CALCULATING WORK

Work has a special meaning in science. It is the product of the force applied to an object and the distance the object moves. The unit of work is the joule (J).

\[
W = \text{Force} \times \text{Distance}
\]

\[
W = F \times d \quad \text{Force} = \text{newtons} \quad \text{Distance} = \text{meters}
\]

Solve the following problems.

1. A book weighing 1.0 newton is lifted 2 meters. How much work was done?
   Answer: __________

2. A force of 15 newtons is used to push a box along the floor a distance of 3 meters. How much work was done?
   Answer: __________

3. It took 50 joules to push a chair 5 meters across the floor. With what force was the chair pushed?
   Answer: __________

4. A force of 100 newtons was necessary to lift a rock. A total of 150 joules of work was done. How far was the rock lifted?
   Answer: __________

5. It took 500 newtons of force to push a car 4 meters. How much work was done?
   Answer: __________

6. A young man exerted a force of 9,000 newtons on a stalled car but was unable to move it. How much work was done?
   Answer: __________
CALCULATING POWER

Power is the amount of work done per unit of time. The unit for power, joules/second, is the watt.

\[
\text{Power} = \frac{\text{work}}{\text{time}} \quad \text{work} = \text{joules} \quad \text{time} = \text{seconds}
\]

Solve the following problems.

1. A set of pulleys is used to lift a piano weighing 1,000 newtons. The piano is lifted 3 meters in 60 seconds. How much power is used?

Answer: __________

2. How much power is used if a force of 35 newtons is used to push a box a distance of 10 meters in 5 seconds?

Answer: __________

3. What is the power of a kitchen blender if it can perform 3,750 joules of work in 15 seconds?

Answer: __________

4. How much work is done using a 500-watt microwave oven for 5 minutes?

Answer: __________

5. How much work is done using a 60-watt light bulb for 1 hour?

Answer: __________
**Reinforcement**

**Work**

**Directions:** Use the formula work = force × distance to calculate the answers to each of the following questions.

1. A box is pushed 40 m by a mover. The amount of work done was 2,240 J. How much force was exerted on the box?

2. A person expended 500 newtons to move a full wheelbarrow 30 meters. How much work was done?

**Directions:** Use the formula power = work/time to calculate the power required in each of the following.

3. A weightlifter lifts a 1,250-N barbell 2 m in 3 s. How much power was used to lift the barbell?

4. A crane lifts a 35,000-N steel girder a distance of 25 m in 45 s. How much power did the crane require to lift the girder? Write your answers in kilowatts.
Physical Science: Critical Thinking

Effort, Resistance, Loads, and Machines

Exercise 26

Name ____________________________ Date ________________

Read the following article. Then use the information from the article to answer the questions.

In science, work means the force moving something for a distance. There are two forces involved in work. One is the force you apply. That is called the effort force. The other is the force that must be overcome. That is called the resistance force. The load is the object that you want moved.

Suppose you had to pick up a heavy sack of grain. Your lifting is the effort force. Gravity holding the bag down is the resistance force. The sack of grain is the load. If you pulled the sack of grain across the ground, your pulling is the effort force. Friction on the ground is the resistance force.

A machine is any device that can change the speed, direction, or amount of a force. The purpose of the machine is to make work easier. If you use a fork lift to raise that heavy sack of grain, your back will be more than grateful!

1. You are swimming through the water.
   a. What is the effort force? ____________________________
   b. What is the resistance force? ____________________________
   c. What is the load? ____________________________
   d. Is there a machine that can make your work easier? If so, what is it? ____________________________

2. You are trying to break up a large piece of firewood with your hands.
   a. What is the effort force? ____________________________
   b. What is the resistance force? ____________________________
   c. What is the load? ____________________________
   d. Is there a machine that can make your work easier? If so, what is it? ____________________________

3. You are trying to run up a mountain as fast as you can.
   a. What is the effort force? ____________________________
   b. What is the resistance force? ____________________________
   c. What is the load? ____________________________
   d. Is there a machine that can make your work easier? If so, what is it? ____________________________
Simple Machines at Work

It would be very difficult for a person to lift the back end of a car, but a machine called a jack makes the job much easier. To lift a car by yourself, it would take a force as large as 6000 newtons. (A newton, named after Sir Isaac Newton, is a metric unit used to measure force.) However, when you use a force of only 100 newtons to push down on the handle of a jack, the jack pushes up on the car with a force of 6000 newtons. Thus, the jack multiplies the force, or effort, that you use.

The number of times a machine multiplies a force is called its mechanical advantage (M.A.). You can determine the mechanical advantage of any machine (minus the effects of friction) by dividing the weight of the object to be moved (resistance) by the force needed to move it (effort).

\[
\text{M.A.} = \frac{\text{Resistance}}{\text{Effort}}
\]

To calculate the mechanical advantage of the inclined plane to the right, you would set up the problem as follows:

\[
\text{M.A.} = \frac{100}{50} = 2
\]

A mechanical advantage of 2 means that this inclined plane doubles the man’s force.

Answer the following questions about this woman and the pulley.

1. The resistance is _______ kg.
2. The effort is _______ kg.
3. The mechanical advantage is _______.
4. By how many times does the pulley multiply the force?

5. Another way to figure mechanical advantage is to divide the distance over which the effort is applied by the distance the load has to travel. Think about the ramp shown above. Imagine it is four feet long and the load will be lifted two feet. Using the ramp would provide a mechanical advantage of \(4 \div 2\), or 2. This means the ramp doubles the force so only half as much effort is needed to raise the load. Would lengthening the ramp increase or decrease the amount of force needed to lift the load? Explain.
Taking Mechanical Advantage

The force you exert on a simple machine is called effort or effort force. The force exerted by the machine is the output or resistance force. The ratio of resistance force to effort force is called the mechanical advantage of the machine.

The formula is: \( MA = \frac{\text{output (or resistance force)}}{\text{effort force}} \)

Solve these problems involving the mechanical advantage.

1. A lever lifts 280 N with an effort of 40 N? What is the MA?

2. A moving pulley lifts a 400 N object with 200 N of effort. Find the mechanical advantage.

3. How much effort is needed to lift a 200 N object with a lever that has a mechanical advantage of 4?

The mechanical advantage of a lever can be determined by using fulcrum distances.

\[ MA = \frac{\text{effort fulcrum distance}}{\text{output fulcrum distance}} \]

4. A man is using a pry bar as a first class lever over a small rock, which serves as the fulcrum. He wants to move a large rock. The length of the lever from the man to the fulcrum is 200 cm, and the length from the fulcrum to the other end of the lever, the part under the large rock, is 20 cm. What is the MA?

5. Suppose you use the lever and set-up in the last problem to move a 500 N boulder. How much effort will you use?