SPH4U
UNIVERSITY PHYSICS

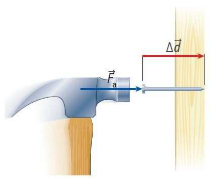
ENERGY & MOMENTUM

☞ Kinetic Energy & Work
(P.171-176)

Kinetic Energy

RECALL!

*A moving object has the ability to do work because it can apply a force to another object and displace it. The energy possessed by moving objects is called **kinetic energy (E_k)**. For example, a moving hammer has kinetic energy because it has the ability to apply a force on a nail and push the nail into a piece of wood.*



NOTE!

The faster the hammer moves or the greater its mass, the greater its kinetic energy, and the greater the displacement of the nail.

Kinetic Energy

KINETIC ENERGY (E_k)

- energy possessed by a moving object

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

where E_k is the kinetic energy (J)
m is the mass (kg)
v is the speed (m/s)

Kinetic Energy

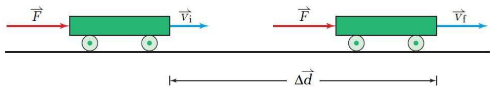
PRACTICE

1. By what factor does a car's kinetic energy increase when the car's speed:
   (a) doubles
   (b) triples
   (c) increases by 26%

   (a) x 4
   (b) x 9
   (c) x 1.6 ☜ $(1.26)^2$

Kinetic Energy & Work

Now, imagine a cart is moving with an initial speed of $\boldsymbol{v_i}$ *when it experiences a force that causes it's speed to increase to* $\boldsymbol{v_f}$ *over a displacement of* $\boldsymbol{\Delta d}$*.*



since $W = F\Delta d$ & $F = ma$ & $v_f^2 = v_i^2 + 2a\Delta d$

then $W = ma(v_f^2 - v_i^2)/2a$

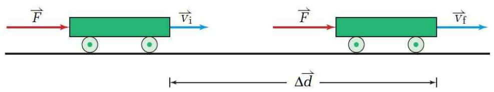
$W = (mv_f^2 - mv_i^2)/2$

$W = mv_f^2/2 - mv_i^2/2$

$W = E_{kf} - E_{ki}$

Kinetic Energy & Work

In this case, the work done on the cart is equal to the change in the kinetic energy of the cart. This is known as the ***work-energy theorem****.*



$W = E_{kf} - E_{ki}$ *or* $W = \Delta E_k$

Kinetic Energy & Work

NOTE!

You can use the work-energy theorem to solve several types of physics problems. However, the theorem is only true if no energy losses occur. In many real-world situations, energy will seem to disappear in the form of light, sound, heat, or changes in the shape of an object. For example, in a car collision, energy goes into the sounds of the crash and the bending of materials in the car. In this case, the work done on the car does ***not*** *equal the change in the kinetic energy of the car.*

Kinetic Energy & Work

WORK-ENERGY THEOREM

- only true if no energy losses occur

$$W = \Delta E_k \quad \text{or} \quad W = E_{kf} - E_{ki} \quad \text{or} \quad W = \tfrac{1}{2}m(v_f^2 - v_i^2)$$

where W is the work done (J)
E_k is the kinetic energy (J) *i = initial & f = final*

NOTE!

Sometimes 1 and 2 are used as the subscripts instead of i and f.

Kinetic Energy & Work

PRACTICE

2. A whale with a mass of 15000 kg is swimming with a speed of 6.1 m/s. A nearby boat startles the whale, and the whale increases its speed to 12.8 m/s. Calculate the work done by the water on the whale.

   $W = \Delta E_k = 9.5 \times 10^5$ J

Kinetic Energy & Work

PRACTICE

3. A police car of mass 2.4×10^3 kg is travelling on the highway when the officers receive an emergency call. They increase the speed of the car to 33 m/s The increase in speed results in 3.1×10^5 J of work done on the car. Determine the initial speed of the police car in km/h.

   v_i = 28.8 m/s or 104 km/h ☜ $E_{ki} = E_{kf} - W$

Kinetic Energy & Work

PRACTICE

4. An archer pulls back her bowstring, loaded with a 22 g arrow, and then releases the string. If the arrow leaves the bowstring at a speed of 220 km/h, calculate the work done on the arrow by the bowstring.

   $W = \Delta E_k = 41$ J

Kinetic Energy & Work

PRACTICE

5. Two objects have the same kinetic energy. One has a speed that is 2.5 times the speed of the other. Determine the ratio of their masses. (Hint: assume $v_1 = 2.5\ v_2$)

   $m_2 = 6.25\ m_1$

✔ Check Your Learning

TEXTBOOK
P.176 Q.1,3,5,7,9 (Review)