EUNOIA JUNIOR COLLEGE
JC1 Promotional Examination 2023
**9749 PHYSICS**
MARK SCHEME

**Paper 2**
**Structured Questions**

| s/n | Answer | Marks |
|---|---|---|
| **1(a)** | Velocity is the rate of change of displacement<br><br>**Examiner comments**<br>Well done by those who memorized the definition. Students are reminded to use definitions from EJC notes as extra words or lack of key words used may unintentionally convey a different meaning. | **B1** |
| **1(b)** | $v^2 = u^2 + 2as$<br>$= 2(4)(30) = 240$<br><br>$v = 15.49 = 15.5$ m s$^{-1}$ (3 s.f.)<br><br>**Examiner comments**<br>The given acceleration of 4 m s$^{-1}$ along the slope is due to the resultant force of the weight of the car, the normal force on the car by the slope, and the friction on the car by the slope.<br><br>Being a "show" question, it was crucial that the substitution to the correct formula is shown clearly. | **M1**<br>Correct substitution<br><br>**A0** |

<table>
<tr><th>s/n</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(c)</td><td>

**Method 1**

$u_x = v_x = 15.5 \cos 27° = 13.81$ m s$^{-1}$

Taking downward as positive:

$v_y^2 = u_y^2 + 2a_ys_y = (15.5 \sin 27°)^2 + 2(9.81)(40)$

$v_y = 28.9$ m s$^{-1}$

$v = \sqrt{13.8^2 + 28.8^2}$ = 32 m s$^{-1}$ or 32.0 m s$^{-1}$

$\theta = tan^{-1}\dfrac{28.9}{13.81} = 64°$ or $64.5°$ to the horizontal

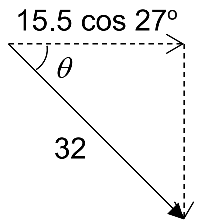
**Method 2**

Gain in KE = Loss in GPE

$\frac{1}{2}m(v^2 - u^2) = mgh$

$\frac{1}{2}m(v^2 - 15.5^2) = m(9.81)(40)$

$v = 32$ m s$^{-1}$




$\theta = \cos^{-1}\dfrac{15.5 \cos 27°}{32} = 64°$ to the horizontal

**Examiner comments**

After point B, the only force acting on the car is its vertically downward weight. The direction of the velocity of the car at point B has both horizontal and vertical components.

</td><td>

C1

C1

A1

A1

</td></tr>
<tr><td>1(d)</td><td>

Consider vertical direction taking downwards as positive:

$s = ut + ½ at^2$

40 = (15.5 sin 27°)$t$ + ½ (9.81)$t^2$

$t$ = **2.22 s** or -3.66 (rejected)

**Examiner comments**

Since the horizontal component of the velocity of the car does not change and horizontal displacement is not given, candidates should use only the vertical component of the velocity to calculate time.

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M1

A1

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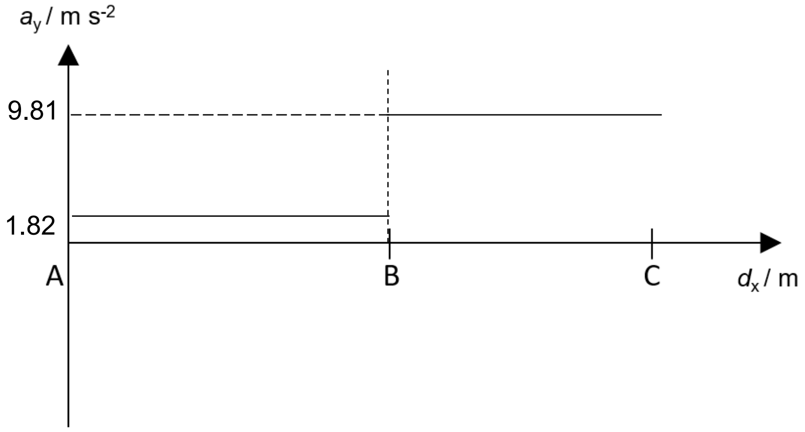
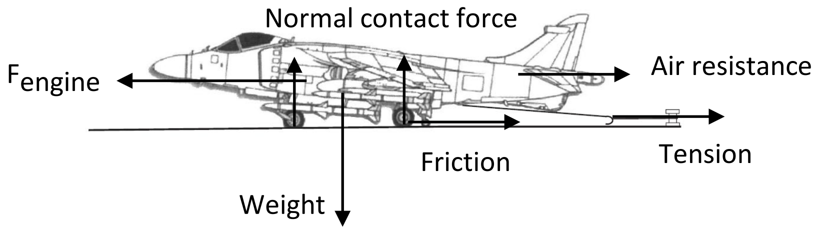
| s/n | Answer | Marks |
|---|---|---|
| 1(e) | <br><br>**Examiner comments**<br>Candidates should write 1.82 instead of 4sin27° on the $a_y$ axis.<br>The positions of 9.81 and 1.82 on the $a_y$ axis should be roughly proportional to their magnitude. | **B1**<br>1.82 m s$^{-2}$<br>from B to C<br><br>**B1**<br>9.81 m s$^{-2}$<br>from B to C |

| s/n | Answer | Marks |
|---|---|---|
| 2(a) | Hooke's Law states that<br>the change in length of a material<br>is directly proportional to<br>the force applied on it,<br>provided that the **limit of proportionality** is not exceeded.<br><br>**Marker's Comments**<br>Most students were penalised for missing out / replacing "limit of proportionality" with other terms. | **B1** |
| 2(b) | $W = 0.5\,Fx = 0.5\,(290\,000)(0.15)$<br>$= 21\,800$ J<br><br>**Marker's Comments**<br>Generally well done.<br>It is possible to obtain the value of *k* and find EPE using the formula:<br>EPE = ½ k $x^2$. | **C1**<br>**A1** |
| 2(c) | $F = ma = m\left\|\frac{v-u}{t}\right\| = \left(2.8\times10^{4}\right)\left\|\frac{0-71}{3.5}\right\| = 568000$ N<br>$2T\cos 12.5° = 568000$<br>$T = 291000$ N<br><br>**Marker's Comments**<br>Generally well done.<br>Common mistakes:<br>1. Assume velocity = 70 $ms^{-1}$ at time = 2 s (Look carefully!)<br>2. Did not resolving the tension as shown in Fig. 2.1 | **M1**<br>(acceleration)<br>**M1**<br>($2T\cos 12.5°$)<br>**A1** |

| s/n | Answer | Marks |
|---|---|---|
| 2(d) | <u>Identify all forces</u><br>1. Normal contact force<br>2. Weight<br>3. $F_{engine}$ / Force by air on plane<br>4. Friction (on wheels)<br>5. Force by wire on plane (Tension)<br><br><u>Correct direction & relative lengths & proper label for all</u><br>Normal contact force, Weight (same length, opposite direction)<br>Forward forces: $F_{engine}$ OR Force by air on plane<br>Backward forces: Air resistance, friction (on wheel), force by wire<br><br><br><br><br>**<u>Marker's Comments</u>**<br>No marks awarded if any of the forces are missing.<br>(optional: air resistance)<br><br>**Rationale for direction of forces:**<br>1. Arrester wire system gives rise to tension (backwards)<br>2. $F_{engine}$ is forward because engines pushed to full power.<br>3. Wheels are free rolling, hence the friction on the wheel is backwards. (Refer to H204 Forces Notes: Pg 9 Example 5)<br>4. Normal contact upwards and weight downwards.<br>5. Air resistance is optional because it is unclear in the question regarding the speed of the aircraft when the force diagram was drawn. Air resistance can be negligible if the aircraft is travelling at a low speed. | B1<br><br><br><br><br><br><br><br>B1 |
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| s/n | Answer | Marks |
|---|---|---|
| 3(a) | The linear momentum of a body is the product of its mass and its velocity.<br><br>**Marker's Comments**<br>Well done across cohort. | **B1** |
| 3(b)(i) | Relative speed of approach = Relative speed of separation<br>Taking to the right as positive,<br>$u_1 - u_2 = v_2 - v_1$<br>$4.5-(-2.8)=v_2-(-1.8)$<br>$v_2 = 5.5$ m s$^{-1}$<br>To the right.<br><br>**Marker's Comments**<br>Generally well done.<br>A handful of students did not show the equation $u_1 - u_2 = v_2 - v_1$<br>**As this is a "show" question, working must be very clear as that is what markers are looking out for.**<br>A1 mark for "Right" will be awarded regardless of the earlier proof. | **B1**<br>**A0**<br>**A1** |
| 3(b)(ii) | By conservation of linear momentum,<br>$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$<br>$(0.050)(4.5)+m_2(-2.8)=(0.050)(-1.8)+m_2(5.5)$<br>$m_2 = 38$ g<br>**Marker's Comments**<br>Generally well done.<br>Students must be aware that momentum is a vector. | **B1**<br>**A1** |
| 3(c) | By conservation of linear momentum,<br>$m_1u_1 + m_2u_2 = (m_1+m_2)v$<br>$(0.050)(4.5)+(0.038)(-2.8)=(0.050+0.038)(v)$<br>$v = 1.35$ OR $1.4$ m s$^{-1}$<br>**Marker's Comments**<br>Generally well done.<br>Students must be aware of that the implication of a perfectly inelastic collision is the objects having the same final velocity. | **B1**<br>**A1** |

| s/n | Answer | Marks |
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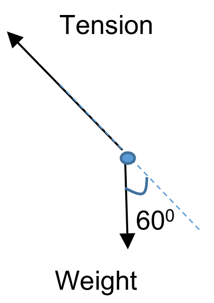
| 4(a) | Velocity is a vector quantity and has both magnitude and direction. Since the object in a circular path keeps **changing direction** despite a constant speed, it has a **changing velocity** over time.<br><br>Since **acceleration is the rate of change of velocity**, the object has acceleration.<br><br>**Marker's Comments**<br>Unexpectedly well done!<br>**Skill demonstrated (or to learn):** From definition of "acceleration", work backwards to argue that velocity has changed due to the changing direction of the object. Then phrase answer from the *starting condition in question* (object moving in circular path) to the *ending condition* (has acceleration). | B1<br><br>B1 |
| 4(b)(i)1. | Loss in GPE $= mg(2R\sin 30°)$<br>$= (0.10)(9.81)2(0.15)\sin 30°$<br>$= 0.15$ m s$^{-1}$<br><br>**Marker's Comments**<br>Being a "show" question, it was crucial that the mathematics to the **drop in height from P to Q** is *shown* clearly. | M1 |
| 4(b)(i)2. | Work done against air resistance<br>$= \text{Force} \times \text{distance}$<br>$= (F_R)\left(\dfrac{60}{360} \times 2\pi \times R\right)$<br>$= (0.14)\left(\dfrac{60}{360} \times 2\pi \times 0.15\right)$<br>$= 0.022$ OR 0.0220 J<br><br>**Marker's Comments**<br>Being a "show" question, it was crucial that the mathematics to the **distance along the arc from P to Q** was *shown* clearly. | M1 |
| 4(b)(i)3. | **By principle of conservation of energy,**<br>**loss in gravitational potential energy**<br>**= gain in kinetic energy + work done against resistive forces**<br><br>$0.15 = \dfrac{1}{2}(0.100)v^2 + 0.0220$<br>$v = 1.6$ m s$^{-1}$<br><br>**Marker's Comments**<br>Part 4(b)(i)1,2 were meant to scaffold your answer towards part 3. As such, the **values you were asked to prove** for gravitational potential energy and work done in part 1, 2 **should have been used in part 3.** This also means, even if you could not work out 4(b)(i)1,2, you could have used the earlier values provided in this part. | B1<br>statement<br><br>A1 |

| s/n | Answer | Marks |
|---|---|---|
| 4(b)(ii) | <br><br>**Resultant / Vector sum** of **tension** and **component of weight** provides centripetal force<br>$\frac{mv^2}{R} = T - mg\cos 60°$<br>$\frac{(0.100)1.6^2}{0.15} = T - (0.100)(9.81)\cos 60°$<br>$T = 2.15$ or 2.2 N<br><br>**Marker's Comments**<br>Reminders<br>• Draw a **force diagram** with the tension and weight<br>• **Identify resultant force** (air resistance should NOT be considered at it would be perpendicular to the centripetal force)<br>• Write the Physics statement at the start in **FULL English words**. Avoid any short forms.<br>• **Apply trigonometry carefully** – several mistakes were spotted. | B1<br><br>M1<br><br>A1 |

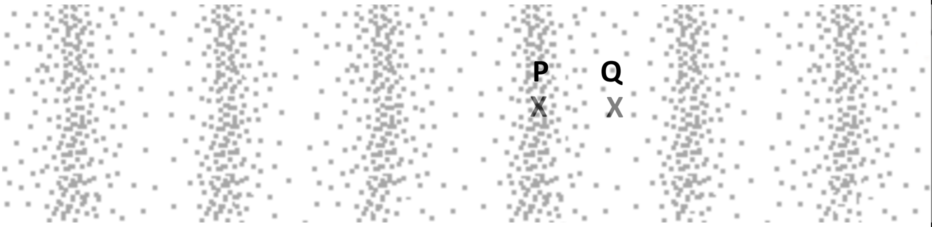
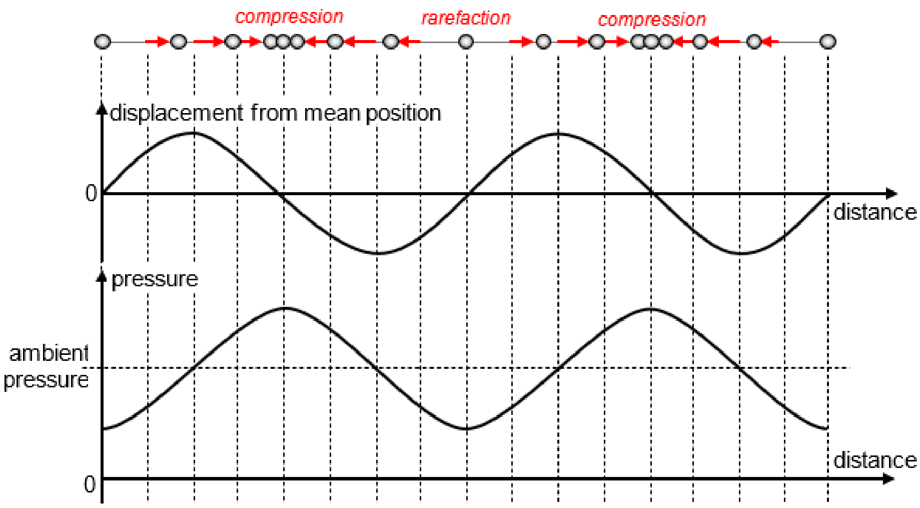
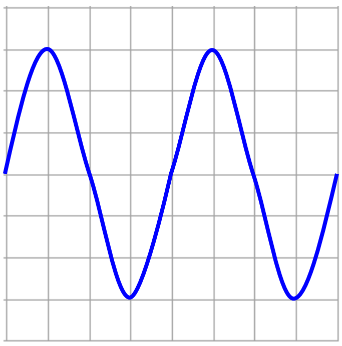
| s/n | Answer | Marks |
|---|---|---|
| 5(a) | **Newton's law of gravitation** states that the gravitational force of attraction between **two point masses** is directly proportional to the product of the masses and inversely proportional to the square of separation between the masses<br><br>**Marker's Comments**<br>Full definition from EJC notes expected. Well done by those who memorized the definition. Most common issue is missing out the "2 point masses" – this was highlighted by Cambridge examiners previously as well. | B1 |
| 5(b)(i) | $F = \frac{GM_1M_2}{r^2}$<br>$= \frac{6.67\times10^{-11}\times2.0\times10^{6}\times1.4\times10^{30}}{(8.0x10^{10})^2}$<br>$= 2.9\times10^{4}$ OR $2.92\times10^{4}$ N<br><br>**Marker's Comments**<br>Mostly well done. Most common error is student forgetting to square the distance during the substitution step even though he/she wrote it in the formula above. | B1<br><br>A1 |
| 5(b)(ii) | $\Delta U = U_f - U_i$<br>$= -\frac{GM_1M_2}{r_f} - (-\frac{GM_1M_2}{r_i})$<br>$= (6.67x10^{-11})(2.0\times10^{6})(1.4\times10^{30})\left(-\frac{1}{4.0\times10^{10}} + \frac{1}{8.0\times10^{10}}\right)$<br>$= -2.33x10^{15}$ J or -2.3x$10^{15}$ J<br><br>**Marker's Comments**<br>Reminders<br>• **Gravitational potential energy** MUST have **negative sign**.<br>• "**Change**": ***final* minus *initial***<br>• When calculating for **gravitational potential**, the "M" in the formula MUST be the **mass of the planet** (the mass that set up the gravitational field) and NOT the mass of the asteroid. | M1<br><br>A1<br>concept of "change" as *final* minus *initial* must be there |

| s/n | Answer | Marks |
|---|---|---|
| 5(b)(iii) | **Differentiating Question [2m]**<br>Shaded area represents the<br>• work done<br>• by gravitational force<br>• on the asteroid<br><br>and is equivalent to the<br>• <u>loss</u> in gravitational potential energy OR<br>• <u>gain</u> in kinetic energy of the asteroid **in the absence of an external force**<br><br>**<u>Marker's Comments</u>**<br>Learning points:<br>• Area under a *force*-distance graph gives the work done by *that* force on the object in question (in this case, it is the gravitational force acting on the asteroid)<br>• If the shaded area is explained as "work done by external force", the assumption of no change in kinetic energy of the asteroid must be provided. (Because "work done by external force as object moved from infinity to P = loss in gravitational potential energy" is only valid in the context when kinetic energy of the asteroid is constant) | **B1**<br>all points seen<br><br><br><br>**B1**<br>must have **gain/loss** of **specific energy** to get credit |

| s/n | Answer | Marks |
|---|---|---|
| 6(a) | $I = \dfrac{P}{\text{Area}}$<br>$= \dfrac{E/t}{4\pi r^2}$<br>$= \dfrac{2.5}{4\pi(1)^2}$<br>$= 0.199$<br>$= 0.20 \text{ W m}^{-2}$<br><br>**Marker's Comments**<br>Generally well done.<br>For "Show" question, best practice is<br>1. Physics concept (statement and/or formula, depending on context)<br>2. Clear substitution<br>3. Answer in more sf than necessary<br>4. Final value as asked for in question. | **M1**<br>correct substitution into formula |
| 6(b) | $I \propto A^2$<br>$\dfrac{I_R}{I_Q} = \left(\dfrac{A_R}{A_Q}\right)^2$<br>$\dfrac{0.20}{1.0} = \left(\dfrac{A_R}{4.0\times10^{-6}}\right)^2$<br>$A_R = 1.79\times10^{-6}$ or $1.8\times10^{-6}$ m<br>$= 1.79\,\mu m$ or $1.8\,\mu m$<br><br>**Marker's Comments**<br>Since $I_R$ = 0.20 W m$^{-2}$ is defined by the question in part (a), students have no choice but to use this value in subsequent calculations. | **C1**<br><br>**A1** |
| 6(c) | $P = I(Area) \quad \Rightarrow P \propto I(Area)$<br>$\dfrac{P_R}{P_Q} = \dfrac{I_R}{I_Q}\dfrac{Area_R}{Area_Q} = \left(\dfrac{0.20}{1.0}\right)\left(\dfrac{1}{2}\right)$<br>$= 0.10$<br><br>**Marker's Comments**<br>Again, students are expected to use $I_R$ = 0.20 W m$^{-2}$ as defined by the question in part (a) for their calculations.<br>Answer should be expressed in decimal to the correct s.f.<br>Some students confused *Area* with *Amplitude* in the formula. Students are advised to use different symbols to represent each. | **C1**<br>**A1**<br>must give in decimal |

| s/n | Answer | Marks |
|---|---|---|
| **6(d)** | There is **no loss of energy** from the wave due to dissipative forces as it travels.<br>OR<br>**Total energy** of wave spreading out from the source **remains constant.**<br><br>**Marker's Comments**<br>The question refers to power "received". Some students misunderstood it to be power "absorbed" and commented on the detectors' efficiency. This is incorrect. | **A1** |

| s/n | Answer | Marks |
|---|---|---|
| 7(a) | *Frequency of wave*:<br>• number of wavefronts/ crests/ troughs passing a point per unit time (NOT per sec)<br>or<br>• number of oscillations per unit time (NOT per sec) of the source/ of a point on the wave. | B1 |
| | *Wavelength of wave*:<br>• distance moved by wavefront/ energy during one cycle/ oscillation/ period of the source/ point on wave<br>or<br>• [***minimum*** distance between 2]/ [distance between 2 ***adjacent*** (NOT consecutive, NOT successive)] [wavefronts]/ [crests or troughs]/ [points having the same displacement and moving in same direction]/ [points on the wave with same phase]<br><br>e.g. "Wavelength is the minimum distance between 2 points on the wave with the same phase." | B1 |
| | Speed of a wave<br>$= \dfrac{\text{distance move by a wavefront in 1 period}}{\text{time between adjacent wavefronts}}$<br>$= \dfrac{\text{minimum distance between 2 points on wave with the same phase}}{\text{1 time period}}$ | B1 |
| | $= \dfrac{\lambda}{T} = f\lambda \quad \text{since } f = \dfrac{1}{T}$ | A0 |
| | **Marker's Comments**<br>Definitions must be clear, precise and unambiguous. Students who used unclear terms or wrote unclear statements will be penalised. For example, "successive" or "consecutive" refers to time sequence, and is not the same as "adjacent", which refers to spatial sequence.<br><br>The question clearly wants students to use the definitions of $f$ and $\lambda$ to derive the equation $v = f\lambda$. Hence the workings for the derivation must refer to the definitions, either by using word equation or writing separate statements of explanation. Only a few students made the link in their derivation. Worse, some students started with $v = f\lambda$ and tried to 'work backwards'. This does not answer the question.<br><br>Note that 1 period for a wave is the<br>• time bet adj wavefronts/pts in phase<br>• shortest time bet wavefronts/pts in phase<br>• time for 1 oscill/vibration/cycle of source/ pt on wave | |

| s/n | Answer | Marks |
|---|---|---|
| 7(b)(i) | <br>*1 at a rarefaction, 1 at a compression.<br><br>**Marker's Comments**<br>This part of the question was surprisingly badly done. Students are advised to revise page 12 of the notes on *pressure variation of sound waves*:<br> | A1 |
| 7(a)(ii) | Wavelength of sound = 2 × 3.2 cm = 0.064 m<br><br>$v = f\lambda = (5.0 \times 10^3)(0.064) = 320 \text{ m s}^{-1}$<br><br>**Marker's Comments**<br>Common mistake here is getting the wavelength wrong. | A1 |
| 7(a)(iii) | <br>**Marker's Comments**<br>Many students lost mark for drawing the wrong period for the graph. A few students get zero mark for drawing a non-sinusoidal graph. | **B1**<br>correct amplitude (@ 3 sq)<br><br>**B1**<br>Correct period (@ 4 sq)<br><br>Zero for non-sinusoidal shape. |

| s/n | Answer | Marks |
|---|---|---|
| 8(a) | Spring constant and mass are constants.<br>$\Rightarrow$ acceleration is proportional to displacement from equilibrium position<br><br>The negative sign in the equation indicates that the direction of acceleration is opposite to the direction of displacement<br><br>**Marker's Comments**<br>Important for students to be aware of the need to be concise and precise with their answers to qualitative questions.<br><br>**Explicit** links are to be made between constants m and k with direct proportionality relationship between acceleration and displacement and between negative sign and acceleration being opposite in direction to displacement.<br><br>Merely rewriting the SHM equation $a = -\frac{k}{m}x$ and then mentioning that a is proportional to m and a is opposite in direction to x WITHOUT describing the above links is NOT acceptable | B1<br><br><br>B1 |
| 8(b)(i)1. | $v_o = \omega x_o = \frac{2\pi}{T}x_o = \frac{2\pi}{0.84}(0.040)$<br>$= 0.30$ OR $0.299$ m s$^{-1}$<br><br>**Marker's Comments**<br>Common mistake is to express the amplitude, $x_O$ as 34 cm instead of measuring $x_O$ with respect to the equilibrium position. Another common mistake is to supposedly find gradient of tangent of *x-t* graph at equilibrium position but instead, taking gradient of straight line joining two coordinate points ON the graph itself. | M1<br><br>A1 |
| 8(b)(i)2. | $\text{KE} = \frac{1}{2}m\omega^2\left(x_o^2 - x^2\right) = \frac{1}{2}\left(\frac{1.4}{9.81}\right)\left(\frac{2\pi}{0.84}\right)^2\left(0.040^2 - 0.020^2\right)$<br>$= 4.8\times10^{-3}$ OR $4.79\times10^{-3}$ J<br><br>**Marker's Comments**<br>Similar to above question, a common mistake is to take $x_O$ = 0.340 m and $x$ = 0.320 m. Correct understanding of displacement is measurement with respect to equilibrium position. | C1<br><br>A1 |

| s/n | Answer | Marks |
|---|---|---|
| **8(b)(i)3.** | Method 1:<br>Consider lowest point of the oscillation.<br>Then **TE = EPE** since GPE = KE = 0.<br>$\text{TE = EPE} = \frac{1}{2}kx^2 = \frac{1}{2}\left(\frac{1.4}{0.18}\right)(0.34-0.12)^2$<br>$= 0.19 \text{ OR } 0.188 \text{ J}$<br><br>Method 2:<br>Consider highest point of the oscillation.<br>**TE = EPE + GPE**.since KE = 0.<br>$\text{TE = EPE } + \text{GPE} = \frac{1}{2}kx^2 + mgh = \frac{1}{2}\left(\frac{1.4}{0.18}\right)(0.14)^2 + (1.4)(0.080)$<br>$= 0.19 \text{ OR } 0.188 \text{ J}$<br><br>**Marker's Comments**<br>Relatively few get this question correct.<br>Most equate total energy to be equal to max kinetic energy without realising that at the position of max Kinetic Energy (i.e. at equilibrium position), the system still possesses elastic and gravitational potential energies. | **M1**<br>Spring constant calculation<br>**A1** |
| **8(b)(ii)1.** | Upthrust on immersed portion, $U = V\rho_{fluid}g = (20\times10^{-6})(1000)(9.81)$<br>$= 0.196 \text{ N}$<br><br>Net force on spring, $F = W - U$<br>$= 1.40 - 0.196$<br>$= 1.20 \text{ N}$<br><br>From Fig. 9.2, $l = 27.5$ cm<br>**OR**<br>Extension of spring, $e = \frac{F}{k}$<br>$= \frac{1.20}{(1.4/18\times10^{-2})}$<br>$= 0.155 \text{ m}$<br><br>New length of spring $= 0.120 + 0.155 = 0.275 \text{ m}$<br><br>**Marker's Comments**<br>Common mistakes:<br>• inability in finding the new total length of the spring after correctly obtaining the net force on the spring.<br>• converting 20 cm$^3$ to m$^3$. Students MUST avoid making such trivial mistakes. | **C1**<br><br>**C1**<br><br>**A1** |

| s/n | Answer | Marks |
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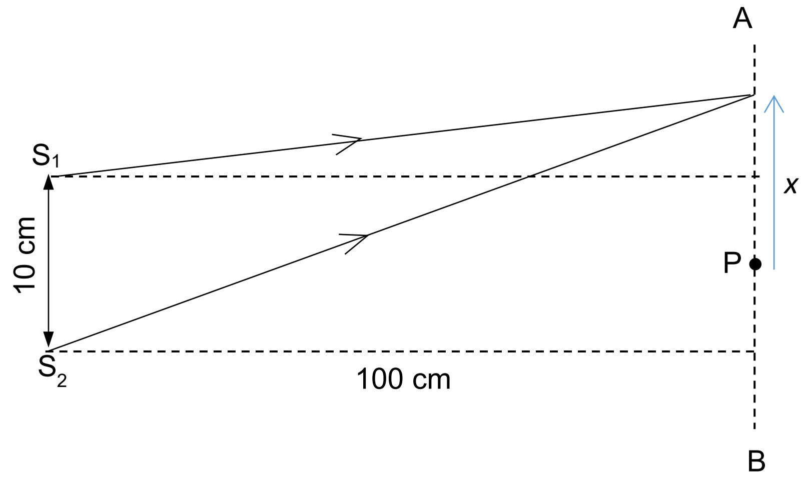
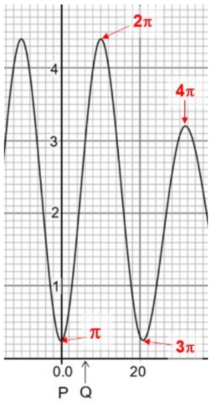
| **8(b)(ii)2.** | • Amplitude decreases exponentially with time<br>• Period increases with time<br>• Oscillations eventually come to a stop.<br><br>**Marker's Comments**<br>The liquid in Fig. 8.4 should be interpreted as providing some form of damping to M. However, since M is oscillating as given in question, any conditions/features of a body subjected to critical or heavy damping are NOT acceptable. Only features of light damping were accepted.<br><br>Statement such as "speed of oscillation is slower" or anything related to that is considered as vague and not acceptable. | **B1**<br>**B1**<br>(any valid reason 1 mark, max 2 marks) |

| s/n | Answer | Marks |
|---|---|---|
| 9(a) | The **Principle of Superposition** states that<br>when two or more waves **meet and overlap**,<br>the resultant displacement is the<br>**vector** sum of the displacement of each individual wave<br><br>**Marker's Comments**<br>Well done by those who memorized the definition.<br>Common mistakes:<br>1. Missing key words / phrases<br>"waves meet and overlap"<br>"resultant"<br>"vector"<br>2. Using "amplitude" instead of "displacement" | B1 |
| 9(b) | 1. Waves of the same type meet and overlap / superpose<br>2. Waves from the sources have constant phase difference with each other<br>3. If waves are transverse, they are either unpolarised or polarized in the same plane<br><br>**Marker's Comments**<br>Well done by those who memorized the definition.<br>Common mistakes:<br>1. Quoted the conditions for formation of stationary waves<br>2. Missing words "same type" and/or "meet" and/or "transverse"<br>3. Mixed up the statement "either unpolarised or polarized in the same plane" | B1<br>B1<br><br>B1 |
| 9(c)(i)1. | **The figure shows an interference pattern** (pattern of maxima and minima) over the region of space where the microwaves meet and overlap/superpose.<br><br>**Marker's Comments**<br>Well done by those understood the question. Interference pattern can only be observed when the waves are coherent. | B1 |
| 9(c)(i)2. | The microwaves from the 2 slits interfere to produce a **central minima.** **(**Since the path difference of the 2 waves is zero, the only way the centra position is a minima is that the 2 waves are emitted in antiphase**)**<br><br>**Marker's Comments**<br>Most candidates could answer that the central position is a minima and therefore the waves are in antiphase. | B1 |

| s/n | Answer | Marks |
|---|---|---|
| 9(c)(i)3. | The interference pattern has **non-zero minimum at P.**<br><br>**Marker's Comments**<br>Most candidates missed out stating that non-zero minimum was observed at position P. Position P is the only conclusive point since it is the position where the path difference of the waves is zero.<br><br>At other positions, the incomplete destructive interference could be due to the different distance travelled by each wave and thus having different displacements when interfering to give non-zero minima. | B1 |

| s/n | Answer | Marks |
|---|---|---|
| 9(c)(ii) | Method 1 (most accurate)<br>At $x$ = 10 cm, it is the 1st maximum. Since $M_1$ and $M_2$ are antiphase to each other, path difference of the waves arriving is $\lambda/2$.<br><br>Path difference $= \lambda / 2$<br>$\sqrt{100^2 + (x+5)^2} - \sqrt{100^2 + (x-5)^2} = \lambda / 2$<br>$\lambda = 2.0$ cm<br><br>Method 2 (rough approximation, at most 2 marks)<br>Consider the two maxima at distance $\pm 10$ cm.<br>Then fringe separation = 0.20 m<br>$x = \dfrac{\lambda D}{a}$<br>$0.20 = \dfrac{\lambda(1.00)}{0.10}$<br>$\lambda = 0.020$ cm<br><br>**Marker's Comment**<br>To get the full credit, candidates must use the path difference method. Most candidates used the Young's double slit formula. Note that Young's double-slit formula is a very rough approximation here as the slit separation is of the same order as the distance of the detector to the slits. One can see that the separation between the maxima is not constant from the intensity graph. In fact, it gets larger as one moves away from the central axis. The requirement given in notes is D >> a. | **M1**<br><br><br><br><br><br>**C1**<br>**A1**<br><br><br><br>**C1**<br>**A1** |

| s/n | Answer | Marks |
|---|---|---|
| **9(c)(iii)** | Phase difference at central minimum is $\pi$. Phase difference at 1st maximum is $2\pi$. By proportion,<br>$\frac{\Delta\phi}{\pi} = \frac{3 \text{ sq}}{5 \text{ sq}}$<br>$\Delta\phi = 0.6\pi$ rad<br><br>Total phase difference<br>$= \phi_{\text{source}} + \phi_{\text{path difference}}$<br>$= \pi + 0.6\pi = 1.6\pi$<br>$= 5.0$ rad<br><br><br><br>**Marker's Comments**<br>Poorly done.<br>Common mistakes:<br>1. Phase difference formula used incorrectly.<br>2. Fail to include the phase difference due the wave being emitted in antiphase. | **C1**<br><br><br><br>**A1** |
| **9(c)(iv)** | Microwave undergoes diffraction after passing through each of the double slits. The single slit diffraction envelope tapers off towards both sides, making the intensities of higher order maxima lower.<br><br>OR<br><br>Intensity of the microwave decreases with distance from the slit. At the locations of higher order maxima, microwaves from both slits must travel longer distances, thus resultant intensities at higher order maxima are lower.<br><br>**Marker's Comments**<br>Most candidates could not explain the effect correctly. The idea of single slit **diffraction** envelope should be shown.<br><br>Some candidates also wrongly stated that energy or power is dissipated or lost to the environment. Rather, due to the wave spreading and propagation, the energy/amplitude/intensity of the wave decreases with distance. Candidates should not use formula in their explanation without explaining each of the variables. | **B1** |