Name _____ Date _____ Class _____

Assess Your Understanding

Work and Power

How Is Work Defined?

1a. DESCRIBE A waiter carries a 5-newton tray of food while he walks a distance of 10 meters. Is work done on the tray? Why or why not?

_____

_____

b. EXPLAIN You're holding your dog's leash and trying to stand still as he pulls on the leash at an angle. You move forward. (All of/Some of/None of) his force does work on you.

c. CALCULATE How much work do you do when you push a shopping cart with a force of 50 N for a distance of 5 m?

_____

got it?

○ **I get it!** Now I know that work is _____

_____

○ **I need extra help with** _____

_____

What Is Power?

got it?

○ **I get it!** Now I know that power _____

_____

○ **I need extra help with** _____

_____

Name ______________ Date ________ Class ________

Key Concept Summaries

Work and Power

How Is Work Defined?

You do **work** when you apply a force to an object and the object moves in the same direction in which you applied the force. There is no work without motion. If an object does not move, no work is done, no matter how much force is applied.

Work is done in the direction of the force applied. Therefore, you can apply the same amount of force to an object but do different amounts of work. To move a cello, you can lift and carry it and do no work. You can push a cello parallel to the ground and do the most work. You can pull a cello at an angle to the ground and do some work.

The amount of work you do depends on the amount of force you exert and the distance the object moves.

The amount of work done can be calculated by multiplying force times distance.

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

If you lift a 5-newton trumpet up 0.5 meters, you do 2.5 N·m of work.

$$\text{Work} = 5\ \text{N} \times 0.5\ \text{m}$$
$$\text{Work} = 2.5\ \text{N·m}$$

The SI unit of work is the Newton x meter (N·m). This unit is also called a joule. One joule (J) is the amount of work you do when you exert one newton of force to move an object one meter.

What Is Power?

Power is the rate at which work is done. Power is the amount of work done on an object in a certain amount of time. An object that has more power than another object does more work in the same time, or does the same amount of work in less time. For example, you need the same amount of work to move instruments either by a handcart or a motorbike. However, the bike is about twice as powerful because you move the instruments with it in half the time.

Power is calculated by dividing the amount of work done by the amount of time it takes to do the work. The SI unit of power is the joule per second (J/s). This unit is also known as the watt (W). One watt of power equals one joule of work done in one second. Power is often measured in larger units like kilowatts or horsepower. One kilowatt (kW) equals 1,000 watts. One horsepower equals 746 watts.

On a separate sheet of paper, give an example of doing work and tell how to calculate the amount of work done in the example.

Name _____ Date _____ Class _____

Lesson Quiz

Work and Power

Fill in the blank to complete each statement.

1. Work divided by time equals _____.
2. The unit of work is the _____.
3. The unit of power is the _____.
4. Force multiplied by distance equals _____.

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

5. _____ Work is done on an object when the object moves in the same direction in which the force is applied.
6. _____ If you pull at an angle instead of in the direction in which the object moves, more of your force does work.
7. _____ The farther you move an object, the more work you do.
8. _____ The more power you use to move an object, the more work you do.
9. _____ If you lift a box from the floor to a height of 1 m and then carry the box for 10 m, you do work only when you carry the box.
10. _____ Power is the rate at which work is done.

Name _____ Date _____ Class _____

Understanding Machines

What Does a Machine Do?

1a. LIST Name two examples of machines for which the output force is greater than the input force.

_____

b. APPLY CONCEPTS Suppose that you use a pair of chopsticks and apply a force of 1 N over a distance of 0.01 m. How much work do you do? If the output force of the chopsticks is only 0.5 N, how far do the tips of the chopsticks move?

_____

_____

got it?

○ **I get it!** Now I know that machines make work easier by _____

_____

○ **I need extra help with** _____

_____

What Is Mechanical Advantage?

got it?

○ **I get it!** Now I know that mechanical advantage _____

_____

_____

○ **I need extra help with** _____

_____

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Name ______________________ Date __________ Class __________

Assess Your Understanding

Understanding Machines

What Is Efficiency?

2a. **RELATE CAUSE AND EFFECT** Real machines have an efficiency of less than 100% because some work is wasted to overcome ____________

b. **PREDICT** What happens to the efficiency of a bicycle as it gets rusty? What must you do to maintain the same amount of output work?

____

got it?

○ **I get it!** Now I know that efficiency ____

____

○ **I need extra help with** ____

____

Name _____ Date _____ Class _____

Understanding Machines

What Does a Machine Do?

A **machine** makes work easier by changing at least one of three factors: the amount of force you exert, the distance over which you apply your force, or the direction in which you exert your force. Machines do not change the amount of work you do, but they do change the way you do the work.

The force you exert when you do work is called the **input force**. You exert your input force over the input distance to do the input work. The machine exerts the **output force** over the output distance to do the output work. The output work can never be larger than the input work.

In some machines, like the faucet handle, the output force is greater than the input force but the input distance is greater. In some machines, like the chopsticks, the output force is less than the input force but the output distance is greater. Some machines don't change either force or distance. They change the direction of the input force so it is easier to move an object.

What Is Mechanical Advantage?

The ratio of output force to input force is the **mechanical advantage** of a machine. Mechanical advantage equals output force divided by input force equation.

$$\text{Mechanical advantage} = \frac{\text{Output force}}{\text{Input force}}$$

When a machine increases force, the output force is greater than the input force. The mechanical advantage is greater than 1. When a machine increases distance, the output force is less than the input force. The mechanical advantage is less than 1. When a machine changes the direction of the force, input force will be the same as the output force. The mechanical advantage will be 1.

What Is Efficiency?

A machine will always have less output work than the work put into it. **Efficiency** compares output work to input work. The efficiency of a machine is calculated by dividing the output work by the input work and multiplying the result by 100 percent.

All machines waste some work overcoming the force of friction. The less friction there is, the closer the output work is to the input work.

A machine with an efficiency of 100 percent would be an ideal machine. All machines lose work to friction, so ideal machines do not exist. The balls of a Newton's cradle will swing for a long time, but they will eventually stop because of friction. Ideal mechanical advantage is your input distance divided by the machine's output distance. Actual mechanical advantage is output force divided by input force. Because of friction, actual mechanical advantage is always less than ideal mechanical advantage.

On a separate sheet of paper, describe the three ways a machine can help you do work and tell why machines are not 100 percent efficient.

Name _____ Date _____ Class _____

Lesson Quiz

Understanding Machines

Fill in the blank to complete each statement.

1. Machines are devices that allow you to do _____ in an easier way.
2. The force you exert when you use a machine is the _____.
3. The force exerted by the machine is the _____.
4. The force exerted on an object multiplied by the distance the object moves is equal to _____, which is expressed in joules.
5. Divide output work by input work and multiply by 100% to find a machine's _____.

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

6. _____ A machine's mechanical advantage is the output force multiplied by the input force.
7. _____ If the output force is greater than the input force, the mechanical advantage of the machine is greater than one.
8. _____ If the machine increases distance, the output force is greater than the input force.
9. _____ If a machine changes the direction, but not the amount of the input force, the mechanical advantage is greater than 1.
10. _____ An ideal machine has no friction.

Name _____ Date _____ Class _____

Assess Your Understanding

Inclined Planes and Levers

How Do Inclined Planes Work?

1a. LIST List three closely related simple machines in the inclined plane family.

_____

b. EXPLAIN A simple inclined plane makes work easier by decreasing the input (force/distance) required to move the object.

c. COMPARE AND CONTRAST Name one way inclined planes and screws are similar and one way they are different.

_____

got it?

○ **I get it!** Now I know that inclined planes _____

○ **I need extra help with** _____

How Are Levers Classified?

2a. DESCRIBE Describe how each class of lever makes work easier.

_____

b. CALCULATE What is the mechanical advantage of a lever with 2 m between the input force and the fulcrum and 1 m between the output force and the fulcrum? _____

c. INFER What class(es) of lever could the lever from the previous question be? Explain.

_____

_____

got it?

○ **I get it!** Now I know that levers are classified by _____

○ **I need extra help with** _____

Name ______________________ Date __________ Class __________

Key Concept Summaries

Inclined Planes and Levers

How Do Inclined Planes Work?

A **simple machine** is the most basic device for making work easier. The inclined plane, the wedge, and the screw are three simple machines that form the inclined plane family. An **inclined plane** is a flat, sloped surface that allows you to exert your input force over a longer distance. The mechanical advantage of an inclined plane is calculated by dividing the length of the incline by its height.

A **wedge** is a device that is thick at one end and tapers to a thin edge at the other end. A wedge is a machine that moves. Instead of moving an object along the inclined plane, you move the inclined plane itself. The ideal mechanical advantage of a wedge is calculated by dividing the length of the wedge by its width. The longer and thinner a wedge is, the greater its mechanical advantage.

A **screw** is like an inclined plane wrapped around a cylinder. The threads of a screw act like an inclined plane to increase the distance over which you exert the input force. The ideal mechanical advantage of the screw is the length of the stretched out threads divided by the length of the screw. The mechanical advantage of a screw is greater if the threads are closer together.

How Are Levers Classified?

A **lever** is a rigid bar that is free to rotate on a fixed point, called the **fulcrum.** A seesaw is a type of lever in which the fulcrum is located half-way between the input and output forces. When you use a spoon, you exert an input force on the handle when you turn your wrist. This causes the spoon to pivot on the fulcrum. The bowl of the spoon digs in, exerting an output force on your food.

The ideal mechanical advantage of a lever is calculated using the following formula: ideal mechanical advantage equals distance from fulcrum to input force divided by distance from fulcrum to output force.

First-class levers change the direction of the input force and increase force or distance. The fulcrum is between the input and output forces. Second-class levers increase force, but do not change the direction of the input force. The output force is between the fulcrum and the input force. Third-class levers increase distance, but do not change the direction of the input force. The input force is between the fulcrum and the output force.

On a separate sheet of paper, explain how to increase the mechanical advantage of inclined planes and levers.

Name _____ Date _____ Class _____

Lesson Quiz

Inclined Planes and Levers

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

1. _____ The ideal mechanical advantage of an inclined plane is the length of the plane divided by its force.

2. _____ When you use a wedge, instead of moving an object along the inclined plane, you move the inclined plane itself.

3. _____ The thicker the wedge, the greater its mechanical advantage.

4. _____ In a first-class lever, the fulcrum is between the input force and the output force

5. _____ A knife is an example of a lever.

6. _____ The lower arm acts like a first-class lever when it bends at the elbow.

Write the letter of the correct answer on the line at the left.

7. ___ A flat, sloped surface is called a(n)
   - A lever
   - B screw
   - C fulcrum
   - D inclined plane

8. ___ A device that is thick at one end and thin at the other end is a
   - A wedge
   - B screw
   - C lever
   - D fulcrum

9. ___ The threads of a screw act like a(n)
   - A lever
   - B wedge
   - C inclined plane
   - D fulcrum

10. ___ The fixed point that a lever pivots around is the
    - A fulcrum
    - B plane
    - C screw
    - D wedge

Name _____ Date _____ Class _____

Assess Your Understanding

Putting Machines Together

What Simple Machines Make Use of Turning?

1a. LIST List two examples of a wheel and axle. Which of your examples has the greater mechanical advantage?

_____

b. APPLY CONCEPTS You exert a 100-N force on a pulley system to lift 300 N. What's the mechanical advantage of this system? How many sections of rope support the weight?

_____

got it?

○ **I get it!** Now I know that pulleys and wheels and axles _____

_____

○ **I need extra help with** _____

_____

How Does a Compound Machine Do Work?

2a. CALCULATE What is the mechanical advantage of a pencil sharpener made from a wheel and axle with a mechanical advantage of 3 and a wedge with a mechanical advantage of 4?

_____

b. ANSWER Explain how simple and compound machines make it easier to do work. _____

_____

got it?

○ **I get it!** Now I know that compound machines _____

_____

○ **I need extra help with** _____

_____

Place the outside corner, the corner away from the dotted line, in the corner of your copy machine to copy onto letter-size paper.

Name _____ Date _____ Class _____

Key Concept Summaries

Putting Machines Together

What Simple Machines Make Use of Turning?

The pulley and the wheel and axle are two simple machines that take advantage of turning. A **pulley** is a simple machine made of a grooved wheel with a rope or cable wrapped around it. You pull on one end of the rope and your force moves an object at the other end of the rope. A pulley can make work easier by decreasing the amount of input force needed to lift the object, and by changing the direction of the input force.

The ideal mechanical advantage of a pulley is equal to the number of sections of rope that support the object. A fixed pulley is attached to a structure. It only changes the direction of force. A movable pulley is attached directly to the object being moved. It only decreases the amount of input force needed. A block and tackle is made up of fixed and movable pulleys. It decreases the amount of input force needed and may change the direction of force.

A **wheel and axle** is made of two connected objects that turn around a common axis. When the object with the larger radius, the wheel, turns, the axle rotates. If you apply input force to the wheel, the axle exerts a larger output force over a shorter distance. If you apply input force to the axle, the wheel exerts a smaller output force over a greater distance.

The ideal mechanical advantage of a wheel and axle is the radius of the wheel divided by the radius of the axle. The mechanical advantage is greater if the ratio of the wheel radius to the axle radius is larger.

How Does a Compound Machine Do Work?

A **compound machine** combines two or more simple machines together into a single machine. For example, an apple peeler consists of three simple machines: a wedge, a screw, and a wheel and axle. Within a compound machine, the output force of one simple machine becomes the input force of another simple machine. The ideal mechanical advantage of a compound machine is found by multiplying the ideal mechanical advantages of the simple machines together.

On a separate sheet of paper, describe the three types of pulleys.

Name _____ Date _____ Class _____

Lesson Quiz

Putting Machines Together

Fill in the blank to complete each statement.

1. One of the simple machines that turns is the wheel and _____.
2. A single fixed pulley changes the _____ of a force.
3. A system of fixed and _____ pulleys is called a block and tackle.
4. A screwdriver and a doorknob are examples of a(n) _____.
5. In a compound machine, the _____ of one simple machine becomes the input force of another simple machine.

If the statement is true, write *true*. If the statement is false, change the underlined word or words to make the statement true.

6. _____ If a compound machine is made of a pulley with a mechanical advantage of 3 and a wheel and axle with a mechanical advantage of 5, the mechanical advantage of the compound machine is 8.
7. _____ To find the mechanical advantage of a wheel and axle, multiply the radius of the wheel by the radius of the axle.
8. _____ To find the mechanical advantage of a pulley, count the sections of rope that support the object.
9. _____ A bicycle is a compound machine because it contains more than one simple machine.
10. _____ The part of a wheel and axle with the smaller radius is the wheel.