Chapter 14: Work, Power, and Machines

Section 14.1: Work and Power

- In science, _____ is the product of _____ and _____. Work is done when a _____ acts on an object in the _____ the object _____.
- For a _____ to do _____ on an object, some of the force must act in the same _____ as the object moves. If there is _____.
- A _____ does not have to act entirely in the _____ of movement to do _____.
- Any part of a _____ that does not act in the direction of motion _____ on an object.

According to the scientific definition, what is work and what is not?

1. A scientist delivers a speech to an audience of his peers. _____
2. A body builder lifts 350 pounds above his head. _____
3. A mother carries her baby from room to room. _____
4. A father pushes a baby in a carriage. _____
5. A woman carries a 20 kg grocery bag to her car? _____

Formula for Work

- The unit of force is _____.
- The unit of distance is _____.
- The unit of work is _____.
- One _____ is equal to one _____.

Sample Problem

1. If a man pushes a concrete block 10 meters with a force of 20 N, how much work has he done?

- _____ is the _____ at which _____ is done.
- Doing work at a _____ rate requires more _____.
- To increase _____, you can increase the _____ done in a given time, or you can do a given amount of work in _____.

Formula for Power

- The unit of _____ is a _____ and the unit of time is a _____.
- A joule per second is a _____ which is the SI unit for power.

Sample Problems

1. Two physics students, Ben and Bonnie, are in the weightlifting room. Bonnie lifts the 50 kg barbell over her head (approximately .60 m) 10 times in one minute; Ben lifts the 50 kg barbell the same distance over his head 10 times in 10 seconds.

Which student does the most work?
Which student delivers the most power?
Explain your answers.

2. How much work does a does a 25 N force do to lift a potted plant from the floor to a shelf 1.5 m high?

3. How much force is needed to complete 72.3 J of work over a distance of 22.8 m?

4. You exert a vertical force of 72 N to lift a box to a height of 2 m in a time of 17 s. How much power is used to lift the box?

5. You lift a book from the floor to a bookshelf 5.4 m above the ground. How much power is used if the upward force is 15.0 N and you do the work in 2.0 s?

Section 14.1 Assessment

1. What conditions must exist in order for a force to do work on an object?

2. What formula relates work and power?

3. How much work is done when a vertical force acts on an object moving horizontally?

4. A desk exerts an upward force on a computer resting on it. Does this force do work?

5. You lift a large bag of flour from the floor to a 1 m high counter, doing 100 J of work in 2 s. How much power do you use to lift the bag of flour?

Section 14.2: Work and Machines

- A _____ is a device that _____ a force.
- Machines make work _____ to do. They change the _____ of the force needed, the _____ of a force, or the _____ over which a force acts.
- Each complete rotation of a car jack handle applies a _____.
- A _____ over a _____ becomes a _____ over a _____.
- If a machine increases the _____ over which you exert a force, then it decreases the _____ you need to exert.
- When you pull an oar a _____, the other end of the oar moves a _____ through the water.
- A machine that _____ the distance through which you exert a force _____ the amount of force required.
- Pulling one end of an oar causes the other end of the oar to move in the _____.
- Because of _____, the work done by a machine is always _____ than the work done on the machine.
- The _____ you exert on a machine is called the _____.
- The _____ the input force acts through is known as the _____.
- The _____ done by the _____ acting through the _____ is called the _____.
- The _____ that is exerted by a machine is called the _____.
- The _____ the output force is exerted through is the _____.
- The _____ of a machine is the _____ multiplied by the _____.
- You cannot get more work out of a machine than _____.

Section 14.2 Assessment

1. How can using a machine make a task easier to perform?

2. How does the work done on a machine compare to the work done by a machine?

3. A machine produces a larger force than you exert. How does the input distance of the machine compare to the output distance?

4. You do 200 J of work pulling the oars of a rowboat. What can you say about the amount of work the oars do to move the boat?

5. How can you increase the work output of a machine?

6. When you swing a baseball bat, how does the output distance the end of the bat moves compare with the distance you move your hands through?

Section 14.3: Mechanical Advantage and Efficiency

- The _____ of a machine is the number of times that the machine increases the _____.
- The _____ is the ratio of the _____ to the _____.

Formula for Actual Mechanical Advantage (AMA)

- The _____ of a machine is the mechanical advantage in the absence of _____.
- Because _____ is always present, the _____ is always less than the _____.
- The _____ is the ratio of the _____ to the _____.

Formula for Ideal Mechanical Advantage (IMA)

Sample Problems

1. A woman drives a car up a ramp that is 1.8 m long. The ramp lifts the car a height of 0.3 m. What is the IMA?

2. A construction worker moves a crowbar through a distance of 0.50 m to lift a load 0.05 m off the ground? What is the IMA of the crowbar?

3. The IMA of a simple machine is 2.5. If the output distance of the machine is 1.0 m, what is the input distance?

- Some _____ is lost due to _____.
- The _____ of work input that becomes work output is the _____ of the machine.
- No machine has _____ efficiency due to _____.

Formula for Efficiency

- Reducing _____ increases the _____ of a machine.

Section 14.3 Assessment

1. Why is the actual mechanical advantage of a machine always less than its ideal mechanical advantage?

2. Why can no machine by 100% efficient?

3. What information would you use to calculate the efficiency of a machine?

4. What is the actual mechanical advantage of a machine that exerts 5 N for each 1 N of force you exert on the machine?

5. You have just designed a machine that uses 1000 J of work from a motor for every 800 J of useful work the machine supplies. What is the efficiency of your machine?

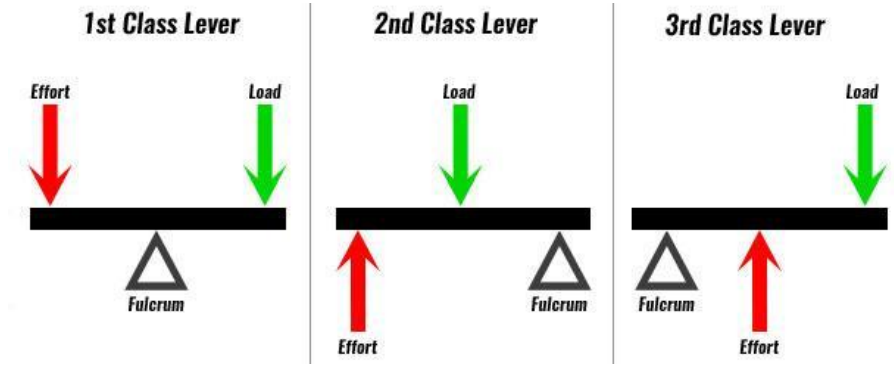
6. If a machine has an efficiency of 40%, and you do 1000 J of work on the machine, what will be the work output of the machine?

Section 14.4: Simple Machines

- Many _____ are combinations of two or more of the six different _____.
- The six simple machines are:

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

- A _____ is a rigid bar that rotates around a _____ called the _____.
- The _____ of a lever is the distance between the _____ and the _____.
- The _____ is the distance between the _____ and the _____.
- The _____ of a lever is determined by the _____ of the _____ and the _____ relative to the _____.



- In a _____ lever the _____ is located at some point _____ the effort and resistance forces.
- Common examples of first-class levers include _____.
- A first-class lever always changes the _____ of force (i.e. a downward effort force on the lever results in an upward movement of the resistance force).
- With a _____ lever, the _____ is located _____ the _____ and the _____.
- Common examples of second-class levers include _____.
- A _____ lever does not change the _____ of force. When the fulcrum is located closer to the load than to the effort force, an _____ (mechanical advantage) results.
- With a _____ lever, the _____ is applied _____ the _____ and the _____.
- Examples of third-class levers include _____.
- A _____ lever does not change the _____ of force; third-class levers always produce a _____ and a corresponding decrease in _____.
- The _____ is a simple machine consisting of a _____ rigidly secured to a _____.
- To calculate the _____, divide the _____ where the input force is located by the radius where the _____ is located.
- An _____ is a slanted surface along which a force moves an object to a _____.
- The _____ of an inclined plane is equal to the length of the _____ divided by the _____ of the inclined plane.
- While the inclined plane produces a mechanical advantage, it does so by _____.
- The _____ is a V-shaped object whose sides are two _____.
- A _____ wedge of a given length has a _____ IMA than a _____ wedge of the same length since _____ force is needed.
- The _____ is an inclined plane wrapped around a _____.
- Screws with _____ that are closer together have a _____ IMA since it takes less _____.
- A _____ is a simple machine that consists of a _____ that fits into a groove in a _____.
- A pulley can be used to simply change the _____ of a force or to gain a _____, depending on how the pulley is arranged.
- The _____ of a pulley is equal to the number of ropes sections supporting the load being lifted.

- A pulley is said to be a _____ if it does not rise or fall with the load being moved. A fixed pulley changes the _____ of a force; however, it does not create a mechanical advantage.
- A _____ rises and falls with the load that is being moved. A single moveable pulley creates a mechanical advantage; however, it does not change the _____ of a force.
- Moveable pulleys are used to reduce the _____ needed to lift a heavy object.
- A _____ is a combination of two or more _____ that operate together.

Section 14.4 Assessment

1. Name six kinds of simple machines. Give an example of each.

2. What is the ideal mechanical advantage of a ramp if its length is 4.0 m and its higher end is 0.5 m above its lower end?

3. Tightening a screw with a larger spacing between its threads requires fewer turns than a screw with smaller spacing. What is the disadvantage of using a screw with a larger spacing between threads?

4. If you want to pry the lid off a paint can, will it require less force to use a long or short screwdriver?

5. When the pedals of a bike move through a distance of 0.25 m, the rear wheel of the bike moves 1.0 m. What is the ideal mechanical advantage of the bike?