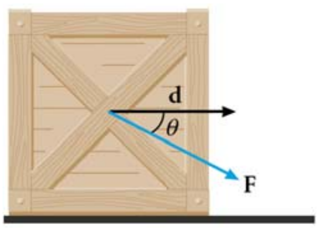
## Definition of Work

- **Work** is done on an object when a force causes a displacement of the object.
- **Work** is done only when components of a force are parallel to a displacement.






## Definition of Work

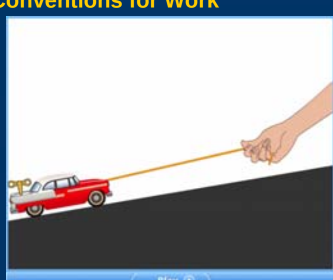



$$W = Fd\cos\theta$$






## Sign Conventions for Work



## Example of Work?

- 1. A teacher applies a force to a wall and becomes exhausted. Is work done?
- 2. A book falls off a table and free falls to the ground. Is work done?
- 3. A waiter carries a tray full of meals above his head by one arm across the room. Is work done?
- 4. A rocket accelerates through space. Is work done?







### *Critical Thinking…*

1. For each of the following cases, indicate whether the work done on the second object in each example will have a positive or a negative value.
   - A) The road exerts a friction force on a speeding car skidding to a stop.
   - B) A rope exerts a force on a bucket as the bucket is raised up a well.
   - C) Air exerts a force on a parachute as the parachutist falls to Earth.





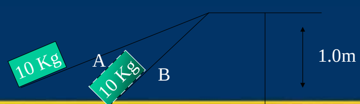


## Conservative Forces

- When work done against a force is independent of the path taken, the force is said to be a *conservative force*
- *Gravitation is an example of this type of a force*
- *Notice no friction is involved*

## Nonconservative Forces

- Air resistance and friction are examples of nonconservative forces
- The work done against a nonconservative force <u>is dependent upon the path taken</u>







## Nonconservative Example



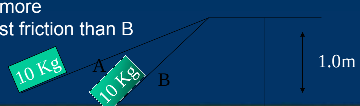
$W_f = F_f d$

$Ff = u_k F_N$

$F_N$ gets larger as the angle gets *smaller*, so…

W = 98 J
Just to lift it

A requires more work against friction than B









## Objectives

- **Relate** the concepts of energy, time, and power.
- **Calculate** power in two different ways.
- **Explain** the effect of machines on work and power.

## Rate of Energy Transfer

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

$$P = W/\Delta t$$

power = work ÷ time interval

- An alternate equation for power in terms of force and speed is

$$P = Fv$$

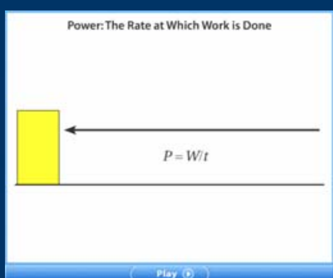
power = force × speed

Chapter menu Resources





## Power




Chapter menu Resources





## Objectives

- **Identify** several forms of energy.
- **Calculate** kinetic energy for an object.
- **Apply** the work–kinetic energy theorem to solve problems.
- **Distinguish** between kinetic and potential energy.
- **Classify** different types of potential energy.
- **Calculate** the potential energy associated with an object's position.

Chapter menu Resources

## Kinetic Energy

- **Kinetic Energy**

  The energy of an object that is due to the object's motion is called **kinetic energy.**

- **Kinetic energy** depends on speed and mass.

$$KE = \frac{1}{2}mv^2$$

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2$$







## Kinetic Energy








## Kinetic Energy, *continued*

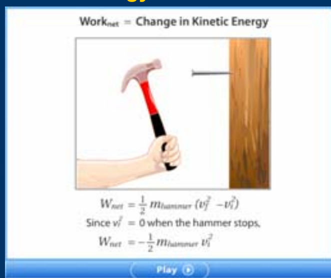
- **Work-Kinetic Energy Theorem**
  - The net work done by all the forces acting on an object is equal to the change in the object's kinetic energy.

- The net work done on a body equals its change in kinetic energy.

$$W_{net} = \Delta KE$$

net work = change in kinetic energy

## Work-Kinetic Energy Theorem









## Potential Energy

- **Potential Energy** is the energy associated with an object because of the position, shape, or condition of the object.
- **Gravitational potential energy** is the potential energy stored in the gravitational fields of interacting bodies.
- **Gravitational potential energy** depends on height from a zero level.

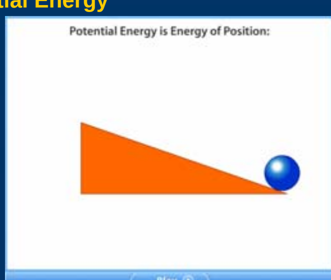
$$PE_g = mgh$$

gravitational PE = mass × free-fall acceleration × height






## Potential Energy



## Objectives

- **Identify** situations in which conservation of mechanical energy is valid.
- **Recognize** the forms that conserved energy can take.
- **Solve** problems using conservation of mechanical energy.





## Conserved Quantities

- When we say that something is *conserved,* we mean that it remains constant.





## Mechanical Energy

- **Mechanical energy** is the sum of kinetic energy and all forms of potential energy associated with an object or group of objects.

$$ME = KE + \sum PE$$

- Mechanical energy is often conserved.

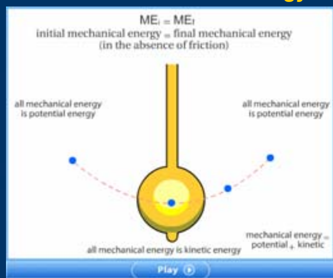
$$ME_i = ME_f$$

initial mechanical energy = final mechanical energy (in the absence of friction)

Chapter 5

Section 5.3 Conservation of Energy

## Conservation of Mechanical Energy



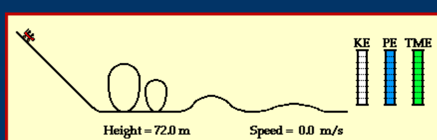

End of Slide

Chapter menu | Resources



## Roller Coasters

- Although not perfectly energy efficient, they are a fun way to view how work, gravitational potential and kinetic energy are exchanged

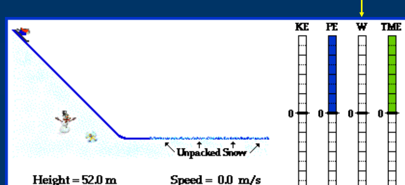



Chapter menu | Resources



## The Downhill skier

What's this?




Chapter menu | Resources