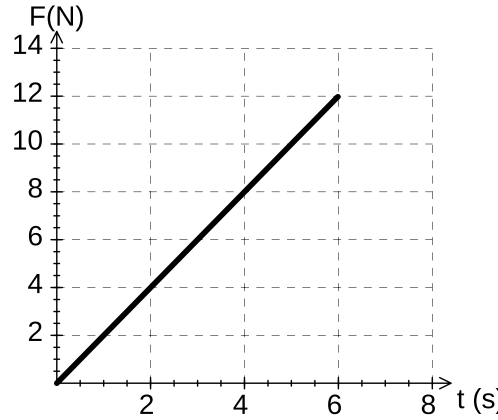
Test Date : Thurs Dec 12th

Energy and Momentum Review

- **Definition of Momentum and Impulse**

$$\vec{p} = m\vec{V} \qquad \vec{j} = \Delta\vec{p} = \vec{F}\Delta t$$

Impulse = area under an F-t graph



- **Law of Conservation of Momentum**

In a closed system (i.e. no external forces acting on it) the momentum is a constant value.
This means that the momentum before a collision must equal the momentum after the collision.

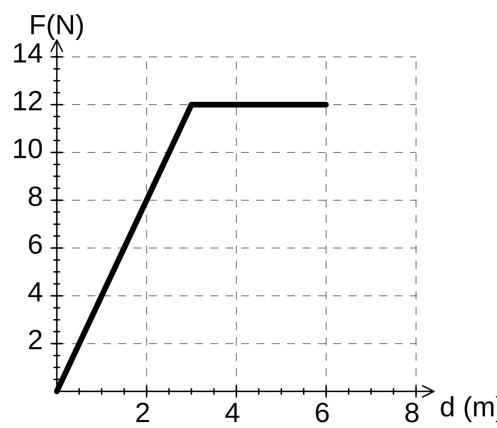
$$\vec{p_i} = \vec{p_f}$$

- **Definition of Work and Energy**

Work is the transfer of energy (change in energy) from one object to another.

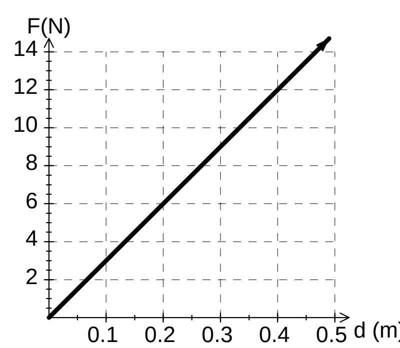
$$W = \Delta E = F\Delta d$$

Work = area under a Force-Distance graph



- **Forms of Energy**

$$E_k = \frac{1}{2}mv^2 \qquad E_g = mgh \qquad E_{p\ spring} = \frac{1}{2}kx^2$$



Hooke's Law Spring

These “forms” of energy can be derived from the basic work-energy formula.

- **Collisions**
  - **Elastic**

    Both momentum and kinetic energy are conserved.
    If the velocity of one object is 0 (i.e. set V_2=0), then the following formulas can be used:

$$V_1' = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)V_1 \qquad V_2' = \left(\frac{2m_1}{m_1 + m_2}\right)V_1$$

  - **In-Elastic**

    Only momentum is conserved (some kinetic is lost during the collision to sound, heat, light etc). These problems must be analyzed using only conservation of momentum principles.

Momentum and Energy – Review Problems

1. Two air track gliders of mass 300g and 200g are moving towards one another in opposite directions with speeds of 50 cm/s and 100 cm/s, respectively. Take the direction of the more massive glider as positive.

   a. If the collision is perfectly elastic, find the velocity of each glider after the collision.

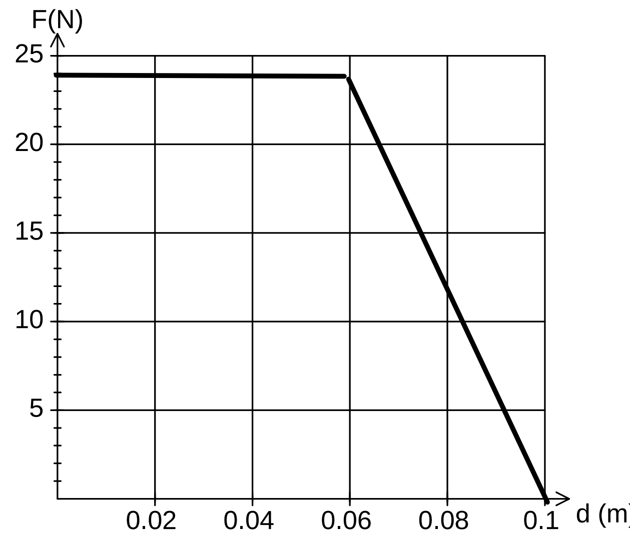
   b. The most "inelastic" collision would occur when the two gliders stick together on impact. If this were the case, find the velocity of the pair after the collision and the kinetic energy lost as a result of the collision.

2. A 4.0 kg object is at rest on a horizontal, frictionless surface when it is hit head-on by a 12.0 kg object moving forward at 0.80 m/s. The **force-separation** graph for the collision is shown below (this is an elastic collision).

   a. Calculate the velocity of each object after the collision.

   b. Calculate the velocity and kinetic energy of each object at the point of minimum separation.

   c. What is the minimum separation of the two objects?

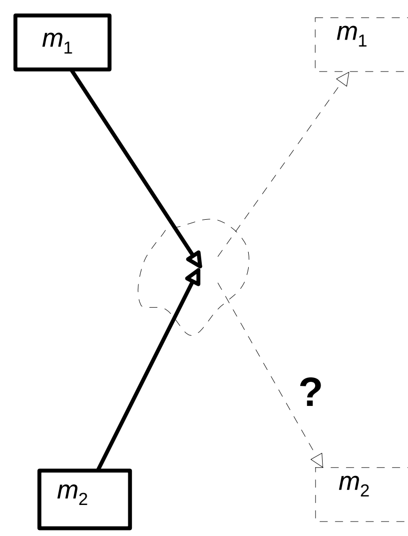


3. A 6.0 kg trolley moving at 6.0 m/s [right] catches up to and collides with a 2.0 kg trolley moving at 2.0 m/s in the same direction on the same track. The collision is cushioned by a perfectly elastic bumper attached to one of the trolleys.

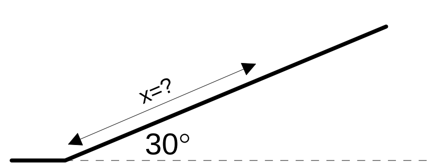
   a. What is the speed and direction of each trolley after the collision?

   b. What is the maximum amount of potential energy stored in the bumper during the collision?

4. An 4.0kg mass (m_1) is sliding on a frictionless surface at 25m/s [E68°S] collides with an 8.0kg mass (m_2) moving at 15m/s [E75°N]. After the collision, the 4.0 kg mass is moving at 14m/s [E45°N]. Find the velocity of the 8.0 kg mass right after the collision.



5. Realizing that he could not drive up a 30°, ice-covered hill because there was no friction, Sir Isaac Newton had stopped his cart, of total mass 500kg, at the bottom. He was struck in the rear by a London stage coach, of total mass 1500kg travelling at 20m/s. The two vehicles stuck together, with nothing breaking loose, and slid up the hill in a straight line. How far up the slope did the wreckage get before coming to a rest?



Answers :

1.a. $V_1'=-70cm/s$, $V_2'=80cm/s$ b. $V_0=-10cm/s$, 0.14J
2.a. $V_1'=0.40m/s$, $V_2'=1.2m/s$ b. $V_0=0.60m/s$ c. 0.04m
3.a. $V_1'=+4m/s$, $V_2'=+8m/s$, b. 12J
4.$V_2'=4.1m/s$[E29°S]
5. x=23m