SECTION 1 (PP. 449-457): MACHINES HELP PEOPLE DO WORK.

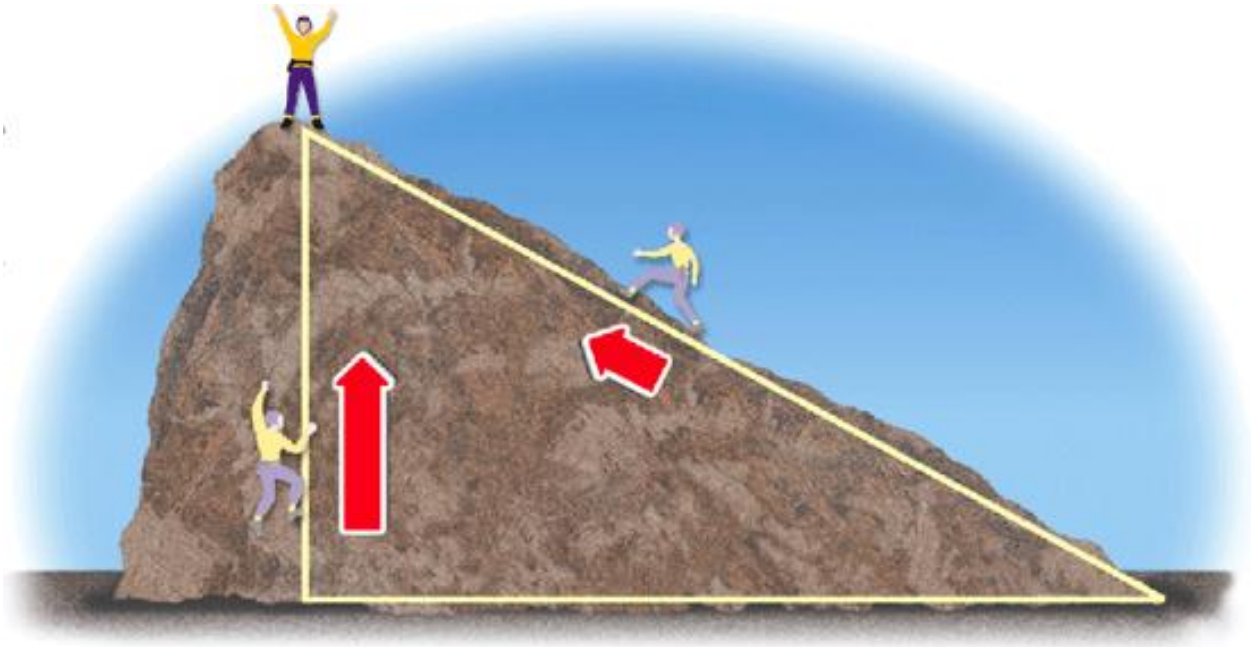
Georgia Standards: S8P3c – *Demonstrate the effect of simple machines (lever, inclined plane, wedge, pulley, screw, and wheel and axle) on work;* S8CS3c – *Apply the metric system to scientific investigations that include metric to metric conversions (i.e.- centimeters to meters).*

1. **Machines change the way force is applied.**
   A ***machine*** is a device that helps people do work. It does not change the amount of work done.
   - If a machine decreases the amount of force needed to do the work, the distance over which that force is applied increases.
   - A machine can change the direction of the applied force.

   Input force is the force applied **to** a machine. ***Output force*** is the force exerted **by** the machine. The number of times a machine multiplies the input force is the machine's ***mechanical advantage (MA).*** To find a machine's mechanical advantage, divide the output force by the input force.

$$\text{Mechanical Advantage} = \frac{\text{Output Force}}{\text{Input Force}}$$

2. **Work transfers energy.**
   A machine increases the potential or kinetic energy of an object by doing work on it. When you use a machine to do work, there is always an exchange, or tradeoff, between the force you use and the distance over which you apply that force. You can use less force over a greater distance or a greater force over a shorter distance to do the same amount of work.



3. **Output force is always less than input force.**
   Efficiency is the ratio of a machine's output work compared to its input work.
   You can calculate the efficiency of a machine by dividing the machine's output work by its input work and multiplying that number by 100.

$$\text{Efficiency (\%)} = \frac{\text{Output work}}{\text{Input work}} \cdot 100$$

Recall that work is measured in joules. Suppose you do 600 J of work in using a rope system to lift a box. The work done on the box is 540 J. You would calculate the efficiency of the rope system as follows:

$$\text{Efficiency} = \frac{540\ \text{J}}{600\ \text{J}} \cdot 100 = 90\%$$

No real machine is 100 percent efficient. Machines lose energy due to friction, which is why we lubricate machine parts. Another source for loss of efficiency is air resistance, which is the reason for streamlined designs **(*aerodynamics)*** for everything from airplanes, automobiles, or bicycle helmets.

CALCULATING EFFICIENCY:

Example

A person is doing 1000 joules of work on a hammer to pry up a nail. The hammer does 925 joules of work on the nail to pull it out of the wood.

(1) Find the ratio of output work to input work.

$$\frac{\text{Output work}}{\text{Input work}} = \frac{925\ \text{J}}{1000\ \text{J}} = 0.925$$

(2) To convert the decimal to a percent, multiply 0.925 by 100 and add a percent sign.

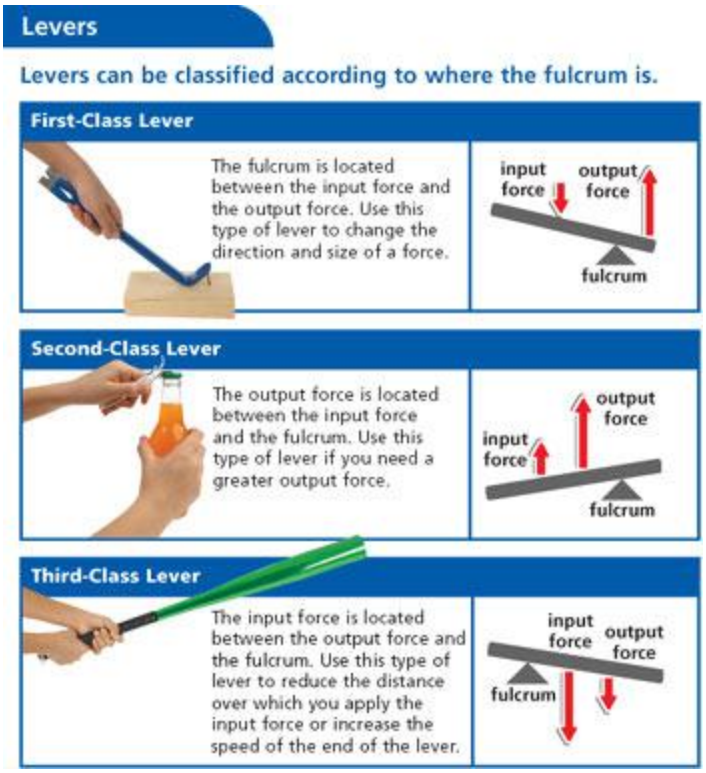
$$0.925 \cdot 100 = 92.5\%$$

ANSWER The efficiency of the hammer is 92.5 percent. This means that the hammer loses 7.5 percent of the input work to friction and other products.

SECTION 2 (PP. 458-467): SIX SIMPLE MACHINES HAVE MAY USES.

Georgia Standards: S8P3c – *Demonstrate the effect of simple machines (lever, inclined plane, wedge, pulley, screw, and wheel and axle) on work;* S8CS3f – *Use ratios and proportions, including constant rates, in appropriate problems.*

1. **There are six simple machines.**
   The lever and the inclined plane are the two main types of ***simple machines***. Other simple machines are based on these two.
   - A **lever** is a solid bar that rotates on a fixed point call a ***fulcrum***. There are three classes of levers based on the relative positions of the fulcrum, input force, and output force.



- A **wheel and axle** is a wheel attached to a shaft. It acts like a rotating collection of levers. The input force can be applied to either part, which transfer force to the other part.
- A **pulley** is a wheel and axle and a grooved rim. A rope or cable moves in the groove. Pulleys can either be fixed or moveable. A ***fixed pulley*** allows you to take advantage of the downward pull of your weight to move a load upward. It does not, however, reduce the force you need to lift the load. Also, the distance you pull the rope through is the same distance that the object is lifted. To lift a load two meters using a fixed pulley, you must pull down two meters of rope. In a ***movable pulley*** setup, one end of the rope is fixed, but the wheel can move. The load is attached to the wheel. The person pulling the rope provides the output force that lifts the load. A single movable pulley does not change the direction of the force. Instead, it multiplies the force. Because the load is supported by two sections of rope, you need only half the force you would use with a fixed pulley to lift it. However, you must pull the rope through twice the distance. A combination of two types of pulleys is called a ***block and tackle***.
- An **inclined plane** is a sloping surface that supports the weight of an object while the object moves from one level to another.
- A **wedge** has a thick and a thin end. A wedge can be used to cut, split, or pierce objects or to hold objects together.
- A **screw** is an inclined plane wrapped around a cylinder or a cone to form a spiral. Screws can be used to hold things together or to raise or lower objects.

2. The mechanical advantage of a machine can be calculated.
The number of times a machine multiplies the input force is the machine's **mechanical advantage**. You can calculate a machine's mechanical advantage using this formula:

$$\text{Mechanical Advantage} = \frac{\text{Output Force}}{\text{Input Force}}$$

$$MA = \frac{F_{out}}{F_{in}}$$

This formula works for all machines, regardless of whether they are simple machines or more complicated machines.

If a machine decreases the force you use to do work, the distance over which you have to apply that force increases. It is possible to use this idea to calculate the mechanical advantage of a simple machine without knowing what the input and output forces are. To make this calculation, however, you must assume that your machine is not losing any work to friction. In other words, you must assume that your machine is 100 percent efficient. The mechanical advantage that you calculate when making this assumption is called the ***ideal mechanical advantage***.

- For an **inclined plane**, divide the length of the incline plane by the height of the incline.

$$\text{Ideal Mechanical Advantage} = \frac{\text{length of incline}}{\text{height of incline}}$$

$$IMA = \frac{l}{h}$$

- For a **wheel and axle**, divide the radius of the input force by the radius of the output force.

$$\text{Ideal Mechanical Advantage} = \frac{\text{Radius of input}}{\text{Radius of output}}$$

$$IMA = \frac{R_{in}}{R_{out}}$$

- For a **lever**, calculate this by dividing distance from the input force to the fulcrum by the distance from the output force to the fulcrum.

$$\text{Ideal Mechanical Advantage} = \frac{\text{distance from input force to fulcrum}}{\text{distance from output force to fulcrum}}$$

$$IMA = \frac{d_{in}}{d_{out}}$$

- For **pulleys**, the mechanical advantage is equal to the number of ropes that support the weight of the object.

SECTION 3 (PP. 468-475): MODERN TECHNOLOGY USES COMPOUND MACHINES.

Georgia Standards: S8P83c - *Demonstrate the effect of simple machines (lever, inclined plane, wedge, pulley, screw, and wheel and axle) on work*; S8CS5a – *Observe and explain how parts can be related to other parts in a system such as the role of simple machines in complex machines*.

1. **Compound machines are combinations of simple machines.**
   A machine that is made of two or more simple machines is a ***compound machine***. Compound machines often have many moving parts and must overcome more friction than simple machines.

   Gears are based on the wheel and axle. Gears have teeth on the edge of the wheel that allows one gear to turn another. A set of gears forms a compound machine in which one wheel and axle is linked to another.

   Two linked gears that are the same size and have the same number of teeth will turn at the same speed. They will move in opposite directions. In order to make them move in the same direction, a third gear must be added between them. The gear that turns another gear applies the input force; the gear that is turned exerts the output force. A difference in

speed between two gears—caused by a difference in size and the distance each turns through—produces a change in force.

The mechanical advantage of a compound machine equals the product of the mechanical advantage of all of the simple machines that make up the compound machine. For example, if a lever with a mechanical advantage (MA) of 2 acts in a series with a lever with an MA of 3, the mechanical advantage of the lever combination will be 2 • 3, or 6. **Remember that mechanical advantage does not have units; it is a number only!**

2. **Modern technology creates new uses for machines.**
Sophisticated machines are often based on or contain several simple machines.
    - Machines built from individual atoms and molecules of material are the result of **nanotechnology**. Most *Nano machines* are still in the experimental stage.

      Nanotechnology could also be used to develop materials that repel water and dirt and make cleaning jobs easy. Nano scale biosensors could be used to detect harmful substances in the environment. Another possible use for nanotechnology is in military uniforms that can change color—the perfect camouflage.

      In the future, nanotechnology may change the way almost everything is designed and constructed. As with any new technology, it will be important to weigh both the potential risks and benefits.

    - Robots are machines that work automatically or by remote control. They do jobs in places where it is difficult or dangerous for people to work.

      Many companies use robots to manufacture goods quickly and efficiently. Robots are widely used for jobs such as welding, painting, and assembling products. Robots do some repetitive work better than humans, because robots do not get tired or bored. Also, they do the task in exactly the same way each time. Robots are very important to the automobile and computer industries.