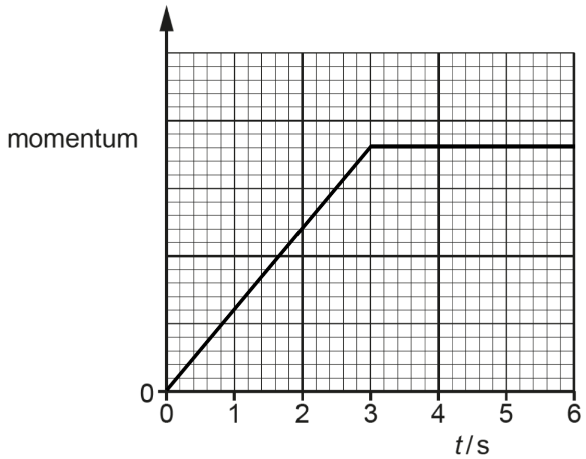
**1**

**(a)** **(i)** Change in momentum $= (1.40 - 0.40 - 0.80 \sin 30°)(3.0) = 1.80\ kg\ m\ s^{-1}$

**(ii)** Resultant force is zero hence velocity is constant

**(iii)**




**(b)** **(i)** Since the total initial momentum is non-zero and in the absence of external force, the total momentum can never be zero by Conservation of Momentum. Hence, stopping times will be different.

**(ii)** curve with positive final speed
same change in momentum or total momentum remains constant or same force (N3L)
since mass of P > mass of Q, change in velocity of Q > change in velocity of P

**2**

**(a)** The rate of change of momentum of a body is directly proportional to the resultant force acting on the body and occurs in the direction of the resultant force.

**(b)** **(i)**
$$p\ =\ \Delta(mv)$$
$$=\ -65\ x\ 10 - 3\ (5.2\ +\ 3.7)$$
$$=\ -0.58\ N\ s$$

**(ii)** $F\ =\ (0.58)\ /\ (7.5\ x\ 10 - 3)\ =\ 77\ N$

**(c)** **(i)** 1. Force on the wall from the ball is equal to the force on ball from the wall but in the opposite direction

2. momentum change of ball is equal and opposite to momentum change of the wall

**(ii)** kinetic energy of ball and wall is reduced / not conserved, inelastic.

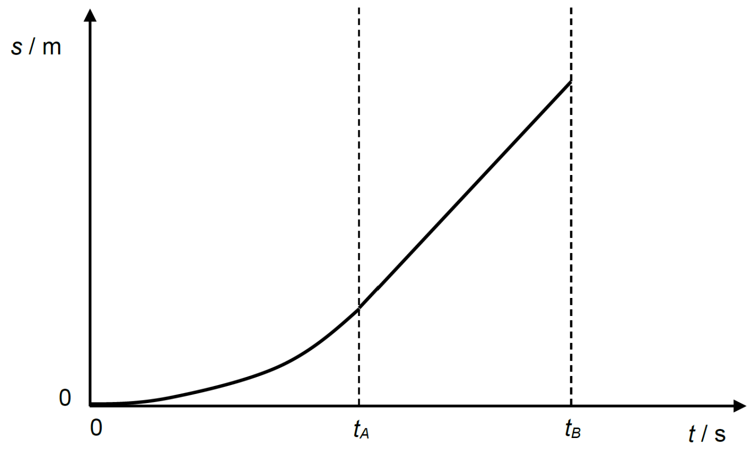
**3**

**(a)** **(i)**
$$s = ut + \frac{1}{2}at^2$$
$$240 - 180 = \frac{1}{2}(9.81)t_1^2$$
$$t_1 = 3.497\ s$$
$$240 - 150 = \frac{1}{2}(9.81)t_2^2$$
$$t_2 = 4.284\ s$$
$$time = t_2 - t_1 = 4.284 - 3.497 = 0.787\ s$$

**(ii)** The time taken will be smaller/shorter as the average speed will be higher and the distance travelled remains the same.

**(iii)** $v^2 = u^2 + 2as$
$v^2 = 2(9.81)(240)$
$v = 68.6\ m\,s^{-1}$

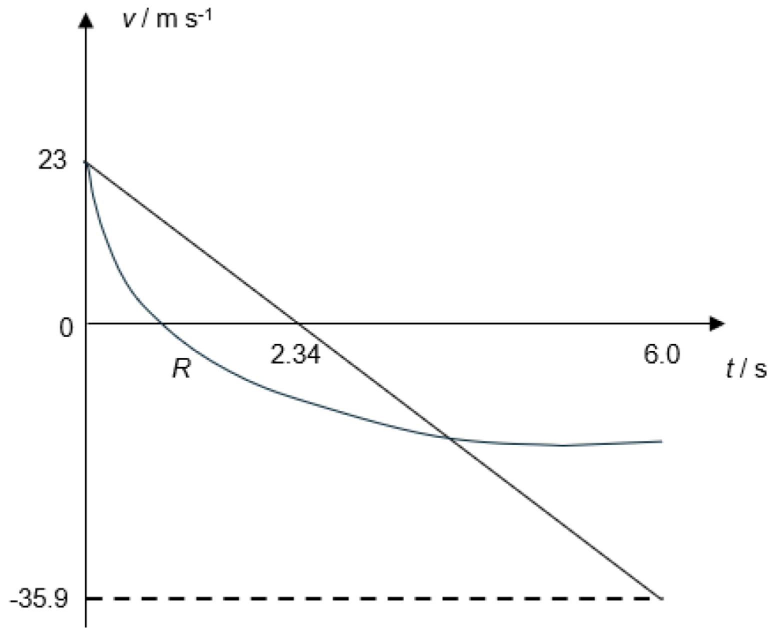
**(b)**




**4**

**(a)** **(i) 1.** Taking upwards as positive,
$v^2 = u^2 + 2as$
$0 = u^2 + 2(-9.81)(27)$
$u = 23.02$
$u = 23\ m\,s^{-1}$ (shown)

**(ii) 2.**



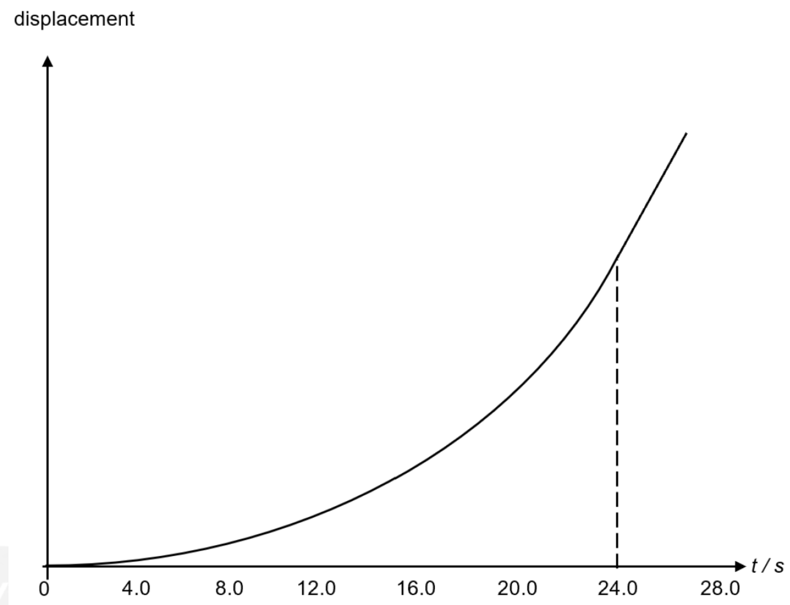
**5**

**(a)** As the sky-diver picks up speed, air resistance increases, the resultant force decreases and hence the acceleration decreases.

**(b)** (Since the sky-diver starts from rest), there is no air resistance initially / the only force he experiences is his weight, hence his initial acceleration is equal to $9.81\ m\ s^{-2}$.

**(c)** Terminal velocity is the area under the a-t graph (by using trapezium rule/counting squares)

**(d)**




**6**

**(b)** **(i)** By Newton's second law, there is a net downward force by the rotor on the air to increase the momentum of air.
By Newton's third law, the air exerts a force of equal magnitude but upward direction (i.e. lift force) on the rotor.
Since the helicopter is hovering, by Newton's first law, the net force on helicopter is zero, that is, lift force = weight of helicopter.

**(ii)** volume of air displaced downwards V
= cross-section area of air x distance moved by the air in 5 seconds
= $\pi$(5.02)(12)(5.0)
mass of air displaced downwards in 5 seconds
= volume of air x density of air
= $\pi$(5.02)(12)(5.0)(1.3)
= 6100 kg (2 s.f.)

**(iii)** By Newton's second law, $F_{net}$ = rate of change of momentum

$= \frac{6000}{5.0}(12)$

$= 1.4 \times 10^4\ N$

**7**

**(a)** **(i)** Applying Newton's Second Law,
$T - (4 \times 10^3)(9.81) = (4.0 \times 10^3)(0.32)$
$T = 4.05 \times 10^4\ N$

**(ii) 1.** Mass per unit volume
$= \rho\left(\frac{V}{t}\right)$
$= \rho(Av)$
$= (1.3)(\pi 10^2)v$
$= 408v$
$= 410v$

**(ii) 2.** Applying Newton's Second Law,
$F_{net} = \frac{d\rho}{dt} = \left(\frac{dm}{dt}\right)v$
$9.1 \times 10^4 = 410v(v)$
$v = 14.9\ m\ s^{-1}$

**(b)** For vertical equilibrium,
$T\cos 65° = mg = (4 \times 10^3)(9.81)$

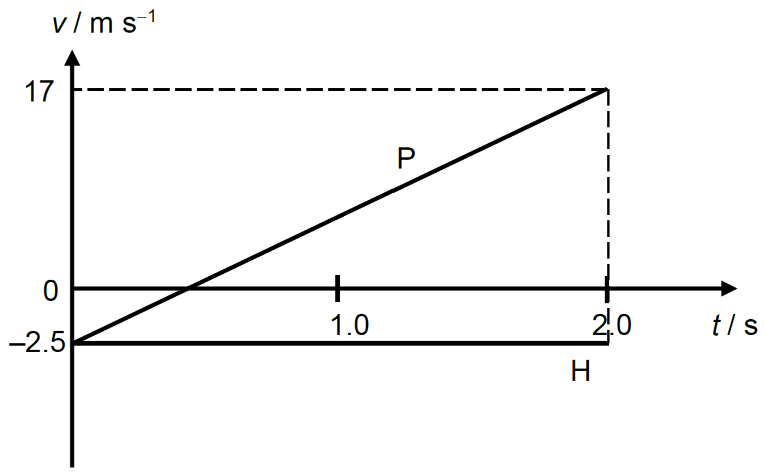
For horizontal equilibrium,
$T\sin 65° - 6 \times 10^3 = ma = (4 \times 10^3)a$
$\tan 65° = \frac{ma + 6 \times 10^3}{mg}$
$ma = 20\ m\ s^{-2}$



**8**

**(a)** $v = u + at$
$= -2.5 + (9.81)(2.0)$
$= 17.1\ m\ s^{-1}$

**(b)**




**(c)** Distance between helicopter and parcel
= area of right-angled triangle
$= \frac{1}{2}(2.0)(17.1 + 2.5) = 19.6\ m$

**9**

**(a)** **(i)** $a = \frac{dv}{dt}$

$\Delta v = area\ enclosed\ by\ (F_{net} - t\ graph)/m$

$= \frac{\frac{1}{2}(1980)(10)}{1100}$

$= 9.0\ m\ s^{-1}$

$\Delta v = v - u$

$v = \Delta v + u$

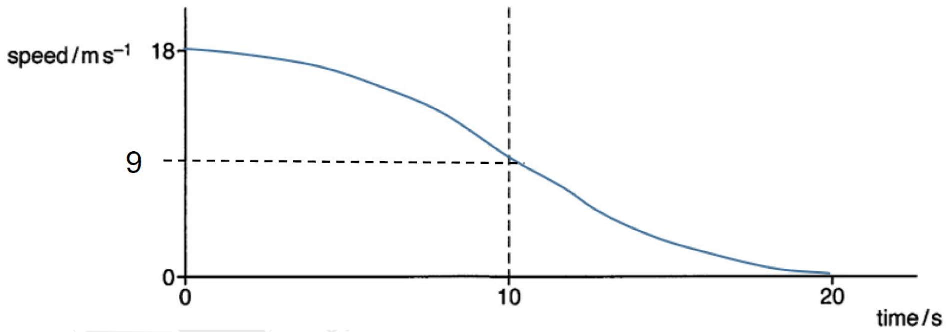
$= 9 - 18$ ($u = -18$ as $\Delta v$ and u are opposite directions)

$= -9.0$

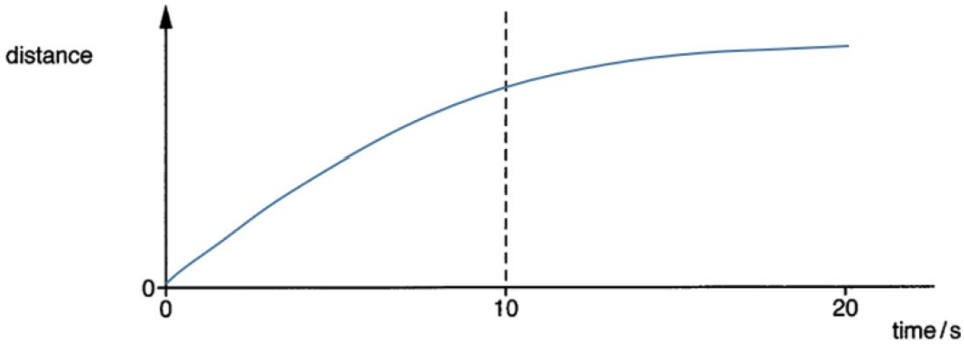
$v = 9.0\ m\ s^{-1}$

**(ii)** The braking force is the only force acting on it. Hence it is also the net force.

**(b)**




**(b)**




**10**

**(a)** $F = \rho g V$

$V = \frac{4}{3}\pi(2.1 \times 10^{-3})^3 = 3.88 \times 10^{-8}\ m^3$

$\rho = 4.8 \times \frac{10^{-4}}{9.81V} = 1300\ kg\ m^{-3}$

**(b)** **(i)** W downwards > U upwards > Fv upwards. total length up = total length down

**(ii)** $F_V = 7.2 \times 10^{-4} - 4.8 \times 10^{-4} = 2.4 \times 10^{-4}\ N$

$v = 6.7 \times 10^{-3}\ m\ s^{-1}$