Kinetic Energy

Kinetic energy is the energy associated with the motion of something that has mass

$$Kinetic\_Energy = \frac{1}{2}mv^2$$

This is also known as *Translational Kinetic Energy*

There is also a kinetic energy associated with rotation of an object that has a *moment of inertia*

Rotational Kinetic Energy = $\frac{1}{2}I\omega^2$

Where *I* is the moment of inertia and ω is the angular velocity in radians/s.

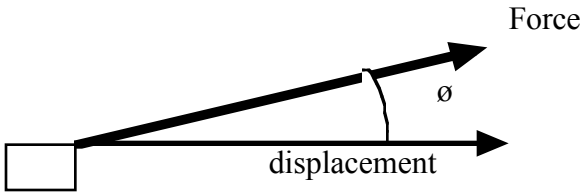
Work, Energy, and Power

Energy is the ability to do work.

Work occurs when a force is applied over a distance or *displacement*. (only the component of the force that acts in the same direction as the distance or *displacement*.

(Distance is a scalar quantity but *displacement* is a vector and requires a direction to be specified)

Thus *WORK = FORCE•Distance • cosø*
where ø is the angle between the force and the displacement



Example 1: A student pulls a 30 kg block along a flat surface by means of a rope that is held at an angle of 30° above horizontal. If the student pulls with a force of 20 N and pulls the block a distance of 10 m in the direction shown, how much work did the student do on the block?

Ans: 20N•10m•cos(30) = 173 Nm or 173 joules (a joules is equal to one newton-meter)
(Notice that the mass of the block is unimportant in this part)

Example 2 If there was no friction in example 1 to slow the block down, how fast would the block be moving after it has been pulled 10 m?

In this case the work done by the student goes into kinetic energy of the block

$$Work = Kinetic\_Energy$$

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

$$173J = \tfrac{1}{2}30kg(v^2)$$

$$\frac{2 \cdot 173J}{30kg} = v^2$$

$$\sqrt{\frac{2 \cdot 173J}{30kg}} = v$$

$$v = 3.4\,{}^{m}\!/_{s}$$

Example 3.

A mousetrap car consists of 2 -12 in LP records that each weigh 5.0 oz. If the car is moving at 2.0 m/s. Determine the rotational kinetic energy of the two wheels.

First find the <u>radius</u> of the wheels in meters.

$$6in\left(\frac{2.54cm}{1in}\right)\left(\frac{1m}{100cm}\right) = 0.15m$$

Find the mass of each wheel in kg

$$5oz\left(\frac{1lb}{16oz}\right)\left(\frac{1kg}{2.2lb}\right) = 0.14kg$$

Now find the moment of inertia of each wheel

$$I = \tfrac{1}{2}mr^2$$

$$I = \tfrac{1}{2}0.14kg(0.15m)^2$$

$$I = 1.6x10^{-3}\,kg \cdot m^2$$

Multiply this by two since there are two of these wheels

I = 3.2 x 10^{-3} kgm^2

From the linear velocity of 2.0 m/s and the radius of the wheel, find the angular velocity of each wheel

$$\omega r = v$$

$$\omega = \frac{v}{r}$$

$$\omega = \frac{2 \, m/s}{0.15 m} = 13 \frac{radians}{s}$$

From the total moment of inertia and the angular velocity find the *rotational kinetic energy*.

$$Rot\_KE = \tfrac{1}{2} I\omega^2$$

$$Rot\_KE = \tfrac{1}{2}(3.2e-3 kg \cdot m^2)(13 \tfrac{rad}{s})^2$$

$$Rot\_KE = 0.27 J$$

Power is the rate that energy is used or produced. You use a lot of energy when you run a marathon but very little power. When you sprint up a hill you use a lot of power for a short period.

$$power = \frac{energy}{time} = \frac{joules}{\text{sec}\, ond} = watts$$

$$power = Force \cdot velocity = N \tfrac{m}{s} = watts$$

example: A spring releases 100 joules of energy in 0.5 s. What power is developed?

$$power = \frac{100 J}{0.5 s} = 200 watts$$

example: A student pushes on a block with a force of 50 N as the block is traveling in the same direction at 5.0 m/s. At what rate is the student expending energy

$$` rate\_of\_energy = power = F \cdot v = 50 N \cdot 5.0 \, m/s = 250 watts$$

Your Turn

1. A student pulls a 50 kg block along a flat surface by means of a rope that is held at an angle of 37° above horizontal. If the student pulls with a force of 20 N and pulls the block a distance of 12 m in the direction shown, how much work did the student do on the block?

2. If there was no friction in example 1 to slow the block down, how fast would the block be moving after it has been pulled 12 m?

3. A mousetrap car consists of 2 -10 in LP records that each weigh 4.0 oz. If the car is moving at 2.0 m/s. Determine the rotational kinetic energy of the two wheels.

(a) First find the radius of the wheels in meters.

(b) Find the mass of each wheel in kg

(c) Now find the moment of inertia of each wheel

(d) Multiply this by two since there are two of these wheels

(e) From the linear velocity of 2.0 m/s and the radius of the wheel, find the angular velocity of each wheel

(f) From the total moment of inertia and the angular velocity find the *rotational kinetic energy*.

4: A student pushes on a block with a force of 70 N as the block is traveling in the same direction at 3.0 m/s. At what rate is the student expending energy