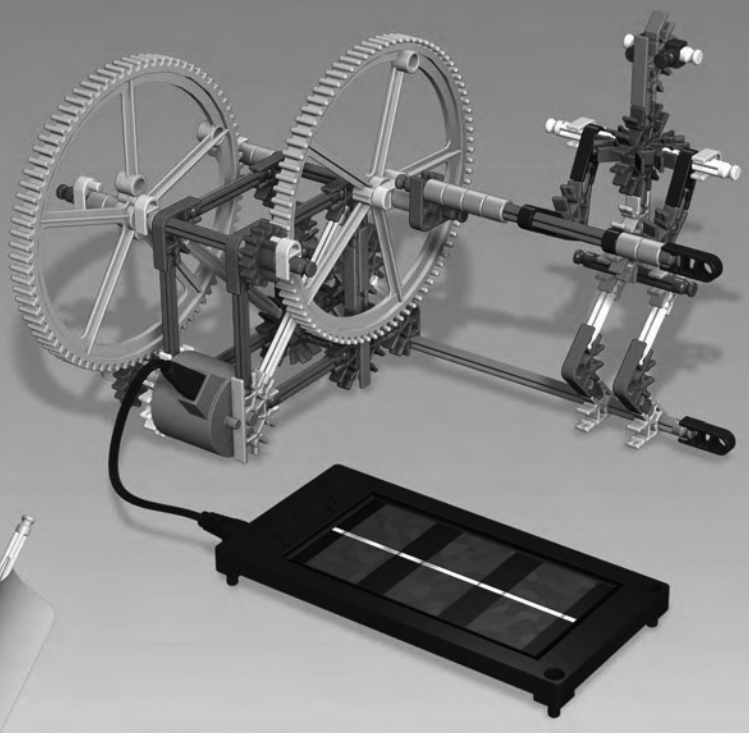
K'NEX® Education™

TEACHER'S GUIDE

RENEWABLE ENERGY™

Hydroelectric Generator
Générateur Hydro-électrique
Generador Hidroeléctrico



Solar Powered Crank Man
Homme Détraqué Actionné Solaire
Hombre Inestable Accionado Solar

Wind Powered Water Lift
Ascenseur Actionné par le Vent de l'eau
Elevación Eólica del Agua

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ITEA & NSES Standards Alignments with the 9 Renewable Energy Lessons

ITEA Standards grades 5-8 **Students will develop an understanding of:**	**Solar:** Lessons 1, 2, 3	**Wind:** Lessons 4, 5, 6	**Hydro:** Lessons 7, 8, 9
The characteristics and scope of technology: • New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. • Technology is closely linked to creativity which has resulted in innovation. • Inventions and innovations are the results of specific, goal directed research.		4	
The core concepts of technology: • Systems Thinking • Involves considering how every part relates to others. • Applies logic and creativity with appropriate compromises in complex real-life problems. • Technological systems can be connected to one another. • Different technologies involve different sets of processes. • New Technologies create new processes.	1	4, 5, 6	7, 8, 9
Relationships among technologies and the connections between technology and other fields: • Knowledge gained from other fields of study has a direct effect on the development of technological products and systems.	1	5	
The cultural, social, economic, and political effects of technology: • Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. • Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.	1	4	7, 8
The effects of technology on the environment: • The management of waste produced by technological systems is an important societal issue. • Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. • Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. • When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.		4	7

ITEA Standards grades 5-8 (continued)	Solar: Lessons 1, 2, 3	Wind: Lessons 4, 5, 6	Hydro: Lessons 7, 8, 9
The attributes of design: • Design is a creative planning process that leads to useful products and systems.		4	7
Engineering Design: • Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.	1, 2, 3	4, 5, 6	7, 8, 9
Apply Design Process: • Apply a design process to solve problems in and beyond the laboratory-classroom. • Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.	1, 2, 3	4, 5, 6	7, 8, 9
Assess the impact of technological products and systems: • Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and the environment.		4	7
Select and use energy and power technologies: • Energy is the capacity to do work. • Energy can be used to do work, using many processes. • Power systems are used to drive and provide propulsion to other technological products and systems. • Much of the energy used in our environment is not used efficiently. • Energy resources can be renewable or non renewable.		4	7

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NSES Standards grades 5-8 **Students will develop an understanding of:**	**Solar:** Lessons 1, 2, 3	**Wind:** Lessons 4, 5, 6	**Hydro:** Lessons 7, 8, 9
Unifying Concepts and processes: • Systems, order, and organization • Evidence, models, and explanation • Measurement • Form and function	1, 2	4	7
Science as Inquiry: • Abilities necessary to do scientific inquiry • Understandings about scientific inquiry	1, 2, 3	4, 5, 6	7, 8, 9
Physical Science: • Motions and forces • Transfer of energy	1, 2, 3	4, 5, 6	7, 8, 9
Science and Technology: • Abilities of technological design • Understandings about science and technology	1, 2	4, 5, 6	7, 8, 9
Science in Personal and Social Perspectives: • Resources • Science and technology in society		4	
History and Nature of Science: • Nature of Science	1, 2, 3		7, 8, 9

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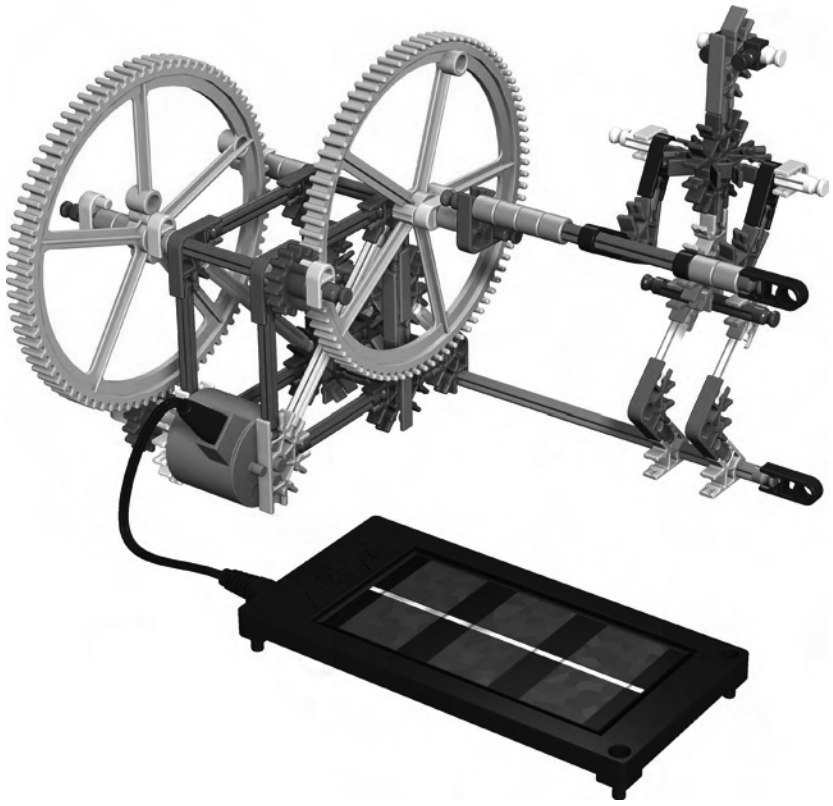
Solar Power - Lesson 2: CRANK MAN



Time Frame:

2 x 40 minute sessions

Student Objectives:

Students will demonstrate the ability to:

- Observe and explore the moving parts of a simple machine.
- Make numerical comparisons of machines and systems in written and in ratio form.
- Evaluate a machine and describe it as a geared down machine (for power) or a geared up machine (for speed).

Materials:

- The K'NEX Education Renewable Energy Set.
- Masking or blue painting tape
- Metric ruler
- Graph paper
- Light sources for inside use (a utility light and a collection of various watt light bulbs (100, 75, 60, 40, 25, or 15) will work very well for the solar car activities. Ensure that the light source is rated for the various wattages used during experimentation.)
- Sunlight for outdoor use
- Calculator
- Timer or stopwatch

Engagement:

Provide several simple machines for students to observe. Demonstrate the operation of each. Ask the following questions of students to gather their ideas and to determine the extent of their simple machine vocabulary knowledge.

1. How do simple machines make work easier?
2. Do simple machines really save us work?

Explore and Explain:

Students will connect a solar cell to the motor on the Crank Man and shine a light on the solar cell. As they observe the model in operation they will trace the flow of energy in this model starting with the light source. This will be in the form of a flow chart of the students' own design.

As the students move the light closer and further away from the solar cell, they will gather useful information that will allow them to complete the following.

Safety Caution: Students should never place the photoelectric cell closer than the length of one K'NEX gray rod (7.5 inches) from the light source at any time.

1. Describe how the speed of the Crank Man changes?
2. What is the relationship between the light's distance from the solar panel and the speed of the model?
3. How far from the solar cell can a 100 watt bulb be placed and still provide enough energy to turn the crank?

Trial #	The distance (cm) from light source to the photocell.
1	
2	
3	
Average distance (cm) =	

Elaborate:

Have students count the number of rotations made by the Crank Man when the light source is held at different distances from the solar cell. The students will take on the responsibility to determine the various distances at which to gather data. Students will then make a chart that shows the relationship between light distance and cranking speed. As students analyze their results and report their findings they should use the term light energy in their conclusion.

The distance (cm) from light source to the photocell.	Number of cranks in 15 sec.

1. Students will graph this relationship.

Students will examine the Crank Man model and draw a conclusion based on their knowledge of the model and simple machine technology.

2. If the Crank Man were really turning the crank, how could we make his job easier? (There are several possible answers to this question.) Draw a picture or write your response.

3. If the Crank Man were really turning the machine, what would be the output of the machine?

Math Extensions:

1. Students can compare the yellow and blue gears on this model and find the ratio of the number of teeth on each. This value is an acceptable way to determine the gear ratio of the gears. The blue gear has _____ teeth and the yellow gear has _____. The ratio of the gear teeth on the large gear/gear teeth on the small gear is _____.

Teacher Note: Suggest that students place a small mark on each gear with a marker or small brightly colored piece of tape for reference.

2. If students examine this machine from the motor to the Crank Man, they should be able to determine if it is geared up for speed or geared down for power? They can then outline their evidence and reasoning.

Evaluate:

3. Ask students to meet this challenge: If the Crank Man turns the lever arm one complete rotation, how many times does the motor turn?

Extension Activities:

1. Earlier students found the number of teeth on the Crank Man's gears and expressed this as a ratio.

a. Is the ratio of the diameters of the yellow gear and the blue gear the same as the value computed for the gear ratio? Have students complete the following to find out for themselves.

- Using a metric ruler measure the diameter of each gear in millimeters. Should you measure to the outer edge or just to the middle of the gears? Why?
- What is the ratio of the diameters?

- How does the ratio of diameters compare to the ratio of the number of gear teeth?
- What do you think the ratio of circumferences between the blue and yellow gear would be?

2. These ratios represent the Ideal Mechanical Advantage (IMA) of a simple machine. The Crank Man has three simple machines: two sets of yellow and blue gears and a lever arm attached to the yellow gear that holds the Crank Man. For the purposes of this extension activity, the students should consider only the sets of blue and yellow gears.

Have students complete the following:

- Moving from the motor toward the Crank Man, what is the ratio of the number of teeth on the first set of one blue and one yellow gear?
- What is the ratio of the number of teeth on the second set of one blue and one yellow gear?
- Now you have two numbers that each describes the IMA of one of the blue/yellow gear trains. How do you determine the IMA of the two gear trains working together? Did you multiply, divide, add, or subtract the two IMAs to determine the total IMA of the gear systems? (Multiply.)
- Explain your reasoning.

3. The model can be investigated with a delicate Newton spring scale. A rubber band scale with a paper backing can be easily calibrated and used to investigate the force needed to move different components of the Crank Man. A #16 rubber band is satisfactory to collect several measurements on this model.

4. Compare this model to the simple machines on a bicycle – gears, wheels, pedals, hand brakes, brake levers, quick release posts, etc.

Lesson 2: CRANK MAN

1. Construct the K'NEX Crank Man using the building instructions provided.
2. Attach a solar cell to the motor and shine a light on the panel. (If the model turns backwards, reverse the plug in the motor.) Trace the flow of energy in this model by making a flow chart starting with the light source.

Safety Caution: Never place the photoelectric cell closer than the length of one K'NEX gray rod (7.5 inches) from the light source at any time.

3. Move the light closer and further away from the solar panel. Describe how the speed of the Crank Man changes? What is the relationship between the distance between the light and solar cell and the speed of the Crank Man?

4. How far from the solar cell can a 100 watt bulb be placed and still provide enough energy to turn the crank?

Trial #	Distance from the light source (cm) to the solar cell
1	
2	
3	
Average =	

5. Begin with the solar panel 20 cm from the light source and move the light further from the solar panel in five centimeter intervals. Count the number of rotations the Crank Man makes in 15 seconds at each interval. Fill in the chart below to show the relationship of light distance and cranking speed

The distance (cm) from light source to the photocell.	Number of cranks in 15 sec.

- Graph this relationship on a separate sheet of graph paper.
- Describe the relationship and use the term light energy in your response.

6. Examine the Crank Man model. If the Crank Man were really turning the crank, how could we make his job easier? (There are several possible answers to this question.) Draw a picture and/or write your response. If the Crank Man were really turning the machine, what would be the output of the machine?

7. Can you think of a practical use of this type of cranking machine other than turning the K'NEX figure?

Math Extensions:

1. Compare the yellow and blue gears on this model and find the ratio of the number of teeth on each. This value is an acceptable way to determine the gear ratio of the gears. The blue gear has _____ teeth and the yellow gear has _____.

   Ratio of Teeth = Gear Ratio: _____

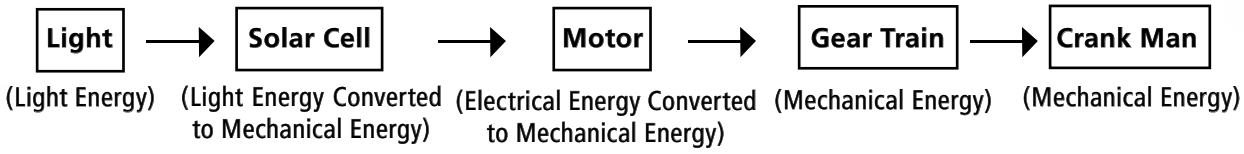
2. If you examine this machine from the motor to the Crank Man, is it geared up for speed or geared down for power?

3. What is your evidence and reasoning?

Lesson 2: CRANK MAN

1. Construct the K'NEX Crank Man using the building instructions provided.

2. Attach a solar cell to the motor and shine a light on the panel. (If the model turns backwards, reverse the plug in the motor.) Trace the flow of energy in this model by making a flow chart starting with the light source.



(The light source produces light energy— the solar cell [converts light to electricity] – the motor converts electrical energy to mechanical energy – the Crank Man moves in response to the mechanical energy provided by the gear train.)

Safety Caution: Never place the photoelectric cell closer than the length of one K'NEX gray rod (7.5 inches) from the light source at any time.

3. Move the light closer and further away from the solar panel. Describe how the speed of the Crank Man changes? What is the relationship between the distance between the light and solar cell and the speed of the Crank Man?

(The speed increases as the light nears the solar panel and decreases as the light is moved away from the solar panel. As the light gets closer to the solar cell, the crank man rotates faster.)

4. How far from the solar cell can a 100 watt bulb be placed and still provide enough energy to turn the crank?

Trial #	Distance from the light source (cm) to the solar cell
1	Answers will vary.
2	Answers will vary.
3	Answers will vary.
Average =	Answers will vary.

5. Begin with the solar panel 20 cm from the light source and move the light further from the solar panel in five centimeter intervals. Count the number of rotations the Crank Man makes in 15 seconds at each interval. Fill in the chart below to show the relationship of light distance and cranking speed

The distance (cm) from light source to the photocell.	Number of cranks in 15 sec.
20	16
25	13
30	10
35	7

Graph this relationship on a separate sheet of graph paper.

Describe the relationship and use the term light energy in your response.

(As the light source is moved further from the solar panel there is less light energy available to turn into electricity.)

6. Examine the Crank Man model. If the Crank Man were really turning the crank, how could we make his job easier? (There are several possible answers to this question.) Draw a picture and/or write your response. If the Crank Man were really turning the machine, what would be the output of the machine?

(Reduce the gear ratio between the blue and yellow gears by using other gears. Lengthen the lever arm that connects to the rod that the crank man is turning.)

(If the Crank Man were really turning the machine, the motor would be turned backwards. Students will learn later that this will make the motor act as a generator.)

7. Can you think of a practical use of this type of cranking machine other than turning the K'NEX figure?

(Answers will vary! Reward originality and answers that have a strong basis in good science.)

Math Extensions:

1. Compare the yellow and blue gears on this model and find the ratio of the number of teeth on each. This value is an acceptable way to determine the gear ratio of the gears. The blue gear has **14** teeth and the yellow gear has **84**.

Ratio of Teeth = Gear Ratio: **6:1 or 6 to 1**

2. If you examine this machine from the motor to the Crank Man, is it geared up for speed or geared down for power?

(It is geared down for power.)

3. What is your evidence and reasoning?

(When a small gear drives a large gear the system is geared down. In the Crank Man, there are two pairs of gears and in each case the small gear is driving the large gear. Therefore, the system is geared down.)