Work-Energy Theorem

Work

$$W = \vec{F} \bullet \vec{d} = Fd\cos\theta$$

- F = Force [N] (+)
- d = distance [m] (+)
- θ = angle between F and d

- Work = [N*m = kgm^2/s^2 = Joules]
- Work can be (+) or (-) depending on cosθ.

- When the force is not constant:

$$W = \int_{x_0}^{x_f} F(x)dx$$

Work-Energy Theorem

- We know: Net work can be found by taking the net force and multiplying it by the displacement.

$$\Sigma W = \Sigma F \bullet d$$

- Plugging in F=ma and calling displacement x instead of d, we get:

$$\Sigma W = \mathrm{max}$$

- Rearranging our 3rd equation, $v^2 - v_0^2 = 2ax$ for an expression for 'ax', we get:

$$ax = \tfrac{1}{2}(v^2 - v_0^2) \qquad \Sigma W = m\tfrac{1}{2}(v^2 - v_0^2) \qquad \Sigma W = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mv_0^2$$

- The quantity ½ mv^2 represents the energy associated with the motion of a particle and is called **kinetic energy**. Kinetic energy is a scalar quantity and has the same units as work.

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

- Therefore,

$$\Sigma W = \Delta KE$$

- This is the work-energy theorem.

Ex 1: A 6.0 kg block initially at rest is pulled along a horizontal, frictionless surface by a constant horizontal force of 12 N. Find the speed of the block after it has moved 3 m.

Ex 2: Find the final speed of the above block if the surface is not frictionless but instead has a coefficient of friction of 0.15.

Ex 3: A crate of mass 10 kg is pulled up a rough incline with an initial speed of 1.50 m/s. The pulling force is 100 N parallel to the incline, which makes an angle of 20^0 with the horizontal. The coefficient of kinetic friction is 0.4, and the crate is pulled 5.0 m.

a) How much work is done by gravity?

b) How much work is done by friction?

c) How much work is done by the applied force?

d) How much work is done by the normal force?

e) What is the net work done on the crate?

f) What is the change in KE of the crate?

g) What is the speed of the crate after it has been pulled 5 m?

Ex 4: A box of mass m is given a push down the hallway. The push imparts an initial speed of 4 m.s. How far does the box go before it stops if the coefficient of kinetic friction between the box and the floor is 0.550?