Chapter 13

Work and NRG

Work, NRG, and Machines

13.1

Key Ideas

- How is work calculated?
- What is the relationship between work and power?
- Hoe do machines make work easier?

What is work?

- To many people, the word *work* means something they do to earn money.
- The word *work* also means exerting a force with your muscles.
- Someone might say they have done work when they push as hard as they can against a wall that doesn't move.
- However, in science the word *work* is used in a different way.

What is Work?

- Work is done when a force is applied to an object and the object moves <u>in the that direction.</u>

Work Equation

$$W = Fd$$

What is Work?

- Which of the following situations display work being done by the underlined word?

1. A <u>man</u> lifts a box up from the ground
2. A <u>lady</u> holds a branch up off the ground
3. <u>You</u> are holding a book and carrying to the other side of the room

What is Work?

- Work is measured in joules (J)
  - 1 joule = 1 N*m
  - 1 joule = 1 $kg*m^2/s^2$
- Work is 0 when an object is not moving
- Are you doing work on a wall when you do a wall sit?
  - Why do you get tired?

Is this beaker doing work?

Quick Lab

(10 minutes)

- Get a 500 gram mass (or make one)
- Grab a BROWN Spring scale
- Hang the mass from the scale and record the reading in N (Is work being done?)
- Lift the mass and record the MAX N reading. (Is work being done?)
- Hold the scale at shoulder length and walk 5 steps SLOWLY. (Is work being done?)

Examples

How much work are you doing if you apply 135 N of force to climb 60 m up a ladder?

135 * 60 = 8100 J

How much force is required to climb up 30 meters of a ladder if you use 550 J of work to do it?

550 / 30 = 18.33 N

Practice

- Complete page 432
  - 1 and 3

Power

- Suppose you and another student are pushing boxes of books up a ramp and load them into a truck.
- To make the job more fun, you make a game of it, racing to see who can push a box up the ramp faster to see who is more powerful.
- **Power** is the amount of work done in one second. It is a rate—the rate at which work is done.
- How can we figure out who is more powerful?

Calculating Power

- To calculate power, divide the work done by the time that is required to do the work.

$$Power\ (W) = \frac{Work\ (J)}{Time\ (s)}$$

$$P = \frac{w}{t}$$

- The SI unit for power is the watt (W). One watt equals one joule of work done in one second.

Calculating Power

- Because the watt is a small unit, power often is expressed in kilowatts.
- One kilowatt (kW) equals 1,000 W.

Examples

How much power is required to perform 450 J of work in 30 seconds?

450 / 30 = 15 W

How much work is required to produce 0.550 kW of power in 10 seconds?

550 * 10 = 5500 J

Practice

- Complete 1-2 on pare 434

Machines and Mechanical Advantage

- Machines help do work by changing the size of the input force, the direction of the force, or both
- Machines can also make a greater force by decreasing the distance
  - Car jack

Machines and Mechanical Advantage

- Mechanical advantage is a number that tells you how much a machine multiplies the force or distance

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

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

Machines and Mechanical Advantage

- What is the MA for a machine that produces 500 N when you apply 300 N?
- What is the MA for a teeter-totter that lifts a box 3.4 meters when you push the other side down 1.9 meters?

Machines and Mechanical Advantage

- What is the output force of a machine that has a MA of 2.6 and a 17 N input force is applied?

- How far did you push down the teeter-totter if it has a MA of 2.2 and it raised 1.2 cm?

More practice on parte 436

Machines and Mechanical Advantage

- Machines do not change the amount of work done!
- How much work is done when you lift a 225 N box 1 meter into the back of a truck?
- How much work is done when you apply a 75 N force to push the same box up a 3 meter long ramp?

Assignment

- Page 437 (1-4)
- CR
- Math Skills
  - Work
  - Power
  - Mechanical Advantage

Simple Machines

13.2

Key Ideas

- What are 6 types of simple machines?
- What are the 2 principle parts of all levers?
- How does using an inclined plane change the force required to do work?
- What is a cmpd machine?

What are Simple Machines?

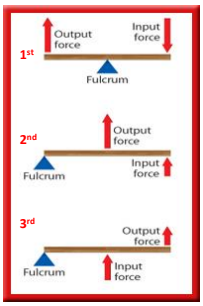
- A **Simple Machine** is one of 6 machines which are the basics of all other machines
  1. Lever
  2. Pulley
  3. Wheel and Axle
  4. Incline Plane
  5. Screw
  6. Wedge

2 Families of SM

- Lever Family
  - Lever
  - Pulley
  - Wheel and Axle
- Incline Plane Family
  - Incline Plane
  - Wedge
  - Screw

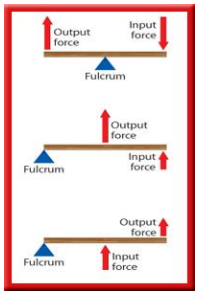
Lever Family

- A **lever** is a bar that is free to pivot or turn around a fixed point.
- The fixed point the lever pivots on is called the fulcrum.
- There are 3 Classes of levers



Levers

- What is an example of a 1st class lever?
- What is an example of a 2nd class lever?
- What is an example of a 3rd class lever



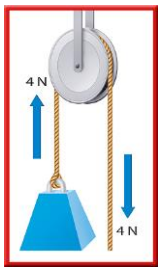
Ideal MA of a lever

- The MA of a lever can be calculated from this equation:

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

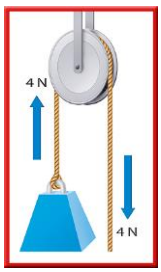
- This is the distance from the fulcrum

Pulley



- A **pulley** is a grooved wheel with a rope, chain, or cable running along the groove.
- A fixed pulley is a modified first-class lever.
- The axle of the pulley acts as the fulcrum.

Pulley



- The two sides of the pulley are the input arm and output arm.
- A pulley can change the direction of the input force or increase input force, depending on whether the pulley is fixed or moveable.

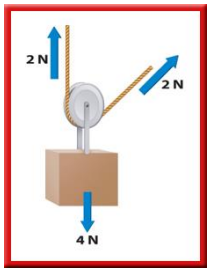
Fixed Pulley

- A fixed pulley is attached to something that doesn't move, such as a ceiling or wall.
- Because a fixed pulley changes only the direction of force, the MA is 1.

Movable Pulley

- A pulley in which one end of the rope is fixed and the wheel is free to move is called a movable pulley.
- Unlike a fixed pulley, a movable pulley does multiply force.

Movable Pulley



- With a movable pulley, the attached side of the rope supports half of the 4-N weight.
- You have to apply a 2-N force to lift the weight.

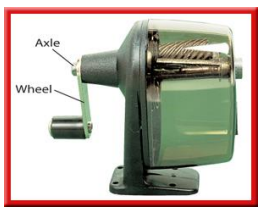
Movable Pulley

- The output force exerted on the weight is 4 N, and the applied input force is 2 N.
- Therefore the MA of the movable pulley is 2.
- For a fixed pulley, the distance you pull the rope downward equals the distance the weight moves upward.
- For a movable pulley, the distance you pull the rope upward is twice the distance the weight moves upward.

The Block and Tackle

- A system of pulleys consisting of fixed and movable pulleys is called a block and tackle.
- The MA of a pulley system is equal to the number of rope segments that support the weight.

Wheel and Axel



- A **wheel and axle** is a simple machine consisting of a shaft or axle attached to the center of a larger wheel, so that the wheel and axle rotate together.

Wheel and Axel

- Doorknobs, screwdrivers, and faucet handles are examples of wheel and axles.
- Usually the input force is applied to the wheel, and the output force is exerted by the axle.

Inclined Plane

- A sloping surface, such as a ramp that reduces the amount of force required to do work, is an **inclined plane**.

$$MA = \frac{d_{in}}{d_{out}} = \frac{Length}{Height}$$

MA of an incline plane

- By pushing a box up an inclined plane, the input force is exerted over a longer distance compared to lifting the box straight up.
- The MA of an inclined plane can be calculated from this equation.

$$Ideal\ Mechanical\ Advantage = \frac{Length\ of\ Slope\ (m)}{Height\ of\ Slope\ (m)}$$

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

- The MA of an inclined plane for a given height is increased by making the plane longer.

Screw

- A **screw** is an inclined plane wrapped in a spiral around a cylindrical post.
- The MA of a screw is related to the spacing of the threads.
- The MA is larger if the threads are closer together. However, if the MA is larger, more turns of the screw are needed to drive it into some material.

Wedge

- The wedge is also a simple machine where the inclined plane moves through an object or material.
- A **wedge** is an inclined plane with one or two sloping sides. It changes the direction of the input force.

Compound Machine

- Two or more simple machines that operate together form a **compound machine**.

The fixed point the lever pivots on is called the _____.

A. Pivot point
B. Fulcrum
C. Center
D. None of the above

If you double the length of the input arm on a lever, the MA will…

- Numeric
- It will become _____ times larger/smaller.
- If the number is smaller place a – in front of the number

What is the MA for a ramp that is 12 meters long and 450 cm tall?

- Numeric

Assignment

- Page 443 (1-4, 6-7)
- Concept Review
- 13.2 Worksheet