Study Guide – Work, Power & Machines Name:____

1. **WORK**:
   a. Define *work*:

   b. Work can also be defined as a transfer of ________________.

   c. In order for work to be done, force and displacement must be in the ____________________ direction.

   d. Give one example in which work is done:

   e. Give one example in which work is <u>not</u> done:

   f. For the following 3 scenarios, explain why work *is* or *is not* done:
   - A woman preparing for a trip lifts her suitcase from the floor to the bed so that she may pack more easily.

   - A man spends 5 minutes thinking about the most efficient way to decorate his roof with Christmas lights.

   - A student carries his book bag down the hallway.

   g. Identify which of the pairs in each scenario illustrates *more* work being done:
   _____ A boy helps a teacher by lifting a 200-N box of books 1.5 meters from the floor to the desktop.
   _____ The same boy lifts a 500-N box of books the same height.
   <u>Explain your choice:</u>

   _____ A girl throws a 1-kg softball with a force of 50 Newtons a distance of 25 meters.
   _____ The same girl throws the softball with the same force a distance of 17 meters.
   <u>Explain your choice:</u>

   h. The formula for calculating work is ______________________, and the unit for work is the ______________.

2. **POWER:**
   a. Define *power*:

   b. How are power and work related?

   c. Identify which of the pairs in each scenario illustrates *less* power being generated:
   _____ A woman pushes a cart with 95 N of force 3 m in 10 seconds.
   _____ A man pushes a cart with 95 N of force 3 m in 13 seconds.
   <u>Explain your choice:</u>

   _____ A 340-N student climbs the stairs in 14 seconds.
   _____ A 420-N student climbs the stairs in 14 seconds.
   <u>Explain your choice:</u>

   d. The relationship between power, force and velocity is ____.

3. **MACHINES:**
   a. A machine is a device that ____.

   b. The 6 simple machines include:

   c. The 2 simple machines that are a modified version of the inclined plane are ______________________ and ________________________.

d. The work input for a machine is ____, while the output is ____.

e. If work input is not equal to work output for a machine, how does the Law of Conservation of Energy explain this "lost" energy?

f. Why is no machine 100 % efficient, or greater than 100 % efficient?

g. The efficiency of a machine can be calculated by ____.

h. Calculate the efficiency of the following machines:
- 1200 N of force are used to push a lever down 1.3 m. The lever raises a 1450-N boulder 0.4 m.

- A machine that places the caps on plastic soda bottles requires 25 kJ of input work. The output work of the machine is 23 kJ.

i. Define *mechanical advantage*:

j. Fill in the blanks with either IMA (Ideal Mechanical Advantage) or AMA (Actual Mechanical Advantage).

____________ the advantage a machine could provide in a perfect world
____________ depends on position of the machine's parts
____________ depends on forces involved in use of the machine
____________ the advantage a machine provides when used in the real world

k. Provide the appropriate formulas for each type of mechanical advantage, and include what the variables mean:

IMA = ______________________ AMA = _____________________

l. Determine the ***ideal*** and ***actual mechanical advantage*** for each of the following machines:
- A lever has an effort arm with a length of 2 m and a resistance arm with a length of 0.5 m. When 900 N of force are applied to the lever, a 1750-N load is raised 0.3 m.

IMA = AMA =

- An engineer is designing a wheelchair ramp for a new school building. She designs a 25-m ramp to help disabled staff and students travel the 3.5 m from the ground to the school's entrance. With her design, a student in his wheelchair with a combined weight of 590 N only has to exert about 90 N of force to climb the ramp.

IMA = AMA =

m. Identify and label the different simple machines used in the complex machine to the right:

1 -

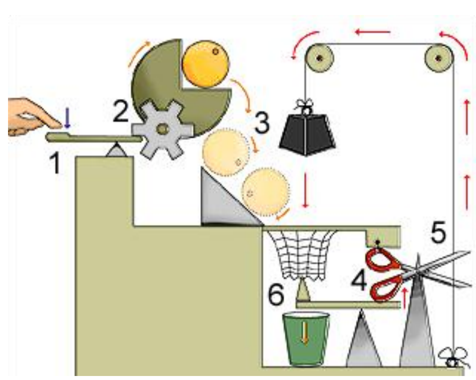
2 -

3 -

4 -

5 -

6 –



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Study Guide – Work, Power & Machines Name:__KEY____________________

1. **WORK**:
   a. Define *work*:
      Work is the transfer of a force over a distance in the same direction of the force.

   b. Work can also be defined as a transfer of __energy__________.

   c. In order for work to be done, force and displacement must be in the ___same_______________ direction.

   d. Give one example in which work is done:
      A teacher pushes a chair across the floor.

   e. Give one example in which work is not done:
      A teacher sits in her chair and explains "work" to her students.

   f. For the following 3 scenarios, explain why work *is* or *is not* done:
      - A woman preparing for a trip lifts her suitcase from the floor to the bed so that she may pack more easily.
        Work is done because she applies the force on the suitcase in the same direction she's moving it.
      - A man spends 5 minutes thinking about the most efficient way to decorate his roof with Christmas lights.
        No work is done because there is no force or motion.
      - A student carries his book bag down the hallway.
        No work is done because the force is applied upward on the book bag, but it is moving forward; the force and displacement are not in the same direction.

   g. Identify which of the pairs in each scenario illustrates *more* work being done:
      ______ A boy helps a teacher by lifting a 200-N box of books 1.5 meters from the floor to the desktop.
      __X__ The same boy lifts a 500-N box of books the same height.
      Explain your choice: Work is Fxd. The displacement is the same in both scenarios, so greater work is done when he must exert a greater force.
      __X__ A girl throws a 1-kg softball with a force of 50 Newtons a distance of 25 meters.
      ______ The same girl throws the softball with the same force a distance of 17 meters.
      Explain your choice: Work is Fxd. The force applied is the same in both scenarios, so greater work is done when the ball experiences a greater displacement.

   h. The formula for calculating work is __$W = F \times d$______________, and the unit for work is the _Joule_________.

2. **POWER:**
   a. Define *power*:
      Power is the rate of work done.

   b. How are power and work related?
      Power can be increased by doing more work; this is a direct relationship.

   c. Identify which of the pairs in each scenario illustrates *less* power being generated:
      ______ A woman pushes a cart with 95 N of force 3 m in 10 seconds.
      __X__ A man pushes a cart with 95 N of force 3 m in 13 seconds.
      Explain your choice: Power is work divided by time, or Fxd over time. Since both people exert the same force over the same distance (doing the same amount of work), the man generates less power because it takes him longer.
      ______ A 340-N student climbs the stairs in 14 seconds.
      __X__ A 420-N student climbs the stairs in 14 seconds.
      Explain your choice: Power is work divided by time, or Fxd over time. Since both students are climbing the same stairs in the same amount of time, the heavier student will generate more power because a greater force is exerted.

   d. The relationship between power, force and velocity is __$P = \frac{W}{t} = \frac{F \times d}{t} = F \times \frac{d}{t} = F \times v$_________________.

3. **MACHINES:**
   a. A machine is a device that __changes either the magnitude or direction of an applied force__________________.

b. The 6 simple machines include:

lever, inclined plane, wedge, screw, wheel and axle, pulley

c. The 2 simple machines that are a modified version of the inclined plane are ___wedge________________ and ___screw________________.

d. The work input for a machine is __work that goes into (or is exerted on) a machine___________, while the output is __work that comes out of (or results from) a machine.

e. If work input is not equal to work output for a machine, how does the Law of Conservation of Energy explain this "lost" energy?

The Law of Conservation of Energy states that energy cannot be created or destroyed, but may be converted into another form.

f. Why is no machine 100 % efficient, or greater than 100 % efficient?

Some portion of the energy input is always converted into another form of energy, usually friction.

g. The efficiency of a machine can be calculated by __ $Efficiency = \frac{W_{out}}{W_{in}} \times 100$ ______________________________.

h. Calculate the efficiency of the following machines:

- 1200 N of force are used to push a lever down 1.3 m. The lever raises a 1450-N boulder 0.4 m.

$$E = \frac{1450 \times 0.4}{1200 \times 1.3} \times 100 = 37\%$$

- A machine that places the caps on plastic soda bottles requires 25 kJ of input work. The output work of the machine is 23 kJ.

$$E = \frac{23}{25} \times 100 = 92\%$$

i. Define *mechanical advantage*:

Mechanical advantage is the number of times a machine increases the input force.

j. Fill in the blanks with either IMA (Ideal Mechanical Advantage) or AMA (Actual Mechanical Advantage).

__IMA_______ the advantage a machine could provide in a perfect world
__IMA_______ depends on position of the machine's parts
__AMA______ depends on forces involved in use of the machine
__AMA______ the advantage a machine provides when used in the real world

k. Provide the appropriate formulas for each type of mechanical advantage, and include what the variables mean:

$$IMA = \frac{d_E}{d_R} = \frac{\text{effort (input) distance}}{\text{resistance (output) distance}}$$

$$AMA = \frac{F_R}{F_E} = \frac{\text{resistance (output) force}}{\text{effort (input) force}}$$

l. Determine the ***ideal*** and ***actual mechanical advantage*** for each of the following machines:

- A lever has an effort arm with a length of 2 m and a resistance arm with a length of 0.5 m. When 900 N of force are applied to the lever, a 1750-N load is raised 0.3 m.

$$IMA = \frac{2}{0.5} = 4$$

$$AMA = \frac{1750}{900} = 1.94$$

- An engineer is designing a wheelchair ramp for a new school building. She designs a 25-m ramp to help disabled staff and students travel the 3.5 m from the ground to the school's entrance. With her design, a student in his wheelchair with a combined weight of 590 N only has to exert about 90 N of force to climb the ramp.

$$IMA = \frac{25}{3.5} = 7.1$$

$$AMA = \frac{590}{90} = 6.6$$

m. Identify and label the different simple machines used in the complex machine to the right:

1 - lever

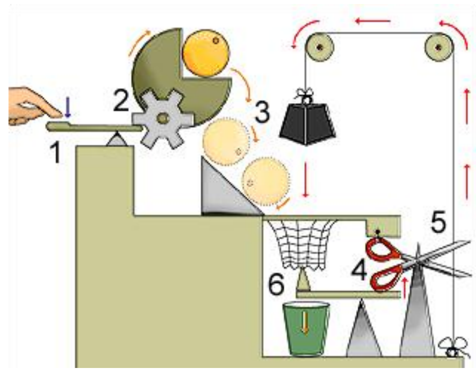
2 – wheel & axle

3 – inclined plane

4 - lever

5 - wedge

6 - lever



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