CHAPTER 5 Content Outline for Teaching

Work and Machines

Underlined words and phrases are to be filled in by students on the Note-taking Worksheet.

Section 2 Using Machines

A. Device that makes doing work easier is a **machine**.

B. Machines increase applied force and/or change direction of applied force to make work easier.

1. Same amount of work can be done by applying a small force over a long distance as can be done applying a large force over a short distance, since work equals force times distance.
2. Increasing distance reduces the amount of force needed to do the work.
3. Some machines change the direction of the applied force to do the work.

C. Machines help move things that resist being moved.

1. Force applied to machine is **input force.**
2. **Output force**—force applied by machine to overcome resistance
3. Amount of energy the machine transfers to the object cannot be greater than the amount of energy transferred to the machine.
   a. Some energy transferred is changed to heat due to friction.
   b. An ideal machine with no friction would have the same input work and output work.

D. **Mechanical advantage** (MA) is the number of times a machine multiplies the effort force. It is calculated by MA equals resistance force divided by effort force.

E. Efficiency—measure of how much of the work put into a machine is changed into useful output work by the machine

1. Calculating efficiency—efficiency equals (output work divided by input work) times 100%
2. Efficiency of a machine is always less than 100%.
3. Lubricants can make machines more efficient by reducing friction.

Discussion Question

Why is a machine's efficiency less than 100%? Some energy is converted to heat due to friction.

END

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Section 3 Simple Machines

A. A machine that does work with only one movement is a **simple machine**.

B. Lever—bar that is free to pivot about a fixed point called the fulcrum

1. Input arm is part of the lever on which effort force is applied.

2. Output arm is part of the lever that exerts the resistance force.

3. Three classes of levers based on positions of effort force, resistance force, and fulcrum

a. First-class lever—fulcrum is located between the effort and resistance forces; multiplies and changes direction of force

b. Second-class lever—resistance force is located between the effort force and fulcrum; always multiplies force

c. Third-class lever—effort force is between the resistance force and fulcrum; doesn't multiply force but does increase distance over which force is applied

4. Calculating ideal mechanical advantage (IMA) of a lever—IMA equals length of input arm divided by length of output arm

C. Grooved wheel with a rope, simple chain, or cable running along the groove is a **pulley**, which is a modified first-class lever.

1. A fixed pulley is attached to something that doesn't move; force is not multiplied but direction is changed; IMA = 1.

2. A movable pulley has one end of the rope fixed and the wheel free to move; multiplies force; IMA = 2.

3. Block and tackle—system of pulleys consisting of fixed and movable pulleys; IMA = number of ropes supporting resistance weight

D. **Wheel and axle**—machine with two wheels of different sizes rotating together; modified lever form

1. IMA = radius of wheel divided by the radius of axle

2. Gears are a modified form of the wheel and axle.

TURN

Work and Machines (continued)

E. **Inclined Plane**—sloping surface that reduces the amount of force required to do work

1. IMA = length of slope (effort distance) divided by height of slope (resistance distance)
2. Less force is required if a ramp is longer and less steep.

F. **Screw**—inclined plane wrapped in a spiral around a cylindrical post

G. Inclined plane with one or two sloping sides is a **wedge**.

H. **Compound machine**—uses a combination of two or more simple machines

Discussion Question

What are the two basic machines, and what other machines can they be modified to become? Lever—modified into pulley, wheel and axle; inclined plane—modified into screw and wedge

END

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Work and Machines

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Section 1 Work

A. Work—transfer of energy that occurs when a force makes an object move
   1. For work to occur, an object must move.
   2. The motion of the object must be in the same direction as the applied force on the object.

B. Work and energy are related, since energy is always transferred from the object doing the work to the object on which the work is done.

C. Work is done on an object only when a force is being applied to the object and the object moves.

D. Calculating work—work equals force (in newtons) times distance

E. Power—amount of work done in a certain amount of time; rate at which work is done
   1. Calculating power—power equals work divided by time.
   2. Power is measured in watts (W).
   3. Since work and energy are related, power also can be calculated—power equals energy divided by time.

Discussion Question

How are work and energy related? Energy is transferred from an object doing work to an object being worked on.

END