

## Part I

- Two teams are having a tug-of-war match. Which of the following can be considered an isolated system?
  - one team
  - both teams
  - both teams and the rope
  - none of the above systems

Answer: (d) Since they are pushing on the earth the earth is part of the system

- A railcar (mass of 1000 kg) moves horizontally at speed 10 m/s. Friction between the railcar and the track can be neglected. A 40-kg bale of hay falls vertically onto the railcar; the car continues to move horizontally.

How do the horizontal momentum and the kinetic energy of the railcar-hay system change, if at all, when the bale of hay falls into the car? (Assume that the vertical speed of the hay just before it lands in the cart is small enough to neglect its contribution to the systems kinetic energy.) Choose all that are true.

- horizontal momentum remains constant
- horizontal momentum increases
- horizontal momentum decreases
- kinetic energy remains constant
- kinetic energy increases
- kinetic energy decreases

Answers:(a) the cart loses the momentum and the hay gains it. (f) it is an inelastic collision so KE is lost.

- Two objects with mass  $m_1$  and  $m_2$  approach each other from opposite directions and collide head-on elastically. Object 1 leaves with a final speed greater than its initial speed. How do  $m_1$  and  $m_2$  compare?
  - $m_1 > m_2$
  - $m_1 = m_2$
  - $m_1 < m_2$
  - not enough information

Answer: (d) it depends on the relative speeds of the objects. If the initial speeds were the same then the answer would be (c)

- A basketball dropped (from rest) from a height of 1 meter strikes the earth and returns to a height of 1 meter. The collision between the basketball and the earth is:
  - elastic
  - inelastic
  - totally inelastic
  - not enough information.

Answer: (a) energy is conserved since the ball returns to the same height.

5. A toy truck with low-friction bearings is rolling on a flat, horizontal surface when a pebble is gently dropped into its bed such that the pebbles horizontal velocity before landing in the truck is zero. Compared to the momentum of the truck before the pebble lands in the bed, the momentum of the truck and pebble after the pebble lands in the truck is
- (a) greater.      (b) less.      (c) the same.

Answer (c) Total momentum is always conserved in an isolated system.

6. A toy truck with low-friction bearings is rolling on a flat, horizontal surface when a pebble is gently dropped into its bed such that the pebbles horizontal velocity before landing in the truck is zero. Compared to the kinetic energy of the truck before the pebble lands in the bed, the kinetic energy of the pebble and truck afterwards is
- (a) greater.      (b) less.      (c) the same.

Answer (b). KE is not conserved in a totally inelastic collision.

7. An explosion splits an object initially at rest into two pieces of unequal mass. Which piece moves at greater speed?
- (a) The more massive piece.  
(b) They both move at the same speed.  
(c) The less massive piece.  
(d) It depends on the nature of the explosion

Answer (c). They each have the same momentum so the lighter one will need to move faster.

8. An explosion splits an object initially at rest into two pieces of unequal mass. Which piece has greater kinetic energy?
- (a) The more massive piece.  
(b) The less massive piece.  
(c) They both have the same kinetic energy.  
(d) It depends on the nature of the explosion.

Answer (b).  $KE = \frac{1}{2}mv^2$  if you half  $m$  and double  $v$  then KE is doubled .

## Part II

1. A 30 cm spring with spring constant 70 N/m is compressed to 10 cm and placed between two carts. Cart A has mass  $m_A = 5$  kg and the mass of cart B is unknown. Initially the system is at rest. After it is released it is observed that cart A has three times the velocity of cart B. (Assume no frictional forces act on the carts.)

- (a) What force must be exerted initially to keep the spring compressed?

$$F = kx = 70 \times 0.2 = 14 \text{ N.}$$

- (b) What is the work done to compress the spring?

$$W = \frac{1}{2}kx^2 = \frac{1}{2}70 \times (0.2)^2 = 1.4 \text{ J.}$$

- (c) By considering conservation of momentum determine the mass  $m_B$ .

$$p_A = p_B \Rightarrow m_A v_A = m_B v_B \text{ and } v_A = 3v_B \text{ so } m_A 3v_B = m_B v_B \Rightarrow m_B = 3m_A = 15.0 \text{ kg}$$

- (d) By considering conservation of energy find the velocities of the carts A and B after the spring is released.

$$\frac{1}{2}kx^2 = \frac{1}{2}m_A v_A^2 + \frac{1}{2}m_B v_B^2 \Rightarrow 1.4 = \frac{1}{2}(5)(3v_B)^2 + \frac{1}{2}(15)(v_B)^2 = \frac{1}{2}(60)v_B^2 \Rightarrow v_B^2 = 1.4/30$$

so  $v_B = 0.22$  m/s and  $v_A = 0.66$  m/s.