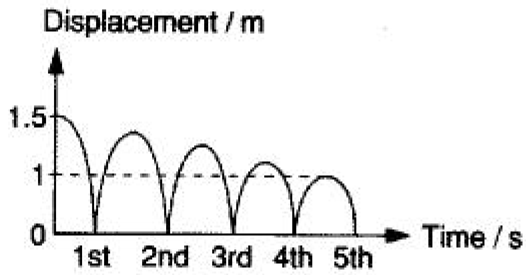
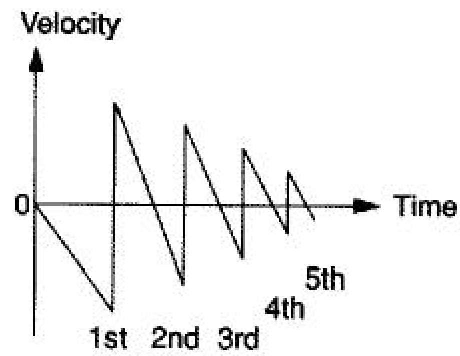
P.140 (9 – 12, 15a,b, 16a,c)

9. (a)

(i)



(ii)



(b) By conservation of energy, $mgh = \frac{1}{2}mv^2$

$$m(10)(1.5) = \frac{1}{2}mv^2$$

$$v = 5.477$$

∴ momentum of the ball just before the first impact = $m\ v$

= (0.025) (5.477)

= 0.137ms^{-1}

(c) Considering the ball and the floor (i.e. the earth) as a system, there is no external force. The total momentum of them is conserved. As the ball moves towards the earth, the earth also moves towards the ball. Their total momentum always remains zero. However, there is mechanical energy lost during each impact. Some mechanical energy is transferred to sound or heat loss to the surrounding during each impact. Hence, the height of rebound reduces after each impact.

10. (a) From conservation of energy, $\frac{1}{2}mu^2 = \frac{1}{2}mv^2 + \frac{1}{2}MV^2$ -------- (1)

From conservation of momentum, $mu = mv + MV$ -----------(2)

(b) From (1), $m(u^2 - v^2) = MV^2$

$m(u+v)(u-v) = MV^2$ -------------------(3)

From (2) $m(u\text{-}v)=MV$ ---------------------------------(4)

Substitute (4)into (3), ∴ $u + v = V$

$v = V - u$

Substitute into (4), $m(2u\text{-}V) = MV$

$2mu = (M+m)\ V$

$$\frac{V}{u} = \frac{2m}{m+M}$$

$$\text{fractional loss of kinetic energy of A} = \frac{\frac{1}{2}MV^2}{\frac{1}{2}mu^2} = \frac{M}{m}\left(\frac{V}{u}\right)^2 = \frac{M}{m}\left(\frac{2m}{m+M}\right)^2$$

$$= \frac{4Mm}{(m+M)^2}$$

(c) fractional loss of kinetic energy of A $= \frac{4(50m)m}{(m+50m)^2}$

$= 0.0769$

11. (a) (i) The linear momentum of a body is the product of its mass and its velocity.

(ii) It is a vector quantity.

(b) The principle of conservation of momentum states that when objects of a system interact, their total momentum before impact is equal to their total momentum after impact if there is no net external force acting on them.

(c) (i) momentum of the plasticine just before it hits the ground = mv = 0.2 (8)

$= 1.6 \text{ kgms}^{-1}$

The momentum of the plasticine is completely transferred to the ground (earth).

The kinetic energy of the plasticine is dissipated as heat and sound.

(ii) $m_1u_1 = m_1v_1 + m_2v_2$

$1\ (6.5\text{x}10^5) = 1\ v_1 + 12\ (10^5)$

$v_1 = -5.5\text{x}10^5$

velocity of the neutron = $5.5\text{x}10^5 \text{ ms}^{-1}$ (in the opposite direction to its initial direction)

The total kinetic energy is conserved.

(iii) Before letting go, the total momentum of the magnets is zero. After letting go, the magnets spring apart in opposite directions and their total momentum is also zero. (The magnetic energy stored is released as the magnets are letting go. This becomes the kinetic energy of the magnets.)

12. (a) Momentum is a vector quantity with both magnitude and direction but kinetic energy is a scalar quantity with magnitude only.

(b) (i) momentum = mv

(ii) kinetic energy = $\frac{1}{2}mv^2$

(c) mv = 2.4 ---------------(1)

$\frac{1}{2}mv^2 = 45$ -------------(2)

Substitute (1) into (2), 1.2 v = 45

$v = 37.5\text{ms}^{-1}$

Substitute into (1), m = 0.064kg

(d) (i) F t = mv – mu

-60 t = 0 – 2.4

t = 0.04s

(ii) $s = \frac{1}{2}(u+v)\ t = \frac{1}{2}(37.5 + 0)(0.04)$

$= 0.75\text{m}$

(e) (i) new momentum = F t = 60 (0.06) = 3.6kgms^{-1} (in the direction of the force)

(ii) new velocity = 3.6/0.064 = 56.25 ms^{-1} (in the direction of the force)

(f) increase in kinetic energy = $\frac{1}{2}mv^2 - 45 = \frac{1}{2}(0.064)(56.25^2) - 45$

= 56.25 J

mean power = 56.25 / (0.04 + 0.06) = 562.5 W

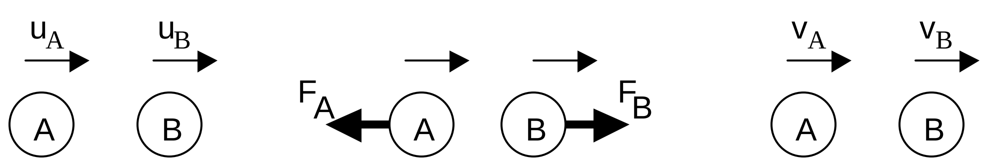
(g) During the contact of the ball with the racket, the deformation of the ball varies. Therefore the force acting on the ball also varies. In practice, the force increases to a maximum and then decreases back to zero.

15\. (a) (i) Inertia is the reluctance of an object to change its state of rest or uniform motion in a straight line unless it is acted by an external force. It is measured by the mass of the object. A larger mass means a greater inertia.

An external net force can accelerate an object. F = ma. For a constant net force, the acceleration produced is inversely proportional to the mass (inertia) of the object.

(ii) When an object is falling in air, there are two forces (air resistance and its weight) acting on it. When the two forces balance, the net force is zero. The object falls with a terminal velocity and is not at rest.

(c)



Before collision During collision After collision

By Newton's second law, F t = m v – m u

∴ for mass A, $F_A t = m_A v_A - m_A u_A$ and for mass B, $F_B t = m_B v_B - m_B u_B$

According to Newton's third law, F_A and F_B are action and reaction pair. They appear for the same period and have same magnitude but opposite direction (i.e. $F_A = -F_B$)

∴ $m_A v_A - m_A u_A = -(m_B v_B - m_B u_B)$

∴ $m_A u_A + m_B u_B = m_A v_A + m_B v_B$

∴ The total momentum of the two spheres remains unchanged during the collision.

16\. (a) (i) The linear momentum of the billiard ball is not conserved as it receives an unbalanced external force from the cushion.

(ii) The linear momentum of the rocket is not conserved as there is an unbalanced external force from the ejected gases.

(iii) The radioactive nucleus does not receive any external force. Therefore, the linear momentum is conserved.

(c) (i) Use a toy gun.

Place a lump of plasticine at the end of the hole.

(ii) Consider the collision, using conservation of momentum, $m v = (m + M) V$

After the collision, using conservation of energy, $\frac{1}{2}(m+M)V^2 = (m+M)gh$

$$\therefore \quad \frac{m^2 v^2}{2(m+M)} = (m+M)g\left(L(1-\cos\theta)\right)$$

$$\therefore \quad v = \left(\frac{m+M}{m}\right)\sqrt{2gL(1-\cos\theta)}$$

The theoretical value of v would be larger than the experimental value.

In the experiment, the block may vibrate horizontally when the bullet embedded in the block as the bullet may not be exactly towards the hole. There may also be energy loss due to friction between the string and the ceiling when the block swings up. Therefore, θ obtained from the experiment would be smaller and hence the experimental value of v would be smaller.