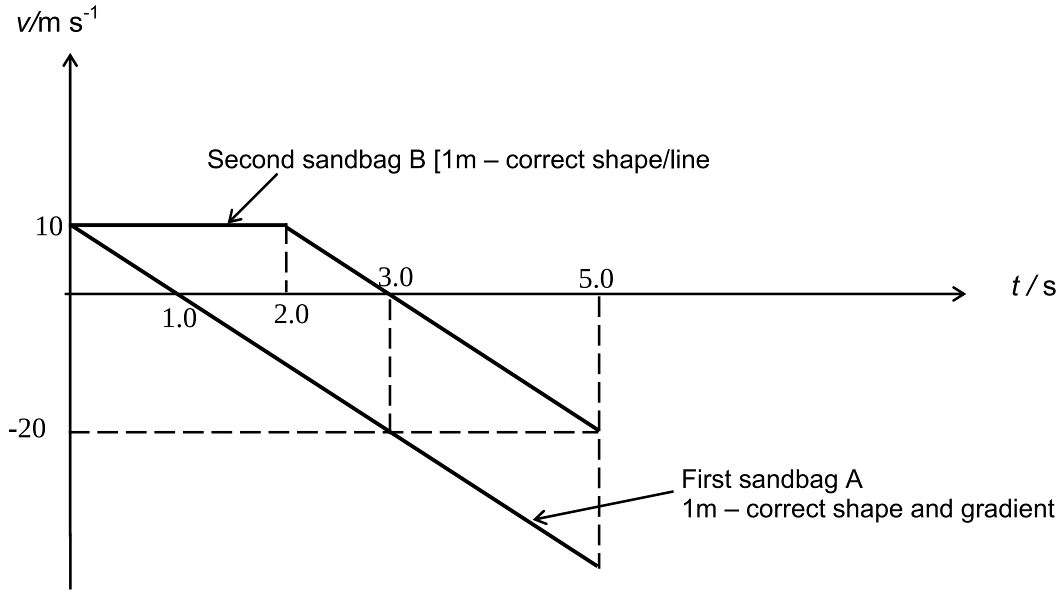
2014H1P2Solutions

1 (a) and (b)



(c) For first sandbag after t = 5.0 s,

Displacement, $s_1 = 10 \times 5.0 - ½ (10)(5.0^2)$
$= -75$ m [1]

For 2nd sandbag, displacement, s_2 = area under graph
$= 10 \times 2.0 + ½ (10)(1.0) - ½ (20)(2.0)$
$= +5.0$ m [1]

(Alternative: $s_2 = 10 \times 2.0 + (10 \times 3.0 - ½ (10)(3.0^2)) = 5.0$ m)

Hence total distance between them = 75 + 5.0 = 80 m. [1]

2 (a) Resultant force acting on the object is zero. [1]
Resultant torque about any point/axis is zero. [1]

2 (b) (i)

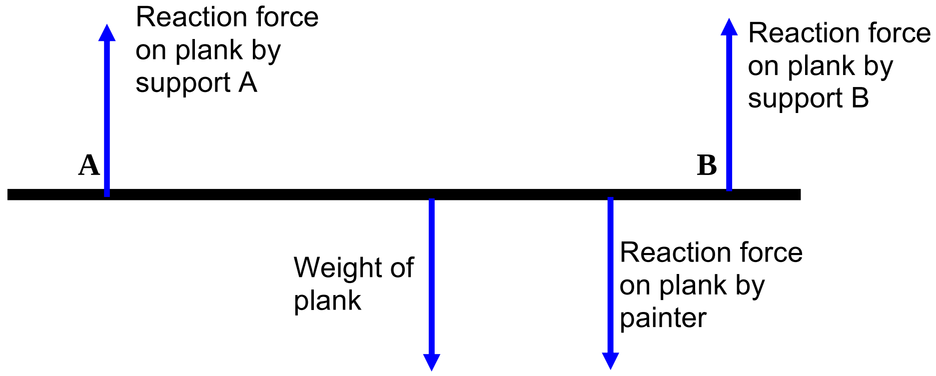


Fig. 1.2

[1m – correct forces identified]
[1m – correct direction and magnitude]

(b) (ii) By taking moments about A,

$$\text{Clockwise moment} = \text{Anti}-\text{clockwise moment}$$
$$W \times (1.00 - 0.15) + R_{painter}(2.00 - 0.55 - 0.15) = R_B(2.00 - 0.15 - 0.15)$$
$$80(0.85) + 650(1.30) = R_B(1.70)$$
$$R_B = 540 \text{ N}$$

[2]

(iii)

$$R_A + R_B = W + R_{painter}$$
$$R_A + 540 = 80 + 650$$
$$R_A = 190 \text{ N}$$

[1]

3 **(a)** The ohm is defined as the resistance of a conductor when the potential difference across it is one volt per ampere of current flowing through it. [1]

(b) The statement is **not valid** because **resistance is the ratio of V/I, not gradient** [1]
At V= 4.0 V, the resistance of tungsten filament (4.0/1.1) is different from that of the nichrome wire (4.0/0.6). [1]

Further explanation
This has not relation to the gradient of the tangent to the curve at V= 4.0V. If we really want to compare the gradient, we can compare the gradient of the line passing through the origin and the desired point.

(c) Connected in series, both devices have **same current but voltage add up to 8.0 V**. [1]
Therefore, draw a horizontal line for the common current such that the voltage of the 2 devices is 8.0 V in total. From the graph, , voltage of tungsten = 2.8 V; voltage of nichrome wire = 5.2 V, **current *I* = 0.85 A** [1]

Accept all answers from **0.75 to 0.90 A**

(d) If the terminal voltage drops to 6.0 V, total current = 1.35 + 0.90 = 2.25 A. [1]
The p.d across the internal resistance is 2.0 V
Internal resistance = 2.0 / 2.25 = 0.88 Ω [1]

4 **(a)** When the switch is closed, current flows downwards in the wire. **By Fleming's left hand rule**, magnetic field in the area ABCD interacts with the current, **an induced magnetic force** pointing to the right is created. [1]
Force acts to **the right** and causes **an anticlockwise moment** about P, causing wire to be kicked out [1]
When the **wire leaves the mercury**, the closed circuit breaks, **no current flows**,
the weight of the wire produces a **clockwise moment** to return the wire to the vertical position. [1]

(b) Torque/Moment = F x d
$5.0 \times 10^{-4} = F \times (1.5 + 4.5) \times 10^{-2}$ show correct substitution [1]
$F = 8.3 \times 10^{-3}$ N

(c) $F = BIL \sin\theta$
$8.3 \times 10^{-3} = 4.0 \times 10^{-2} \times (I) \times 9.0\times10^{-2}$ [1]
$I = 2.3$ A [1]

(d) When the diameter is doubled, the resistance is ¼ of the original, so given the same voltage, current will be 4 times larger. [1]
Therefore the electromagnetic force will be 4 times larger. [1]

5 **(a)**

Wind speed v / m s^{-1}	Output Power P / kW	ln (P / kW)	ln (v / m s^{-1})
2	0.05	-3.0	0.69
3	0.15	-1.90	1.10
4	0.35	-1.05	1.39
5	**0.68**	**-0.390**	**1.61**
6	1.15	0.140	1.79
7	1.85	0.615	1.95
8	2.80	1.030	2.08

[2]

(b)
Plot in the point correctly---- [1]

(c) **(i)** ln P = ln k + n ln v --------- (1)
Plotting ln P vs ln v *and* obtaining a straight line with gradient and intercept supports the proposed equation [1]

(ii) Show gradient n = 3.0 by reading 2 points and finding the gradient. [2]
.

(d) Power = *ke per sec* = $\frac{1}{2} mv^2/t = \frac{1}{2} (\rho A v)v^2$ = ½ x 1.3 x π x 3.0^2 x 6.0^3 [1]
= 3970 or 4.0 kW [1]

(e) Fraction of Power = 1150 / 3970 = 0.29 [1]

(f) To move the wheel that is so big, we need a massive amount of force from the wind to turn the windmill.
To build such a big windmill, we need a huge open space.
Any relevant [2]

6 (a) The rate of change of momentum is proportional to the resultant force acting on the object. [1]

(b) (i) The upward force of tension opposes the weight. Hence net force acting downwards is less than mg and the acceleration is less than g.[1]

(ii) Considering both masses as a system:

$$F_{net} = ma$$

$$m_A g - m_B g = (m_A + m_B)a \qquad [2]$$

$$a = \frac{m_A - m_B}{m_A + m_B} g$$

(iii) s = ut + 1/2 at^2

$$4.0 = 0 + \frac{1}{2}\left[\frac{5.0 - 3.6}{5.0 + 3.6}(9.81)\right]t^2 \quad [2]$$

$$t = 2.2 \text{ s}$$

(c)(i) k is the reciprocal of the gradient of the graph. [1]

k = 32/(4 x 10^{-2}) = 800 N m^{-1} [1]

(ii) EPE = area under the graph or EPE = ½ kx^2 = ½ (800)(35 x 10^{-2})^2

= ½ x 28 x 3.5 x 10^{-2} = 0.49 J

= 0.49 J Method –[1], Ans- [1]

(d)(i) Total momentum of a system is constant provided no resultant external force acts on the system. [1]

(ii) Initial momentum = 0, hence both trolleys have equal and opposite momentum

0 = mv – MV [1]

$$\frac{v}{V} = \frac{M}{m} = \frac{2400}{800} = 3.0 \; [1]$$

(iii) EPE in spring = KE of trolleys [1]

0.49 = ½ (800 x 10^{-3})(v^2) + ½ (2400 x 10^{-3})(1/3 v^2) [1]

v = 0.96 m s^{-1} [1]

(e) gain in energy of trolley = ½ (800)(0.060^2 – 0.045^2) – ½ (800)(0.030^2 – 0.045^2) [1]

= 0.18 J [1]

KE = ½ (0.850)v^2 = 0.18

v = 0.65 m s^{-1} [1]

7 **(a)** **(i)** A progressive wave is the movement of a disturbance from a source [1] which transfers energy but not material to places around it. [1]

(ii) Longitudinal wave [1]

(iii) **1.** 0.50 m [1]

2. 0.50 mm [1]

3. $v = f\lambda$

$v = 660 \times 0.50 = 330 \text{ m s}^{-1}$ [1]

(b) **(i)** π rad/ 180^{o} out of phase [1]

(ii) 1.5λ = 1.8 m $\Rightarrow$ λ = 1.2 m [1]

[$v = f\lambda$]

7.2 = f(1.2) [1]

f = 6.0 Hz [1]

(iii) Largest wavelength = 3.6 m [1]
Fundamental frequency = 7.2/3.6 = 2.0 Hz, [1]

(c) **(i)** Waves that have a constant phase difference between them. [1]

(ii) The same wavefront reaches slit $\mathbf{S_1}$ and $\mathbf{S_2}$ at the same time. [1]

(iii) Path difference = 3/2 λ [1]

(iv) $$\frac{3}{2}\Delta x = 12mm$$

$\Rightarrow \Delta x$ = 8.0 mm [1]

$\Delta x = \dfrac{\lambda D}{a} \Rightarrow$ [1]

$$a = \frac{\left(\dfrac{3.0\times10^{8}}{4.7\times10^{14}}\right)\times1.5}{8.0\times10^{-3}} = 1.20\times10^{-4}\,m$$ [1]

8 (a) (i) photon – a packet or quantum of energy of electromagnetic radiation. [1]
(ii) quantised – has discrete values rather than continuous or varies in discrete steps [1]

(b)(i) Classical explanation – intensity proportional to $(\text{wave amplitude})^2$
OR intensity is energy delivered per second per unit area of wave front [1]
Quantum explanation – intensity proportional to the rate of photons or photons per second [1]
(ii) Classical explanation – continuous absorption of energy from wave [1]
Quantum explanation – discrete absorption in quanta or photons/energy absorbed in discrete packets called photons [1]

(c) (i) $KE_{max} = hf - \phi$
Gradient = h [1]
$=(40-0)\times10^{-20} /(15-7.5)\times10^{14} = 5.3 \times 10^{-34}$ Js [1]
(ii) x-intercept gives threshold frequency f_o [1]
$\phi = hf_o = 5.33 \times 10^{-34} \times 7.5 \times 10^{14} = 4.0 \times 10^{-19}$ J [1]

(d) (i) electrons in discharge tube bombard/collide atoms of vapour and give energy to electrons in atom. [1]
(ii) By Bohr's theory, electrons in atoms can only occupy discrete energy levels.
After excitation, electron jumps to a higher energy level [1]
Excited atoms move down to lower energy levels losing energy by emitting photons.[1]
of characterisitic/discrete f or λ *emitted* since by Einstein's photon theory $\Delta E = hf$ [1]

(iii) 1. visible region [1]
2. correct arrows and labels, see below [2]

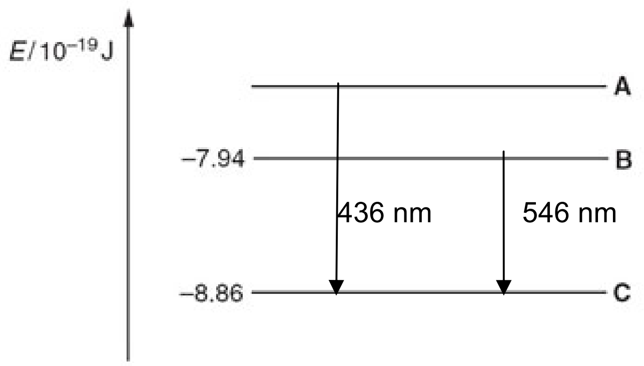


Fig. 3.3

3. . Energy of 436 nm photon = $hc/\lambda = 4.56 \times 10^{-19}$ J [1]
Energy of 546 nm photon = $hc/\lambda = 3.64 \times 10^{-19}$ J
Energy of A = $(4.56 - 3.64) \times 10^{-19} + (-7.94\times10^{-19})$ [1]
$= -7.02 \times 10^{-19}$ J [1]