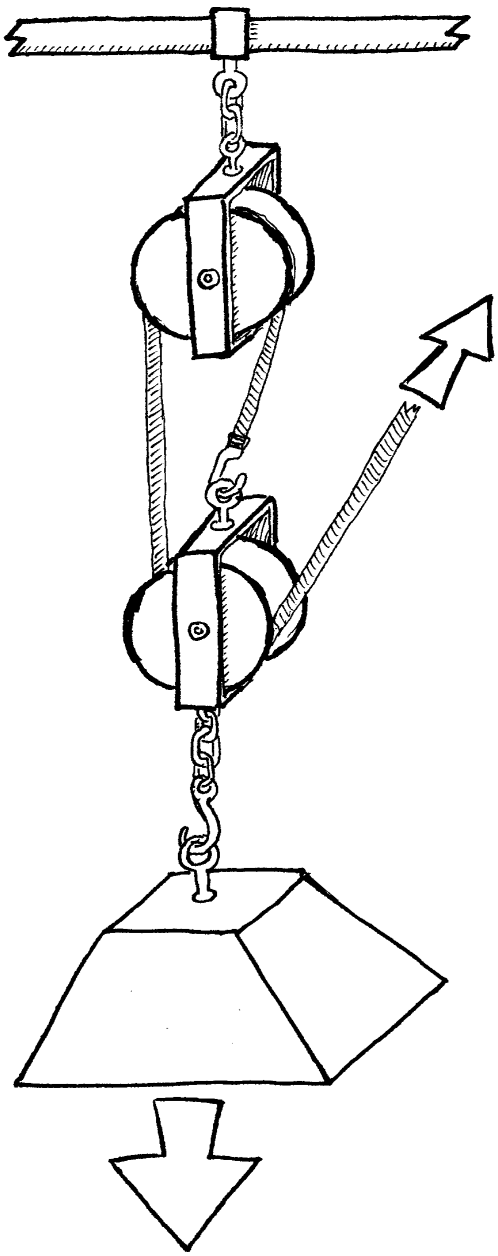
Simple Machines

Teacher's Guide
Grades 5-9



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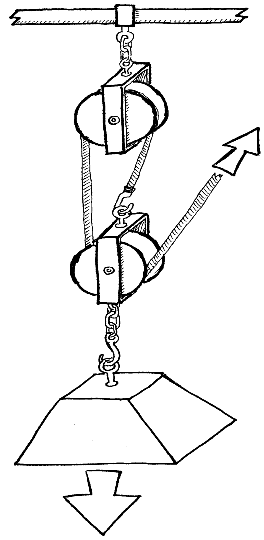

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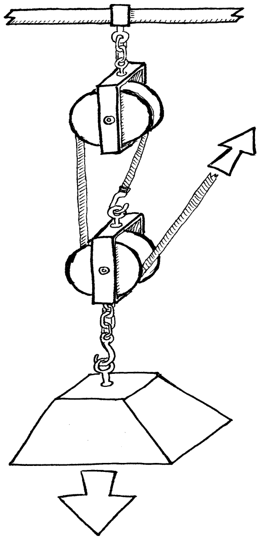

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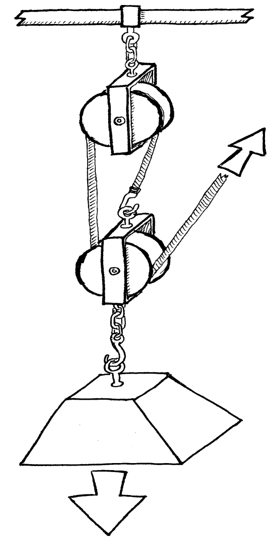

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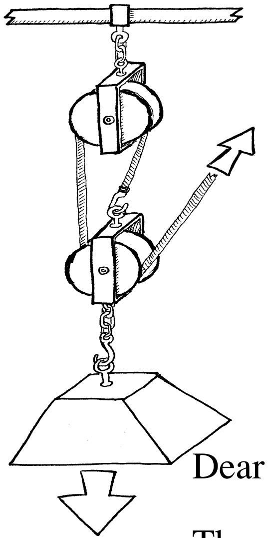


A Message from our Company . . .

Dear Educator:

Thank you for your interest in the educational videos produced by the *Visual Learning Company*. We are a Vermont-based, family owned and operated business specializing in the production of quality educational science videos and materials.

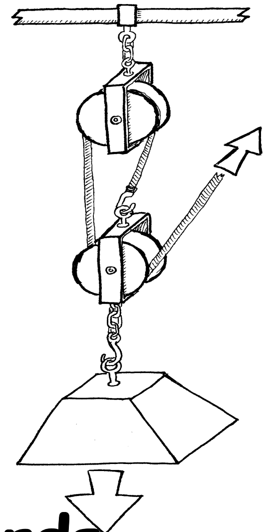
We have a long family tradition of education. Our grandmothers graduated from normal school in the 1920's to become teachers. Brian's mother was an elementary teacher and guidance counselor, and his father was a high school teacher and superintendent. This family tradition inspired Brian to become a science teacher, and to earn a Ph.D. in education, and lead Stephanie to work on science education programs at NASA.

In developing this video, accompanying teacher's guide, and student activities, our goal is to provide educators with the highest quality materials, thus enabling students to be successful. In this era of more demanding standards and assessment requirements, supplementary materials need to be curricular and standards based - this is what we do!

Our videos and accompanying materials focus on the key concepts and vocabulary required by national and state standards and goals. It is our mission to help students meet these goals and standards, while experiencing the joy and thrill of science.

Sincerely,

Brian and Stephanie Jerome



National Standards Correlations

National Science Education Standards

(Content Standards: 5-8, National Academy of Sciences, c. 1996)

Science as Inquiry - Content Standard A:

As a result of activities in grades 5-8, all students should develop:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Physical Science - Content Standard B:

As a result of their activities in grades 5-8, all students should develop an understanding of:

- Motions and Forces

Benchmarks for Science Literacy

(Project 2061 - AAAS, c. 1993)

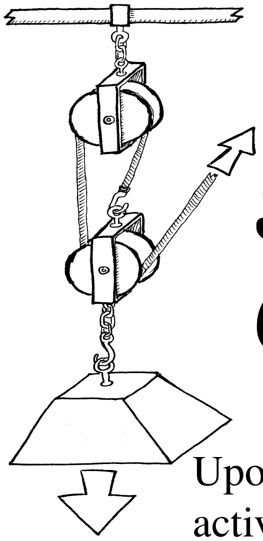
The Physical Setting - Motion (4F)

By the end of the eighth grade, students should know that:

- In the absence of retarding forces such as friction, an object will keep its direction of motion and its speed. Whenever an object is seen to speed up, slow down, or change direction, it can be assumed that an unbalanced force is acting on it.

By the end of the 12th grade, students should know that:

- The change in motion of an object is proportional to the applied force and inversely proportional to the mass.
- All motion is relative to whatever frame of reference is chosen.

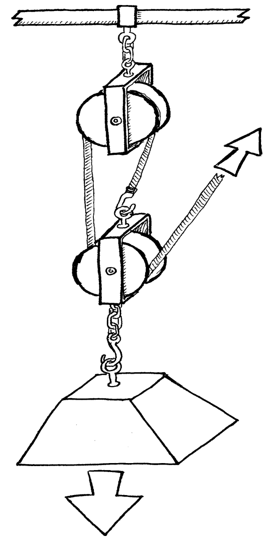


Student Learning Objectives

Upon viewing the video and completing the enclosed student activities, students should be able to do the following:

- Define and calculate work as a function of force and distance;
- Define and calculate power as a function of work and time;
- Understand the two ways by which simple machines make work easier;
- Identify the effort force and the resistance force of a machine;
- Calculate the mechanical advantage of a simple machine;
- Identify the three classes of levers and describe how they function;
- Identify an inclined plane and describe how it makes work easier;
- Understand how a wedge and screw, two variations of an inclined plane, function to make work easier;
- Identify the parts of a wheel and axle and understand how they function together as a simple machine; and
- Understand the functioning of fixed and movable pulley systems.

Assessment



Preliminary Test:

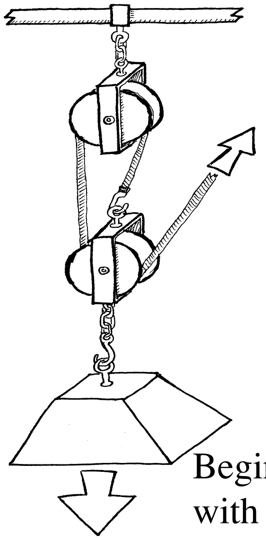
The Preliminary Test, provided in the Student Master section, is an assessment tool designed to gain an understanding of student preexisting knowledge. It can also be used as a benchmark upon which to assess student progress on the objectives stated on the previous pages.

Video Review:

The Video Review, provided in the Student Masters section, can be used as an assessment tool or as a student activity. There are two main parts. The first part contains questions titled "You Decide" that can be answered during the video. The second series of ten questions consists of video review questions to be answered at the conclusion of the video.

Post-Test:

The Post-Test, provided in the Student Masters section, can be utilized as an assessment tool following student completion of the video and student activities. The results of the Post-Test can be compared against the results of the Preliminary Test to assess student progress.



Introducing the Video

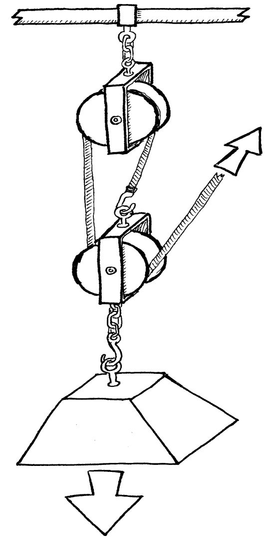
Begin by asking students to formulate a general definition of *work* to share with the class. Discuss this definition until the class can reach an agreement. Next, attempt to define the term *machine*. Divide the class into small groups. Ask each group to compile a list of everyday activities made easier by machines. Next, ask students to make a list of the machines they see everyday, at home or at school. Have one representative from each group write their list on the board. Discuss the lists as a class. Allow the lists to remain on the board during the video. Following the video, ask students for new examples of machines that they learned about from watching the video.

Video Viewing Suggestions

The Student Master, "Video Review", is provided for distribution to students. You may choose to have your students complete this Master while viewing the program or to do so upon its conclusion.

The program is approximately 20-minutes in length and includes a ten-question video quiz. Answers are not provided to the Video Quiz on the video, but are included in this teacher's guide. You may decide to grade student quizzes as an assessment tool or to review the answers in class.

The video is content-rich with numerous vocabulary words. For this reason you may want to periodically stop the video to review and discuss new terminology and concepts.



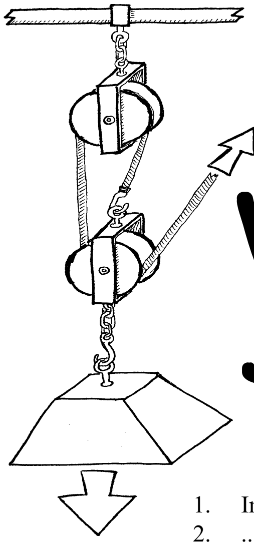
Student Assessments and Activities

Assessment Masters:

- Preliminary Test
- Video Review
- Post-Test

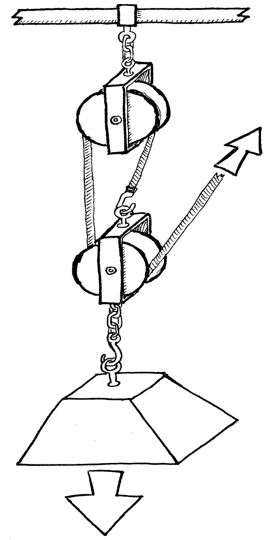
Student Activity Masters:

- Calculating Mechanical Advantage
- Art of Machines
- Calculating Work
- The Power of Pulleys
- A Lesson on Levers
- Vocabulary of *Simple Machines*



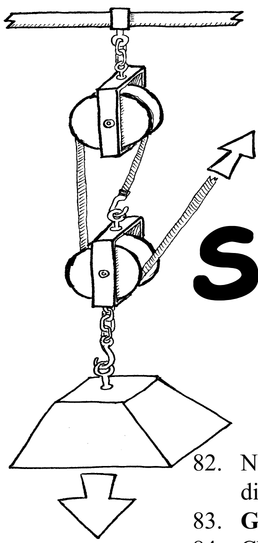
Video Script: *Simple Machines*

1. Imagine how strong your hand would have to be to turn this screw into this piece of wood without a screwdriver,...
2. ...or how long it would take to dig a deep hole with a spoon, instead of a shovel.
3. Imagine how frustrating it would be to ride a bike with no wheels,...
4. ...or how difficult it would be to open a can without a can opener.
5. These simple tasks are very difficult to accomplish without the right tools,...
6. ...but with some simple, common sense tools these tasks become much easier.
7. Everyday we use simple tools or simple machines to make our lives easier.
8. Whether brushing your teeth,...
9. ...or screwing in a light bulb,...
10. ...or riding a skateboard,...
11. ...or cutting your food, you are using simple machines.
12. A simple machine is a tool used to make work easier.
13. During the next few minutes we are going to take a look at the different kinds of simple machines, and how we use them to do work everyday.
14. **Graphic Transition- Work**
15. This girl is pulling on this cow in order to get her to move.
16. **You Decide!**
17. Is the girl doing work?
18. No, even though it looks as if she is working very hard, she is technically not doing work.
19. Similarly, if you push against a brick wall as hard as you can and it doesn't move, then you are not doing any work.
20. That is because in order for work to occur the object has to move and the movement must be in the direction in which the force is applied.
21. For example, when pushing a lawn mower, the mower moves in the direction in which it is pushed.
22. We have just discussed the definition of work, now let's see how we can measure and calculate work.
23. **Graphic Transition- Calculating Work**
24. Different tasks require different amounts of work. **You Decide!**
25. What task requires more work- lifting the large rock one and a half meters off the ground...
26. ...or lifting this marshmallow one and a half meters off the ground?
27. Of course it takes more work to lift the rock because it weighs more than the marshmallow and requires a greater force to lift it.
28. We can actually use a mathematical formula to calculate the amount of work necessary. The formula for work is: Work = Force x Distance.
29. The amount of force exerted on an object is measured in newtons...
30. ...and the distance the object is being moved is measured in meters.
31. When multiplied together we get units called newton-meters, also called joules.
32. Going back to our rock, let's say it takes 40 newtons of force to lift it over a distance of 1.5 meters.
33. When multiplied together we get 60 newton-meters or 60 joules.
34. But the marshmallow required only 2 newtons of force to move it 1.5 meters,...
35. ... resulting in a total amount of work of just 3 newton-meters or 3 joules.
36. Therefore we can see that it took a lot more work to lift the rock than the marshmallow.
37. **Graphic Transition- Power**
38. The oxen pulling this plow have tremendous power.
39. **You Decide!**
40. Which has greater power, the oxen pulling the plow or the tractor?
41. The tractor has greater power. Power is the rate at which work is done.



Script

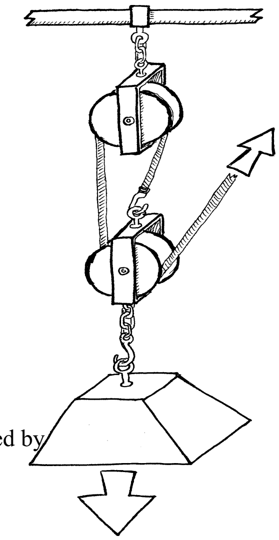
42. So even though both the oxen and the tractor can plow the field,...
43. ...the tractor has the power to do the work quicker or in less time.
44. We can write the mathematical formula for power as follows:
45. Power = Work/ Time
46. We have already learned that work is measured in units of newton-meters or joules. Time can be measured in seconds.
47. When divided we get a unit of power, which is referred to as a joule per second. This is also called a watt.
48. The watt is a common term used when discussing electric power.
49. One watt is about equivalent to the amount of power it takes to lift a glass of water 1 meter in one second.
50. This 100-Watt light works at a rate of 100 watts or 100 joules per second.
51. **Graphic Transition- Machines**
52. Earlier we mentioned how hard it would be to do certain jobs by hand,...
53. ...such as turning a screw...
54. ...or digging a hole with a spoon,...
55. ...but simple machines help make the tasks much easier.
56. There are many different types of machines, from complex machines such as car engines...
57. ...and computers,...
58. ...to simple machines that don't have any moving parts, such as this crowbar lever.
59. A machine is an instrument that makes work easier.
60. In order to make machines do useful work it is necessary to put work into machines. This is called work input.
61. For example, to make these hedge clippers do work it is necessary to put work or effort into the clippers by moving the handles back and forth.
62. The clippers then exert a force called the work output. The moving of the clipper blades is the work output.
63. In the process, the branches are resisting the work output. This is called the resistance force.
64. In most cases the work output of the blades is able to overcome the resistance force.
65. But when the blades attempt to cut a thicker branch, the resistance force is too great and the blades cannot cut through the branch.
66. While machines cannot increase the amount of work put into them, they can make work easier by either changing the amount of force put into the machine...
67. ...or by changing the direction of the force.
68. When a machine enables you to use less force, such as using a crowbar to pull a nail from a board, the effort force must be applied over a greater distance.
69. Let's take a look at how simple machines multiply effort force.
70. **Graphic Transition-Calculating Mechanical Advantages**
71. **You Decide!**
72. How does this screw driver easily remove the lid that was firmly attached to this paint can?
73. This screwdriver is multiplying the effort needed to pry open the lid of this can.
74. Most simple machines increase or multiply the effort force.
75. Mechanical advantage is the number of times a machine multiplies the effort force.
76. For example, a simple machine such as this inclined plane has a mechanical advantage of 3, meaning it triples the effort force of a person pushing the barrel up the ramp.
77. It is possible to compute the mechanical advantage of a machine using a simple mathematical formula. The formula is as follows:
78. Mechanical Advantage = Resistance Force / Effort Force
79. Let's put the formula to use with this pulley system used for hoisting this brick.
80. The brick represents a resistance force of about 40 newtons and the effort force is 20 newtons.
81. When divided we get a mechanical advantage of 2. This means that the pulley system doubles the effort force required to raise the brick.



Script

82. Now that we have learned a little bit about how simple machines multiply effort, let's take a look at some of the different types of simple machines.
83. **Graphic Transition - Levers**
84. Chances are that you've already used a lever today to open a door,...
85. ...written something with a pencil,...
86. ...or eaten your food.
87. There are hundreds of ways levers are used. A lever consists of a straight part that pivots about a fixed point.
88. The fixed point is referred to as the fulcrum.
89. As is the case with other simple machines, levers either multiply the effort force or change its direction.
90. There are 3 main classes of levers.
91. In the first class lever, the fulcrum is located between the effort force and the resistance force.
92. Most of you probably played on a seesaw when you were younger. This is a classic example of a first class lever.
93. Have you ever used a bottle opener? If so, you've used a second class lever.
94. In a second class lever the resistance force lies between the fulcrum and the effort force.
95. Take a wheelbarrow for example - this is also a second class lever. You exert an effort force when you pick up the handles, while the load in the wheelbarrow acts as the resistance force and the wheel acts as the fulcrum.
96. This type of lever makes work easier by multiplying the effort force.
97. In exchange for multiplying the effort force, the handles must be lifted a greater distance than the actual load.
98. Third class levers include levers such as a fishing pole.
99. In this type of lever, the effort force lies between the fulcrum and the resistance force.
100. Picture yourself curling a dumbbell. Your forearm exerts the effort force and the dumbbell serves as the resistance force. Your elbow serves as the fulcrum because the forearm pivots at that point.
101. In the case of third class levers, the effort force is not multiplied. Instead, the distance the object is moved is increased.
102. We have already learned that the mechanical advantage is the amount by which an effort force is multiplied.
103. For levers, mechanical advantage may be calculated by dividing the distance from the effort force to the fulcrum by the distance from the resistance force to the fulcrum.
104. **Graphic Transition-Inclined Planes and Screws**
105. An inclined plane is a simple machine with a sloped surface. This machine will not change the amount of work necessary to complete a task. Rather, it will reduce the effort force.
106. Take a ramp for example. It would require much less effort to push a heavy object up a ramp than it would take to lift it straight up.
107. In return for the reduction in the amount of force necessary to move the object, you must pull the object over a longer distance than if you lifted it straight up.
108. **You Decide!**
109. What type of simple machine are you using when you split wood with an ax?
110. When you use an ax, you are using a wedge. A wedge is composed of two inclined planes put together.
111. The wedge of the ax decreases the amount of effort force needed to split a log. As a trade-off, the effort force must be applied over a longer distance.
112. A screw is a fourth type of simple machine which functions much like an inclined plane. A common example of a screw is a jack.
113. Even though it takes many turns of the jack to move the jack only a little bit, the force produced by the jack is much greater then the force applied.
114. **Graphic Transition - Wheel and Axle**
115. Have you ever turned the handle on a water faucet? If so, you've experienced a fifth type of simple machine called the wheel and axle.
116. This simple machine is composed of two circular parts.
117. The axle, the part of the machine about which the wheel turns, is smaller than the wheel. When an effort force is

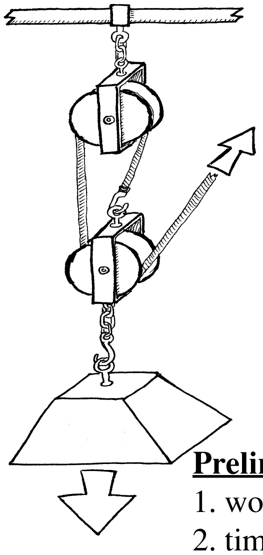
Script



applied to the wheel, it is multiplied at the axle, overcoming the resistance force.
118. Since the effort force is always multiplied, the mechanical advantage is always over 1. It may be calculated by dividing the radius of the wheel by the radius of the axle.
119. **Graphic Transition - Pulleys**
120. Have you ever raised a flag up a flagpole...
121. ...or raised and lowered a window shade?
122. If so, you have already used the last type of simple machine - the pulley.
123. Like the other simple machines we've explored, pulleys make work easier by multiplying the effort force or changing its direction.
124. A pulley consists of a rope wrapped around a grooved wheel.
125. There are two types of pulley configurations that can make work easier.
126. A fixed pulley works by changing the direction of the effort force.
127. Since the effort force is not multiplied, the distance the object travels is equal to the distance you pull.
128. The second type of pulley configuration does multiply the effort force. This is called a movable pulley and is attached to the object that is being moved.
129. Like the other simple machines we have discussed, there is a trade-off for multiplying the effort force. The effort force must be applied over a longer distance.
130. A pulley system consists of more than one pulley. The mechanical advantage of a pulley system is equal to the number of ropes which are exerting a pull on the resistance force.
131. **Graphic Transition - Summing Up**
132. During the past few minutes we have explored the world of simple machines.
133. We have defined work and learned how to calculate the amount of work accomplished.
134. We've also learned what power is and how to calculate power using work and time.
135. We've explored the different types of simple machines and how they make our everyday activities much easier. Finally, we learned how to calculate the mechanical advantage of each of these types of simple machines.
136. Next time you see someone at work with a hammer or eating their food, remember the different types of simple machines we've discussed. You might just look at them a little differently

Video Quiz

1. When an object is moved in the direction of the applied force, __________ is occurring.
2. In order to calculate work, you multiply the force needed to move an object by the _______ it is moved.
3. __________ is the amount of work accomplished per unit time.
4. Joules per second are also known as_________.
5. A _________ is an instrument that makes work easier.
6. In most simple machines the work output of a machine will overcome the _______ ______.
7. _______ ________ is the number of times a machine multiplies the effort force.
8. A seesaw is an example of a first class ________.
9. An ________ _______ is a simple machine with a sloping surface.
10. A _________ may be either fixed or stationary.



Answers to Student Assessments

Preliminary Test
1. work
2. time
3. machine
4. watt
5. mechanical advantage
6. inclined plane
7. lever
8. resistance force
9. pulley
10. fulcrum
11. True
12. False
13. True
14. False
15. False
16. True
17. False
18. False
19. True
20. True

Video Review

You Decide:

A. no

B. Lifting the rock requires more work.

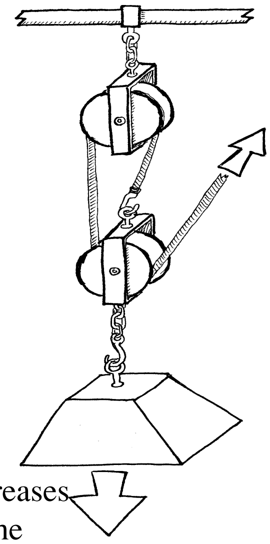
C. The tractor has the greatest power.

D. The screwdriver is multiplying the effort force required to pry the lid off of the can.

E. a wedge (double inclined plane)

Video Quiz:
1. work
2. distance
3. power
4. watts
5. machine
6. resistance force
7. mechanical advantage
8. lever
9. inclined plane
10. pulley

Post Test
1. True
2. False
3. True
4. False
5. False
6. True
7. True
8. False
9. True
10. False
11. lever
12. fulcrum
13. machine
14. pulley
15. watt
16. inclined plane
17. work
18. resistance force
19. time
20. mechanical advantage



Answers to Student Activities

Calculating Mechanical Advantage
1. 5
2. 1.5
3. 1.25 ft.
4. 2
5. 75 cm

The Art of Machines
Answers will vary.

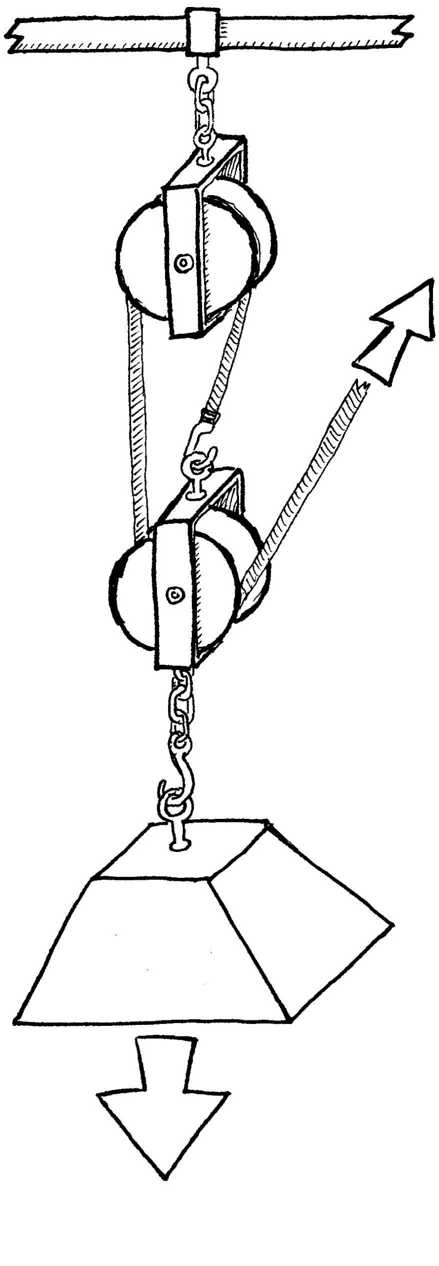
Calculating Work
Conclusions: Answers will vary. If you lift an object twice as high, the amount of work done will double. Answers will vary depending on objects used.

The Power of Pulleys
Conclusions: The fixed pulley made work easier by changing the direction of the effort force. The movable pulley made work easier by multiplying the effort force. You could improve these pulley systems by combining a fixed pulley and a movable pulley. As you increase the number of pulleys in a system, you increase the number of rope segments exerting an upward force on the object. Therefore, less effort force is required.

A Lesson on Levers
Conclusions: The effort force decreases as the fulcrum moves away from the area where the force is applied. The mechanical advantage of a lever is calculated by dividing the length of the effort arm by the length of the resistance arm. Therefore, as the effort arm gets longer, the resistance arm gets shorter and the mechanical advantage increases. This is a first class lever.

Vocabulary Lesson
1. pulley, j
2. lever, m
3. watt, l
4. mechanical advantage, i
5. power, e
6. fulcrum, h
7. inclined plane, g
8. wedge, k
9. wheel and axle, o
10. screw, n
11. machine, b
12. work, a
13. joule, f
14. effort force, c
15. resistance force, d

Assessment and Student Activity Masters



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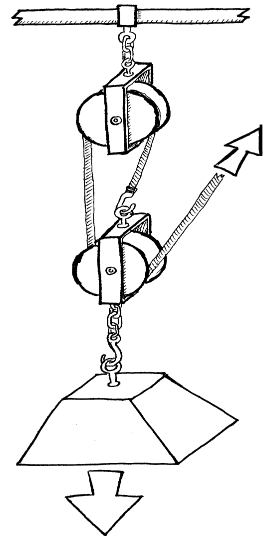


Preliminary Test

Directions: Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

1. When a girl lifts a heavy box, she is doing _______.

2. Power is the amount of work done per unit _______.

3. A ________ is used to make work easier.

4. A term commonly used to measure electrical power is a _______.

5. If a machine triples the effort force, it has a ____________ _____________ of three.

6. A ramp is an example of an _________ ________.

7. A wheelbarrow is an example of a second class ________.

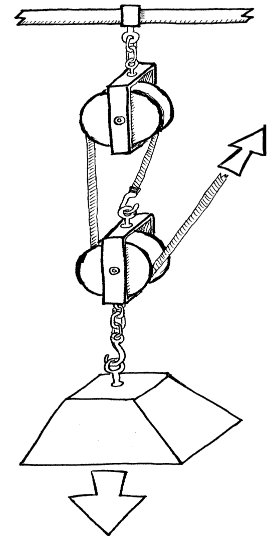
8. The force that works against the work output of a machine is called the ____________ ____________.

9. A fixed _______ is attached to a stationary object.

10. The fixed point on a lever is know as the ________.

fulcrum	machine
mechanical advantage	time
work	pulley
inclined plane	lever
watt	resistance force
newton	input

Name________________



Preliminary Test

Directions: Decide whether the answer is True (T) or False (F).

11. One newton-meter equals one joule. T F

12. If a boy pushes a car and it does not move, he is doing work. T F

13. Work is equal to the applied force multiplied by the distance the object is moved. T F

14. Power is a measure of the distance an object is moved per unit force. T F

15. Simple machines are unable to multiply the applied effort force. T F

16. Some simple machines are able to change the direction of the applied effort force. T F

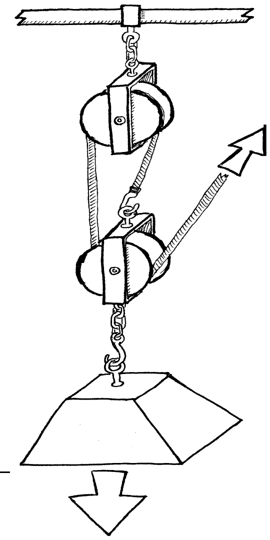
17. If a machine doubles the effort force, it has a mechanical advantage of 4. T F

18. A seesaw is an example of a wedge. T F

19. A ferris wheel is an example of a wheel and axle. T F

20. Pulley systems may be either fixed or movable. T F

Name_________________



Video Review

Directions: During the course of the program answer the "You Decide" questions as they are presented in the video. Answer the Video Quiz questions at the end of the video.

You Decide:

A. Is the girl doing work? Answer: _______________

B. What task requires more work- lifting the large rock one and a half meters off the ground, or lifting this marshmallow one and a half meters off the ground? Answer: _______________

C. Which has greater power- the oxen pulling the plow or the tractor? Answer: _______________

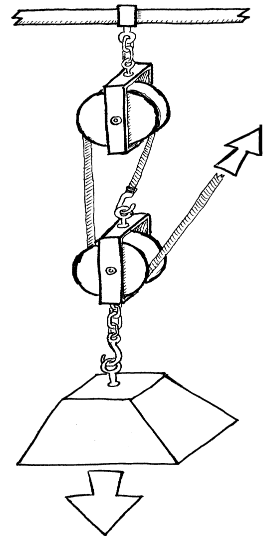
D. How does this screw driver easily remove the lid that was firmly attached to the paint can? Answer: _______________

E. What type of simple machine are you using when you split wood with an ax? Answer: _______________

Video Quiz:

1. When an object is moved in the direction of the applied force, _______ is occurring.
2. In order to calculate work, you multiply the force needed to move an object by the _____________ it is moved.
3. _________ is the amount of work accomplished per unit time.
4. Joules per second are also known as ______.
5. A _________ is an instrument that makes work easier.
6. In most simple machines the work output of a machine will overcome the _____________ ________.
7. ____________ ____________ is the number of times a machine multiplies the effort force.
8. A seesaw is an example of a first class ________.
9. An ___________ _______ is a simple machine with a sloping surface.
10. A _________ may be either fixed or stationary.

Name________________



Post Test

Directions: Decide whether the answer is True (T) or False (F).

1. Simple machines are able to change the direction of the applied effort force. T F

2. Power is a measure of the distance an object is moved per unit force. T F

3. A ferris wheel is an example of a wheel and axle. T F

4. If a boy pushes a car and it does not move, he is doing work. T F

5. Simple machines are unable to multiply the applied effort force. T F

6. One newton-meter equals one joule. T F

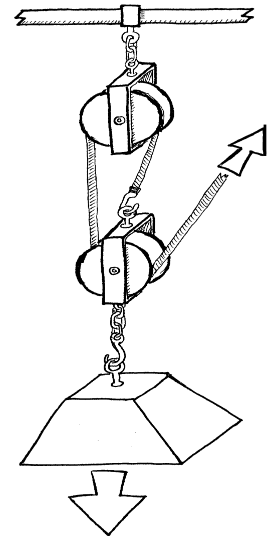
7. Pulley systems may be either fixed or movable. T F

8. A seesaw is an example of a wedge. T F

9. Work is equal to the applied force multiplied by the distance an object is moved. T F

10. If a machine doubles the effort force, it has a mechanical advantage of 4. T F

Name________________



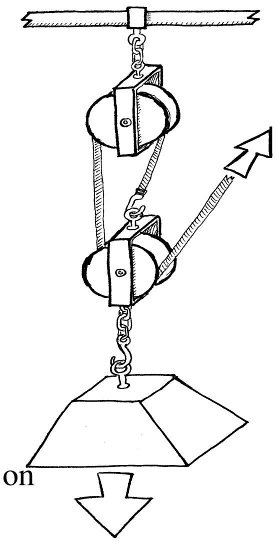
Post Test

Directions: Fill in the blank with the correct word. A list of possible answers is provided at the bottom of the page.

11. A wheelbarrow is an example of a second class ________.
12. The fixed point on a lever is know as the ________.
13. A ________ is used to make work easier.
14. A fixed _______ is attached to a stationary object.
15. A term commonly used to measure electrical power is a _______.
16. A ramp is an example of an _________ ________.
17. When a girl lifts a heavy box, she is doing _______.
18. The force which works against the work output of the machine is called the __________ ______.
19. Power is the amount of work done per unit _______.
20. If a machine triples the effort force, it has a ____________ _____________ of three.

newton	machine
mechanical advantage	inclined plane
resistance force	watt
input	fulcrum
time	work
lever	pulley

Name________________



Calculating Mechanical Advantage

Directions : Use the provided background information to solve the math problems on the following page.

Background:
We use simple machines everyday to make work easier. We use inclined planes to lift heavy objects. We use screws such as car jacks to change flat tires. These machines are able to make work easier by multiplying the amount of effort put into them, also known as the **effort force**. By multiplying the effort force, a simple machine is able to overcome the **resistance force**, or the force that opposes the effort force and the force of the machine. The number of times the machine multiplies the effort force is called its **mechanical advantage**. The most basic equation used to calculate mechanical advantage is as follows:

$$\text{Mechanical Advantage} = \frac{\text{Resistance Force}}{\text{Effort Force}}$$

We must now consider how to calculate mechanical advantage for each type of simple machine. Below are the equations needed to calculate mechanical advantage for each simple machine.

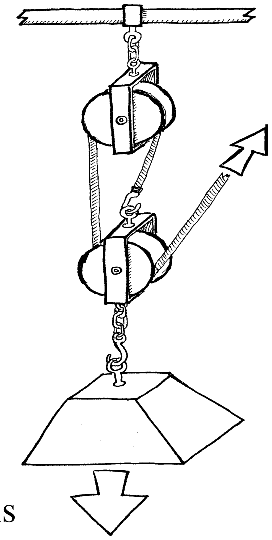
Lever : Mechanical Advantage = $\frac{\text{length of effort arm}}{\text{length of resistance arm}}$

Pulley: Count the number of rope segments that exert an upward force on the object being moved.

Wheel and Axle: Mechanical Advantage = $\frac{\text{radius of wheel}}{\text{radius of axle}}$

Inclined Plane: (Includes wedge and screw) Mechanical Advantage = $\frac{\text{length of slope}}{\text{height of slope}}$

Name________________



Calculating Mechanical Advantage (cont.)

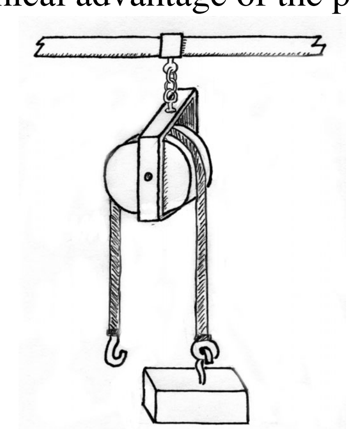
Questions:

1. A crow bar (lever) is often used to lift a large object. If the crowbar is 100 cm long and the object is 20 cm from the fulcrum, what is the mechanical advantage of the crowbar?

2. The wheel of a small dirt bike has a radius of 30 cm. The axle has a radius of 20 cm. What is the mechanical advantage of the wheel and axle?

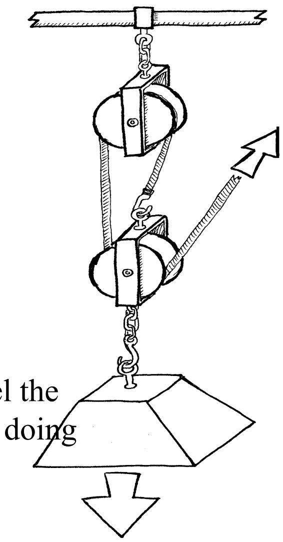
3. You are using a ramp to move a heavy box into a moving truck. If the mechanical advantage of the ramp is 2 and the ramp is 2.5 meters long, how high is the slope of the ramp?

4. What is the mechanical advantage of the pulley seen here?



5. The mechanical advantage of a steering wheel is 15. If the radius of the steering column (axle) is 5 cm, what is the radius of the steering wheel?

Name________________



Art of Machines

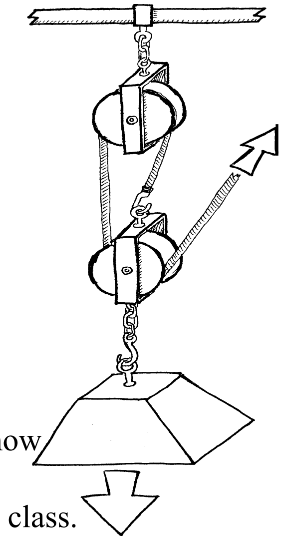
Objective: In this activity you will sketch a diagram of a compound machine, label the different simple machines represented, and understand how simple machines make doing work easier.

Materials:
Paper, pencils and eraser
Diagrams from instructional manuals of home products (e.g. car, cheese grater, tools).
Compound machines or devices (e.g. pliers, three-hole punch, paper-cutter, rollerblade).
The Way Things Work by David Macaulay, Houghton Mifflin Co., Boston, 1988 (if available)

Background:
Leonardo da Vinci, the famous 15th century artist and inventor, was well-noted for his inventions and detailed sketches of simple machines. When sketching a machine, da Vinci drew detailed diagrams of the individual simple machines that composed the larger machine. He also wrote explanations of what mechanisms cause machines to work and how different aspects of machines can be combined. In this activity, you will diagram different devices and learn how simple machines make work easier by manipulating the amount and direction of applied force.

Procedure:
1. As a class, examine the diagrams in the different instructional manuals of home devices. Note how the diagrams label the different parts, use arrows to show direction, and explain connections. If Davis Macaulay's book, *The Way Things Work* is available, discuss how other artists have created diagrams of machines to explain how they work.
2. Separate into groups of five. Your teacher will provide your group with a piece of paper, pencils, eraser and one compound machine.
3. Designate one person in your group to demonstrate how your machine works.
4. Next, answer the questions on the following page in regards to your machine. Be sure to explain the simple machines involved.
5. After considering the answers to the questions, as a group draw a sketch of your machine. Remember that like Leonardo da Vinci, it is important to show what simple machines within the object make it work. Be sure to cooperate and consider each group member's input.

Name________________



Art of Machines cont...

6. In your diagram, label the different types of simple machines. Use arrows to show movement, as well as notations to explain the connections between parts.
7. Choose one member in the group to present the diagram of your machine to the class.

Questions:

1. What is the purpose of your machine or what job is it designed to make easier?

2. Which part(s) of your group's object provides the source of energy?

3. Which part(s) of your machine represents different simple machines? For example, which part is a lever, a pulley, an inclined plane or a wheel and axle? If there is a lever represented in your machine, is it a first class, second class, or third class lever? Where is the fulcrum or pivot point?

4. How does the machine make work easier?

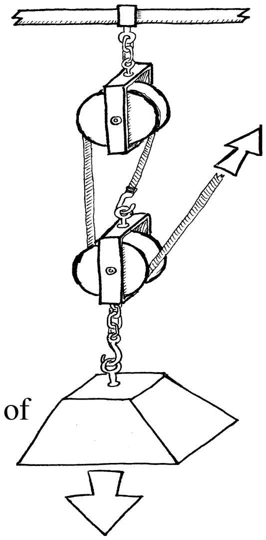
5. What are some of the drawbacks to using this machine?

6. Are there any additions that could be made to make this machine more efficient?

Conclusions:

Think of another machine with which you are familiar. List the different simple machines found in the device and explain how each simple machine functions to make work easier. If time permits, use the formulas on page 23 of this Teacher's Guide to calculate the mechanical advantage of a simple machine found within your group's compound machine. Compare your diagram to the original diagrams in the instructional manuals and in *The Way Things Work*. Which diagrams are easiest to understand? State the changes you can make in your diagram to make it easier to follow.

Name_______________



Calculating Work

Objective:
In this activity you will learn to calculate the amount of work required to lift objects of different sizes.

Background:
Work is occurring around us everyday. Many think that work is only accomplished when you have a job or a project to do. But as we have already learned, work occurs whenever a force is applied over a distance. If you move an object by applying a force, you have accomplished a certain amount of work. Of course, when you turn the pages of a book or pick up the phone, you are doing less work than if you lift a heavy box or push a stalled car up a hill. So how do we measure the amount of work being done? Work can be calculated using the following simple formula:

$$\text{Work} = \text{Force} \times \text{Distance}$$

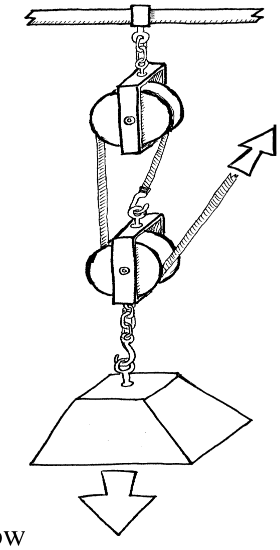
Materials:
Spring scale
Rope or string (about 1-2 feet)
5 objects with different masses
Pen and paper
Meter stick

Procedure:
1. Tie one end of the string to the spring scale.
2. Tie the other end of the string to your first object.
3. Pull up on the spring scale until you have lifted the object a certain distance.
4. Record the force needed to lift the object.
5. Using the meter stick, measure the distance the object was lifted (in meters).
6. Use the above equation to determine the amount of work done.
7. Repeat steps 2-6 for the four remaining objects.
8. Make a data chart that includes force, distance, and work done for each object.

Conclusions:
Which object required the most work to lift? How would the amount of work change if you were to lift the objects twice as high? Which simple machines could have been used to make lifting each object easier?

Name________________

The Power of Pulleys



Objective:
In this lab activity you will construct two pulley systems and observe how these simple machines make work easier.

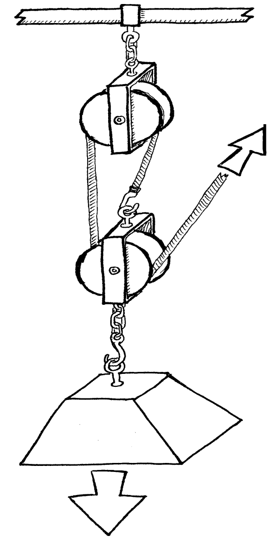
Background:
Pulley systems are used all around us. If you have ever raised and lowered a window shade, chances are you have used a pulley system. As we have already learned, a pulley consists of a rope or chain wrapped around a grooved wheel. Pulley systems make work easier in one of two ways. A **fixed pulley** makes work easier by changing the direction of the force. This type of pulley is attached to a stationary object. A second type of pulley makes work easier by multiplying the effort force. This is called a **movable pulley** because the pulley is attached directly to the object it is moving.

Materials:
Ring stand and ring
Single pulley
Small weight
String
Spring balance (newtons)

Procedure:
1. Tie one end of the string to the weight and the other to the balance. Record the weight in newtons.
2. Attach the ring to the ring stand (about 3/4 of the way up the ring stand).
3. Construct a fixed pulley system by attaching the pulley to the ring stand.
4. Pass the string holding the balance and the weight over the pulley so that the balance hangs on one side of the pulley and the weight hangs on the other.
5. Pull the balance down slowly. Record the force required to lift the weight.
6. Construct a movable pulley by attaching one end of the string to the ring.
7. Pass the string under the pulley (which is below the ring) and attach the other end to the balance.
8. Next, attach the weight to the pulley.
9. Pull up on the balance slowly until the weight is lifted. Record the force used to lift the weight.

Conclusions:
How did each of the pulley systems make it easier to raise the weight? How could you improve these systems to make work even easier?

Name________________



A Lesson on Levers

Objective:
In this activity you will construct a homemade lever and observe how this simple machine can make work easier. You will also come to understand the relationship between effort force, resistance force, and the location of the fulcrum.

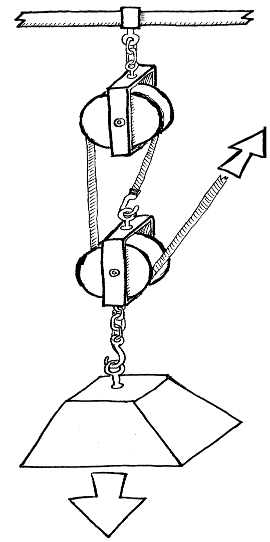
Background:
If you have ever used a crowbar or ridden on a seesaw, you have used a simple machine called a lever. We have already learned that a lever is a straight bar that pivots on a fixed point known as the **fulcrum**. The arm where the effort force is applied is called the **effort arm**, and the arm on which the load is located is called the **resistance arm**. There are three different classes of levers. In a **first class lever**, the fulcrum lies between the effort force and the resistance force. A seesaw is the classic example of this type of lever. In a **second class lever**, the resistance force lies between the fulcrum and the effort force. A wheelbarrow serves as a good example of this type of lever. Finally, in **third class levers**, the effort force lies between the fulcrum and the resistance force. We use third class levers whenever we use our forearm to curl a dumbbell.

Materials:
5 dimes
30 cm plastic ruler
Pen

Procedure:
1. Stack the five dimes on top of one another and tape them together. This will be the resistance force.
2. Construct a lever using the ruler as the straight bar and the pen as the fulcrum.
3. Place the pen beneath the ruler at the 15 cm mark. Place the stack of dimes over the 2 cm mark.
4. Push down on the 30 cm mark on the ruler. When you push on the ruler, you are exerting an effort force.
5. Move the fulcrum to the 20 cm mark and repeat step 4.
6. Move the pen back to the 10 cm mark and repeat step 4.

Conclusions:
How did your effort force differ between the three trials? Explain how increasing and decreasing the distance between the effort force and the fulcrum affected the effort force. What type of lever is this?

Name________________



Vocabulary of *Simple Machines*

Directions: Unscramble the following vocabulary words and match each word with the correct definition.

___ 1. luylpe

___ 2. rvlee

___ 3. twta

___ 4. maiclehnca dvtaangea

___ 5. oprwe

___ 6. cfurmlu

___ 7. cilendin nelpa

___ 8. gwdee

___ 9. leewh adn xlae

___ 10. cwsre

___ 11. chinmae

___ 12. krow

___ 13. leuoj

___ 14. feftro crofe

___ 15. siscnatree fcore

a. force acting over a distance to move an object

b. an instrument that makes work easier

c. force applied to a machine

d. force that opposes the effort force

e. amount of work done per unit time

f. 1 newton-meter

g. simple machine with a sloped surface

h. the fixed point on a lever

i. the number of times a machine multiplies the effort force

j. rope wrapped around a grooved wheel

k. simple machine made up of two inclined planes

l. 1 joule per second

m. straight bar that moves about a fixed point

n. inclined plane wrapped around a bar to make a spiral

o. simple machine made up of two circular objects