2022 Year 5 Promotion Examination H2 Physics Solutions

1 **C**

$$T = 2\pi\sqrt{\frac{L}{g}}$$

$$g = \frac{4\pi^2}{T^2}L$$

$$\frac{\Delta g}{g} = \frac{2\Delta T}{T} + \frac{\Delta L}{L} = 2(0.020) + 0.030 = 0.070$$

2 **B**

units of $p = \text{N m}^{-2} = (\text{kg m s}^{-2}) \times \text{m}^{-2} = \text{kg m}^{-1}\ \text{s}^{-2}$

units of $Q = \dfrac{\text{m}^3 \times (\text{kg m}^{-1}\text{s}^{-2})}{\text{m} \times (\text{m s}^{-1})} = \text{kg s}^{-1}$

3 **D**

$$s_y = u_y t + \frac{1}{2}a_y t^2$$

$$-0.80 = (12\sin 25°)t + \frac{1}{2}(-9.81)t^2$$

Using GC, $t = 1.173$ or $t = -0.13905$

$$s_x = u_x t = (12\cos 25°)(1.173) = 12.8 \text{ m}$$

4 **D**

$$T_Y - m_c g = m_c a$$

$$12 - (1.0 \times 9.81) = 1.0 \times a$$

$$a = 2.19 \text{ m s}^{-2}$$

$$T_X - (m_c + m_B)g = (m_c + m_B)a$$

$T_x - (1.0 + 2.0)(9.81) = (1.0 + 2.0) \times 2.19$ OR Since B and C have the same acceleration, $T_X = (2+1)T_Y = (2+1)(12) = 36$ N

$$T_X = 36.0 \text{ N}$$

$$m_A g - T_X = m_A a$$

$$(m_A \times 9.81) - 36 = m_A \times 2.19$$

$$m_A = 4.72 \text{ kg}$$

5 **D**

Net force $= 2(30\sin 45°) - 2(20\sin 45°) = 14.1$ N (SW direction)

By taking moments about the c.g.,

clockwise moments $= (20)(r) + (30)(r) = 50r$

Anticlockwise moments $= (20)(r) + (30)(r) = 50r$

Hence, net torque = 0

6 **C** At constant speed on horizontal road, driving force F is equal to drag force D.

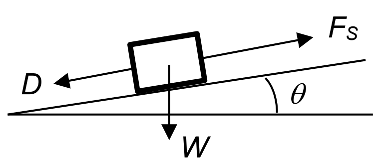
$$P = Fv$$

$$5000 = D \times 14$$

$$D = 357.1 \text{ N}$$

$$F_S = D + W\sin\theta = 357.1 + (1800 \times 9.81 \times \sin 5.0°) = 1896 \text{ N}$$

$$P_S = 1896 \times 14 = 26.5 \text{ kW}$$



7 **A** $F = -\dfrac{dU}{dx}$

The force F acting on the particle is the negative of the potential energy U gradient.

8 **B** gain in KE = loss in GPE

$$\frac{1}{2}mv^2 - 0 = mg\left(L - L\cos 30\right) - 0$$

$$v^2 = 0.2679gL$$

$$T - mg = \frac{mv^2}{r}$$

$$T - mg = \frac{m\left(0.2679gL\right)}{L}$$

$$T = 1.3mg$$

9 **A** Considering the star of mass $2M$, gravitational force provides centripetal force.

$$\frac{G(3M)(2M)}{(5x)^2} = 2M(3x)\omega^2$$

$$\omega = 0.20\sqrt{\frac{GM}{x^3}}$$

10 **B**

$$G\frac{Mm}{r^2} = m\frac{v^2}{r}$$

$$\frac{1}{2}mv^2 = \frac{GMm}{2r} = -\frac{1}{2}\text{GPE}$$

$$\text{GPE}_1 = -\frac{GMm}{r} = -5.6\text{ MJ}$$

$$\text{GPE}_2 = -\frac{GMm}{2r} = -2.8\text{ MJ}$$

$$\text{KE}_2 = -\frac{1}{2}(\text{GPE}_2) = 1.4\text{ MJ}$$

$$\left(\text{KE}_2 + \text{GPE}_2\right) = -2.8 + 1.4 = -1.4\text{ MJ}$$

11 **B**

$$E = \frac{1}{2}mv^2 = \frac{1}{2}m\omega^2(x_0 - x)^2 = \frac{1}{2}m\omega^2{x_0}^2 - \frac{1}{2}m\omega^2x^2$$

Thus, E vs x is an inverted parabola, with $E = \frac{1}{2}m\omega^2{x_0}^2$ at $x = 0$ and $E = 0$ at $x = x_0$.

12 **A**

If the mass decreases, the natural frequency of the system $\sqrt{\frac{k}{m}}$ increases, hence the frequency response curve peaks at a higher driving frequency. The new curve intersects with X.

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13 C

$$I = \frac{P}{4\pi r^2} \text{ and } I \propto A^2$$

$$\frac{I_1}{I_2} = \frac{\dfrac{P}{4\pi r^2}}{\dfrac{0.5P}{4\pi (3r)^2}}$$

$$\left(\frac{A_1}{A_2}\right)^2 = 2\left(\frac{3r}{r}\right)^2$$

$$A_2 = 0.24A$$

14 C

$$I' = I_0 \cos^2\theta$$

$$I'' = I'\cos^2\theta = \left(I_0\cos^2\theta\right)\cos^2\theta$$

$$\frac{I_0}{5} = \left(I_0\cos^2\theta\right)\cos^2\theta$$

$$\cos^4\theta = \frac{1}{5}$$

$$\theta = 48°$$

15 C

$$L_1 = \frac{\lambda}{4}$$

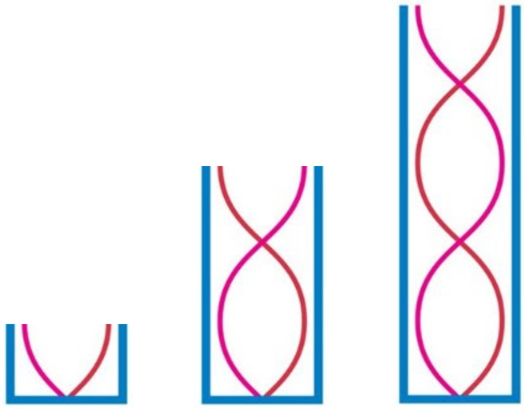
$$L_2 = \frac{3\lambda}{4}$$

$$L_3 = \frac{5\lambda}{4}$$

$$L_n = \frac{(2n-1)\lambda}{4}$$

$$1.3 = \frac{5\lambda}{4}$$

$$\lambda = 1.04 \text{ m}$$



1st resonance 2nd resonance 3rd resonance

Hence, distances that will hear loud sound are: 0.26 m, 0.78 m, 1.30 m, 1.82 m

16 (a) In order for the man to accelerate downwards with a magnitude larger than g, there must be an additional downward force acting on the man other than its weight. B1
There are no other forces acting downwards. B1
Or
The resultant force acting downwards is given by weight minus normal contact force. B1
The minimum value of the normal contact force is zero. Hence, the maximum downward force is equal to the weight and the maximum value of q is equal to g. B1

Some candidates did not clearly state that normal contact force can only act upwards on the man standing in the lift. Some even stated the man is in equilibrium which he is clearly not.

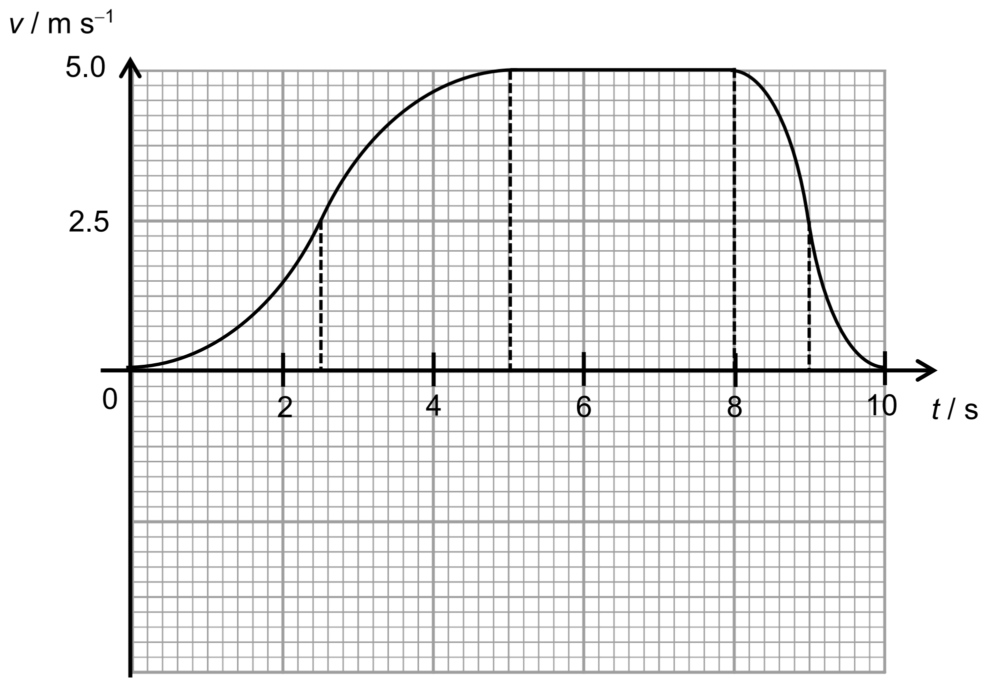
(b) Since the man starts from rest, and comes to rest at t = 10 s, thus sum of the positive and negative areas on the graph must be zero.

$$\frac{1}{2}\times 5\times 2+\frac{1}{2}\times 2\times (q)=0$$ M1

$$q=-5.0 \text{ m s}^{-2}$$ A1

Many candidates gave the magnitude of q rather than its value.

(c) (i)



1 mark – correct shape of curve from t = 0 to t = 5.0
1 mark – correct shape of curve from t = 8.0 to t = 10
1 mark – correct values (2.5 and 5.0) on vertical axis

Most candidates answered this part well.

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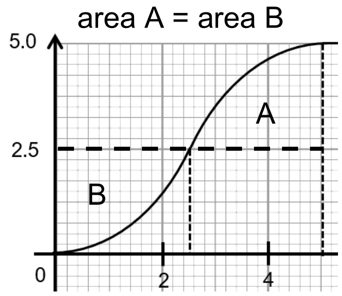
(ii) total distance travelled

$= \text{area under } v\text{ - }t \text{ graph}$

$= 5 \times 2.5$

$= 12.5 \text{ m}$



B1

Some candidates did not read the question carefully and gave the total distance travelled in 10 seconds.

(iii) total work done by normal contact force

$= \text{total increase in energy of man}$

$= \text{increase in KE} + \text{increase in GPE}$

$= \dfrac{1}{2} \times 50 \times 5^2 + 50 \times 9.81 \times 12.5$ M1

$= 6760 \text{ J}$ A1

Or

average acceleration $= \dfrac{\Delta v}{t} = \dfrac{\frac{1}{2} \times 5.0 \times 2.0}{5.0} = 1.0 \text{ m s}^{-2}$ M1

work done by normal contact force

$= m\left(a_{ave} + g\right) \times \text{distance travelled by lift}$

$= (50)(1.0 + 9.81) \times 12.5$

$= 6760 \text{ J}$ A1

This part was poorly attempted. Many students used force multiply by distance travelled but failed to realise that the force acting on the man is constantly changing. Thus, merely taking the magnitude of the man's weight multiply by 12.5 m is in correct.

17 (a) (i) Considering the man, lion and rope as a system, tension is considered as an internal force and is not taken into consideration. B1

The external forces acting on the system would be the friction acting on the man as well as the friction acting on the lion. M1

There is no winner only if the friction acting on the lion is equal to that acting on the man, resulting in no net force. A1

Or The winner will the one that experience a larger friction from the ground.

Alternative

The tension acts on the man and the lion separately and does not cancel out. B1

Considering the man, if the frictional force acting on the man due to the ground is less than 500 N, M1

the man will lose as the net force will be towards the lion. A1

Many students failed to define the system that they were referring to in their explanation, so a lot of this was taken to be implied.

There was a lot of answers that stated "even though tension acts on the man/lion, the force on the rope is not the same as the tension".
This is not correct as the force on the rope by the man = the force on the man by the rope.

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Many students then went on to incorrectly conclude that the resultant force = (force on the rope by the man) – (the force on the man by the rope)
This statement is wrong because:
1. Force on A cannot cancel out force on B.
2. The resultant force here is not clearly defined, is it the resultant force on A or B or A+B?

The students that managed to state that there were external forces like friction, did not clearly state how tension plays into the conclusion as to whether there will be a winner.

Some students mentioned that weight plays a part without relating this to friction. Weight by itself acts perpendicular to tension, and hence does not affect the horizontal resultant force on the system.

(ii) **1.** Since the man is still at equilibrium, by taking moments about his toes,

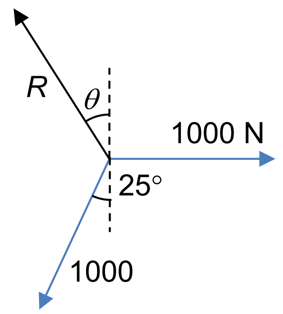
$500(0.80) = mg(0.50)$ M1

$m = 81.5$ kg A1

2. The man can lower the rope to reduce the clockwise moment about his toes. (Decrease perpendicular distance between tension and his toes.) A1
The man can lean backwards to increase the anti-clockwise moment about his toes. (Increase horizontal distance between CG and his toes.)

Common mistakes here include:
- equating weight to 500 N (these forces are perpendicular and do not add up that way)
- mixing up moments with work done
- resolving the tension and weight to be perpendicular to the line joining the c.g. and the tip of the man's toes. (not necessary)

(b) Since the rope is stationary, $F_{net} = 0$



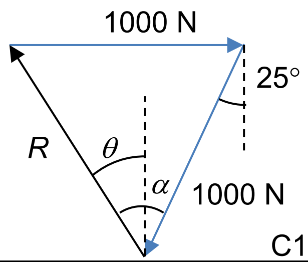
In the x direction, $R_x = 1000 - 1000\sin 25° = 577.38$ N M1
In the y direction, $R_y = 1000\cos 25° = 906.307$ N

$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(577.38)^2 + (906.307)^2}$ M1

$= 1070$ N A1

$\tan\theta = \dfrac{R_x}{R_y} = \dfrac{577.38}{906.307} \Rightarrow \theta = 32.5°$ A1

OR



C1

$R^2 = 1000^2 + 1000^2 - 2(1000)(1000)\cos 65°$

$R = 1070$ N M1

$\alpha = \dfrac{180° - 65°}{2} = 57.5°$ A1

$\theta = \alpha - 25° = 32.5°$ A1

Many students forgot to consider the 1000 N or the 1000sin25° when calculating the x component of *R*.
The question also asks for the angle with respect to the glass panel. This was largely ignored but BOD was given if the angle was correctly calculated with the appropriate descriptions and/or labelling on a clear diagram.
The few students who attempted to use a scaled diagram, used scales that resulted in very large percentage errors due to different lengths for the 1000 N vectors, and/or measure the angle between the two vectors wrongly.

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18 **(a)** As the water level is higher on the left side of the ice cube, the average <u>pressure on the left side of the ice cube is larger than on the right side</u>. M1

There is a horizontal <u>resultant force</u> towards the right that provides the centripetal force. A1

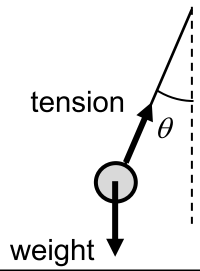
Or

The <u>difference in the water pressure results in an upthrust acting perpendicular to the plane of the water</u>. B1

The <u>horizontal component of the upthrust</u> provides the centripetal force. B1

Most students fail to mention water pressure in their answers. Some students misinterpreted the question and gave answers for why a centripetal force act on the ice cube.

(b) B1



In labelling the forces, the tension and weight must be spelt out in full. Symbols such as *W*, *mg*, F_g or *T* should not be used. The centripetal force should not be drawn as it is the resultant of tension and weight. The horizontal and vertical components of tension should not be drawn together with the tension.

(c) **(i)**

$v = r\omega$

$7.0 = 8.5 \times \omega$

$\omega = 0.824 \text{ rad s}^{-1}$ B1

(ii)

$T \sin\theta = \dfrac{mv^2}{r}$ ---(1) B1

$T \cos\theta = mg$ ---(2) B1

$\dfrac{(1)}{(2)}$: $\tan\theta = \dfrac{v^2}{rg}$

$\tan\theta = \dfrac{7.0^2}{8.5 \times 9.81}$

$\theta = 30.4°$ A1

Students should not quote $\tan\theta = \dfrac{v^2}{rg}$ without any explanation or working as the syllabus does not required students to recall and use this equation.

(d) From **(c) (ii)**, <u>tan θ depends on speed and radius</u> only. M1

since the speed and radius of the turn remain the same, there is <u>no change</u> to angle θ. A1

OR

From **(c) (ii)**, since the speed and radius of the turn remain the same, the <u>centripetal acceleration and/or centripetal force or tan θ remain the same</u>. M1

There is <u>no change</u> to angle θ. A1

Many students considered the forces acting on the car. The angle θ is the angle of the pendant to the vertical and students should consider the motion of the pendant.

19 (a)

$$M = \frac{4}{3}\pi R^3 \times \text{density}, \quad m = \frac{4}{3}\pi\left(\frac{R}{2}\right)^3 \times \text{density}$$

$$\frac{m}{M} = \frac{\frac{4}{3}\pi\left(\frac{R}{2}\right)^3 \times \text{density}}{\frac{4}{3}\pi R^3 \times \text{density}} = \frac{1}{8}$$

density = 1796 kg m^{-3} B1

$$m = \frac{M}{8} = \frac{1.3\times10^{22}}{8} = 1.625\times10^{21} = 1.6\times10^{21} \text{ kg}$$

Working should be shown clearly and the formula for volume of a sphere should be written down correctly.

(b) The **gravitational field strength** at a point in space is defined as the gravitational force experienced per unit mass at that point. B1

The definition should include "at a point in space".

(c)

$$g_{planet} = G\frac{M}{R^2} = 6.67\times10^{-11}\times\frac{1.3\times10^{22}}{\left(1.2\times10^6\right)^2} = 0.602 \text{ N kg}^{-1}$$ B1

$$g_{moon} = G\frac{m}{\left(\frac{R}{2}\right)^2} = 6.67\times10^{-11}\times\frac{1.6\times10^{21}}{\left(\frac{1.2\times10^6}{2}\right)^2} = 0.296 \text{ N kg}^{-1}$$ B1

Well done for this part.

(i) At distance d, $g_{net} = g_{planet} - g_{moon} = 0$

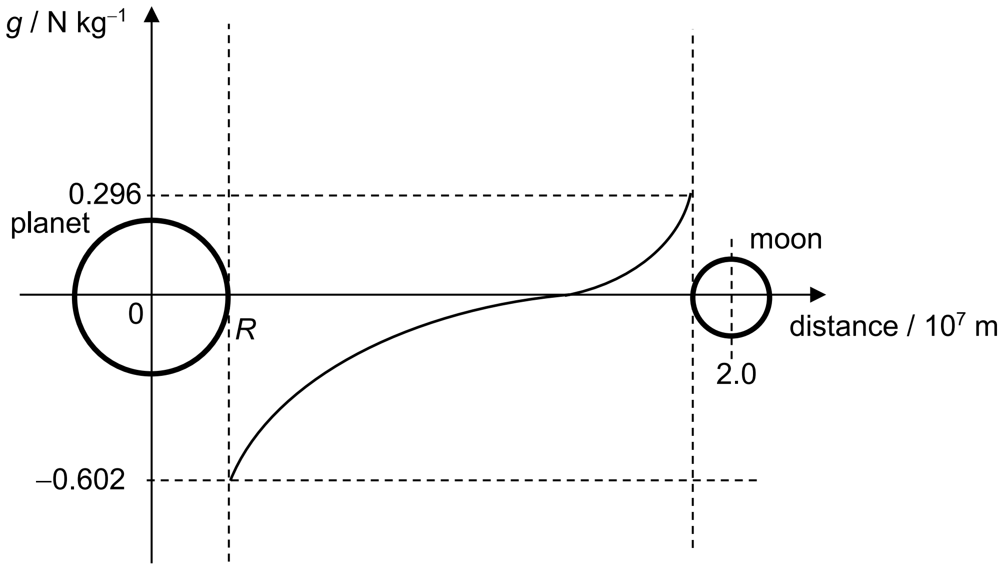
$$G\frac{M}{d^2} = G\frac{m}{\left(2.0\times10^7 - d\right)^2}$$ M1

$$\left(\frac{2.0\times10^7 - d}{d}\right)^2 = \frac{1.6\times10^{21}}{1.3\times10^{22}}$$

$$d = 1.48\times10^7 \text{ m}$$ A1

This part was well done.

(ii)



- Correct shape of curves and gradient at X is not zero B1
- start curve on negative side of axis, end curve other on positive side B1
- Correct label of values of g_m and g_p and value of d B1

Quite a number of students could sketch the graph very well, so keep it up. The values of g_m and g_p and value of d should be labelled clearly.

(iii) The minimum amount of energy required is numerically equal to the product of the mass m and area under the graph of Fig.19.1, B1
from the surface of the planet to the distance d. B1

Not many students attempted this part correctly. Quite a number did not mention to determine the area under the graph from the surface of the planet to the point where net g is zero.

20 **(a)** At maximum compression, the initial kinetic energy of the block is completely converted into the elastic potential energy in the spring.

$$\text{loss in KE} = \text{gain in EPE}$$
$$\frac{1}{2}mu^2 - 0 = \frac{1}{2}kx_0^{\,2} - 0$$
B1

$$\frac{1}{2}\times 0.50\times 2.0^2 = \frac{1}{2}\times 50\times x_0^{\,2}$$
$$x_0 = 0.200 \text{ m}$$
B1

A number of students confused Hook's law ($F = kx$) with elastic potential energy (EPE = $kx^2/2$). Many students had their final answers in 1 s.f., which is unacceptable.

(b) **(i)** It is a quarter of a period from the point of contact to the point of maximum compression.

$$\omega = \frac{v_0}{x_0} = \frac{2.0}{0.20} = 10.0 \text{ rad s}^{-1}$$
M1

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{10.0} = 0.628 \text{ s}$$
M1

$$t = \frac{T}{4} = \frac{0.628}{4} = 0.157 \text{ s}$$
A1

Students need to realize that the motion is SHM, for which spring-mass is a typical system. The point of contact between the mass and the spring is the equilibrium position ($F_{\text{net}} = 0$), and the point of maximum compression is the position of maximum displacement. The duration between these two positions is a quarter of a period.

One also needs to know that neither the acceleration nor the spring force is constant during the motion. Hence, any form of averaging or application of kinematics equations of motion is not accepted. They yield results that are too different from a quarter of a period.

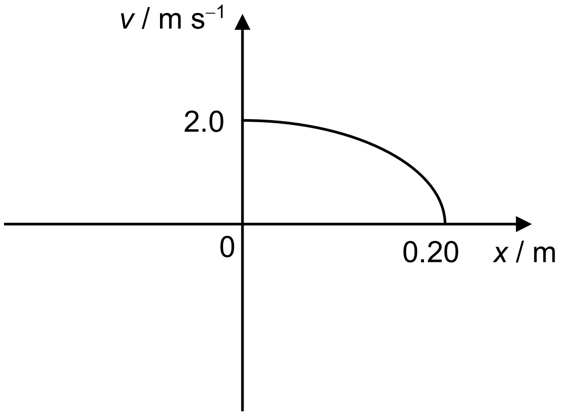
(ii) $a = \omega^2 x_0 = 10.0^2 \times 0.20$ M1

$= 20.0 \text{ m s}^{-2}$ A1

OR

$$a = \frac{F_{\text{net}}}{m} = \frac{kx_0}{m} = \frac{50\times 0.20}{0.50} = 20.0 \text{ m s}^{-2}$$

(b)



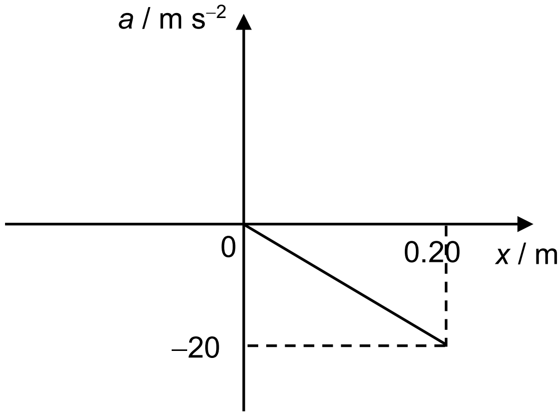


Fig. 20.2:
Correct shape (quarter of an ellipse) M1
Correct quadrant (1st) and values for x_0 and v_0 A1
Fig. 20.3:
Correct shape, quadrant (4th) and value for x_0 and a_0 B1

> Many students, instead of drawing for the time duration required (a quarter period), drew for a complete period. Such answers are not accepted.
> Some students drew for the wrong quadrant. In order to determine which quadrant to draw for, one notes firstly that the equilibrium position is the point of contact. Consider the velocity-displacement as an example. The displacement after that point is to the left of the equilibrium position (according to the diagram in the question). The velocity is also leftward. Hence, the correct quadrant is either the first (both displacement and velocity are positive) or the third (both quantities are negative).
> One also has to know that an ellipse intersects its semi-major and semi-minor axes at 90°.

21 (a) Using $b\sin\theta = n\lambda$, for $n = 1$

$$1.50\times10^{-4}\times\sin\theta = 589.0\times10^{-9}$$
$$\theta = 0.2250^\circ$$ M1

$$\frac{y}{D} = \tan\theta$$
$$\frac{y}{2.000} = \tan 0.2250$$ M1
$$y = 7.85\times10^{-3}\text{ m}$$ A1

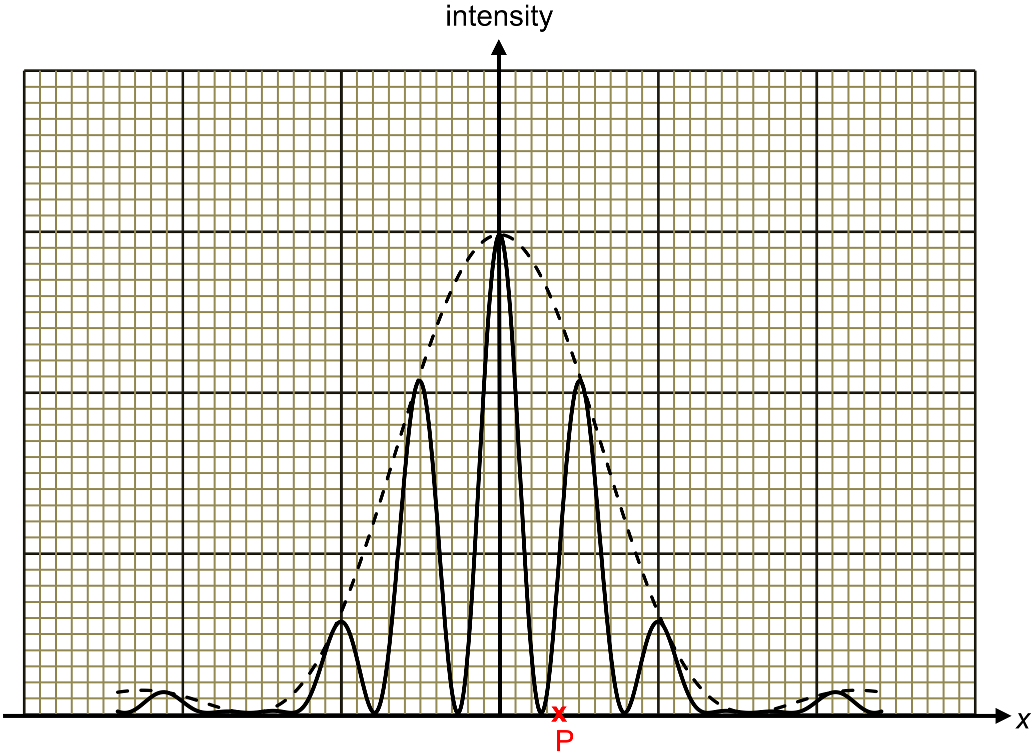
> Students should use standard symbols such as *b* to represent slit width and *a* for slit separation. Those who use the same symbol to represent either quantity run a risk of confusing the examiner and losing marks unnecessarily. In addition, students should not quote $y = \frac{2D\lambda}{b}$ directly because it is not a standard formula in the syllabus. Finally, students should note that when they use small angle approximation or $l = r\theta$, the angle θ must be measured in radians and **not in degrees**.

(b) (i)

$$x = \frac{\lambda D}{a}$$
$$= \frac{589.0\times10^{-9}\times2.00}{0.450\times10^{-3}}$$ M1
$$= 2.62\times10^{-3}\text{ m}$$ A1

> Most students find this question easy as it only requires direct substitution. Students should note that the slit separation refers to the centre to centre distance of the two slits.

(ii)



Deduct one mark for each of the following, up to a maximum of two marks:

- No modulation
- No missing third order
- Did not draw up to the fourth order
- Uneven fringe width or fringe spacing

Students are advised to include the single slit envelope in dotted line so that they can accurately sketch the modulation of the fringe intensity. In this question, because $a = 3b$, the third order of the double slit pattern will coincide with the first minimum of the single slit envelope and hence it will be a missing order (see figure above). Note that all fringes are of equal width, consistent with the formula $\Delta x = \frac{\lambda D}{a}$. This is different from the single slit pattern in which the central fringe has double the width of other fringes.

(c) **(i)** **1.** $\frac{\pi}{2}$ or $\frac{3\pi}{2}$ rad — A1

(The peak of S_1 is at the equilibrium position of S_2.)

2. $\frac{\text{intensity of wave from } S_1}{\text{intensity of wave from } S_2} = \left(\frac{15}{14}\right)^2$ — M1

$= 1.15$ — A1

For **(c)(i) 1.**, the phase difference should be $\frac{3\pi}{2}$ but $\frac{\pi}{2}$ is also accepted. This is explained in **(ii)** below.
For **(c)(i) 2.**, students should not leave their answers in the form of a fraction. In Physics, all answers should be in decimal form.

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(ii) At ¾ Δx from the central bright fringe. A1

Note

The waveform with larger amplitude should be emitted by the slit closer to the detector. So, it should be ahead in phase. Hence waveform from S_1 should be **leading** the other waveform by $\frac{3\pi}{2}$ rad rather than lagging behind by $\frac{\pi}{2}$ rad.

Since the phase difference of the two waves at the screen is proportional to x, the detector should be ¾ Δx from the central bright fringe.

Most students did not realise it is the wave of S_1 that leads the wave of S_2 by $3\pi/2$ radians and hence point P should be closer to the first order fringe rather than the zeroth order fringe.

(d) **(i)** B1

$$d = \frac{1\times10^{-3}}{500} = 2.00\times10^{-6}\ \text{m}$$

$$\theta_1 = \sin^{-1}\left(\frac{2\times589.0\times10^{-9}}{2.00\times10^{-6}}\right) = 0.629821\ \text{rad}$$

$$\theta_2 = \sin^{-1}\left(\frac{2\times589.6\times10^{-9}}{2.00\times10^{-6}}\right) = 0.630564\ \text{rad}$$ M1

Angular separation $= \theta_2 - \theta_1 = 7.43\times10^{-4}$ rad A1

Students should identify that the angular separation is very small in this question and leave θ_1 and θ_2 to more s.f. (5 or more) in the intermediate steps. This is also applicable in general when the difference in values is very small.

(ii)

$$\theta_{min} = \frac{\lambda}{b}$$

$$7.44\times10^{-4} = \frac{589.0\times10^{-9}}{D}$$ M1

$$D = 7.92\times10^{-4}\ \text{m}$$ A1

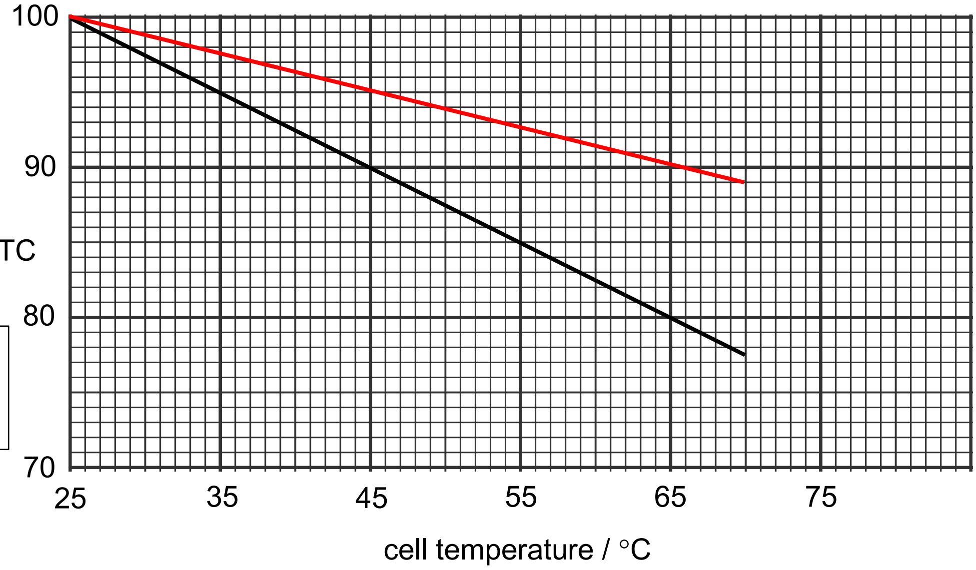
22 **(a)** **(i)** This is to <u>allow rainwater to wash the dirt off</u> the panels. B1

This statement is provided in the passage itself. No credit given for “tilted so that it captures more sunlight / perpendicular to the sunlight” – as the direction of the rays shifts through the day, there is no reason for that particular tilt that will capture more of the light.

(ii) power loss = (70 – 25) × temperature coefficient
= (70 – 25) × 0.25
= 11.3 % A1

There were a significant number of students who presented the correct workings and yet end up with a value of 12.5 (instead of 11.25). This may be due to doing mental calculation and making the mistake. It is suggested to check your answers using a calculator instead.

(iii)



1st point (25,100)
2nd point (70, 89)
[1 mark]

The first graph for Silicon was meant to help students understand the description for the calculation of the output.
At 25 °C, the percentage loss in power is (25 – 25) × temperature coefficient = 0.
Hence the output is 100 % (no power loss).

At 70 °C, the percentage loss in power is (70 – 25) × temperature coefficient.
Hence percentage power loss is (70 – 25) × 0.50 = 22.5 % for Silicon
and (70 – 25) × 0.25 = 11.25 % for Thin Film

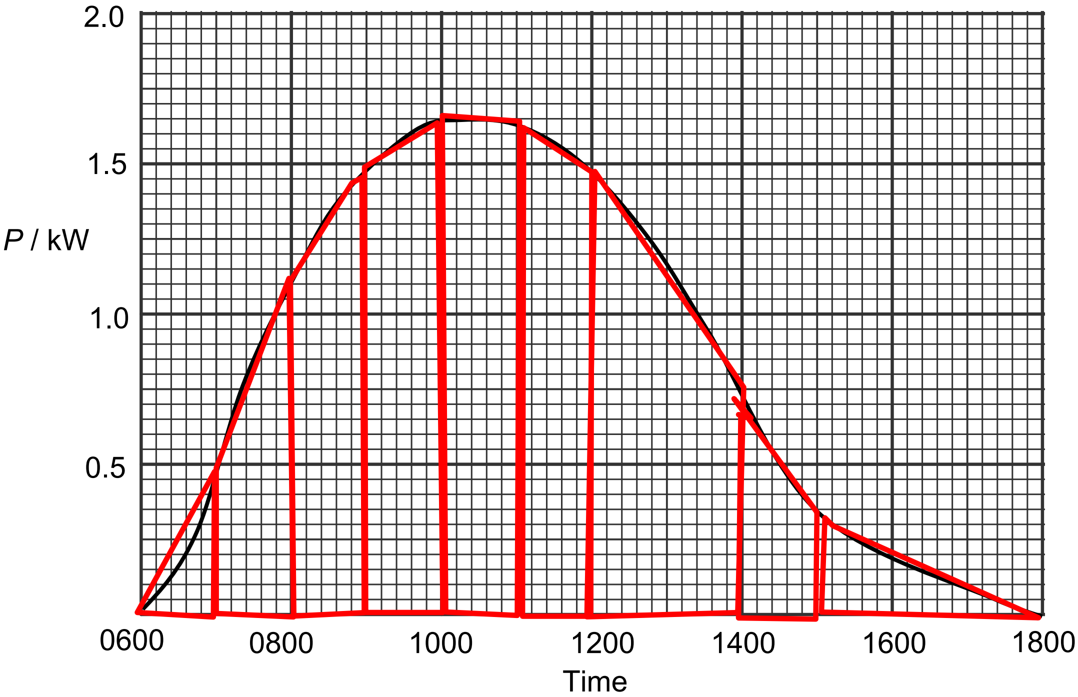
The power output is therefore 100 – 22.5 = 77.5 % for Silicon
and 100 – 11.25 = 88.75 % (or 89 %) for Thin Film.

Students should make an effort to plot the point (70, 89) to an accuracy of half smallest square.

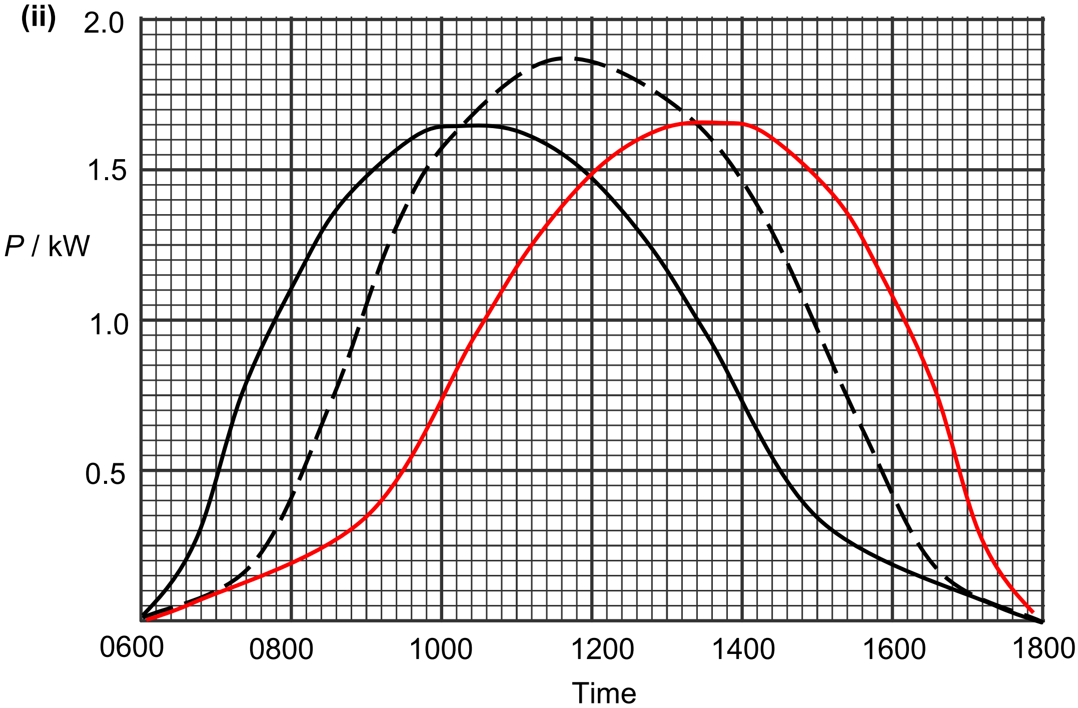
(b) (i) Area under graph
= ½(1×0.5) + ½(0.5+1.0) + ½(1.0+1.5) + ½(1.5+1.65) + (1.65) + ½(1.65+1.5)
+ ½(1.5 +0.75) × 2 + ½(0.75+0.30) + ½(3×0.30) × 1000 × 3600
= 10.275 × 1000 × 3600
= 3.70×10^7 J
OR
Counting large squares, there are 10.5 large squares.
Energy = 10.5 × (2 × 3600) × 500 = 3.78×10^7 J

Acceptable method to determine area under graph (if use triangles/trapezium to estimate, must at least use 3 or more segments) M1
Correct conversation to Joules from kWh B1
Accurate value of area (3.6×10^7 J to 4.0×10^7 J) A1

Students who used triangles/trapeziums to find the area under graph must divide the area into at least 3 segments to get more accurate answer. Those who only used 1 or 2 segments ended up with values out of the acceptable range.



(ii)



A1

*New graph is a reflection of the East facing graph about Time = 1200]
*The peak of the new graph should intercept the dotted line at *P* = 1.65 kW.

(iii) The performance of a PV cell system at homes is affected by shades cast on the solar cells, reducing the intensity of sunlight incident on the cells. This could be from trees or bushes, dirt or leaves on the solar panels, or shadows from other buildings. B1

The question should be interpreted as why the PV cell did not perform as well given the availability of sunlight. Hence answers that focused on the lack of sunlight due to longer or shorter days of the year are not accepted.

The question asked to state and explain. However, several students simply stated without explaining. For example, many students stated that on rainy days the performance of PV cell system drops. This is insufficient. Students should go on to explain that on rainy days, clouds will reduce the amount of sunlight reaching the cells. Some students mentioned that when it rains, there is no sun or less sun (should be less sunlight). Sun is always there!

Another example is students stated that higher temperature reduced the performance of a PV cell system. You should go on to explain that it will lead to higher percentage loss in power output or decreased efficiency.

Some students misunderstood that higher temperature leads to different temperature coefficient. Temperature coefficient is dependent on the film used not temperature.

(c) **(i)** Glide ratio = horizontal distance / vertical drop = 40
Vertical drop = 8500 – 1500 = 7000 m
Horizontal distance = 40 × 7000 = 280 000 m A1

Students should make effort to explain their workings and not simply present a string of mathematical calculations to get the answer.
In presenting the answers, it is suggested to use standard form 2.8×10^5 m which can be easily obtained from the calculator with the press of a button.
A significant number of students wrote one zero less and hence lose the mark.

(ii) For horizontal flight, lift = weight = 2300 × 9.81 = 22563N

$$\text{glide ratio} = \frac{\text{lift}}{\text{drag}} = 40$$

$$\frac{22563}{\text{drag}} = 40$$ M1

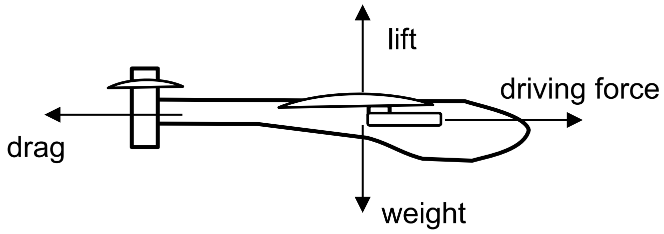
$$\text{drag} = 564\ \text{N}$$ A1

When flying horizontally, the upward force (lift) must be equal to the downward force (weight).
Students need to recognise this in order to get this part right.

(iii) kW h is the unit for energy. (Watt is the unit for power)
kW h kg^{-1} is the unit for the amount of energy per unit mass. A1
Hence, *energy density* refers to amount of energy the battery can provide per unit mass.

Students should not mix “quantity” and “unit” in the description (e.g. “energy per kg”). They should explain that “kg” is the unit for “mass”.
A significant number of students did not realise that power = work done / time. Instead, they thought that work done = power/ time.

(iv)



Magnitude of vertical forces must be the same. B1
Magnitude of horizontal forces must be the same.
Forces must be labelled; symbols must be defined. B1

Students should not confuse with these terms: "lift", "thrust" and "upthrust". "Lift" is an upward force acting on the aircraft due to pressure difference acting on the top of the wings compared to the bottom of the wings. "Thrust" refers to the driving force due to the engine (motors). "Upthrust" refers to the force acting on a object from the fluid it is immersed in. In this case, it is air. The upthrust due to air is very small compared to the weight of object. It is insufficient to support it in flight. Since it is moving in a "horizontal flight at constant speed" – the forces (vertically and horizontally) must be balanced.

(v) At higher altitudes, there is <u>lower absorption and scattering of light by the atmosphere</u>. B1
Hence, the higher intensity of light incident on the photovoltaic cells at higher altitudes leads to greater power being collected by the cells.

Alternative answer:
At higher altitudes, the <u>temperature is lower</u>, and the photovoltaic <u>cells are more efficient</u>.

Students should note that there are different categories of clouds – "low-level, mid-level and high-level clouds". Hence, the assumption that "at high altitudes, there is less clouds" may not be true. Students should also appreciate that the distance between different altitudes is very much smaller than the distance Earth is from the Sun. Hence that change in altitude does not significantly affect the amount of sunlight the aircraft can receive. It is common knowledge that at a higher altitude, temperature decreases and the atmosphere is thinner. The part of "temperature lower leading to higher efficiency" is obtained from the earlier passage.

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