Section 1: Work, Power, and Machines

Preview

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Key Ideas

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

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Bellringer

1. Which of the following is an example of work: bowling or reading?

2. a. A man pushes against a brick wall, which doesn't move. Is this an example of work?

   b. A student carries her books to class. Is this an example of work?

   c. A woman raises and lowers dumbbells at the gym. Is this an example of work?

   d. A book falls off a table and lands on the floor. Is this an example of work?

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What Is Work?

- How is work calculated?
- Work is calculated by multiplying the force by the distance over which the force is applied.
  - work = force x distance, or $W = Fd$
  - The force must be applied in the direction of the object's motion.

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What Is Work?, *continued*

- **work:** the transfer of energy to an object by the application of a force that causes the object to move in the direction of the force

- Work is zero when an object is not moving.

- Work is measured in joules (J):

$$1\ \text{N} \cdot \text{m} = 1\ \text{J} = 1\ \text{kg} \cdot \text{m}^2/\text{s}^2$$

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Visual Concept: Work

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Math Skills

Work

Imagine a father playing with his daughter by lifting her repeatedly in the air. How much work does he do with each lift if he lifts her 2.0 m and exerts an average force of 190 N?

1. List the given and unknown values.

Given: *force*, F = 190 N

distance, d = 2.0 m

Unknown: *work*, W = ? J

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Math Skills, *continued*

2. **Write the equation for work.**

$$work = force \times distance$$

$$W = f \times d$$

3. **Insert the known values into the equation, and solve.**

$$W = 190\ \text{N} \times 2.0\ \text{m} = 380\ \text{N}\cdot\text{m}$$

$$\boxed{W = 380\ \text{J}}$$

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Power

- What is the relationship between work and power?

- Power is the rate at which work is done, or how much work is done in a given amount of time.

$$\text{power} = \frac{\text{work}}{\text{time}}, \text{ or } P = \frac{W}{t}$$

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Power, *continued*

- **power:** a quantity that measures the rate at which work is done or energy is transformed

- Power is measured in watts (W):

  $1\ W = 1\ J/s$

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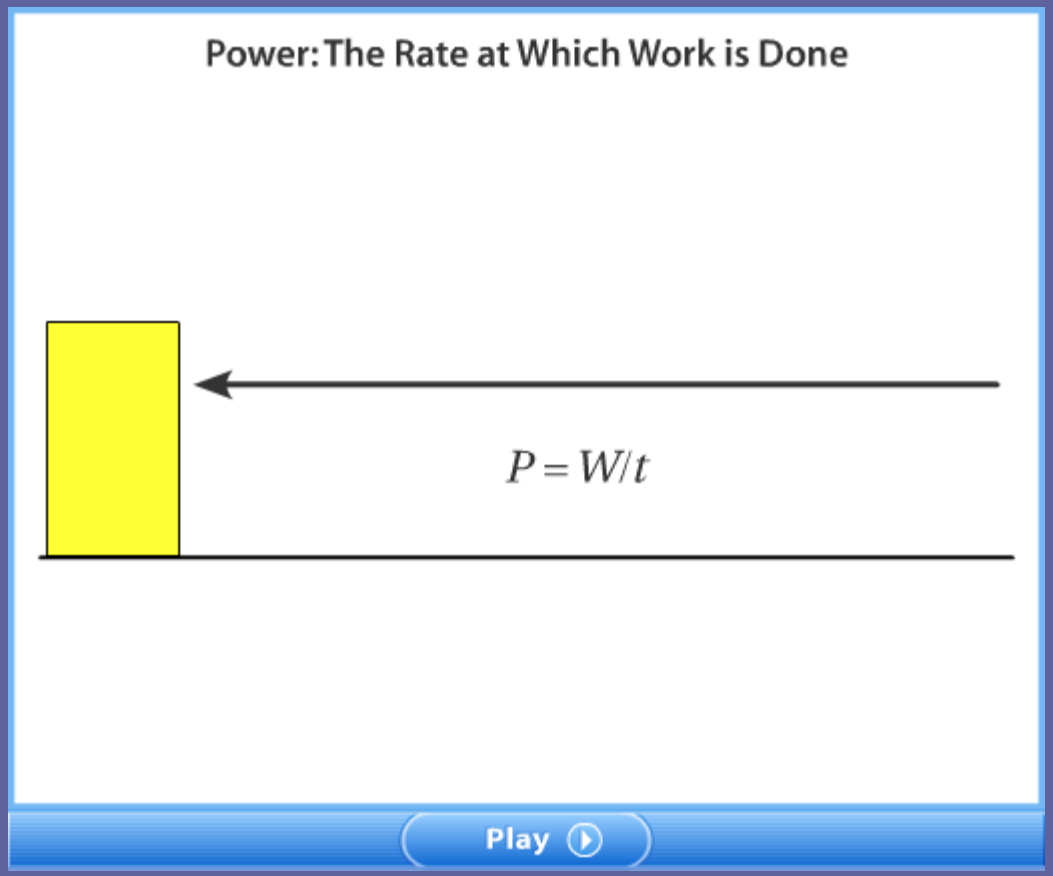
Visual Concept: Power



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Math Skills

Power

Lifting an elevator 18 m takes 100 kJ. If doing so takes 20 s, what is the average power of the elevator during the process?

1. List the given and unknown values.

Given: *work*, $W = 100\ \text{kJ} = 1 \times 10^5\ \text{J}$

time, $t = 20\ \text{s}$

Distance is not needed.

Unknown: *power*, $P = ?\ \text{W}$

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Math Skills, *continued*

2. Write the equation for power.

$$power = \frac{work}{time}$$

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

3. Insert the known values into the equation, and solve.

$$P = \frac{1 \times 10^5 \text{ J}}{20 \text{ s}} = 5 \times 10^3 \text{ J/s}$$

$$P = 5 \times 10^3 \text{ W} = 5 \text{ kW}$$

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Machines and Mechanical Advantage

- How do machines make work easier?

- Machines help do work by changing the size of an input force, the direction of the force, or both.

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Machines and Mechanical Advantage, *continued*

- Mechanical advantage is an important ratio.

- **mechanical advantage:** a quantity that expresses how much a machine multiplies force or distance

$$\text{mechanical advantage} = \frac{\text{output force}}{\text{input force}} = \frac{\text{input distance}}{\text{output distance}}$$

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Math Skills

Mechanical Advantage

Calculate the mechanical advantage of a ramp that is 5.0 m long and 1.5 m high.

1. List the given and unknown values.

Given: *input distance* = 5.0 m
output distance = 1.5 m

Unknown: *mechanical advantage* = ?

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Math Skills, *continued*

2. Write the equation for mechanical advantage.

We need only the distance part of the full equation:

$$\textit{mechanical advantage} = \frac{\textit{input distance}}{\textit{output distance}}$$

3. Insert the known values into the equation, and solve.

$$\text{mechanical advantage} = \frac{5.0\ \text{m}}{1.5\ \text{m}} = \boxed{3.3}$$

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