Section 5.2 - Energy

Learning Goal: By the end of today, I will be able to calculate the kinetic energy of an object.

Kinetic Energy - The Energy of Moving Things

We will combine several ideas of the past chapters to give us insight into what is Kinetic Energy.

Work Equation - measured in N·m or Joules

$$W_{Net} = F_{Net}(\cos\theta)\Delta d$$

Force Equation - measured in Newtons (N)

$$F_{Net} = m \cdot a$$

$$W_{Net} = m \cdot a(\cos\theta)\Delta d$$

$$W_{Net} = m(\cos\theta) \cdot a\Delta d$$

$$W_{Net} = m(\cos\theta) \cdot \frac{V_f^2 - V_i^2}{2}$$

Kinematic Equation

$$V_f^2 = V_i^2 + 2a \cdot \Delta d$$

$$\frac{V_f^2 - V_i^2}{2} = a \cdot \Delta d$$

$$W_{Net} = m \cdot \frac{V_f^2 - V_i^2}{2}$$

Assumption #1 - Force (and therefore acceleration) are in the same direction as displacement, θ = 0, cosθ = cos 0 = 1

$$W_{Net} = \frac{mV_f^2}{2} - \frac{mV_i^2}{2}$$

Assumption #2 - object is starting from Rest, therefore $V_i = 0$

$$W_{Net} = \frac{mV_f^2}{2}$$

Almost there....

$$W_{Net} = \frac{mV_f^2}{2}$$

$$E_K = \frac{mv^2}{2}$$

Analyze from a unit perspective

$$kg \cdot \left(\frac{m}{s}\right)^2$$
$$= \frac{kg \cdot m^2}{s^2}$$
$$= \frac{kg \cdot m}{s^2} \cdot m$$
$$= N \cdot m$$
$$= Joule$$

This is the formula for the Energy of an object, it is measured in Joules or N·m .

Sample Problem 1

Calculate the kinetic energy of a 150 g baseball that is travelling toward home plate at a constant speed of 35 m/s.

Given: m = 150 g or 0.150 kg; v = 35 m/s

Required: E_k, kinetic energy

Analysis: $E_k = \frac{mv^2}{2}$

Practice Pause and Try

1. A 70.0 kg athlete is running at 12 m/s in the 100.0 m dash. What is the kinetic energy of the athlete? T/I
2. A dynamics cart has a kinetic energy of 4.2 J when moving across a floor at 5.0 m/s. What is the mass of the cart? T/I
3. A 150 g bird goes into a dive, reaching a kinetic energy of 30.0 J. What is the speed of the bird? T/I

Something to consider.

A mass "m" is travelling at "v" m/s, what happens to the kinetic energy when:

(a) the mass doubles in magnitude

(b) the velocity doubles in magnitude

(c) the mass is tripled, and the velocity is tripled.

The Relationship between Mechanical Work and Kinetic Energy

You can observe the relationship between mechanical work and kinetic energy by analyzing the mechanical work and kinetic energy equations. Since $E_k = \frac{mv^2}{2}$, the equation $W_{net} = \frac{mv_f^2}{2} - \frac{mv_i^2}{2}$ may be written as $W_{net} = E_{k_f} - E_{k_i}$ or $W_{net} = \Delta E_k$, where E_{k_f} is the final kinetic energy and E_{k_i} is the initial kinetic energy of the object. In words, this equation tells us that the total mechanical work, W, that increases the speed of an object is equal to the change in the object's kinetic energy, $E_{k_f} - E_{k_i}$. In other words, work is a change in energy. This relationship between kinetic energy and mechanical work is known as the **work–energy principle**.

work-energy principle the net amount of mechanical work done on an object equals the object's change in kinetic energy

$$W_{net} = E_{k2} - E_{k1}$$ (stays on the same plane)

Total work done

$$W_{net} = F_{net} \times d$$

Sample Problem 1

A 165 g hockey puck initially at rest is pushed by a hockey stick on a slippery horizontal ice surface by a constant horizontal force of magnitude 5.0 N (assume that the ice is frictionless), as shown in **Figure 3**. What is the puck's speed after it has moved 0.50 m?

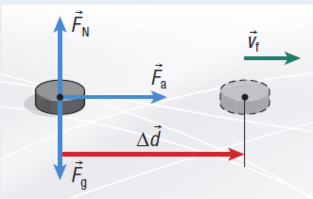

Figure 3

$$W_{net} = E_{k2} - E_{k1}$$

Practice

1. A 1300 kg car starts from rest at a stoplight and accelerates to a speed of 14 m/s over a displacement of 82 m. T/I
   (a) Calculate the net work done on the car.
   (b) Calculate the net force acting on the car.
2. A 52 kg ice hockey player moving at 11 m/s slows down and stops over a displacement of 8.0 m. T/I C
   (a) Calculate the net force on the skater.
   (b) Give two reasons why you can predict that the net work on the skater must be negative.