Teacher Instruction Guide:

Harnessing the Sun's Energy with a Solar-Powered Car

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Context:

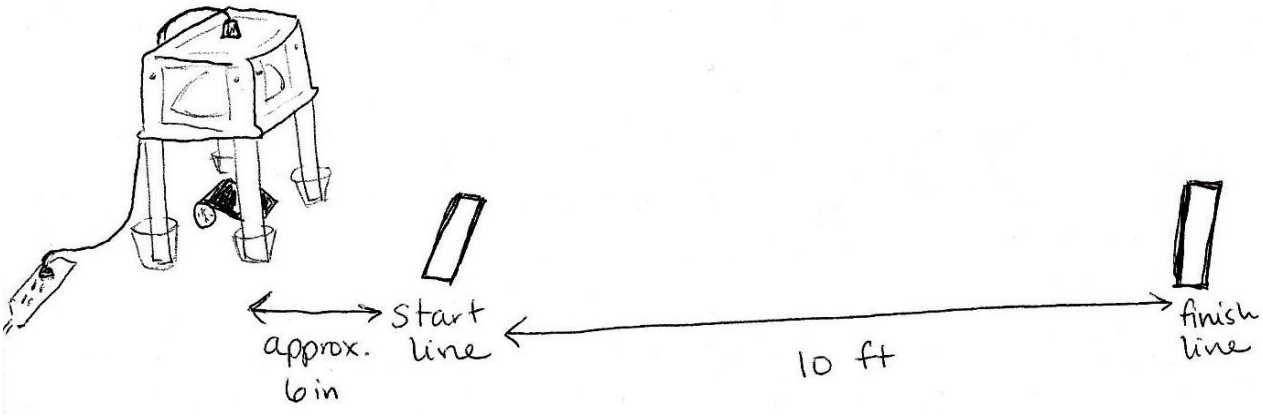
The solar-powered car project is designed to teach 4th and 5th grade students of all abilities about the importance of solar power and its necessity in the future as a primary energy source through hands-on activities. The main activity involves computing the speed of a small solar powered toy car by measuring out a distance and timing the car while it travels the distance. The light source which powers the car is mounted to a structure at three different heights which show a big difference in the energy output of the car. The inspiration behind the activity is one of the fourteen grand challenges for engineering: make solar energy economical. The usual take on this challenge is to improve the materials inside the solar panel or improving the connection between a solar panel and a battery which is the typical method of storing solar energy. Instead, this demonstration focuses on creating the optimal environment for a solar panel to collect the most solar energy and immediately turn it into kinetic energy, the energy of motion. Making solar energy more economical can also be accomplished by getting more energy out of the exact same solar panel. The solar-powered car activity highlights this focus by having the students compare the average speeds of the car when the light source is located at differing heights above the car. The students will be able to relate the proximity of the light source to the maximum speed of the car while gaining experience with the scientific process of running multiple trials, finding averages of the data, and dealing with error caused by variables in an experiment.

Instructions:

1. Divide the students into groups of two to three. Each group will need a solar-powered car, one light box, four cups, and one timer. See Appendix A for material identification.

2. Instruct each group of students to measure out a distance of 10 feet (or less) depending on the area of the classroom on the ground. The students should use the tape measurer. The students should mark the start and finish lines with masking tape.

3. Have each group place the front of their car approximately 6 in. before the start line and place one of the light boxes directly over the car with cups under each of the PVC footings.



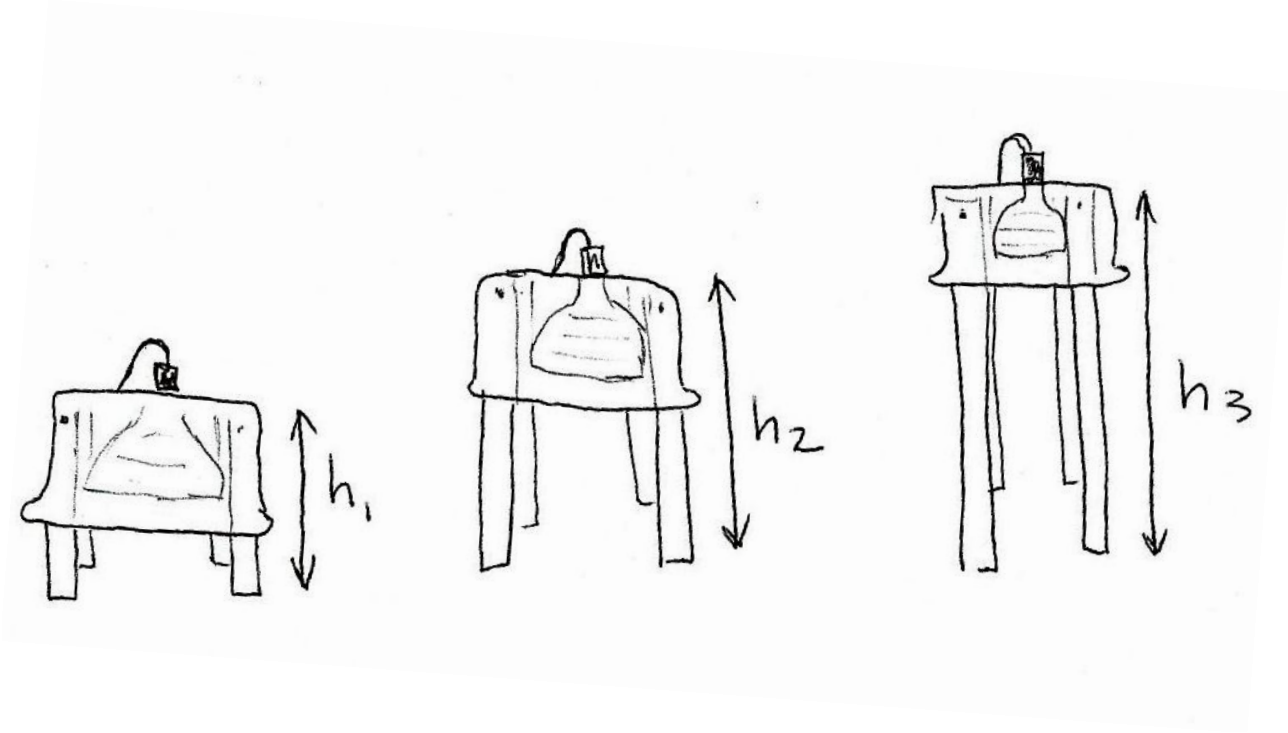
4. Have another student in the group plug in the light box into an outlet and turn on the switch.

5. Slide the light box along the path of the car. Always turn the light off between trials to prevent the box from overheating.

6. Instruct one student to time how long it takes for the front of the car to travel the distance between the start line and the finish line.

7. Instruct the group to record the measurements from each trial on their handout (see Appendix B).

8. Repeat steps 3-6 with each different height light box. Perform two trials at each height.



9. Have the students calculate the speed for each trial by using the equation speed = distance/time by using long division or a calculator.

10. Instruct each student to plot their speeds on a graph of speed vs height of light box to compare the speeds the car traveled to the height of the light box used.

11. Instruct the student to complete the handout then distribute the take home activities (Appendix C).

Budget:

Item	Retail Cost	Out of Pocket Cost	Unit/Size	Units/One Car and Three Light Boxes
Solar Panel	$23.99	$23.99	5	2
Bread Board	$1.00	Donated	1	1/5th
Rear Wheels	$4.99	Donated	4	2
Front Wheels and Axel	$1.00	Donated	2	1
Large Gear	$1.00	Donated	2	1
Small Gear	$0.99	Donated	2	1
Axel	$2.75	Donated	10	3
Axel Hole Lego	$2.00	Donated	6	2
Motor	$9.99	Donated	1	1
Wire (100ft)	$8.71	Donated	1	~3 ft
Light Socket and Plug	$4.05	$4.05	1	3
PVC Pipe (10ft., 1.25")	$4.20	Donated	1	2
Light Reflector	$6.47	Donated	1	3
Light Bulbs	$2.38	$2.38	2	3
12 qt Bin	$48.60	Donated	12	3
Tape of Choice	$1-$3	$1-$3	varies	varies
10’ Quilters Tape Measure	$2.50	Donated	1	1
8 Digit Calculator	$1.50	Donated	1	1
Plastic Cups	$6.50	Donated	100	4
Total for 1 Car/3 Light Boxes:	**$94.78**	**$26.32**		

Additional Learning Resources:

What is the solar energy grand challenge?

It is currently very expensive to extract energy from the sun through the use of solar panels. How can solar energy begin to be implemented worldwide? To start, it would be much easier if it was more efficient and more economical. The energy from the sun can provide 10,000 times the energy currently used on earth each day, and is renewable. Current solar panels are only 10 to 20% efficient in retrieving the energy from the sun, and are quite expensive to produce. Engineers are needed in order to help find ways to capture the energy from the sun more efficiently and in a more cost effective way.

http://www.engineeringchallenges.org/cms/8996/9082.aspx

What are semiconductors, and how do they work?

A Semiconductor Is essentially a material that is better at conducting electricity than an insulator, such as rubber, but not as good at conducting electricity as a conductor, such as metal. The semiconductors can be either missing electrons or have extra electrons. When voltage is applied to the semiconductors, either the holes where electrons should be are filled, or the extra electrons leave. The movement of these electrons causes current, which can be used to provide power to items.

http://www.dummies.com/how-to/content/electronics-basics-what-is-a-semiconductor.html

How do photovoltaic cells work?

The solar panel is layered with two materials, which are semiconductors. One has an extra electron, and one is missing an electron. When the energy from the sun, which comes in photons, impacts the material with the extra electron, the electron gains enough energy to jump and fill a spot for an electron that was missing on the other material. These electrons then flow through metal contacts from the material that was missing an electron, through a wire, back to the material that has extra electrons. This creates a current that can provide power to items connected to the wires.

http://www.solarworld-usa.com/solar-101/how-solar-panels-work

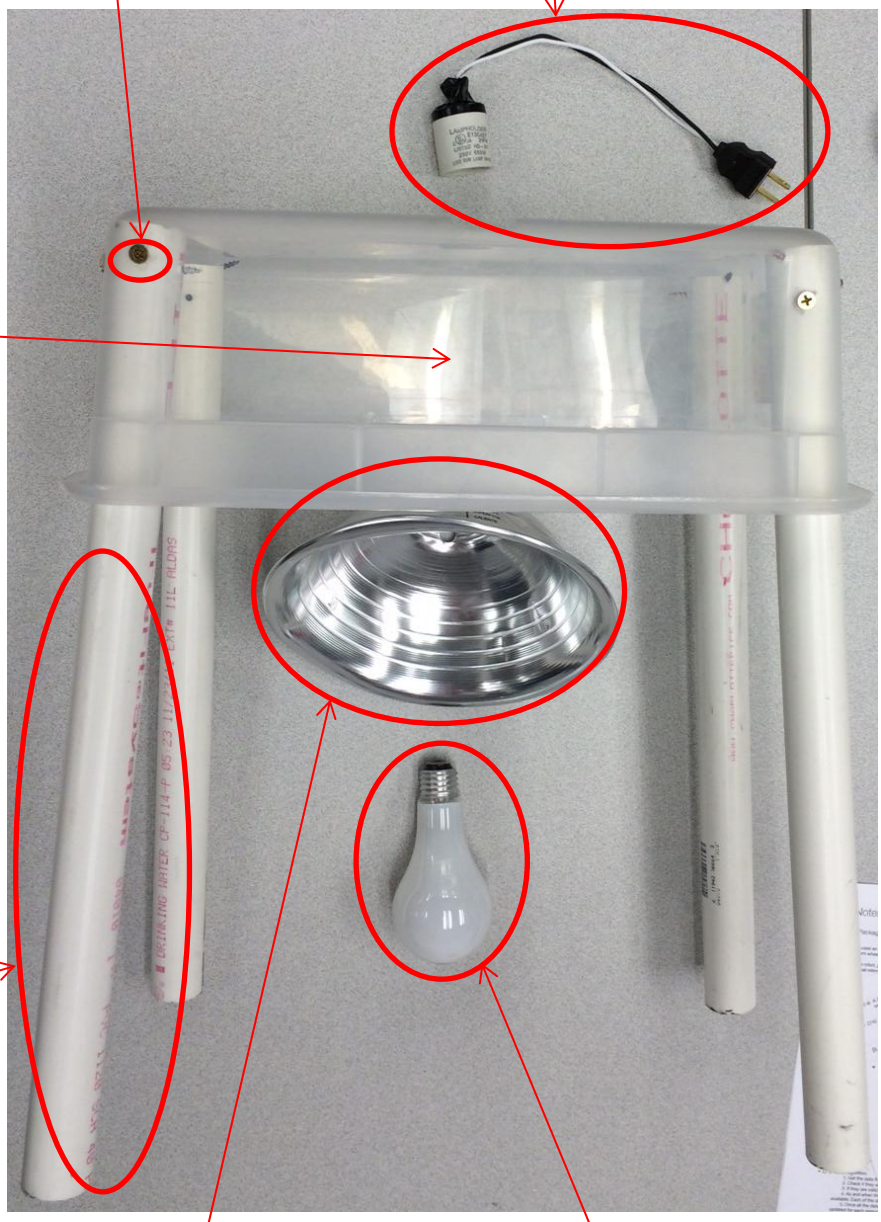
What other uses are there for solar energy?

Heat from the sun can be used to heat concrete and keep buildings warm at night. Heat from the sun may also be used to heat water pipes in homes and reduce the need for a water heater. On larger scales, solar panels may be used to produce steam from boiling water to turn turbines and create electricity.

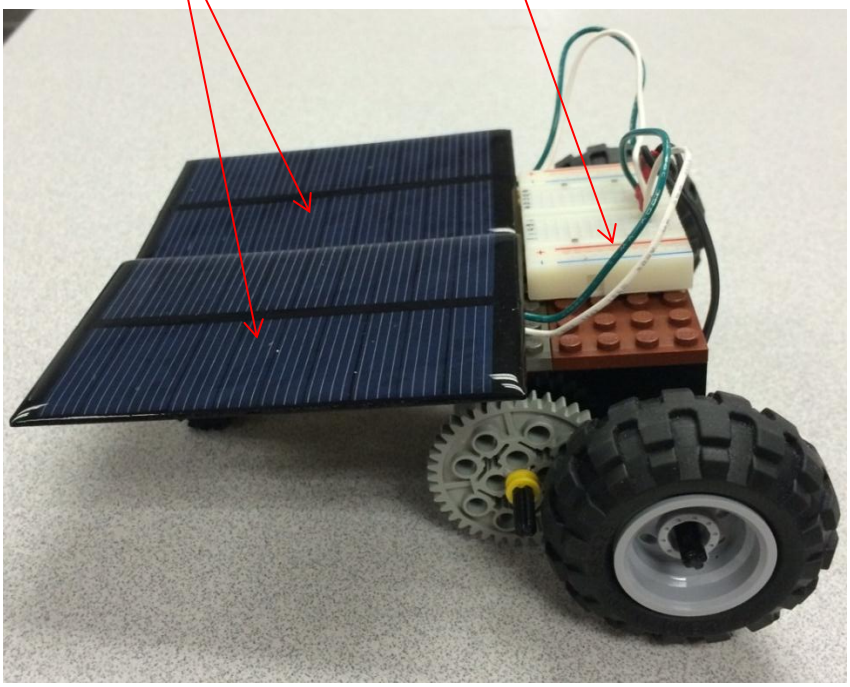
http://environment.nationalgeographic.com/environment/global-warming/solar-power-profile/

Appendix A: Material Identification

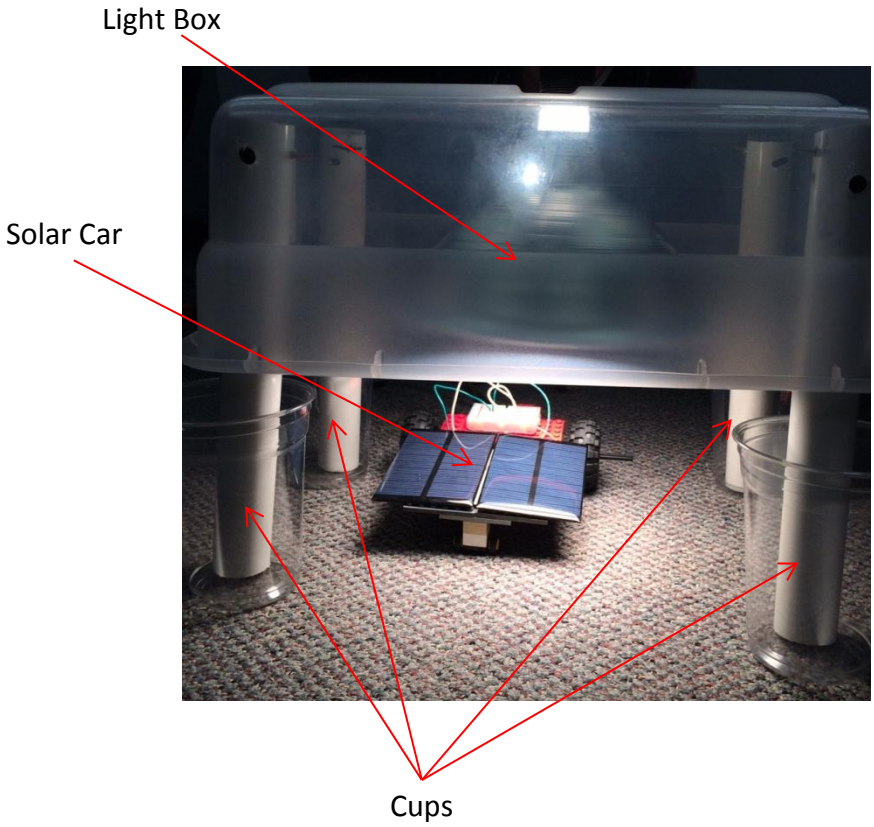
Light Box:



Solar Car:



Experiment Setup:



Name: Key Date: _____

How fast will the solar powered car go?

Trial:	Height of light:	Distance:	Time:	Speed:
1		ft	s	ft/s
2		ft	s	ft/s
3		ft	s	ft/s
4		ft	s	ft/s
5		ft	s	ft/s
6		ft	s	ft/s

1. Why are the speeds different when the light is at the same height?

The light box may not have always been directly over the car. The timings may not have been taken perfectly.

2. Why are the speeds different when the light is at different heights?

The closer the light box is to the solar car, the more light the car can absorb which causes the car to move faster.

Name:_____ Date: _____

How fast will the solar powered car go?

Trial:	Height of light:	Distance:	Time:	Speed:
1		ft	s	ft/s
2		ft	s	ft/s
3		ft	s	ft/s
4		ft	s	ft/s
5		ft	s	ft/s
6		ft	s	ft/s

1. Why are the speeds different when the light is at the same height?

_____

_____

2. Why are the speeds different when the light is at different heights?

_____

_____

Solar Energy: Fill in the Blank Key

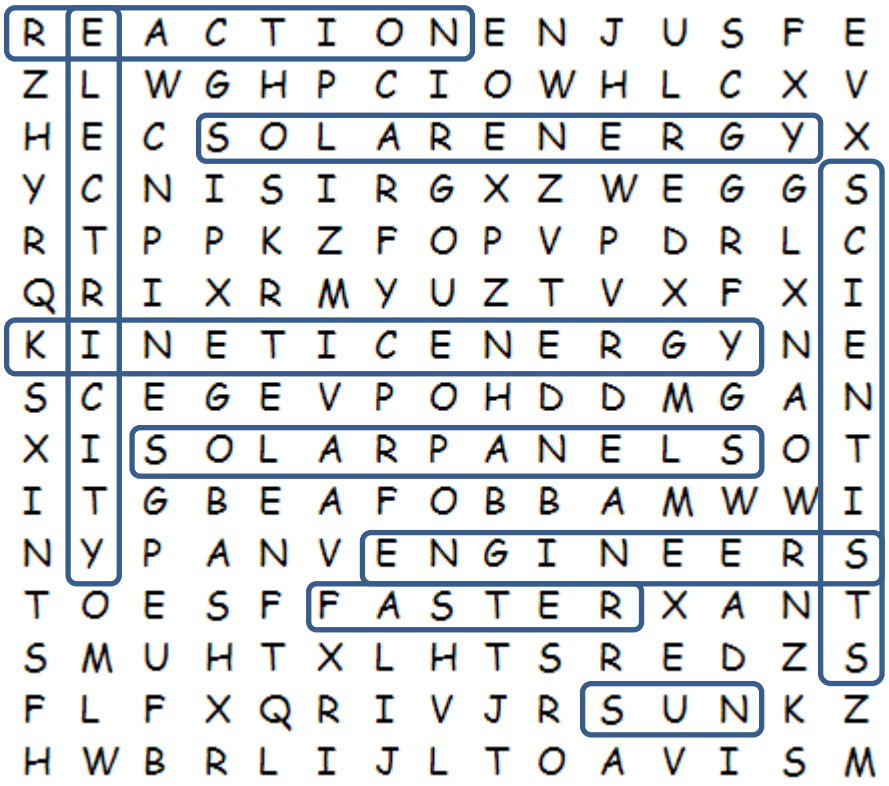
Energy from the sun can be used in many ways. The type of energy a solar panel uses is called solar energy. This type of energy can be turned into electricity by solar panels. The energy from the sun starts a chemical reaction in the solar panel which makes electrons flow through it. The flow of electrons is called electricity. When a solar panel is connected to a car, it can use the energy from the sun to make the car move.

Kinetic energy is a type of energy that is present when something is moving. The better a solar panel is at gathering the sun's energy, the faster the car will go! Scientists and engineers work hard to make solar panels affordable and even better at using the energy from the sun.

Word Bank:

Electricity	Kinetic Energy	Solar energy
Engineers	Reaction	Solar panels
Faster	Scientists	Sun

Solar Energy: Word Search Key



Word Bank:

Electricity

Engineers

Faster

Kinetic Energy

Reaction

Scientists

Solar Energy

Solar Panels

Sun

Draw your solar car below:

Solar Energy: Fill in the Blank

Energy from the _____ can be used in many ways. The type of energy a solar panel uses is called _____. This type of energy can be turned into electricity by _____. The energy from the sun starts a chemical _____ in the solar panel which makes electrons flow through it. The flow of electrons is called _____. When a solar panel is connected to a car, it can use the energy from the sun to make the car move.

_____ is a type of energy that is present when something is moving. The better a solar panel is at gathering the sun's energy, the _____ the car will go! _____ and _____ work hard to make solar panels affordable and even better at using the energy from the sun.

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Engineers	Reaction	Solar panels
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Solar Energy: Word Search

R E A C T I O N E N J U S F E
Z L W G H P C I O W H L C X V
H E C S O L A R E N E R G Y X
Y C N I S I R G X Z W E G G S
R T P P K Z F O P V P D R L C
Q R I X R M Y U Z T V X F X I
K I N E T I C E N E R G Y N E
S C E G E V P O H D D M G A N
X I S O L A R P A N E L S O T
I T G B E A F O B B A M W W I
N Y P A N V E N G I N E E R S
T O E S F F A S T E R X A N T
S M U H T X L H T S R E D Z S
F L F X Q R I V J R S U N K Z
H W B R L I J L T O A V I S M

Word Bank:

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Kinetic Energy

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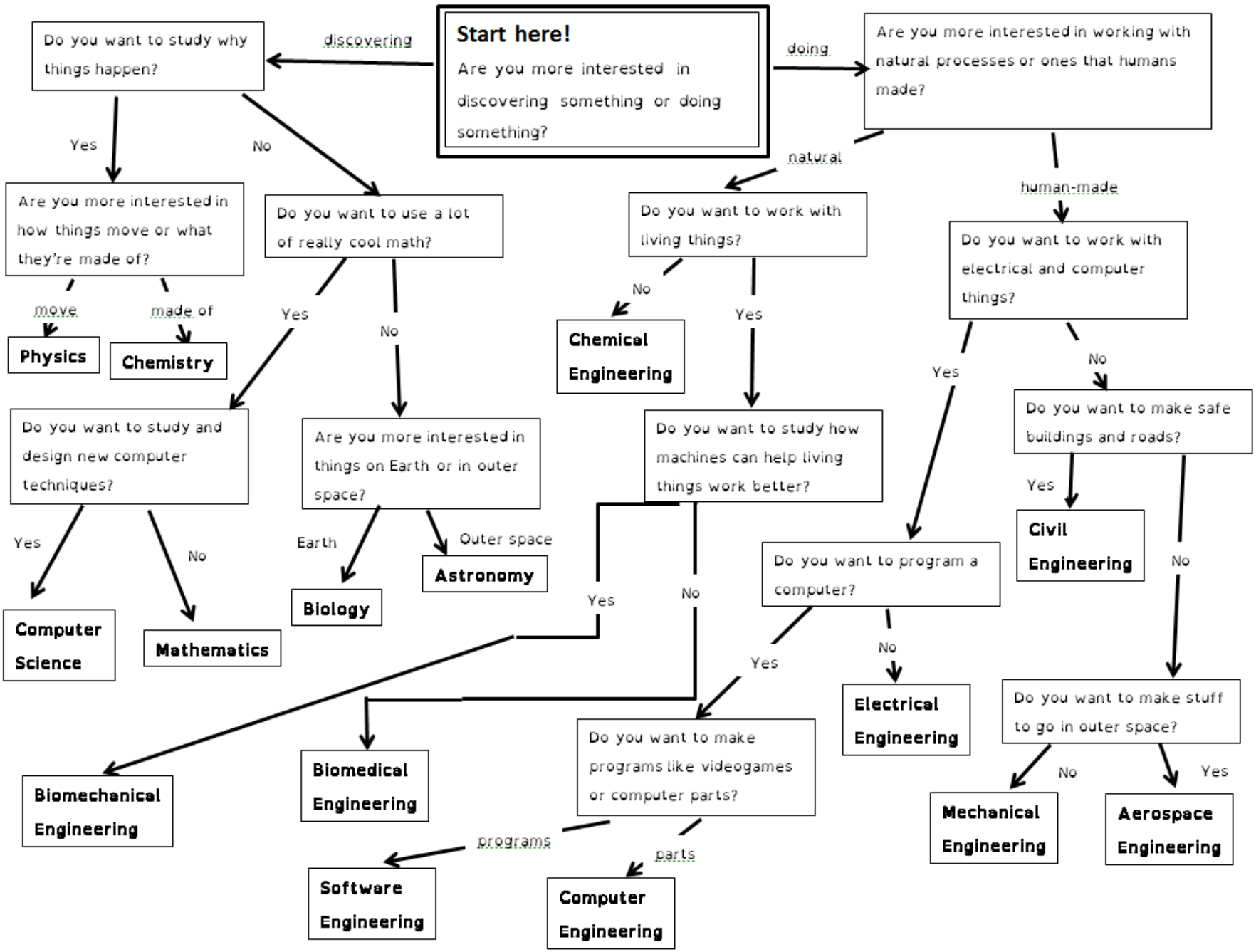
Start here!
Are you more interested in discovering something or doing something?
discovering
doing
Do you want to study why things happen?
Are you more interested in working with natural processes or ones that humans made?
Yes
No
natural
human-made
Are you more interested in how things move or what they're made of?
Do you want to use a lot of really cool math?
Do you want to work with living things?
Do you want to work with electrical and computer things?
move
made of
Yes
No
No
Yes
Yes
No
Physics
Chemistry
Chemical Engineering
Do you want to study and design new computer techniques?
Are you more interested in things on Earth or in outer space?
Do you want to study how machines can help living things work better?
Do you want to make safe buildings and roads?
Yes
No
Earth
Outer space
Yes
No
Yes
No
Computer Science
Mathematics
Biology
Astronomy
Civil Engineering
Do you want to program a computer?
Biomechanical Engineering
Biomedical Engineering
Do you want to make programs like videogames or computer parts?
Yes
No
Yes
No
Electrical Engineering
Do you want to make stuff to go in outer space?
programs
parts
No
Yes
Software Engineering
Computer Engineering
Mechanical Engineering
Aerospace Engineering