**Simple Machine Questions and Answers**

How Machines Do Work? (707)

1. What is a simple machine? A machine makes work easier by changing at least one of three factors. A machine may change the amount of force you exert, the distance over which you exert your force, or the direction in which you exert your force.
2. What is an input force and output force? The force you exert on the machine is called the input force. The force the machine exerts on an object is called the output force.
3. What is an input work and output work? The input force times the input distance is called the input work. The output force times the output distance is called the output work.
4. Figure 7: *The amount of input work done by the gardener equals the amount of output work done by the shovel.* When are you doing more work—using a shovel or using your hands? The same amount of work is involved. The shovel makes the work easier.
5. What is one way a pulley makes work easier? Some pulleys change the direction of a force; others require less force.

Changing Force/ Distance/ Direction (708-709)

1. Does a machine change the amount of work required to do a task? No
2. What does a machine do? It makes work easier by changing the amount of force applied, changing the direction of the applied force, or changing the distance over which the force is exerted.
3. How does the cable system on a weight machine make raising the weights easier? The cable system enables you to raise the weights more conveniently by changing the direction in which you exert force.
4. Figure 8: Look at the arrows indicating input work and output work:
   a. Do any of the machines shown here produce more output work than input work? No, the arrows indicate that the amounts of output work and input work are the same.
   b. *No machine produces more work than is input.* If machines don't decrease the work required to do a task, how can they be helpful? Machines make work easier by increasing the force, increasing the distance, or changing the direction of the input force.
   c. Which machine shown here makes work easier by changing the direction of the input force? The weight machine changes the direction of the input force.

Mechanical Advantage (710)

1. Define mechanical advantage. The ratio of output force to input force.
2. What do you need to know to calculate mechanical advantage? Input force and output force
3. What kinds of machines have a mechanical advantage greater than 1? Those that multiply force
4. What kinds of machines have a mechanical advantage of less than 1? Those that change distance
5. What kinds of machines have a mechanical advantage of exactly 1? Those that change only direction
6. What is the ideal mechanical advantage of a pulley, such as one used on a flagpole? Explain. 1, because it only changes the direction of a force
7. Name a machine that multiplies the distance over which the input force acts. Wooden spoon
8. What is true about the mechanical advantage of a simple machine that increases distance? It is always less than 1
9. Are machines with a mechanical advantage of less than 1 useful? Explain. Yes, because such machines allow you to exert your input force over a longer distance
10. Math: Analyzing Data (Page 711) – The input force and output force for three different ramps are shown in the graph.
    1. What variable is plotted on the horizontal axis? Input force
    2. If an 80-N input force is exerted on Ramp 2, what is the output force? 400 N
    3. Find the slope of the line for each ramp. Ramp 1: 10; Ramp 2: 5; Ramp 3: 2
    4. Why does the slope represent each ramp's mechanical advantage? Which ramp has the greatest mechanical advantage? The slope of each ramp's graph equals the change in output force divided by the change in input force. This is the formula for mechanical advantage. Ramp 1 has the greatest mechanical advantage.

Efficiency (711)

1. What is efficiency of a machine? The efficiency of a machine compares the output work to the input work. Efficiency is expressed as a percent.
2. Why is output work always less than input work in real situations? Because friction exists in every machine and reduces the machine's efficiency.
3. A person is described as an efficient worker. What other phrases could describe this person? Doesn't waste time, works effectively
4. Friction is a force that opposes motion. If friction in a machine increases, what happens to the machine's efficiency? It decreases
5. Is any machine 100% efficient? No, all machines waste some work overcoming friction
6. Why is it important to maintain machines? To maintain as high an efficiency as possible

Calculating Efficiency (712)

1. Efficiency is expressed as a percentage. It is important to divide output work by input work (rather than the reverse). If your calculations result in an efficiency greater than 100%, is your answer reasonable? Why? No; no machine has an efficiency greater than 100%.
2. Write down the Math Sample problem.

**Math Sample Problem**

**Calculating Efficiency**

You do 250,000 J of work to cut a lawn with a hand mower. If the work done by the mower is 200,000 J, what is the efficiency of the lawn mower?

**1 Read and Understand.**

**What information are you given?**

Input work ($W_{input}$) = 250,000 J

Output work ($W_{output}$) = 200,000 J

**2 Plan and Solve**

**What quantity are you trying to calculate?**

The efficiency of the lawn mower = ■

**What formula contains the given quantities and the unknown quantity?**

$$\text{Efficiency} = \frac{\text{Output work}}{\text{Input work}} \times 100\%$$

**Perform the calculation.**

$$\text{Efficiency} = \frac{200{,}000\ \text{J}}{250{,}000\ \text{J}} \times 100\%$$

$$\text{Efficiency} = 0.8 \times 100\% = 80\%$$

**The efficiency of the lawn mower is 80%.**

**3 Look Back and Check**

**Does your answer make sense?**

An efficiency of 80% means that 80 out of every 100 J of work went into cutting the lawn. This answer makes sense because most of the input work is converted to output work.

3. You do 20 J of work while using a hammer. The hammer does 18 J of work on a nail. What is the efficiency of the hammer? 90%
4. Suppose you left your lawn mower outdoors all winter. Now it's rusty. Of your 250,000 J of work, only 100,000 J go to cutting the lawn. What is the efficiency of the lawn mower now? 40%

Assessment

**1. a.** What is a machine? A machine is a device that allows work to be done in a way that is easier or more effective.

**b.** In what three ways can machines make work easier? Machines can make work easier by changing the amount of force you exert, the distance over which you exert force, or the direction in which you exert force.

**c.** How does a screwdriver make work easier? A screwdriver multiplies force because you exert an input force on the handle over a greater distance than the output force is exerted on the tip of the screwdriver.

**2. a.** What is the mechanical advantage of a machine? A machine's mechanical advantage is its output force divided by its input force

**b.** What is the mechanical advantage of a machine that changes only the direction of the applied force? If only direction changes, the mechanical advantage is 1.

**c.** If a machine has an input force of 40 N and an output force of 80 N, what is its mechanical advantage? The mechanical advantage is 2.

**3. a.** What must you know in order to calculate a machine's efficiency? To calculate a machine's efficiency, you must know its output work and input work

**b.** What is an ideal machine? An ideal machine is one with an efficiency of 100%.

**c.** How is a real machine like an ideal machine, and how is it different? Both ideal machines and real machines perform work. Because of friction, however, real machines operate at less than the 100% efficiency of ideal machines.

**4.** The input work you do on a can opener is 12 J. The output work the can opener does is 6 J. What is the efficiency of the can opener? 50%

**5.** Suppose the efficiency of a manual pencil sharpener is 58%. If the output work needed to sharpen a pencil is 4.8 J, how much input work must you do to sharpen the pencil? About 8.3 J

Real and Ideal Machines (713)

1. M. C. Escher's print Waterfall illustrates an ideal machine. Why won't Escher's waterfall machine work in real life? In real life, work is lost due to friction. Also, this illustration shows no input work to raise the water above the wheel after the water falls.
2. What is a machine's ideal mechanical advantage? A machine's ideal mechanical advantage is its mechanical advantage when it operates at 100% efficiency.

Simple Machine (716)

1. What are the six basic kinds of simple machines? There are six basic kinds of simple machines: the inclined plane, the wedge, the screw, the lever, the wheel and axle, and the pulley.

Inclined planes (717)

1. What is an inclined planes? Give examples. An inclined plane is a flat, sloped surface. Example, ramp.
2. Figure 12: When you use a ramp, what happens to the distance over which you exert your force? The distance over which you exert your force increases
3. How does a ramp help you to move heavy objects? It helps by allowing a smaller input force to be exerted over a longer distance.
4. What is the formula to determine the ideal mechanical advantage of an inclined plane?

$$\text{Ideal mechanical advantage} = \frac{\text{Length of incline}}{\text{Height of incline}}$$

5. Why does an inclined plane have a mechanical advantage greater than 1? Because the input force is less than the output force

Wedge (718)

1. What is a wedge? Give examples. A wedge is a device that is thick at one end and tapers to a thin edge at the other end. Example knife
2. Other than the examples of wedges shown in your book, what are other examples of wedges? Knives, shovels
3. What other simple machine are wedges most similar to? Inclined planes
4. **Materials**: butter knife, claw hammer, simple can opener, nail
   a. Which of these tools are wedges? All are wedges or contain wedges
   b. Which tool would be best to open a juice can? Can opener
   c. How does the wedge on the can opener use input force to open a can? The input force exerted on the handle of the can opener is multiplied by the wedge. The larger output force of the thin edge can puncture the juice can
5. What is the formula to determine the ideal mechanical advantage of a wedge? The ideal mechanical advantage of a wedge is determined by dividing the length of the wedge by its width.

Screws (719)

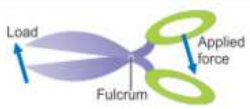
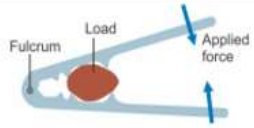
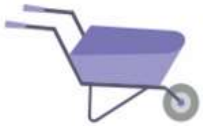
1. What are screws? Give examples. A screw can be thought of as an inclined plane wrapped around a cylinder. Example, nail
2. Write the formula for the ideal mechanical advantage of a screw. Ideal mechanical advantage = Length around threads/ Length of the screw
3. *The threads of a screw change the distance over which the input force is applied.* What are two ways to increase the ideal mechanical advantage of a screw? Increase the length around the threads by increasing the number of threads; decrease the length of the screw
4. A screw increases the input distance. How does this affect output force? It increases output force
5. Figure 15: How does the length around the threads of a screw compare to an inclined plane? The closer together the threads of a screw are, the greater its mechanical advantage.

Levers (720)

1. What are levers? Give examples. A lever is a rigid bar that is free to pivot, or rotate, on a fixed point. Example, seesaw
2. What are some everyday examples of levers? Paint can opener, seesaw, wheelbarrow
3. What is a fulcrum? The fixed point that a lever pivots around is called the fulcrum.
4. What is the formula to determine the ideal mechanical advantage of levers? The ideal mechanical advantage of a lever is determined by dividing the distance from the fulcrum to the input force by the distance from the fulcrum to the output force.
5. What point on a lever does not move? The point on a lever in contact with the fulcrum does not move.

Types of Levers (721)

1. Figure 17: Make a compare/contrast table that analyzes the three classes of levers.

| First class lever | Second class lever | Third class lever |
|---|---|---|
| Lever in which fulcrum is situated in between load and effort is called first class lever. e.g. pair of scissors, see-saw, pliers | Lever in which load is situated inbetween fulcrum and effort is called second class lever. e.g. nut cracker, wheel barrow, bottle opener | Lever in which effort is situated inbetween the fulcrum and the load is called third class lever. e.g. fishing road, pair of tongs, stapler |
|   Scissor |   Nut cracker |   Pair of tongs |
|  See-saw |  Wheel barrow |  Fishing rod |

2. In which class of lever is the fulcrum located between the input force and the output force? Third-class levers have an ideal mechanical advantage of less than 1.

Wheel and Axle (722-724)

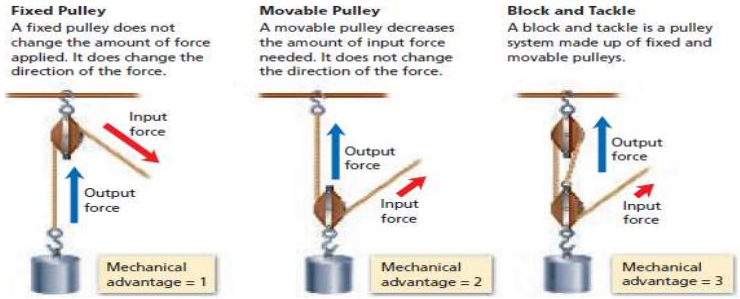
1. What are wheel and axle? Give examples. A wheel and axle is a simple machine made of two circular or cylindrical objects fastened together that rotate about a common axis. Example, car steering wheel
2. Figure 18: *a screwdriver is an example of a wheel and axle. The output force over a shorter distance.* Which has a larger radius, the wheel or the axle? The wheel has a larger radius
3. When using a screwdriver, do you apply the input force to the wheel or the axle? To the wheel
4. What is the formula to determine the ideal mechanical advantage of Wheel and Axle? You can find the ideal mechanical advantage of a wheel and axle by dividing the radius of the wheel by the radius of the axle.

Pulley (724)

1. What is a pulley? Give examples. A pulley is a simple machine made of a grooved wheel with a rope or cable wrapped around it. Example flagpole
2. Read under the headings **How It Works and Types of Pulleys**. Write facts from these two paragraphs. Create a concept map describing pulleys.
3. How can a pulley make work easier? By changing the direction of the input force or by multiplying the strength of the input force.
4. A pulley is attached to the object that is being moved. What kind of pulley is it? A movable pulley.
5. What is the ideal mechanical advantage of a pulley? The ideal mechanical advantage of a pulley is equal to the number of sections of rope that support the object

Types of Pulleys (725)

1. *A fixed pulley and a movable pulley are the two basic types of pulleys. A block and tackle combines a fixed and movable pulley.* Comparing and contrast – Which type of pulley has the greatest mechanical advantage?




Simple Machines in the Body (726)

1. What kind of simple machine is your lower arm? It is a third-class lever
2. What type of simple machine do your front teeth resemble? Human front teeth resemble a wedge
3. Identify other types of levers in the human body. The lower leg is also a third-class lever, with the fulcrum at the knee

Compound Machines (727)

1. What is a compound machine? Give examples. A compound machine is a machine that utilizes two or more simple machines. Example, apple peeler
2. What is one compound machine you have used today? a bicycle
3. What is the ideal mechanical advantage of a compound machine? The ideal mechanical advantage of a compound machine is the product of the individual ideal mechanical advantages of the simple machines that make it up

Assessment

1.
   a. **Listing** List the six kinds of simple machines. The six simple machines are the inclined plane, the wedge, the screw, the lever, the wheel and axle, and the pulley.
   b. **Classifying** What type of simple machine is a door stopper? A rake? A windmill? A slide? Door stopper—wedge; rake—lever; windmill—wheel and axle; slide—inclined plane
   c. **Developing Hypotheses** Can you consider your thumb to be a lever? Why or why not? Yes, because the muscles in your hand provide the input force and the output force is used to move your thumb.
2.
   a. **Identifying** What is the ideal mechanical advantage of each type of simple machine? Ideal mechanical advantage: inclined plane—length of incline ÷ height of incline; wedge—length of wedge ÷ width of wedge; screw—length around threads ÷ length of screw; lever—distance from fulcrum to input force ÷ distance from fulcrum to output force; wheel and axle—radius of wheel ÷ radius of axle; pulley—number of sections of rope that support object.
   b. **Inferring** How can you increase a pulley's mechanical advantage? You can increase a pulley's mechanical advantage by combining fixed and movable pulleys to increase the number of sections of rope that support the object.
   c. **Drawing Conclusions** How is calculating the ideal mechanical advantage of an inclined plane similar to calculating that of a screw? The length of incline of an inclined plane is similar to the length around the threads of a screw.
3.
   a. **Reviewing** How many simple machines are needed to make a compound machine? A compound machine is made up of two or more simple machines
   b. **Describing** How do you find the mechanical advantage of a compound machine? Multiply the ideal mechanical advantages of the simple machines that make up the compound machine.