Part I

1. Two teams are having a tug-of-war match. Which of the following can be considered an isolated system?

   (a) one team

   (b) both teams

   (c) both teams and the rope

   (d) none of the above systems

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

2. 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?

   (a) $m_1 > m_2$ (b) $m_1 = m_2$ (c) $m_1 < m_2$ (d) 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)

3. 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:

   (a) elastic (b) inelastic (c) totally inelastic (d) not enough information.

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

4. 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.

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 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.

6. 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.

7. 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?
   $F = kx = 70 \times 0.2 = 14$ N.

   (b) What is the work done to compress the spring?
   $W = \frac{1}{2}kx^2 = \frac{1}{2}70 \times (0.2)^2 = 1.4$ J.

   (c) By considering conservation of momentum determine the mass m_B.
   $p_A = p_B \;\Rightarrow\; m_A v_A = m_B v_B$ and $v_A = 3v_B$ so $m_A 3v_B = m_B v_B \;\Rightarrow\; m_B = 3m_A = 15.0$ 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.

2. A 30 g ball is attached to the end of a string of length $L = 50$ cm to form a pendulum. The ball is pulled back to an angle of 53^o and released. At the lowest point in its path it makes a totally inelastic collision with stationary piece of clay of mass 100 g.

   (a) What was the velocity of the ball just before the collision?
   Using conservation of energy $mgh = \frac{1}{2}mv^2 \Rightarrow v^2 = 2gh$ where h is the height of the pendulum before it is released. Using trigonometry $h = L - L\cos\theta = 0.5 - 0.3 = 0.2$ m. Thus $v = \sqrt{(2)(9.8)(0.2)} = 1.98$ m/s

   (b) Assuming the clay originally rested on a frictionless surface how high do the ball and clay rise after the collision?
   We must first use conservation of momentum to determine the velocity after the collision, and then use conservation of energy to determine how high the ball and clay rise. For conservation of momentum we have a totally inelastic collision. Hence $mv_i = (m + M)v_f \;\Rightarrow\; v_f = v_i m/(m + M)$, where m is the mass of the ball and M is the mass of the clay. Hence, $v_f = (1.98)(0.03)/(0.13) = 0.46$ m/s. Now we apply conservation of energy to find h. Hence $(m + M)gh = \frac{1}{2}(m + M)v^2 \;\Rightarrow\; h = \frac{1}{2}v^2/g = 0.0107$ m ≈ 1.1 cm

   (c) What fraction of the initial mechanical energy is lost during the collision?
   The fraction lost will be $(PE_i - PE_f)/PE_i$. $PE_i = mgh = (0.03)(9.8)(0.2) = 0.059$ J, and $PE_f = (M + m)gh = (0.13)(9.8)(0.0107) = 0.014$ J, so the fraction lost is $(0.059 - 0.014)/(0.059) = 0.76$, of 76%.