**Answers to 2024 JC2 H2 Preliminary Examinations Paper 2**

**Suggested Solutions:**

| No. | Solution | Remarks |
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| **1(a)** | $I = f^2 A^2 v k$ <br> $k = \dfrac{I}{f^2 A^2 v}$ <br> SI base units of $k$ <br> $= \dfrac{\text{W m}^{-2}}{\text{s}^{-2}\ \text{m}^2\ \text{m s}^{-1}} = \dfrac{\text{kg m}^2\ \text{s}^{-3}\ \text{m}^{-2}}{\text{s}^{-3}\ \text{m}^3} = \text{kg m}^{-3}$ | [1] for correct units of frequency and amplitude <br> [1] for correct base units of power <br> [1] for correct answer |
| **1(b)** | $P = v^3 b$ <br> $v = \sqrt[3]{\dfrac{P}{b}} = \sqrt[3]{\dfrac{84\times10^3}{0.56}} = 53.133\ \text{m s}^{-1}$ <br> $P = v^3 b$ <br> $v = \sqrt[3]{\dfrac{P}{b}}$ <br> $\dfrac{\Delta v}{v} = \dfrac{1}{3}\dfrac{\Delta P}{P} + \dfrac{1}{3}\dfrac{\Delta b}{b}$ <br> $\dfrac{\Delta v}{53.133} = \dfrac{1}{3}(0.05) + \dfrac{1}{3}(0.07)$ <br> $\Delta v = 2.1253\ \text{m s}^{-1}$ <br> $\Delta v \approx 2\ \text{m s}^{-1}$ | [1] for correct value of $v$ <br> [1] for correct substitution <br> [1] for correct answer to 1 s.f. |
| **2(a)(i)** | Applying Newton's second law, <br> $T - \left(4\times10^3\right)(9.81) = \left(4\times10^3\right)(0.32)$ <br> $T = 4.05\times10^4\ \text{N}$ | [1] for correct substitution <br> [1] for answer |
| **2(a)(ii)1.** | mass per unit time $= \rho(\text{vol per unit time})$ <br> $= \rho(Av)$ <br> $= (1.3)\left[\pi(10)^2\right]v$ <br> $= 408v$ <br> $= 410v$ | [1] for correct substitution <br> [1] for correct intermediate value |
| **2(a)(ii)2.** | Applying Newton's second law, <br> $F_{net} = \dfrac{dp}{dt} = \left(\dfrac{dm}{dt}\right)v$ <br> $9.1\times10^4 = (410v)v$ <br> $v = 14.9\ \text{m s}^{-1}$ | [1] for correct substitution <br> [1] for correct answer |

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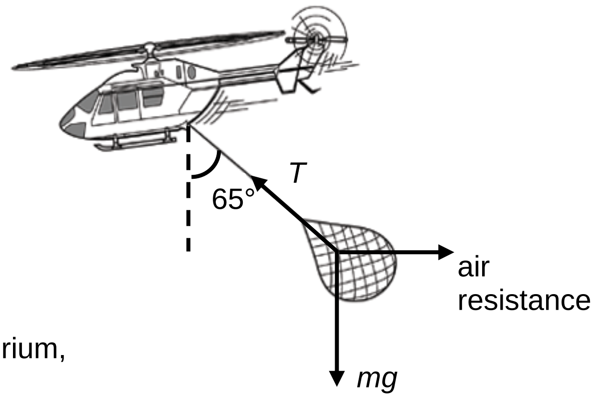
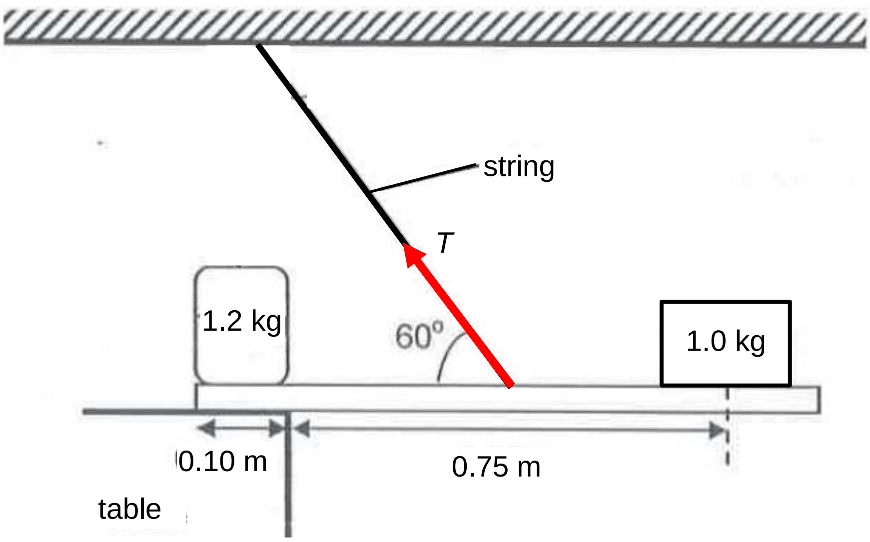
| **2(b)** | <br>For vertical equilirium,<br>$T\cos 65° = mg = (4\times10^3)(9.81)$ --- (1)<br>Horizontally,<br>$T\sin 65° - 6\times10^3 = ma = (4\times10^3)a$<br>$T\sin 65° = (4\times10^3)a + 6\times10^3$--- (2)<br>$\frac{(2)}{(1)}: \tan 65° = \frac{ma + 6\times10^3}{mg}$<br>$a = 19.5\text{ m s}^{-2} = 20\text{ m s}^{-2}$ | [1] for correct substitution<br><br>[1] for correct answer |
| **3(a)(i)** | The moment of a force about a pivot is the <u>product</u> of the <u>force</u> and the <u>perpendicular distance from the pivot to the line of action of the force</u>. | [1] |
| **3(a)(ii)** | Let $N$ be the number of 5.0 g mass needed for equilibrium.<br>Taking moments about the edge of the table,<br>anti-clockwise moments = clockwise moments<br>$(1.2)g(0.05) = (0.11)g(0.40) + N(0.005)g(0.75)$<br>$N = 4.3$<br>Since $N$ is a whole number, the maximum number is 4. | [1] correct substitution<br><br>[1] correct answer |
| **3(b)(i)** |  | [1] for $T$ |

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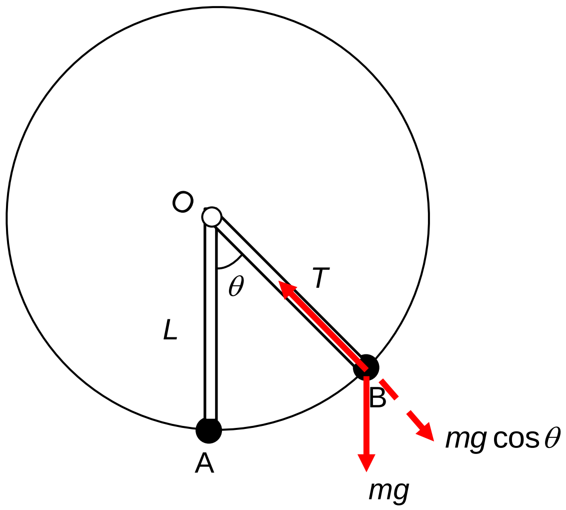
| **3(b)(ii)** | Taking moments about the edge of the table,<br>anti-clockwise moments = clockwise moments<br>$(1.2)g(0.05)+T\sin 60°(0.40)=(0.11)g(0.40)+(1.0)g(0.75)$<br>$0.346T=7.2$<br>$T=20.8\text{ N}=21\text{ N}$ | [1] correct substitution<br><br>[1] correct answer |
| **4(a)** | Since the direction of motion of the body is always changing, its velocity is not constant and thus a resultant force acts on the body.<br><br>Since the speed of the body is constant, the resultant force acts perpendicular to its velocity and thus, direction of motion, which is towards the centre of the circle. | [1]<br><br>[1] |
| **4(b)(i)** | <br>The net force towards centre of the circle provides the centripetal force required to move in a circular path.<br><br>$T-mg\cos\theta=\dfrac{mv^2}{r}$<br><br>$T=mg\cos\theta+\dfrac{mv^2}{L}$, as $r=L$. | [1] for statement and equation<br><br>[1] for $r = L$ |
| **4(b)(ii)** | The point where the force in the rod changes from tension to compression is when $T = 0$ N.<br><br>$T=mg\cos\theta+\dfrac{mv^2}{L}=0$<br><br>$mg\cos\theta=-\dfrac{mv^2}{L}$<br><br>$\cos\theta=-\dfrac{v^2}{gL}=-\dfrac{(2.0)^2}{(9.81)(0.80)}=-0.51$<br><br>$\theta=120.6°=120°$ | [1] for $T = 0$ N<br><br>[1] for correct substitution and answer |

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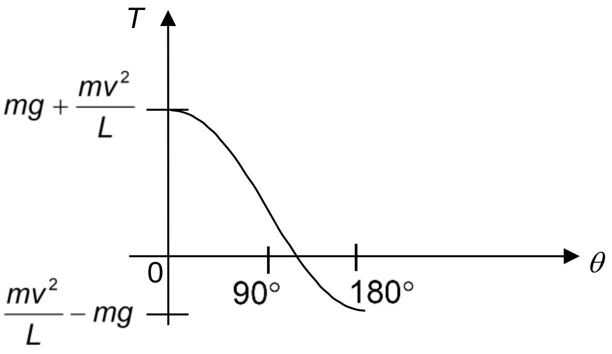
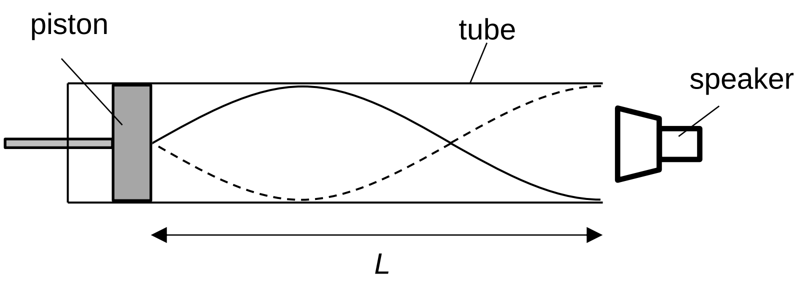
| **4(b)(iii)** |  | [1] graph is cosine and cuts at about 120°<br><br>[1] correct values |
| **4(b)(iv)** | The K.E. of the mass is constant but its G.P.E. is constantly changing. So as the mass is moving upwards, an external device is needed to supply energy to increase its G.P.E.<br>As the mass moves downwards, its G.P.E. is decreasing and the external device must absorb the lost in G.P.E. | [1] energy supply<br><br>[1] energy absorb |
| **5(a)(i)** | A longitudinal wave is one where the oscillations of the wave particles is parallel to the direction of the wave propagation / energy transfer. | [1] |
| **5(a)(ii)** | Sound waves are longitudinal. Since there is no component of a sound wave's oscillation that is perpendicular to its direction of motion, sound waves cannot be polarised. | [1]<br><br>[1] |
| **5(b)(i)** | Sound waves from the speaker travel leftward through the tube and gets reflected by the piston rightwards.<br><br>The incident sound waves from the speaker superpose with the reflected sound waves by the piston to form stationary waves. | [1]<br><br>[1] |
| **5(b)(ii)1.** |  | [1] |
| **5(b)(ii)2.** | wavelength, $\lambda = \frac{v}{f} = \frac{330}{440} = 0.75$ m<br>$L = \frac{3\lambda}{4} = \frac{3}{4} \times 0.75 = 0.563$ m = 56.3 cm | [1] for wavelength<br><br>[1] for correct answer |
| **5(b)(iii)** | Stationary waves can only form at specific lengths of the air column, such that a node and an antinode are formed at the closed and opened end of the tube respectively. | [1]<br><br>[1] |

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| | This can only occurs when $L$ is odd number multiples of quarter wavelength or $L = (\text{odd number})\dfrac{\lambda}{4}$. | |
| **6(a)** | At $V$ = 12 V, $I$ = 2.5 A<br>$\Rightarrow \dfrac{I}{V} = 0.208$<br>At $V$ = 6 V, $I$ = 1.25 A<br>$\Rightarrow \dfrac{I}{V} = 0.208$<br>At $V$ = 9.6 V, $I$ = 2.0 A<br>$\Rightarrow \dfrac{I}{V} = 0.208$<br>Since ratio of $I$ to $V$ is constant, $I$ is proportional to $V$. | [1] show at least 2 values of ratio of $\dfrac{I}{V}$ or $\dfrac{V}{I}$.<br>[1] conclusion |
| **6(b)(i)** | Resistance of resistor X = $\dfrac{12}{2.5}$ = 4.8 Ω | [1] answer |
| **6(b)(ii)1.** | Current in wire AB = $\dfrac{9.0}{4.0+5.0}$ = 1.0 A | [1] answer |
| **6(b)(ii)2.** | Current in resistor X = $\dfrac{9.0}{4.8+2.7}$ = 1.2 A | [1] answer |
| **6(b)(iii)** | Resistance of wire AC = $\dfrac{0.70}{1.0} \times 4.0$ = 2.8 Ω<br>Potential difference across AC = $\dfrac{2.8}{4.0+5.0} \times 9.0$ = 2.8 V<br>Potential difference across AD = $\dfrac{4.8}{4.8+2.7} \times 9.0$ = 5.76 V<br>Potential difference between C and D = 5.76 − 2.8 = 2.96 V<br>= 3.0 V | [1] value of $V_{AC}$<br>[1] value of $V_{AD}$<br>[1] answer |
| **6(b)(iv)** | With internal resistance, the potential difference across the power supply would be less than 9.0 V.<br>The potential difference across AC and AD would also be less, and hence the answer in (iii) would be less. | [1] |
| **7(a)** | Electric field strength $E = \dfrac{V}{d} = \dfrac{40-(-40)}{40\times10^{-3}}$ = 2.0 × 10$^3$ V m$^{-1}$ | [1] answer |
| **7(b)** | Acceleration $a = \dfrac{F}{m} = \dfrac{eE}{m} = \dfrac{(1.6\times10^{-19})(2.0\times10^{3})}{9.11\times10^{-31}}$<br>= 3.51 × 10$^{14}$ m s$^{-2}$ | [1] substitution<br>[1] answer<br>(2 or 3 s.f.) |
| **7(c)** | Duration of time for electron to stay in electric field is given by<br>$t = \dfrac{s}{v} = \dfrac{80\times10^{-3}}{1.5\times10^{7}}$ = 5.333 × 10$^{-9}$ s | [1] for value of $t$ |

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| | Vertically, using $v = u + at$,<br>$v = 0 + (3.51 \times 10^{14})(5.333 \times 10^{-9})$<br>$= 1.87 \times 10^{6}$ m s$^{-1}$<br>$= 1.9 \times 10^{6}$ m s$^{-1}$ | [1] for velocity $1.87 \times 10^{6}$ m s$^{-1}$ |
| **7(d)** | $\tan\theta = \dfrac{v_y}{v_x} = \dfrac{1.9\times10^{6}}{1.5\times10^{7}} \rightarrow \theta = 7.2°$ | [1] answer |
| **7(e)(i)** | Magnetic force provides centripetal force<br>$Bev = \dfrac{mv^2}{R}$<br>$\rightarrow R = \dfrac{mv}{Be} = \dfrac{(9.11\times10^{-31})(1.9\times10^{6})}{(1.62\times10^{-4})(1.60\times10^{-19})}$<br>$= 6.68 \times 10^{-2}$ m $= 6.7 \times 10^{-2}$ m | [1] statement<br>[1] substitution<br>[1] answer |
| **7(e)(ii)** | $Bev = \dfrac{mv^2}{R} \rightarrow Be = \dfrac{mv}{R} = m\omega = \dfrac{2\pi m}{T}$<br>$\rightarrow T = \dfrac{2\pi m}{Be} = \dfrac{2\pi(9.11\times10^{-31})}{(1.62\times10^{-4})(1.60\times10^{-19})}$<br>$= 2.21 \times 10^{-7}$ s $= 2.2 \times 10^{-7}$ s | [1] substitution<br>[1] answer |
| **8(a)(i)** | 20.8 knots = 10.6912 m s$^{-1}$<br><br>Maximum KE of ship<br>$= \dfrac{1}{2}\left(3.40\times10^{7}\right)\left(10.6912\right)^2$<br>$= 1.94\times10^{9}$ J | [1] for correct substitution<br>[1] for correct answer |
| **8(a)(ii)** | Angular speed<br>$= \dfrac{115\left(2\pi\right)}{60}$<br>$= 12.0428$ rad s$^{-1}$<br>$\approx 12.0$ rad s$^{-1}$ | [1] for correct substitution<br>[1] for correct answer |
| **8(b)** | Power required to convert water at 100 °C to steam at 100 °C every hour<br>$= \dfrac{\left(2.15\times10^{5}\right)\left(2.26\times10^{6}\right)}{3600}$<br>$= 1.3497\times10^{8}$ W<br><br>Maximum efficiency<br>$= \dfrac{29400\times10^{3}}{1.3497\times10^{8}}\times100\%$<br>$= 21.8\%$ | [1] for correct substitution for power required<br>[1] for correct substitution for efficiency<br>[1] for correct answer |

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| **8(c)(i)** | In the case of fission, the neutrons produced by each reaction causes further neutron capture by other uranium atoms. This in turn produces more neutrons to cause further reactions. | [1] |
| **8(c)(ii)** | At the beginning, the number of neutrons available for capture is small but this escalates to a tremendous value towards the final stages, when there are a large number of simultaneous reactions taking place at the same time. | [1] |
| **8(c)(iii)** | Electromagnetic radiation.<br>One example is gamma radiation, light/photons. | [1] |
| **8(d)(i)** | 108, 127, 152<br><br>(All have a percentage yield of 0.06% to 0.08%.) | [2] for all correct<br>[1] for one or two correct |
| **8(d)(ii)** | By conservation of mass number<br><br>235 + 1 = 82 + c + 2<br>OR<br>235 + 1 = 82 + c + 3<br><br>Therefore c = 152 or 151<br>Based on **(d)(i)**, c = 152 | [1] |
| **8(d)(iii)** | 6.1% ≤ percentage yield ≤ 6.9% | [1] |
| **8(d)(iv)** | For fission products to have the same masses, the nucleon number must be around 0.5(236 – 2) = 117 (the subtraction of 2 takes into account the estimated number of neutrons produced).<br><br>For the nucleus with nucleon number 117, the percentage yield is 0.01%.<br><br>Taking the yield as 6.4%,<br>the ratio is 6.4% divided by 0.01% = 640 times. | [1]<br><br><br>[1] if use 0.012% incorrect |
| **8(e)** | $\beta^-$-particles are fast moving electrons and the $\beta^-$-particles emitted will collide with the atoms of the lead container.<br><br>These collisions result in the $\beta^-$-particles undergoing deceleration, either being slowed down by collision (or by deflection).<br><br>The electrons will then release energy in the form of the continuous spectrum of the X-ray produced, also called Bremsstrahlung radiation. | [1] for fast moving electrons<br>[1] for collision with atoms<br>[1] for deceleration of $\beta^-$-particles<br>[1] for releasing energy in the form of X-ray |