell, Chambers, Cloutier, Cornwell, Cunningham, Fisher, Jones, Kawano, Layton, Lui, McCormack, Mayhew, Mech, Mirth, Moorhead, Moseley, Olson, Onyancha, Purdy, Riley, Sanders, Stamper, White and Winck.

Mechanical Engineering - Course Descriptions

ME 123 Computer Programming 4R-0L-4C F,W,S
Prerequisites: ME/PHOE major or permission of instructor
Corequisites: There are no corequisites for this course.
Software tools and engineering processes for mechanical engineers. Topics may include: structured programming (Matlab), simulation of rigid body motion, presentation software, and spreadsheets. Introduction to teaming and creativity.

ME 193 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 293 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. F,W,S
Prerequisites: Sophomore class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Prerequisites: ES 201 Conservation & Accounting Principles 4R-0L-4C F,W* or CE 205 Thermodynamics 4R-0L-4C F *With a grade of C or better
Corequisites: There are no corequisites for this course.
Extend the conservation and accounting framework to examine energy-conversion systems. Topics include thermodynamic properties of pure substances, gas mixtures, exergy analyses, power and refrigeration cycles, psychrometric processes, combustion, and propulsion.

ME 302 Heat Transfer 4R-0L-4C S,F
Prerequisites: MA 211 Differential Equations 4R-0L-4C F,W,S, and ES 202 Fluid Systems 2 2/3R-1L-3C W,S or CHE 301 Fluid Mechanics 4R-0L-4C F,S or EM 301 Fluid Mechanics 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Introduces the basic modes of heat transfer, heat transfer properties, steady and unsteady one-dimensional heat conduction, free and forced convection, radiation and heat exchangers. Other topics may include numerical methods and boiling and condensation.

ME 305 Introduction to Aerospace Engineering 4R-0L-4C S
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.

Application of fundamental engineering concepts to aerospace systems. Aircraft performance and stability. Physical properties of the standard atmosphere. Aerodynamics of the airplane including lift, drag and pitching moment estimation. Introduction to orbital mechanics.

ME 317 Design for Manufacturing 4R-0L-4C W
Prerequisites: EM 104 Graphical Communications 1R-2L-2C F
Corequisites: There are no corequisites for this course.
This is an introductory course that examines the interactions between design and manufacturing from the designer's point of view. Common manufacturing processes will be introduced and design guidelines will be developed for each process. The successful student will leave this class with an appreciation that a designer must consider the method of manufacture during the design process to ensure that a product is functional, economically viable, and safe.

ME 318 Material Processing in Manufacturing 4R-0L-4C
Prerequisites: ME 328 Materials Engineering 4R-0L-4C W
Corequisites: There are no corequisites for this course.
An introductory course in the control of the properties of materials during manufacturing. Covers the interrelationship between material properties and the principal manufacturing processes like hot and cold working, casting, welding, heat treating and machining. Emphasizes the importance of considering manufacturability when making material selection decisions in design.

ME 321 Measurement Systems 3R-3L-4C W,S
Prerequisites: EM 103 Introduction to Design 1R-3L-2C S, and ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F, and MA 223 Engineering Statistics I 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Fundamentals of measurement systems in mechanical engineering including transducer operation, signal conditioning, data reduction, and presentation of results. Transducer and measurement system characteristics including resolution, sensitivity, loading, time response, and frequency response. Operating principles of basic instrumentation for measurement of mechanical quantities such as force, torque, pressure, temperature, and flow. Topics include uncertainty analysis, data analysis, calibration, data acquisition, presentation of results, and an introduction to experiment design.

ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Prerequisites: ME 123 Computer Programming 4R-0L-4C F,W,S or CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Engineering problems often lead to analytically intractable equations. This course combines structured programming and applied numerical methods to obtain approximate engineering solutions. Strategies include root finding, numerical integration, finite difference, initial value and boundary value problems. Matlab is used as the programming language for solving iterative problems numerically.

ME 327 Numerical Methods of Engineering Analysis 3R-3L-4C W,S
Prerequisites: ME 123 Computer Programming 4R-0L-4C F,W,S or BE 100 Problem Solving in the Biological Sciences & Engineering 3R-3L-4C S or CSSE 120 Introduction

to Software Development 3R-3L-4C F,W,S, MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
This is an inter-disciplinary course focusing on the generation and interpretation of numerical solutions and the processing of numerical data for engineering problems. Topics include approximate solutions to nonlinear algebraic and differential equations, initial and boundary value problems, numerical integration and differentiation, optimization, data conditioning, and regression analysis. Trade-offs between accuracy and cost are emphasized. Matlab is used as the programming language.

ME 328 Materials Engineering 4R-0L-4C W
Prerequisites: CHEM 111 General Chemistry I 3R-0L-3C F,W,S
Corequisites: There are no corequisites for this course.
Introduces properties of metals, ceramics, polymers, and composites. Relates material processing to properties through underlying material structure. Overviews the materials available to engineers and discusses applications and material selection.

ME 380 Creative Design 4R-0L-4C W
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
Emphasis on the creative process in engineering design. Students will develop their design capability by exploring various conceptual blocks, using creative enhancement techniques and participating in on-the-spot design.

ME 393 Selected Topics in Design As assigned. Maximum 4 credits per term. F,W,S
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 397 Special Topics in Mechanical Engineering 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interest in mechanical engineering at the 300-level.

ME 401 Foundations of Fluid Mechanics 3R-3L-4C
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S or EM 301 Fluid Mechanics 4R-0L-4C S or MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Covers the fundamental concepts of fluid dynamics with an emphasis on physical understanding. Topics include control-volume and differential analyses of fluid motion, similitude, potential flow, vorticity transport, low Reynolds number flow, boundary-layer physics, turbulent transport, and compressible flow. Numerical and experimental methods for solving fluid engineering problem are introduced in a weekly laboratory including wind tunnel, particle image velocimetry, hot wire anemometry, and optical techniques. Other topics may be added or deleted as needed.

ME 402 Advanced Heat Transfer 4R-0L-4C
Prerequisites: ME 302 Heat Transfer 4R-0L-4C S,F
Corequisites: There are no corequisites for this course.

This course covers additional topics in conduction, convection and radiation heat transfer as well as an introduction to mass transfer, phase change and numerical methods.

ME 403 Kinematics of Machinery 4R-0L-4C
Prerequisites: ES 204 Mechanical Systems 2 2/3R-1L-3C W,S, and ME 323 Numerical Methods in Engineering 1R-3L-2C W,S or CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S or MA 332 Introduction to Computational Science 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
This is an introduction to kinematics, the study of the motion of machinery without regard to forces. Students perform both kinematic analysis and kinematic design of planar and spatial mechanisms, cams, and gear trains. Computer programming is used for iterative methods in both analysis and design. A design project is assigned to explore a particular kinematics problem in detail.

ME 405 Theoretical Aerodynamics 4R-0L-4C W
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduction to aerodynamics theory. Development of equations of conservation of mass and momentum. Vorticity, induced velocity and irrotational flow. Stream function, velocity potential, Laplace's equation and the principle of superposition. Flow about a body, the Kutta-Joukowski Theorem. Concepts of thin airfoil and finite wing theory. Exact solutions to elementary viscous flow problems.

ME 406 Control Systems 3R-3L-4C F
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Basic principles of feedback control theory. Mathematical modeling and performance analysis of dynamical systems. Includes stability analysis, root locus compensation and design, frequency response analysis. Implementation of control system analysis and design is gained with several laboratory experiences.

ME 407 Power Plants 4R-0L-4C S
Prerequisites: ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Steam, cogeneration and combined cycles are studied with the aid of property software. Various components of the cycles are studied in detail. A survey of alternative power sources is presented. Tours of power plants are taken when available.

ME 408 Renewable Energy 4R-0L-4C
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S or equivalent
Corequisites: There are no corequisites for this course.
Covers renewable energy sources such as solar heating and cooling, wind energy, biomass, and photovoltaic energy. Surveys the energy availability of these sources and life cycle cost and present value used to evaluate the system. Students will design a system which utilizes a renewable energy source and economically evaluate the system.

ME 409 Air Conditioning 4R-0L-4C S
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S, and ME 302 Heat Transfer 4R-0L-4C S,F

Corequisites: There are no corequisites for this course.
Human comfort and the properties of air. Air conditioning in residences, public and industrial buildings using vapor compression and absorption units. Cooling loads, psychrometry, fans, duct sizing and layout, automatic control, and acoustic design considerations.

ME 410 Internal Combustion Engines 4R-0L-4C F
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Study of spark ignition and compression ignition engines. Influences of engine design features on performance, economy, and air pollution. Influence of the combustion process, carburetion, fuel injection and ignition characteristics on engine operation.

ME 411 Propulsion Systems 4R-0L-4C S
Prerequisites: ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Application of basic principles in the study of the performance characteristics of air and space vehicles. Aerodynamics of steady one dimensional isentropic compressible flow. Shock waves, gas turbines, turbojet, turbofan, turboprop, turboshaft, ram jet, rocket, nuclear propulsion and space propulsion systems are discussed and compared.

ME 415 Corrosion & Engineering Materials 4R-0L-4C
Prerequisites: ME 328 Materials Engineering 4R-0L-4C W or CHE 315 Materials Science and Engineering 4R-0L-4C F,S
Corequisites: There are no corequisites for this course.
Presents fundamentals of metallurgy and corrosion mechanisms in engineering metals. Discusses various classes of corrosion and methods of mitigating corrosion with emphasis on practical situations.

ME 416 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 410, ECE 416, and CHE 405.

ME 417 Advanced Materials Engineering 4R-0L-4C
Prerequisites: ME 328 Materials Engineering 4R-0L-4C W, and EM 203 Mechanics of Materials 4R-0L-4C W or EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Fundamentals of deformation and fracture in metals, polymers, and ceramics with application to design. Emphasis on time-temperature dependence of polymers, brittle behavior of advanced ceramics, and the fracture mechanics approach to design of high strength and critical application materials.

ME 419 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent
Corequisites: There are no corequisites for this course.

Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics.

ME 420 Consulting Engineering Seminar 2R-0L-2C S
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
Discusses problems in the field of consulting engineering; seminars presented by practicing consulting engineers. Cross-listed with BE 400, ECE 466, CHE 420, and CE 420.

ME 421 Mechanical Engineering Laboratory 0R-6L-2C F,W
Prerequisites: ME 321 Measurement Systems 3R-3L-4C W,S, and RH 330 Technical & Professional Communication 4R-OL-4C W,S
Corequisites: There are no corequisites for this course.
Introduction to engineering experimentation, centered on an experimental project planned and executed by students. Uncertainty analysis, instrumentation systems, and statistical design of experiments. Emphasis on project on project planning and execution, developing a scope of work, interim deliverables, and reporting engineering results.

ME 422 Finite Elements for Engineering Applications 4R-1L-4C W
Prerequisites: EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Introduces finite element methodology from a strongly theoretical perspective. Emphasizes solving various one-dimensional, transient, non-linear problem statements including heat conduction, beam deflection, convection/diffusion (transport), gas dynamic shocks, and open channel flows. Assesses higher order bases, time stepping procedures, iterative solvers, and finite difference methodologies. Utilizes Matlab for computational experiments.

ME 424 Composite Materials & Mechanics 3R-3L-4C Arranged
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduces materials and mechanics of composites with emphasis on high performance polymer matrix composites. Topics include material selection, laminate analysis, manufacturing, joining, and testing. A team design-built-test project is required.

ME 425 Aerospace Engineering Laboratory 1R-3L-2C
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduction to experiment planning and execution. Projects involve wind tunnel testing including measurement of forces and moments and flow visualization. Student organized and executed with direct faculty consultation. Emphasis on written presentation.

ME 426 Turbomachinery 4R-0L-4C
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F or consent of instructor
Corequisites: There are no corequisites for this course.

Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency.

ME 427 Introduction to Computational Fluid Dynamics 3R-3L-4C F
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S, and ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Corequisites: There are no corequisites for this course.
Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution.

ME 430 Mechatronic Systems 3R-3L-4C F,W
Prerequisites: ME 323 Numerical Methods in Engineering 1R-3L-2C W,S or CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Applications of microprocessors and microcontrollers and digital electronics to the design and utilizations of embedded control systems in smart systems and products. Topics include Boolean logic and algebra, system hardware and software development, and interfacing for mechanical applications.

ME 435 Robotics Engineering 3R-3L-4C S
Prerequisites: ME 430 Mechatronic Systems 3R-3L-4C F,W or ECE 230 Introduction to Embedded Systems 3R-3L-4C W,S
Corequisites: There are no corequisites for this course.
Interdisciplinary course in robotics focusing on communication, software development, kinematics, robot GUI design, sensing, control, and system integration. Labs in the course cover MATLAB GUI development with GUIDE, Denavit-Hartenberg parameters, Arduino programming, Arduino to Android communication, Android app development, and OpenCV4Android image recognition. Students in the course will program an Android + Arduino, 6-wheeled mobile robot with 5 DOF servo arm to participate in an outdoor GPS robotics challenge. Cross-listed with CSSE 435.

ME 447 Visualizing Data 4R#0L#4C
Prerequisites: Junior class standing
Corequisites: There are no corequisites for this course.
The course is about creating truthful and compelling data visuals. We study elements of statistical analysis, programming in R, human perception, graphic design, and visual rhetoric and ethics. After successfully completing this course, students should be able to design effective and truthful data displays, credibly explain their design rationale, produce publication-quality visuals, and credibly critique a data display. Prior experience with R is not required.

ME 450 Combustion 4R-0L-4C
Prerequisites: ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves,

combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises.

ME 461 Aircraft Design 4R-0L-4C F
Prerequisites: ME 305 Introduction to Aerospace Engineering 4R-0L-4C S or consent of instructor
Corequisites: There are no corequisites for this course.
Fundamentals of conceptual aircraft design. Aerodynamic analysis, design constraints based on customer requirements, mission profiles, aircraft sizing, optimization, and presentation of performance capabilities. Oral and written communication emphasized. Design teams.

ME 462 Thermal Design 4R-0L-4C W,S
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S, and ME 302 Heat Transfer 4R-0L-4C S,F
Corequisites: There are no corequisites for this course.
Applications of the thermodynamic, heat transfer, and fluid flow principles to the modeling and design of thermal systems. These systems include pumps, fans, and heat and mass exchangers. A team project which includes the design, construction and testing of a fluid or thermal device or system provides the focus for the course.

ME 470 Capstone Design I 2R-3L-4C F,S
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F, and EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S, and ME 301 Applications of Thermodynamics 4R-0L-4C F,W and Junior standing
Corequisites: There are no corequisites for this course.
Students work in teams with three to five members on design projects furnished from clients. The emphasis is on creating design solutions, with appropriate analyses, to meet stakeholders' needs. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in interim reports which are submitted to the clients.

ME 471 Capstone Design II 1R-4L-4C F,W
Prerequisites: ME 470 Capstone Design I 2R-3L-4C F,S
Corequisites: There are no corequisites for this course.
This course is a continuation of ME470. Students continue work in teams with three to five members developing the project started in ME470. The emphasis is on detailing design solutions identified in the first quarter. In addition to regular meetings with their faculty advisors, the teams are expected to maintain close and continuous communications with their clients during the quarter. The ten week projects culminate in interim reports which are submitted to the clients. This course is intended to be taken in the quarter immediately following ME470.

ME 472 Capstone Design III 1R-4L-4C W,S
Prerequisites: ME 471 Capstone Design II 1R-4L-4C F,W
Corequisites: There are no corequisites for this course.
This course is a continuation of ME 471. The student teams test their prototype solutions and transfer the project results to their client. Continuous and regular communication with the outside clients, as well as with the faculty advisors, is expected.

The course culminates with a final report that documents the design process. This course is intended to be taken in the quarter immediately following ME471.

ME 480 Machine Component Design 4R-0L-4C S,F
Prerequisites: EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Applications of fundamentals of engineering mechanics in analysis and synthesis of machine components and systems. Special emphases placed on stress/strength analyses and fatigue failures. Design of mechanical components and systems including threaded fasteners, springs, bearings, gears, shafts, clutches, brakes, belts, chains, and couplings.

ME 490 Directed Research As assigned. Maximum 4 credits per term. F,W,S
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.

ME 491 Directed Research As assigned. Maximum 4 credits per term. F,W,S
Prerequisites: Completion of freshman and sophomore course requirements and approval of adviser and course instructor
Corequisites: There are no corequisites for this course.
Selected projects for student research.

ME 493 Selected Topics in Design Hours as assigned. Maximum 4 credits per term. F,W,S
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Selected student design projects. May include testing and/or computer aided design.

ME 497 Special Topics in Mechanical Engineering 4R-0L-4C Arranged
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics of current interests in mechanical engineering.

ME 501 Advanced Thermodynamics 4R-0L-4C F
Prerequisites: ME 301 Applications of Thermodynamics 4R-0L-4C F,W or equivalent
Corequisites: There are no corequisites for this course.
Study of advanced thermodynamic topics: modeling of transient systems, exergy (availability) analysis, equations of state and thermodynamics relationships for simple, compressible substances.

ME 502 Topics in Heat Transfer 4R-0L-4C Arranged
Prerequisites: ME 302 Heat Transfer 4R-0L-4C S,F
Corequisites: There are no corequisites for this course.
Course may be repeated for different heat transfer topics.

ME 503 Viscous Fluid Flow 4R-0L-4C
Prerequisites: ME 401 Foundations of Fluid Mechanics 3R-3L-4C S,F
Corequisites: There are no corequisites for this course.
Material and spatial descriptions of fluid motion. The Reynolds transport equation. The stress tensor and governing equations for the motion of viscous fluids. Newtonian fluids,

the Navier-Stokes equations. Asymptotic solutions including fully developed channel flow, oscillating flat plate, wakes and jets. Introduction to boundary layers and turbulent flow including Reynolds averaging.

ME 505 Modeling & Simulation of Dynamic Systems 4R-0L-4C
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Modeling and simulation of engineering components and systems. Emphasis on a unified work-energy approach to modeling physical systems, model formulation using a differential-algebraic form of Lagrange's equation, and the numerical solution of the resulting initial-value problem. Applications are explored using modeling and simulation projects.

ME 506 Advanced Control Systems 4R-0L-4C
Prerequisites: ME 406 Control Systems 3R-3L-4C F or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Physical models for control; system response, analysis and design. Time domain; system response, analysis and design. Frequency domain; state variable representation/description; stability, controllability, observability; linear quadratic regulator, pole-placement, state estimation/observers.

ME 507 Applied Nonlinear Control Systems 4R-0L-4C
Prerequisites: ME 406 Control Systems 3R-3L-4C F or equivalent or consent of instructor
Corequisites: There are no corequisites for this course.
Analysis and design of controls for inherently nonlinear systems and the use of nonlinear elements in design. Techniques for analysis and design include, stability by Liaqunov, describing functions, phase plane analysis, sliding control, adaptive control and control of multi-input systems.

ME 510 Gas Dynamics 4R-0L-4C F
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S
Corequisites: There are no corequisites for this course.
Introduction to the dynamics of a compressible flow. Equations of motion for subsonic and supersonic flow. Nozzle flow. Normal and oblique shock waves, Prandtl-Meyer flow. Steady and unsteady, one dimensional gas flow with friction and heat transfer.

ME 511 Numerical Methods for Dynamic Systems Analysis 4R-0L-4C
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F, and ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Corequisites: There are no corequisites for this course.
Applications of approximate numerical solution techniques, including the finite element method, to the analysis of dynamic, continuous systems. Introduction to variational principles in mechanics for purposes of formulating governing equations of motion.

ME 512 Light Weight Structures 4R-0L-4C S
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, and EM 203 Mechanics of Materials 4R-0L-4C W or EM 204 Statics & Mechanics of Materials II 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.

Applies the principles of mechanics to the structural analysis of mechanical and aerospace components. Covers stress tensors, shear flow in open and closed sections, beam columns, unsym-metrical bending. Castigliano's theorem, statically indeterminate structures , thin walled pressure vessels, introduction to elasticity.

ME 513 Environmental Noise 4R-0L-4C F
Prerequisites: Senior class standing
Corequisites: There are no corequisites for this course.
Introduces noise and its sources as a potential public health hazard. Covers the basics of sound propagation relating to noise measurement and analysis. Emphasizes effects on humans and the environment. Covers methods of noise and vibration control and abatement including absorption, enclosures, vibration isolation, damping, and mufflers. Team projects involving noise measurement and reduction are required.

ME 516 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S
Prerequisites: Junior or Senior class standing
Corequisites: There are no corequisites for this course.
Properties of silicon wafers; wafer-level processes, surface and bulk micromachining, thin-film deposition, dry and wet etching, photolithography, process integration, simple actuators. Introduction to microfluidic systems. MEMS applications: capacitive accelerometer, cantilever and pressure sensor. Cross-listed with EP 510, ECE 516, CHE 505, and BE 516.

ME 518 Advanced Kinematics 4R-0L-4C S
Prerequisites: ME 403 Kinematics of Machinery 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Considers the analysis, design, and simulation of planar and spatial mechanisms. The mechanisms examined are parallel manipulators, serial manipulators, and compliant mechanisms. These mechanisms are analyzed for position, velocity, acceleration, and workspace. The techniques used for the analysis include vector approaches, homogeneous transformations, and dual number techniques.

ME 519 Advanced MEMS: Modeling & Packaging 3R-3L-4C F
Prerequisites: EP 410 Introduction to MEMS: Fabrication & Applications 3R-3L-4C S or equivalent
Corequisites: There are no corequisites for this course.
Design process, modeling; analytical and numerical. Actuators; dynamics and thermal issues. Use of software for layout and simulation. Characterization and reliability of MEMS devices. Electrical interfacing and packaging of MEMS. Microsensors, microfluidic systems, applications in engineering, biology, chemistry, and physics. Cross-listed with ECE 519, EP 511, and CHE 519.

ME 520 Computer-Aided Design & Manufacturing (CAD/CAM) 4R-0L-4C W
Prerequisites: EM 104 Graphical Communications 1R-2L-2C F and Senior class standing
Corequisites: There are no corequisites for this course.
Use and management of computer in engineering for drafting, design management, documentation, and manufacturing. Covers drafting methods and standards, design data management, CNC operations and implementation.

ME 522 Advanced Finite Element Analysis 4R-1L-4C S
Prerequisites: ME 422 Finite Elements for Engineering Applications 4R-1L-4C W

Corequisites: There are no corequisites for this course.
A continuation of ME 422. Includes multi-dimensional extensions of 2-D theory for transient, nonlinear problem statements in engineering. Utilizes Matlab and Ansys for developing and assessing FEA solutions to real world problems via theory developed in ME 422.

ME 526 Turbomachinery 4R-0L-4C
Prerequisites: ES 205 Analysis & Design of Engineering Systems 3R-3L-4C S,F or equivalent, or permission of instructor
Corequisites: There are no corequisites for this course.
Introduces the theory and issues related to the design of axial and radial flow turbines, compressors and pumps. Euler's equation and vector diagrams are used to evaluate energy transfer and efficiency. Students enrolled in ME 526 must complete a design project including complexities not covered in ME 426. Students may not receive credit for both ME 426 and ME 526

ME 527 Computational Fluid Dynamics 3R-3L-4C
Prerequisites: ES 202 Fluid Systems 2 2/3R-1L-3C W,S, and ME 323 Numerical Methods in Engineering 1R-3L-2C W,S
Corequisites: There are no corequisites for this course.
Covers the key components of a CFD calculation: mesh generation, numerical algorithm and turbulence modeling. Survey of solution strategy includes both the finite volume and the finite difference methods. Issues on formal order of accuracy, dissipation, dispersion, stability and space-time coupling are discussed in detail. Both structured programs and commercial software will be used as vehicles in obtaining a CFD solution. Students enrolled in ME527 must complete a design project not covered in ME 427. Students may not receive credit for both ME 427 and ME 527.

ME 536 Computational Intelligence in Control Engineering 4R-0L-4C
Prerequisites: ME 406 Control Systems 3R-3L-4C F or equivalent, or consent of instructor
Corequisites: There are no corequisites for this course.
Machine learning and adaptation applied to feedback control, guidance and navigation. Neural Networks for pattern recognition, modeling and control. Radial basis function model identification by recursive least squares. Fuzzy logic controllers. Genetic algorithm for optimization and turning of controllers including fuzzy logic control.

ME 547 Visualizing Data 4R#0L#4C
Prerequisites: Graduate standing and instructor consent.
Corequisites: There are no corequisites for this course.
Same as ME 447 with the added requirement that the course is open only to graduate students having a graduate project or thesis generating quantitative data that the course instructor has agreed meets the 500-level course objectives.

ME 550 Combustion 4 R-0L-4C
Prerequisites: ME 301 Applications of Thermodynamics 4R-0L-4C F,W
Corequisites: There are no corequisites for this course.
Study of the thermodynamics and kinetics of combustion processes and the underlying chemical processes. Topics covered include deflagration and detonation waves, combustion of solid, liquid, and gaseous fuels, and environmental impacts of combustion. Laboratory experience via in-class, hands-on exercises. Students enrolled

in ME 550 must complete a design project not covered in ME 450. Students may not receive credit for both ME 450 and ME 550.

ME 590 Thesis Research As assigned F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Credits as assigned; however, not more than 12 credits will be applied toward the requirements of an M.S. degree.

ME 597 Selected Topics for Graduate Students As assigned. Maximum 4 credits per term. F,W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Topics arranged by instructor.

ME CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

Last updated: 08/02/2017

Rose-Hulman
Institute of Technology
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Terre Haute, IN 47803
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Rose-Hulman Institute of Technology Course Catalog

Multi-Disciplinary Studies - Course Descriptions

MDS 302 Sustainability in Practice 2R-0L-2C
Prerequisites: GS 130 Introduction to Sustainability 4R#OL#4C, BIO 191 Special Topics in Biology XR-0L-XC, and SV 150 Introduction to Microeconomics 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
This is a project-based course to provide hands-on experiences for student teams working on real-world problems related to sustainability. This could include design projects, scientific research, modeling-based projects, or studies to improve campus sustainability. The course instructor will mentor teams with routine assignments that relate to their design or research process through oral and written communication.

MDS 401 Independent Project/Research Opportunities Seminar 1R-0L-1C F,W,S
Prerequisites: Permission of instructor
Corequisites: There are no corequisites for this course.
Companion seminar for students participating in the Independent Project/Research Opportunities Program. Students attend an organizational seminar, attend one additional IPROP seminar during the quarter, complete first week and tenth week surveys, acknowledge their sponsor, and generate publicity graphics. Students present their work as a poster at a tenth week End of Quarter Symposium. This course may not be used as credit toward any degree program. This course is given Pass/Fail.

MDS 402 Seminar in Sustainability 2R-0L-2C
Prerequisites: MDS 302 Sustainability in Practice 2R-0L-2C F,W,S
Corequisites: There are no corequisites for this course.
This course provides students with the opportunity to examine, analyze, and reflect upon sustainability as it related to their project or research work. Course work includes weekly readings and discussions, individual essays, and in-class and public presentations. Successful completion of this course will require students to have completed the co-curricular requirements.

Last updated: 07/20/2017

Rose-Hulman
Institute of Technology
5500 Wabash Avenue
Terre Haute, IN 47803
812-877-1511

Professors Bunch, Ditteon, Duree, Granieri, Joenathan, E. Kirkpatrick, S. Kirkpatrick, Kirtley, Leisher, Letfullin, Liptak, McInerney, Moloney, Siahmakoun, Syed, and Wagner.
NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

Optical Engineering - Course Descriptions

OE 171 Photography and Holography 2R-0L-2C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Introduce students to basic knowledge of optics, principles and operation of a camera, shutters, films, and film development, color photography. Basic understanding of interference of waves, concept of holography, properties of various holograms, application of holography, and each student makes an individual hologram that can be seen in sunlight.

OE 172 Lasers and Fiber Optics 2R-0L-2C S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Light, optics, image formation, and optical instruments. Introduction to the properties, physics of operation, types, and applications of lasers. Characteristics of optical fibers and optical communication systems. Applications of lasers and fibers in industry, medicine, and consumer products. Laser safety.

OE 280 Geometrical Optics 3.5R-1.5L-4C W
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W
Corequisites: There are no corequisites for this course.
First-order optics including graphical ray tracing, Gaussian methods, y-nu ray tracing, cardinal points, apertures, stops, pupils, vignetting, and obscuration. Optical invariant, dispersion, chromatic aberrations, glass selection, exact ray tracing, third-order monochromatic aberrations, introduction to computer-aided design and analysis. Relevant laboratory experiments.

OE 290 Directed Research Arranged
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for freshmen and sophomore students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with the faculty member for the research project prior to registering for this course.

OE 295 Photonic Devices & Systems 3.5R-1.5L-4C S
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Optical radiation, radiometry, and photometry. Blackbody radiation and thermal sources. Introduction to optoelectronic devices. Light emitting diodes and other optical sources. Optical detectors (thermal, photoemissive, and semiconductor detectors).

Sources/effects of noise and SNR. Flux transfer in optical systems. Relevant laboratory experiments.

OE 360 Optical Materials 4R-0L-4C W (every other year)
Prerequisites: PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W, and PH 316 Electric & Magnetic Fields 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Electromagnetic waves in dielectrics/metals and complex refractive index. Optical, thermal, and mechanical properties of materials. Thin film interference, optical coatings, and design of multilayer films. Optical characterization of materials. Electromagnetic waves in anisotropic materials, double refraction, optical activity, and polarization devices.

OE 392 Linear Optical Systems 4R-0L-4C F
Prerequisites: PH 292 Physical Optics 3.5R-1.5L-4C F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Propagation of light and scalar diffraction theory. Fraunhofer and Fresnel diffraction, coherence, Fourier series and transforms, convolution and correlation. Linear system theory, impulse and step response, transfer functions. Coherent and incoherent image formation, optical transfer function (OTF), modulation transfer function (MTF). Image quality assessment methods. Optical information processing applications.

OE 393 Fiber Optics & Applications 3.5R-1.5L-4C W (every other year)
Prerequisites: OE 295 Photonic Devices & Systems 3.5R-1.5L-4C S, and PH 316 Electric & Magnetic Fields 4R-0L-4C F or ECE 340 Electromagnetic Fields 4R-0L-4C F,W or consent of instructor
Corequisites: There are no corequisites for this course.
Basic dielectric waveguide equations; wave optics and ray optics; step-index and graded-index fibers; single mode and multi-mode fibers; mode cutoff conditions; numerical aperture; fabrication of optical fibers; fiber measurements; fiber cable designs; source coupling, splices and connectors; fiber optic sensors; fiber optic components and systems. Relevant laboratory experiments.

OE 395 Optomechanics & Optical Engineering Lab 2R-6L-4C F
Prerequisites: PH 292 Physical Optics 3.5R-1.5L-4C F, and OE 280 Geometrical Optics 3.5R-1.5L-4C W, and OE 295 Photonic Devices & Systems 3.5R-1.5L-4C S
Corequisites: There are no corequisites for this course.
Design, assembly, and alignment of bench top optical systems. Introduction to experimental techniques in optics. Data collection and analysis. Relevant lecture topics including principles of opto-mechanical design, fold mirrors and prisms, lens and mirror mounting, kinematic mounts, precision adjustments and control.

OE 415 Optical Engineering Design I 2R-6L-4C S
Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W or EP 280 Introduction to Nano-engineering 3.5R-1.5L-4C W and Junior/Senior standing
Corequisites: RH 330 Technical & Professional Communication 4R-OL-4C
Principles of design. Codes of ethics appropriate to engineers. Case studies related to optical engineering and engineering physics professional practice, teamwork, contemporary issues, patents and intellectual property. Team-oriented design project work on selected topics in optical engineering and engineering physics. Introduction to

product development practices, product research, planning and project management. Preliminary design of a product and product specifications. Deliver a design document specific to customer needs and constraints. Cross-listed with EP 415.

OE 416 Optical Engineering Design II 2R-6L-4C F
Prerequisites: OE 415 Optical Engineering Design I 2R-6L-4C S
Corequisites: There are no corequisites for this course.
Team-based capstone design project following structured design processes and utilizing knowledge gained from prior coursework. Project planning and budgeting, development of product/process specifications, application of engineering standards, system design and prototyping subject to multiple realistic constraints (cost, schedule, and performance). Formal midterm design review. Deliver initial statement of work and interim technical report. Laboratory activities supporting the formal design process. Cross-listed with EP 416.

OE 417 Optical Engineering Design III 2R-6L-4C W
Prerequisites: OE 416 Optical Engineering Design II 2R-6L-4C F
Corequisites: There are no corequisites for this course.
Continuation of OE 416. System design and prototyping, performance testing, and data analysis. Formal midterm design review. Demonstration of a functional prototype. Deliver oral presentation and final technical report. Cross-listed with EP 417.

OE 434 Non-Imaging Optics 4R-0L-4C S (every other year)
Prerequisites: OE 295 Photonic Devices & Systems 3.5R-1.5L-4C S
Corequisites: There are no corequisites for this course.
Lighting, illumination, and solar concentration systems. Radiometry and photometry for illumination, etendue, and concentration. Color coordinates, color vision, and color measurements. Sources, light transfer components, and systems evaluation. Introduction to design methods (edge-ray, compound parabolic concentrator, tailored reflector). Design examples and case studies.

OE 435 Biomedical Optics 4R-0L-4C W
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Cross-listed with BE 435.

OE 437 Introduction to Image Processing 3R-3L-4C W
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Basic techniques of image processing. Discrete and continuous two dimensional transforms such as Fourier and Hotelling. Image enhancement through filtering and histogram modification. Image restoration through inverse filtering. Image segmentation including edge detection and thresholding. Introduction to image encoding. Relevant laboratory experiments.

OE 450 Laser Systems & Applications 3.5R-1.5L-4C S

Prerequisites: PH 292 Physical Optics 3.5R-1.5L-4C F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Ray transfer matrix methods, Gaussian beam propagation, and beam quality. Optical resonators and stability, longitudinal and transverse modes. Stimulated emission, population inversion, rate equations, gain and threshold. Q-switching and mode-locking. Applications and types of lasers. Laser safety and relevant laboratory experiments.

OE 470 Special Topics in Optical Engineering 2-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in optics.

OE 480 Optical System Design 4R-0L-4C F
Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W
Corequisites: There are no corequisites for this course.
Review of geometrical optics and exact ray tracing. Chromatic and monochromatic aberrations. Image quality assessment, spot size, point spread function, Strehl ratio, and modulation transfer function. Classical lens design and design of various imaging, non-imaging, and diffractive optical systems. First-order layout, computer-based optimization, tolerancing, and manufacturing considerations.

OE 490 Directed Research 1-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn a maximum of 8 credits between PH/OE 290 and PH/OE 490 for meeting graduation requirements. Maximum of 4 credits per term. The student must make arrangements with the faculty member for the research project prior to registering for this course.

OE 493 Fundamentals of Optical Fiber Communications 3.5R-1.5L-4C S (every other year)
Prerequisites: OE 393 Fiber Optics & Applications 3.5R-1.5L-4C W (every other year)
Corequisites: There are no corequisites for this course.
Analysis and design of common fiber optic communication systems and optical networks. Transmission penalties: dispersion, attenuation. Optical transmitters and receivers: fundamental operation and noise. Intensity and phase modulation. Optical amplification: types of amplifiers, noise and system integration. Point-to-point links: power budget and rise-time analysis. Performance analysis: BER and eye diagrams. WDM concepts and components: multiplexers, filters, common network topologies. Non-linear effects in fibers. Relevant laboratory experiments.

OE 495 Optical Metrology 3.5R-1.5L-4C W
Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W, and OE 392 Linear Optical Systems 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Geometrical test methods (refractometers, knife edge, Ronchi, Wire, Hartmann). Review of interference and coherence. Third-order aberrations, Zernike polynomials, and fringe analysis. Interferometers (Newton, Fizeau, Twyman-Green, and shearing),

fringe localization, and phase shifting. Holographic, Moire, photoelastic and speckle interferometry. Applications of optical metrology. Relevant laboratory experiments.

OE 497 Senior Thesis 1-2C F
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 498 Senior Thesis 1-2C W
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 499 Senior Thesis 1-2C S
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work. This sequence is designed to result in a completed senior thesis or initiation of research to be completed in an MSOE degree at Rose-Hulman.

OE 520 Principles of Optics 2R-0L-2C F
Prerequisites: Graduate standing
Corequisites: There are no corequisites for this course.
Introduction to optics for incoming graduate students. Geometric optics; wave optics; sources and detectors. Students progressing towards or holding a bachelor’s degree in Optical Engineering may not receive credit for OE 520.

OE 535 Biomedical Optics 4R-0L-4C W
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Optical techniques for biomedical applications and health care; imaging modalities; laser fundamentals, laser interaction with biological cells, organelles and nanostructures; laser diagnostics and therapy, laser surgery; microscopes; optics-based clinical applications; imaging and spectroscopy; biophotonics. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 435 and OE 535. Cross-listed with BE 535.

OE 537 Advanced Image Processing 3R-3L-4C S
Prerequisites: CSSE 120 Introduction to Software Development 3R-3L-4C F,W,S or ME 123 Computer Programming 4R-0L-4C F,W,S and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Introduction to image segmentation and recognition. Use of neural networks, fuzzy logic and morphological methods for feature extraction. Advanced segmentation, detection, recognition and interpretation. Relevant laboratory experiments and required project. Cross-listed with ECE 582.

OE 570 Special Topics in Optics 2 or 4C F,W,S

Prerequisites: Consent of instructor and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Lectures on contemporary topics in optical science, optical engineering, and photonics.

OE 580 Optical System Design 4R-0L-4C F

Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Review of geometrical optics and exact ray tracing. Chromatic and monochromatic aberrations. Image quality assessment, spot size, point spread function, Strehl ratio, and modulation transfer function. Classical lens design and design of various imaging, non-imaging, and diffractive optical systems. First-order layout, computer-based optimization, tolerancing, and manufacturing considerations. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 480 and OE 580.

OE 585 Electro-Optics and Applications 3R-3L-4C W

Prerequisites: PH 292 Physical Optics 3.5R-1.5L-4C F, and PH 316 Electric & Magnetic Fields 4R-0L-4C F and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Optical wave propagation in anisotropic media. Normal surface and the index ellipsoid. Double refraction. Optical activity and Faraday rotation. Pockels and Kerr effects. Electrooptic modulators. Acousto-optic effect. Modulators and scanners. Introduction to nonlinear optics. Second-harmonic generation and frequency doubling. Relevant laboratory experiments.

OE 592 Fourier Optics & Applications 3.5R-1.5L-4C W

Prerequisites: OE 392 Linear Optical Systems 4R-0L-4C F and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Two-dimensional linear systems. Scalar diffraction theory, Fresnel & Fraunhofer diffraction. Coherent optical systems analysis. Frequency analysis of optical imaging systems. Spatial filtering and analog optical information processing. Wavefront reconstruction and holography. Relevant laboratory experiments.

OE 593 Fundamentals of Optical Fiber Communications 3.5R-1.5L-4C S (every other year)

Prerequisites: OE 393 Fiber Optics & Applications 3.5R-1.5L-4C W (every other year) Senior or Graduate Standing
Corequisites: There are no corequisites for this course.
Analysis and design of common fiber optic communication systems and optical networks. Transmission penalties, dispersion, attenuation. Optical transmitters and receivers: fundamental operation and noise. Intensity and phase modulation. Optical amplification: types of amplifiers, noise and system integration. Point-to-point links: power budget and rise-time analysis. Performance analysis: BER and eye diagrams. WDM concepts and components: multiplexers, filters, common network topologies. Non-linear effects in fibers. Relevant laboratory experiments. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 493 and OE 593.

OE 594 Integrated Optics 4R-0L-4C F

Prerequisites: OE 393 Fiber Optics & Applications 3.5R-1.5L-4C W (every other year) and Senior or Graduate standing
Corequisites: There are no corequisites for this course.
Theory of dielectric optical waveguides. Waveguide modes. Coupled-mode formalism and periodic structures. Input and output coupling of optical beams to planar structures. Waveguide losses. Phase, frequency and polarization modulators. Waveguide gratings, electro-optic modulators, and switching. Applications of integrated optics.

OE 595 Optical Metrology 3.5R-1.5L-4C W
Prerequisites: OE 280 Geometrical Optics 3.5R-1.5L-4C W, OE 392 Linear Optical Systems 4R-0L-4C F Senior or Graduate standing or consent of instructor
Corequisites: OE 480 Optical System Design 4R-0L-4C F
Geometrical test methods (refractometers, knife edge, Ronchi, Wire, Hartmann). Review of interference and coherence. Third-order aberrations, Zernike polynomials, and fringe analysis. Interferometers (Newton, Fizeau, Twyman-Green, and shearing), fringe localization, and phase shifting. Holographic, Moire, photoelastic and speckle interferometry. Applications of optical metrology. Relevant laboratory experiments. Students must do additional project work on a topic selected by the instructor. Students may not receive credit for both OE 495 and OE 595.

OE 599 Thesis Research 1-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Graduate students only. Credits as arranged; however not more than 12 credits will be applied toward the requirements for the MS (OE) degree.

OE CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of department head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

Last updated: 07/20/2017

Rose-Hulman
Institute of Technology
5500 Wabash Avenue
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Professors Bunch, Ditteon, Duree, Granieri, Joenathan, E. Kirkpatrick, S. Kirkpatrick, Kirtley, Leisher, Letfullin, Liptak, McInerney, Moloney, Siahmakoun, Syed, and Wagner.
NOTE: In courses which include a laboratory, satisfactory completion of the laboratory work is required in order to pass the course.

Physics - Course Descriptions

PH 090 College Preparatory Physics 4R-0L-4C
Prerequisites: College Algebra II
Corequisites: There are no corequisites for this course.
Topics covered include: Units, significant figures, vectors, 1 and 2 dimensional motion; kinematic equations, objects in free-fall, motion in a circle, projectile motion, Newton’s Laws, contact forces, non-contact forces: gravity, Coulomb’s Law, magnetic force; centripetal force; collisions, linear momentum, rotational kinematics, torques, angular momentum, mechanical equilibrium - static equilibrium. The credits from this course cannot be counted toward any degree completion at Rose-Hulman.

PH 111 Physics I 3.5R-1.5L-4C F,W
Prerequisites: There are no prerequisites for this course.
Corequisites: MA 111 Calculus I 5R-0L-5C F,W
Kinematics, Newton's laws of motion, gravitation, Coulomb's law, Lorentz force law, strong and weak nuclear forces, conservation of energy and momentum, relevant laboratory experiments.

PH 112 Physics II 3.5R-1.5L-4C W,S,F
Prerequisites: PH 111 Physics I 3.5R-1.5L-4C F,W, and MA 111 Calculus I 5R-0L-5C F,W
Corequisites: MA 112 Calculus II 5R-0L-5C F,W,S
Torque and angular momentum, oscillations, one-dimensional waves, electric fields and potentials, electric current and resistance, DC circuits, capacitance, relevant laboratory experiments.

PH 113 Physics III 3.5R-1.5L-4C S,F,W
Prerequisites: PH 112 Physics II 3.5R-1.5L-4C W,S,F, and MA 112 Calculus II 5R-0L-5C F,W,S
Corequisites: MA 113 Calculus III 5R-0L-5C F,W,S
Sources of magnetic fields, Faraday's law, inductance electromagnetic waves, reflection and polarization, geometric and physical optics, introduction to relativity, relevant laboratory experiments.

PH 200 Career Preparation 1R-0L-1C W,S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This course is for physics majors to be taken in the second year. The course addresses career choices, summer opportunities, employment and graduate school preparation, and curriculum vitae and resumes preparation. This course is cross-listed with CHEM200, MA200 and SV200.

PH 215 Introduction to CHAOS 2R-0L-2C W

Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
What constitutes chaotic behavior, detection of chaos in real systems using phase space plots, Poincare sections, bifurcation plots, power spectra, Lyupunov exponents, and computer simulation of chaotic systems.

PH 231 Observational Astronomy 1R-3L-2C F
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W, and PH 111 Physics I 3.5R-1.5L-4C F,W or EM 120 Engineering Statics 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Celestial coordinates; basics of celestial mechanics; electromagnetic radiation, atomic structure, spectra, blackbody radiation; telescopes and detectors; quantitative observational work using modern telescopes and detectors.

PH 235 Many-Particle Physics 3.5R-1.5L-4C F
Prerequisites: PH 111 Physics I 3.5R-1.5L-4C F,W
Corequisites: MA 112 Calculus II 5R-0L-5C F,W,S, and EM 202 Dynamics 4R-0L-4C S if PH111 has not been taken.
Dynamics of rigid body, harmonic motion; mechanics of fluids; heat, kinetic theory, thermodynamics. Alternate week laboratories.

PH 241 Physics of Stars 4R-0L-4C W
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W, and PH 111 Physics I 3.5R-1.5L-4C F,W or EM 120 Engineering Statics 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Binary stars and stellar parameters; stellar spectra; stellar atmospheres; stellar interiors; star formation; stellar evolution; star death; stellar remnants; black holes and binary stars.

PH 250 Planets and Galaxies 4R-0L-4C S
Prerequisites: MA 111 Calculus I 5R-0L-5C F,W, and PH 111 Physics I 3.5R-1.5L-4C F,W or EM 120 Engineering Statics 4R-0L-4C F, S
Corequisites: There are no corequisites for this course.
Overview of planets and planetary science; origin and evolution of the solar system; structure and evolution of galaxies; origin and evolution of the universe; introduction to cosmology.

PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W
Corequisites: MA 211 Differential Equations 4R-0L-4C F,W,S
Wave-particle nature of matter and radiation, Bohr model, Schrodinger equation, quantum description of the hydrogen atom, atomic and molecular spectra, and introduction to statistical physics.

PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Prerequisites: PH 112 Physics II 3.5R-1.5L-4C W,S,F, and MA 211 Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Relativity, black-body radiation, the Bohr model, physics of the nucleus, fission and fusion, reactors, nuclear radiation, radiation damage, medical applications.

PH 270 Special Topics in Physics 1-4C

Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in physics. Maximum of 4 credits per term.

PH 290 Directed Research 1-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for freshmen and sophomore students under the direction of a physics and optical engineering faculty member. May earn up to a maximum of 2 credits for meeting the graduation requirements. The student must make arrangements with a faculty member for the research project prior to registering for this course.

PH 292 Physical Optics 3.5R-1.5L-4C F
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W
Corequisites: There are no corequisites for this course.
The wave equation; electromagnetic waves; phase and group velocities; complex refractive index; dispersion, interference; interferometers and applications, optical interferometry; coherence; polarized light; Jones vectors/matrices; production of polarized light; birefringence, Fraunhoffer diffraction; diffraction gratings.

PH 302 Biophysics 4R-0L-4C F
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W or consent of instructor
Corequisites: There are no corequisites for this course.
Biological examples of the interaction of radiation and matter; medical uses of x-rays, nuclear medicine, magnetic resonance imaging, and current applications in biophysics.

PH 310 Introduction to Special Relativity 2R-0L-2C F
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W Consent of instructor
Corequisites: There are no corequisites for this course.
Experimental background of the special theory of relativity, the structure of the theory and its consequences in measurements involving space, time and motion. Relativistic mechanics, relativity and electromagnetism, and applications in modern physics.

PH 314 Theoretical Mechanics I 4R-0L-4C S
Prerequisites: PH 111 Physics I 3.5R-1.5L-4C F,W, and PH 235 Many-Particle Physics 3.5R-1.5L-4C F, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Statics and dynamics of particles and systems of particles, including rigid bodies. Conservation of energy, linear and angular momentum. Central forces. Lagrangian and Hamiltonian equations of motion. Vibrations.

PH 315 Theoretical Mechanics II 4R-0L-4C W
Prerequisites: PH 314 Theoretical Mechanics I 4R-0L-4C S
Corequisites: There are no corequisites for this course.
Statics and dynamics of rigid bodies. Lagrangian treatment of rigid body dynamics. Euler method of rigid body dynamics. Small oscillations about positions of equilibrium and about steady motion. Statics and dynamics of deformable bodies. Computational analysis of mechanical systems.

PH 316 Electric & Magnetic Fields 4R-0L-4C F

Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and MA 211 Differential Equations 4R-0L-4C F,W,S, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Maxwell's equations in integral and point form, vector calculus; electric field and potential, electric fields in matter, boundary conditions; the magnetic field.

PH 317 Electromagnetism 4R-0L-4C W
Prerequisites: PH 316 Electric & Magnetic Fields 4R-0L-4C F
Corequisites: There are no corequisites for this course.
Further methods in electrostatics, Poisson's equation; magnetostatics, the vector potential; electromagnetic induction; magnetic properties of matter; further applications of Maxwell's equations, properties of electromagnetic radiation.

PH 322 Celestial Mechanics 4R-0L-4C S
Prerequisites: PH 112 Physics II 3.5R-1.5L-4C W,S,F or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Dynamics of point masses; the two-body problem; the restricted three-body problem; orbital position as a function of time; orbits in three dimensions; preliminary orbit determination; orbital maneuvers; interplanetary trajectories.

PH 325 Advanced Physics Laboratory I 2R-6L-4C S
Prerequisites: PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Introduction to the methods of experimental physics; topics may include error analysis, component fabrication, transducers, ac circuits, operational amplifiers, electrical signal conditioning, and automated data acquisition.

PH 327 Thermodynamics & Statistical Mechanics 4R-0L-4C S
Prerequisites: PH 235 Many-Particle Physics 3.5R-1.5L-4C F or consent of instructor
Corequisites: There are no corequisites for this course.
First, second, and third laws of thermodynamics. Ideal gases, real gases, liquids, solids, change of phase. The Joule-Thompson effect, adiabatic demagnetization. Kinetic theory of gases, classical and quantum statistical mechanics.

PH 401 Introduction to Quantum Mechanics 4R-0L-4C W
Prerequisites: PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 113 Physics III 3.5R-1.5L-4C S,F,W, and PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Review of wave-particle experiments, atomic model, Bohr theory, deBroglie's hypothesis. Uncertainty principle, Schroedinger equation, quantum mechanical operators and stationary states, quantization and role of angular momentum.

PH 402 Introduction to Atomic Physics 4R-0L-4C S (odd years)
Prerequisites: PH 401 Introduction to Quantum Mechanics 4R-0L-4C W
Corequisites: There are no corequisites for this course.
Solutions of Schroedinger equation, perturbation theory, applications to one electron system. Quantum numbers, spin and magnetic moments, multi-electron systems including LS coupling. Zeeman effect, transition rates, hyperfine structure, X-rays.

PH 404 Acoustics 4R-0L-4C W (odd years)
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W, and MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S
Corequisites: There are no corequisites for this course.
Harmonic motion, waves on strings, membranes, eigenfunctions and eigenvalues; waves in rods and fluids; behavior of waves at interfaces; radiation from vibrating piston; resonators, absorption.

PH 405 Semiconductor Materials & Applications 3R-3L-4C F
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W or PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films. Cross-listed with PH 505.

PH 407 Solid State Physics 4R-0L-4C S (even years)
Prerequisites: PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Selected topics in the field are discussed in detail; e.g., crystal structures, lattice vibrations and electronic band structure; electrical, optical and thermal properties of solids and semi-conductors; and the properties of materials at very low temperatures.

PH 410 General Relativity 4R-0L-4C W (odd years)
Prerequisites: PH 310 Introduction to Special Relativity 2R-0L-2C F, and MA 421 Tensor Calculus & Riemannian Geometry 4R-0L-4C Arranged
Corequisites: There are no corequisites for this course.
An in-depth study of Einstein’s theory of General Relativity. Gravity as geometry and curved space-time, metrics, and geodesics. Orbits and light paths around spherical masses. Detailed study of Einstein’s equation in vacuum and with sources of space-time curvature.

PH 425 Advanced Physics Laboratory II 0R-8L-4C W
Prerequisites: PH 325 Advanced Physics Laboratory I 2R-6L-4C S
Corequisites: There are no corequisites for this course.
Selected experiments in various areas of physics, with primary emphasis on nuclear physics and a significant independent student project

PH 440 X-rays and Crystalline Materials 2R-6L-4C S (even years)
Prerequisites: PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
X-ray emission, absorption, fluorescence, and diffraction. Methods of analyzing crystalline solid materials. Applications in solid-state physics, materials science, chemistry, metallurgy, and biology.

PH 460 Directed Study 1-4C

Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Permits study in an area of physics not available in regular course offerings. Maximum of 4 credits per term.

PH 470 Special Topics in Physics 2-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Lectures on special topics in physics.

PH 480 Seminar 0C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Lectures by staff, students, and outside speakers on topics of special interest.

PH 490 Directed Research 1-2 C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Research for junior and senior students under the direction of a physics and optical engineering faculty member. May earn a maximum of 8 credits between PH 290 and PH 490 for meeting graduation requirements. Maximum of 2 credits per term. The student must make arrangements with a physics and optical engineering faculty member for the research project prior to registering for this course.

PH 496 Senior Thesis 2-4C
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 497 Senior Thesis 2-4C F
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 498 Senior Thesis 2-4C W
Prerequisites: Consent of PHOE faculty
Corequisites: There are no corequisites for this course.
Literature search, research proposal preparation, and laboratory project work with a total number of 8 credit hours over the three quarter sequence. This sequence is designed to result in a completed senior thesis.

PH 499 Physics Ethics and Communication 1R-0L-1C S
Prerequisites: PH 497 Senior Thesis 2-4C F, PH 498 Senior Thesis 2-4C W or PH 425 Advanced Physics Laboratory II 0R-8L-4C W
Corequisites: There are no corequisites for this course.
Guidelines will be discussed to encourage ethical reporting and conduct of research performed by individuals. Situations in physics research and publication will be presented and discussed in regards to ethical reporting and conduct. As the final

component of the students' Senior Thesis, students will prepare oral and written presentations of their research and present them at a public forum held near the end of the spring term. Students not in the thesis track will present (in both oral and written form) the projects conducted in PH425 Advanced Physics Lab II.

PH 505 Semiconductor Materials & Devices I 3R-3L-4C F
Prerequisites: PH 113 Physics III 3.5R-1.5L-4C S,F,W or PH 255 Foundations of Modern Physics 3.5R-1.5L-4C W or PH 265 Fundamentals of Nuclear Physics & Radiation 3R-3L-4C S
Corequisites: There are no corequisites for this course.
Material structure electronic levels and energy bands; semiconductor doping; optical and electronic material characteristics; p-n junction and diode characteristics; bipolar junction transistor; basics of device fabrication. Laboratories on X-ray and Scanning Electron Microscope investigations, device characteristics and a three-week design project on production and testing of thin films. Students must do additional project work on a topic selected by the instructor. Cross-listed with PH 405.

PH 512 Methods of Mathematical Physics 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Ordinary and partial differential equations, linear vector spaces, matrices, tensors. Strum-Liouville theory and eigenvalue problems, special functions, function of a complex variable, theory of groups, linear integral equations.

PH 514 Quantum Mechanics 4R-0L-4C
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Development of quantum mechanical theory to the present time. Examples from spectroscopy, chemistry, nuclear physics.

PH 530 Advanced Acoustics 4R-0L-4C
Prerequisites: PH 404 Acoustics 4R-0L-4C W (odd years)
Corequisites: There are no corequisites for this course.
Waves in solids, electrodynamics and piezoelectric sound transducers, ultrasonics. Architectural acoustics. Underwater sound.

PH 537 Advanced Image Processing 3R-3L-4C S
Prerequisites: MA 212 Matrix Algebra & Systems of Differential Equations 4R-0L-4C F,W,S, CSSE 220 Object-Oriented Software Development 3R-3L-4C F,W,S or CSSE 221 Fundamentals of Software Development Honors 3R-3L-4C F,W,S, and ME 323 Numerical Methods in Engineering 1R-3L-2C W,S or ECE 380 Discrete-Time Signals and Systems 4R-0L-4C F,W or consent of instructor
Corequisites: There are no corequisites for this course.
Introduction to color image processing and image recognition. Morphological methods, feature extraction, advanced segmentation, detection, recognition and interpretation. Integral laboratory. Same as ECE 582.

PH 538 Introduction to Neural Networks 3R-3L-4C
Prerequisites: Senior or Graduate Standing
Corequisites: There are no corequisites for this course.

Classifiers, linear separability. Supervised and unsupervised learning. Perceptrons. Back-propagation. Feedback networks. Hopfield networks. Associative memories. Fuzzy neural networks. Integral laboratory.

PH 540 Computer Physics 3R-3L-4C
Prerequisites: Consent of instructor
Corequisites: There are no corequisites for this course.
Exploration of physics by simulation including planetary motion, waves, chaos, cellular automata and fractals; application of numerical methods of differentiation and integration; computer hardware and machine language as it affects laboratory use; curve fitting and smoothing of data.

PH CPT Curricular Practical Training 1R-0L-1C
Prerequisites: Consent of Department Head
Corequisites: There are no corequisites for this course.
Any international student with an F-1 Visa employed by any company in the form of an internship, co-op, or practicum must enroll in a CPT course. The CPT experience is to be complimentary training to the student's curriculum and should contribute substantially to his/her learning experience. Students must have an offer of employment from a company prior to registering for this course. The CPT must be approved by the Department Head, Director of International Student Services, and the student's advisor. Students are required to submit a report at the conclusion of the employment to his/her instructor to receive a grade for the CPT experience.

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Rose-Hulman
Institute of Technology
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Rose-Hulman Institute of Technology Course Catalog

ROTC-Air Force - Course Descriptions

AS 101 Foundations of the United States Air Force I 1R-2L-1C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
This is a survey course designed to introduce students to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officership and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

AS 101L Leadership Laboratory - F,W,S
Prerequisites: AS 101 Foundations of the United States Air Force I 1R-2L-1C F* or AS 102 Foundations of the United States Air Force II 1R-2L-1C W* or AS 103 Foundations of the United States Air Force III 1R-2L-1C W* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 102 Foundations of the United States Air Force II 1R-2L-1C W
Prerequisites: AS 101 Foundations of the United States Air Force I 1R-2L-1C F or consent of instructor
Corequisites: There are no corequisites for this course.
This course is a continuation of the fall quarter course designed to introduce students to the United States Air Force and Air Force Reserve Officer Training Corps.

AS 102L Leadership Laboratory - F,W,S
Prerequisites: AS 101 Foundations of the United States Air Force I 1R-2L-1C F* or AS 102 Foundations of the United States Air Force II 1R-2L-1C W* or AS 103 Foundations of the United States Air Force III 1R-2L-1C W* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 103 Foundations of the United States Air Force III 1R-2L-1C W
Prerequisites: AS 102 Foundations of the United States Air Force II 1R-2L-1C W or consent of instructor
Corequisites: There are no corequisites for this course.

This course is a continuation of the winter quarter course designed to introduce students to the United States Air Force and Air Force Reserve Officer Training Corps.

AS 103L Leadership Laboratory - F,W,S
Prerequisites: AS 101 Foundations of the United States Air Force I 1R-2L-1C F* or AS 102 Foundations of the United States Air Force II 1R-2L-1C W* or AS 103 Foundations of the United States Air Force III 1R-2L-1C W* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 2 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 201 The Evolution of Air and Space Power I 2R-3L-2C F
Prerequisites: AS 103 Foundations of the United States Air Force III 1R-2L-1C W or consent of instructor
Corequisites: There are no corequisites for this course.
This course designed to examine the general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space-age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today's USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g. Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences.

AS 201L Leadership Laboratory 0 F,W,S
Prerequisites: AS 201 The Evolution of Air and Space Power I 2R-3L-2C F* or AS 202 The Evolution of Air and Space Power II 2R-3L-2C W* or AS 203 The Evolution of Air and Space Power III 2R-3L-2C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 202 The Evolution of Air and Space Power II 2R-3L-2C W
Prerequisites: AS 201 The Evolution of Air and Space Power I 2R-3L-2C F or consent of instructor
Corequisites: There are no corequisites for this course.

This course is a continuation of the fall quarter course designed to examine the general aspects of air and space power through a historical perspective.

AS 202L Leadership Laboratory 0 F,W,S
Prerequisites: AS 201 The Evolution of Air and Space Power I 2R-3L-2C F* or AS 202 The Evolution of Air and Space Power II 2R-3L-2C W* or AS 203 The Evolution of Air and Space Power III 2R-3L-2C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 203 The Evolution of Air and Space Power III 2R-3L-2C S
Prerequisites: AS 202 The Evolution of Air and Space Power II 2R-3L-2C W or consent of instructor
Corequisites: There are no corequisites for this course.
This course is a continuation of the winter quarter course designed to examine the general aspects of air and space power through a historical perspective.

AS 203L Leadership Laboratory 0 F,W,S
Prerequisites: AS 201 The Evolution of Air and Space Power I 2R-3L-2C F* or AS 202 The Evolution of Air and Space Power II 2R-3L-2C W* or AS 203 The Evolution of Air and Space Power III 2R-3L-2C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 301 Air Force Leadership Studies I 3R-3L-4C F
Prerequisites: Enrollment in Professional Officer Corps
Corequisites: There are no corequisites for this course.
This course is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course.

AS 301L Leadership Laborator - F,W,S
Prerequisites: AS 301 Air Force Leadership Studies I 3R-3L-4C F* or AS 302 Air Force Leadership Studies II 3R-3L-4C W* or AS 303 Air Force Leadership Studies III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.

Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 302 Air Force Leadership Studies II 3R-3L-4C W
Prerequisites: AS 301 Air Force Leadership Studies I 3R-3L-4C F
Corequisites: There are no corequisites for this course.
This course is a continuation of the fall quarter course designed to study leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer.

AS 302L Leadership Laborator - F,W,S
Prerequisites: AS 301 Air Force Leadership Studies I 3R-3L-4C F* or AS 302 Air Force Leadership Studies II 3R-3L-4C W* or AS 303 Air Force Leadership Studies III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 303 Air Force Leadership Studies III 3R-3L-4C S
Prerequisites: AS 302 Air Force Leadership Studies II 3R-3L-4C W
Corequisites: There are no corequisites for this course.
This course is a continuation of the winter quarter course designed to study leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer.

AS 303L Leadership Laborator - F,W,S
Prerequisites: AS 301 Air Force Leadership Studies I 3R-3L-4C F* or AS 302 Air Force Leadership Studies II 3R-3L-4C W* or AS 303 Air Force Leadership Studies III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F
Prerequisites: AS 303 Air Force Leadership Studies III 3R-3L-4C S
Corequisites: There are no corequisites for this course.

This course examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officership, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and management principles of this course.

AS 401L Leadership Laboratory - F,W,S
Prerequisites: AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F* or AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W* or AS 403 National Security Affairs & Preparation for Active Duty III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W
Prerequisites: AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F
Corequisites: There are no corequisites for this course.
This course is a continuation of the fall quarter course designed to examine the national security process, regional studies, advanced leadership ethics, and Air Force doctrine.

AS 402L Leadership Laboratory - F,W,S
Prerequisites: AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F* or AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W* or AS 403 National Security Affairs & Preparation for Active Duty III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

AS 403 National Security Affairs & Preparation for Active Duty III 3R-3L-4C S
Prerequisites: AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W
Corequisites: There are no corequisites for this course.
This course is a continuation of the winter quarter course designed to examine the national security process, regional studies, advanced leadership ethics, and Air Force doctrine.

AS 403L Leadership Laboratory - F,W,S

Prerequisites: AS 401 National Security Affairs and Preparation for Active Duty I 3R-3L-4C F* or AS 402 National Security Affairs and Preparation for Active Duty II 3R-3L-4C W* or AS 403 National Security Affairs & Preparation for Active Duty III 3R-3L-4C S* *Enrollment in one of the three courses
Corequisites: There are no corequisites for this course.
Meets one day a week for 3 hours. This class is mandatory for cadets who apply for membership in the AFROTC program and who are pursuing a commission in the United States Air Force. Cadets apply leadership concepts and principles, and practice critical skills needed to be an effective Air Force officer. Activities include physical fitness training, communication exercises, drill and ceremonies, and active duty Air Force experiences.

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Academic Electives

In order to fulfill commissioning requirements, cadets in the Military Science program must take and successfully complete one college undergraduate course to satisfy the Professional Military Education (PME) requirement for American Military History. This should be taken during the course of the student's four years of academic studies and completed prior to graduation and commissioning. A complete listing of all applicable PME courses is available through the ROTC department.

ROTC-Army - Course Descriptions

MS 101 Introduction to the Army and Critical Thinking 1R-3L-1C F
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
MS 101 introduces Cadets to the personal challenges and competencies that are critical for effective leadership. Cadets learn how the personal development of life skills such as critical thinking, time management, goal setting, stress management, and comprehensive fitness relate to leadership, and the Army profession.

MS 102 Adaptive Leadership & Professional Competence 1R-3L-1C W
Prerequisites: MS 101 Introduction to the Army and Critical Thinking 1R-3L-1C F or consent of instructor
Corequisites: There are no corequisites for this course.
MS 102 introduces Cadets to the personal challenges and competencies that are critical for adaptive leadership. Cadets learn the basics of the communications process and the importance for leaders to develop the essential skills to effectively communicate in the Army. Students will examine the Army Profession and what it means to be a professional in the U.S. Army.

MS 103 Basic Tactical leadership 1R-3L-1C S
Prerequisites: MS 101 Introduction to the Army and Critical Thinking 1R-3L-1C F, and MS 102 Adaptive Leadership & Professional Competence 1R-3L-1C W or consent of instructor
Corequisites: There are no corequisites for this course.
MS 103 continues the exploration of leadership fundamentals and examines the leadership process as affected by individual differences and styles, group dynamics, and personality behavior of leaders. Students will experience an introduction of fundamental leadership concepts, and examine factors that influence leader and group effectiveness. Students will fully explore the basic soldier skills and squad level tactical operations. Students participate in briefings and hands-on practical exercises. Attention is devoted to development of leadership potential through practical exercises both in and out of the classroom.

MS 201 Leadership and Decision Making 2R-3L-2C F
Prerequisites: MS 101 Introduction to the Army and Critical Thinking 1R-3L-1C F, and MS 102 Adaptive Leadership & Professional Competence 1R-3L-1C W, and MS 103 Basic Tactical leadership 1R-3L-1C S or consent of instructor
Corequisites: There are no corequisites for this course.

MS 201 explores the dimensions of creative and innovative tactical leadership strategies and styles by examining team dynamics and two historical leadership theories that form the basis of the Army leadership framework. Aspects of personal motivation and team building are practiced planning, executing and assessing team exercises.

MS 202 Army Doctrine & Team Development 2R-3L-2C W
Prerequisites: MS 201 Leadership and Decision Making 2R-3L-2C F or consent of instructor
Corequisites: There are no corequisites for this course.
MS 202 examines the challenges of leading teams in the complex operational environment. The course highlights dimensions of terrain analysis, patrolling, and operation orders. Further study of the theoretical basis of the Army Leadership Requirements Model explores the dynamics of adaptive leadership in the context of military operations. Cadets develop greater self awareness as they assess their own leadership styles and practice communication and team building skills.

MS 203 Foundations of Tactical Leadership II 2R-3L-2C S
Prerequisites: MS 201 Leadership and Decision Making 2R-3L-2C F, and MS 202 Army Doctrine & Team Development 2R-3L-2C W or consent of instructor
Corequisites: There are no corequisites for this course.
MS203 continues the examination of the challenge of leading tactical teams in the complex contemporary operational environments. Dimensions of the cross-cultural challenges of leadership in a constantly changing world are highlighted and applied to practical Army leadership tasks and situations. Cadets develop greater self-awareness as they practice communication and team building skills. Contemporary Operational Environment case studies give insight into the importance and practice of teamwork and tactics in real world scenarios.

MS 206 ROTC Cadet Initial Entry Training Course -
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
Covering a training period of approximately thirty days, the Department of Military Science ROTC battalion provides travel to and from Fort Knox. Students may attend to access their desire to continue and contract into the ROTC Advanced Course. While in the course, you will meet students from all over the nation while earning $700 in pay and receive free room and board. You may apply for a two-year Full-tuition scholarship and receive up to $1200 annually for books and earn a monthly stipend of over $450 per month for 10 months per year. The Cadet Initial Entry Training Course is a way to catch up on missed Military Science courses in order to qualify the student for progression as a contracted Advanced Course ROTC cadet.

MS 301 Training Management and the Warfighting Functions 3R-3L-4C F
Prerequisites: MS 206 ROTC Cadet Initial Entry Training Course - W or completion of Basic Course requirements, or prior military service (contact Military Science Department for specific requirements established in Army Regulations)
Corequisites: There are no corequisites for this course.
MS 301 Cadets will study, practice, and apply the fundamentals of Army Leadership, Officership, Army Values and Ethics, Personal Development, and small unit tactics at the platoon level. At the conclusion of this course, Cadets will be capable of planning, coordinating, navigating, motivating and leading a squad and platoon in the execution

of a mission during a classroom PE, a Leadership Lab, or during a Leader Training Exercise (LTX).

MS 302 Applied Leadership in Small Unit Operations 3R-3L-4C W
Prerequisites: MS 301 Training Management and the Warfighting Functions 3R-3L-4C F
Corequisites: There are no corequisites for this course.
MS 302 uses increasingly intense situational leadership challenges to build cadet awareness and skills in leading small units. Skills in decision-making, persuading and motivating team members when under fire are explored, evaluated, and developed. Aspects of military operations are reviewed as a means of preparing for the ROTC Cadet Leader Course (CLC). Cadets are expected to apply basic principles of the Law of Land Warfare, Army training, and motivation to troop leading procedures. Emphasis is also placed on conducting military briefings and developing proficiency in garrison operation orders. Cadets are evaluated on what they know and do as leaders.

MS 303 Leadership under Fire II 3R-3L-4C S
Prerequisites: MS 302 Applied Leadership in Small Unit Operations 3R-3L-4C W
Corequisites: There are no corequisites for this course.
MS 303 continues development in decision making, persuading, and motivating team members in operational situations are explored, evaluated and developed. Aspects of military operations are reviewed as a means of preparing for CLC. Cadets are expected to apply basic principles of Law of the Land Warfare, Army training, and motivation to troop leading procedures. Emphasis is also placed on conducting military briefings and developing proficiency in garrison operations orders. Cadets are evaluated on what they know and do as leaders.

MS 401 Mission Command & Ethics 3R-3L-4C F
Prerequisites: MS 303 Leadership under Fire II 3R-3L-4C S
Corequisites: There are no corequisites for this course.
MS 401 is an advanced course that places primary emphasis on Officership with our MS IV cadets who are our educational main effort; MS 401 and 402 together refine and ultimately completes the Cadet-tocommissioned officer transition. In MS 401 Mission Command and ethics is stressed in order to assist the Cadet in further embracing their future role as an Army officer.

MS 402 Mission Command and the Army 3R-3L-4C W
Prerequisites: MS 401 Mission Command & Ethics 3R-3L-4C F
Corequisites: There are no corequisites for this course.
MS 402 and MS 403 are the culmination of a four-year sequential, progressive, challenging developmental leadership experience. It is during this quarter and MSL 403 that the Cadet is undergoing final preparation for the duties and responsibilities of a commissioned officer along with their integration into the Army. The emphasis is placed on critical knowledge, skills, abilities and competencies skills newly commissioned officers will need to succeed in their first unit of assignment, and the modern operating environment where they will be expected to plan, prepare, execute, and assess platoon-level training strategies and more to enable mission accomplishment.

MS 403 Leadership in a Complex World II 3R-3L-4C S
Prerequisites: MS 401 Mission Command & Ethics 3R-3L-4C F
Corequisites: There are no corequisites for this course.

MS 403 continues the exploration of the dynamics of leading in the complex situations of current military operations from MS 402. Cadets examine differences in customs and courtesies, military law, principles of war, and rules of engagement in the face of international terrorism. Aspects of interacting with non-government organizations, civilians on the battlefield, and host nation support are examined and evaluated. Significant emphasis is placed on preparing cadets for their first unit of assignment as Second Lieutenants.

MS 497 Military Science Independent Study Variable Credit
Prerequisites: MS 301 Training Management and the Warfighting Functions 3R-3L-4C F, and MS 302 Applied Leadership in Small Unit Operations 3R-3L-4C W, and MS 303 Leadership under Fire II 3R-3L-4C S and consent of instructor
Corequisites: There are no corequisites for this course.
MS 497 provides ROTC cadets who have completed their Cadet Leader Course the opportunity to conduct detailed research and independent study on a current problem or topic associated with the military. Program of study will be arranged individually with the Professor of Military Science.

Overview of CLC Cadet Leader Course - S
Prerequisites: There are no prerequisites for this course.
Corequisites: There are no corequisites for this course.
The purpose of the course is to train U.S. Army ROTC Cadets to Army standards, to develop their leadership skills, and to evaluate their officer potential. The 29-day course starts with individual training and leads to collective training, building from simple to complex tasks. This building-block approach permits integration of previously-learned skills into follow-on training. This logical, common-sense training sequence is maintained for each training cycle. Every day at CLC is a day of training.

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