EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2022
General Certificate of Education Advanced Level
Higher 2

PHYSICS — 9749

MARK SCHEME

Aug/Sep 2022

Paper 1 Multiple Choice

Question	Key	Question	Key	Question	Key
1	B	6	D	11	B
2	A	7	C	12	A
3	C	8	B	13	D
4	C	9	D	14	C
5	A	10	C	15	D
16	D	21	A	26	A
17	A	22	B	27	A
18	B	23	D	28	C
19	D	24	A	29	D
20	C	25	D	30	B

1 mass of electron negligible compared to nucleons

question similar to asking for nuclear density:

$$\rho_{material} \approx \frac{mass}{V_{nucleus}} = \frac{\cancel{A}u}{\frac{\cancel{4}}{3}\pi r^3_{nucleus}}$$

$$\approx \frac{10^{-27}}{10^{-45}} = 10^{18}\ \text{kg m}^{-3}$$

2 $R = s\left(\frac{Et^2}{\rho}\right)^{0.2}$

units of s = units of $R\left(\frac{Et^2}{\rho}\right)^{-0.2}$

$$= \text{m}\left(\frac{(\cancel{\text{kg}}\ \text{m}^2\ \cancel{\text{s}^{-2}})(\cancel{\text{s}^2})}{\cancel{\text{kg}}\ \text{m}^{-3}}\right)^{-0.2}$$

$$= \text{m}\left(\text{m}^5\right)^{-0.2} = 1\ \text{(dimensionless)}$$

3 constant acceleration so

$$s = ut + \frac{1}{2}at^2 = t\left(u + \frac{-g}{2}t\right)$$

$$0 = u + \frac{-9.81}{2}(3.20)$$

$$u = 15.7\ \text{m s}^{-1}$$

4 upthrust depends on weight of fluid displaced so need to displace a greater volume of fluid, increase either x or z

5 each spring supports 4 N; area under force-extension graph up till 4 N:

$$\frac{1}{2}(3\times10^{-2})(4) = 0.060\ \text{J}$$

6 a counter example is friction between tyres exists, but does not reduce total energy when there is no slippage even as vehicle (the machine) does work (increase KE)

7 apply knowledge from Newton's cradle that transfer of KE between 2 masses is 100% if masses are equal and one mass is initially stationary

we model the system as separated blocks doing elastic collisions, take right +ve:

consider A and B only:

PCLM: $m_A u_A + 0 = m_A v_A + m_B v_B$

relative speed: $v_B - v_A = 10$

$$\cancel{m}(10) = \cancel{m}v_A + (4\cancel{m})(v_A + 10)$$

$$10 = 5v_A + 40$$

$$v_A = -\frac{30}{5} = -6\ \text{m s}^{-1}$$

$$v_B = v_A + 10 = 4\ \text{m s}^{-1}$$

so A will move left. B will undergo newton's cradle style collision until E moves to hit F

consider E and F only

PCLM: $m_E u_E + 0 = m_E v_E + m_F v_F$

relative speed: $v_F - v_E = 4$

$$(4\cancel{m})(4) = (4\cancel{m})v_E + \cancel{m}(4 + v_E)$$

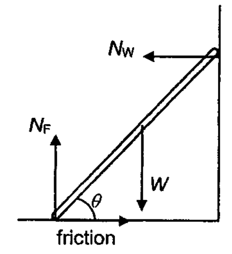
$$16 = 5v_E + 4$$

$$v_E = \frac{12}{5} = +2.4\ \text{m s}^{-1}$$

$$v_F = \frac{32}{5} = +6.4\ \text{m s}^{-1}$$

so both E and F moves to the right. that leaves B, C and D at rest.

8 sketch in order visualize



$N_F = W$

N_W = friction

pivot at wall

$$W\left(\frac{\cancel{L}}{2}\cos\theta\right) + (\text{friction})(\cancel{L}\sin\theta) = N_F(\cancel{L}\cos\theta)$$

$$N_F = \frac{W}{2} + N_W\tan\theta$$

$$N_W\tan\theta = N_F - \frac{W}{2}$$

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9 tension in string 1 provides centripetal force for 3 masses so must be largest magnitude; eliminate **A** and **C**

centre of mass of 3 separate masses is at centre i.e. mass 2 so tension in string 1 is equivalent to a string providing centripetal force to a mass of $3m$ at radius $2r$.

$T_1 = (3m)(2r)\omega^2$

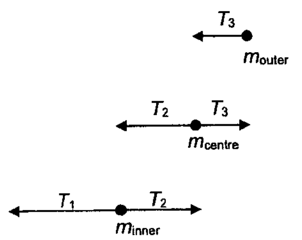
$T_3 = m(3r)\omega^2$

$\frac{T_1}{T_3} = 2$

eliminate **B**

or

via considering free bodies:



T_3 provides centripetal force on outer mass

$m(3r)\omega^2 = T_3$

vector sum of T_2 and T_3 provides centripetal force on centre mass

$m(2r)\omega^2 = T_2 - T_3$

$T_2 = m(2r)\omega^2 + T_3$

$= m(2r)\omega^2 + m(3r)\omega^2$

$= m(5r)\omega^2$

vector sum of T_2 and T_1 provides centripetal force on inner mass

$mr\omega^2 = T_1 - T_2$

$T_1 = mr\omega^2 + T_2$

$= mr\omega^2 + m(5r)\omega^2$

$= m(6r)\omega^2$

10 mass on moon needs just enough KE to reach location of 0 field strength, then it will accelerate towards earth "from rest":

loss in KE = gain in EPE

$\frac{1}{2}\cancel{m}v^2 - 0 = \cancel{m}(\Delta\phi)$

$v^2 = 2(\text{smaller area})$

$v = \sqrt{2(2.6\times10^6)}$

$= 2280 \text{ m s}^{-1}$

11 satellite is now further away from earth so GPE must increase

12 kinetic energy is directly proportional to thermodynamic temperature

$\frac{3}{\cancel{2}}kT = \frac{1}{\cancel{2}}mv^2$

$v = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3k}{m}}\left(\sqrt{T}\right)$

$\frac{v_{new} - v_{old}}{v_{old}} \times 100\%$

$= \frac{\sqrt{T_{new}} - \sqrt{T_{old}}}{\sqrt{T_{old}}} \times 100\%$

$= \frac{\sqrt{273.15+40.5} - \sqrt{273.15+32.1}}{\sqrt{273.15+32.1}}$

$= 1.4\%$

13 $pv = NkT \rightarrow p = \frac{Nk}{V}(T)$

X has less steep gradient

14 coin loses contact when piston retracts downwards at an acceleration larger than magnitude of free fall acceleration i.e.

$|a_{SHM}| \geq |g|$

$(\omega^2)x_0 \geq g$

$= (2\pi f)^2 x_0$

$f = \sqrt{\frac{9.81}{0.07}\frac{1}{4\pi^2}}$

$= 1.9 \text{ Hz}$

15 $\lambda = 2(0.90) = 1.80$ m

$\frac{\Delta\phi}{2\pi} = \frac{\Delta x}{\lambda}$

$\Delta\phi = (360°)\left(\frac{\Delta x}{\lambda}\right)$

$= (360°)\left(\frac{1.30}{1.80}\right)360$

$= 260°$

16 check for max observable order for violet:

$d \sin\theta = n\lambda$

let $\sin\theta \rightarrow 1$

$n \rightarrow \frac{d}{\lambda} = \frac{\frac{1\times10^{-2}}{5000}}{400\times10^{-9}}$

$= 5$

fourth order violet is visible

17 aim is the NOT distinguish the pixels

hence use the smallest wavelength to determine the shortest pixel distance that can be distinguished.

$\sin\theta \approx \frac{\lambda}{b} \approx \frac{s}{r}$

for maximum distance between pixels s_{max}, we consider shortest wavelength (blue):

$\frac{d}{0.1} < \frac{\lambda}{b}$

$\frac{d}{0.1} < \frac{470\times10^{-9}}{4.0\times10^{-3}}$

$d < 1.2\times10^{-5}$ m

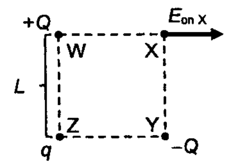
18 connecting wire so all metallic surfaces at same potential

$V_1 = V_2$

$\left(\frac{1}{\cancel{4\pi\varepsilon_0}}\right)\frac{q_1}{r_1} = \left(\frac{1}{\cancel{4\pi\varepsilon_0}}\right)\frac{q_2}{r_2}$

$\frac{E_1}{E_2} = \frac{\left(\frac{1}{\cancel{4\pi\varepsilon_0}}\right)\left(\frac{q_1}{r_1^2}\right)}{\left(\frac{1}{\cancel{4\pi\varepsilon_0}}\right)\left(\frac{q_2}{r_2^2}\right)} = \frac{\left(\frac{q_1}{r_1}\right)\frac{1}{r_1}}{\left(\frac{q_2}{r_2}\right)\frac{1}{r_2}} = \frac{r_2}{r_1}$

19 electric force is vector quantity, and the charge at X is negative so electric field strength actually points to right:



$\overline{E_X} = \overline{E_{by\,W}} + \overline{E_{by\,Z}} + \overline{E_{by\,Y}}$

vertically :

$0 = \frac{q}{L^2+L^2}\cos 45° - \frac{Q}{L^2}$

$= \frac{q}{L^2+L^2}\cos 45° - \frac{Q}{L^2}$

$= \frac{q}{2L^2}\frac{1}{\sqrt{2}} - \frac{Q}{L^2}$

$q = \frac{2\sqrt{2}\cancel{L^2}}{\cancel{L^2}}Q$

20 resistance of R_3 alone is larger than the effective resistance of R_2 in parallel with R_3

by potential divider rule:
p.d. across R_1 larger
p.d. across R_3 smaller
total circuit resistance drops so battery outputs more power $P = \frac{(\text{emf})^2}{R_{total}}$

21 by potential divider rule:

$$\frac{R_1}{R_1+R_2}E_{sec}=\frac{60}{L}E_{main} \quad \text{——(1)}$$

$$\frac{R_2}{R_1+R_2}E_{sec}=\frac{20}{L}E_{main} \quad \text{——(2)}$$

$$\frac{(2)}{(1)}:\frac{R_2}{R_2}=\frac{20}{60}=\frac{1}{3}$$

22 with resistor across A and B, there is complete circuit for which induced current can flow, so there is damping on oscillations.

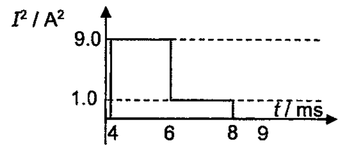
23 consider change in magnetic flux:

$$\Delta(BA)=A(B_{final}-B_{initial})$$
$$=-2AB_{initial}$$
$$=-2(25\times10^{-4})(2.0\times10^{-4})\sin 60°$$
$$=-\left(\frac{\sqrt{3}}{2}\right)(10^{6})$$

by Faraday's law, induced e.m.f. E is:

$$|E|=\frac{d}{dt}(N\phi)$$
$$=IR=\left(\frac{d}{dt}Q\right)R$$
$$\Delta N\phi=R\langle Q\rangle$$
$$\langle Q\rangle=\frac{N\Delta\phi}{R}=\frac{N\Delta BA}{R}$$
$$=\frac{(500)\frac{\sqrt{3}}{2}(10^{-6})}{5.0}$$
$$=8.66\times10^{-5}\text{ C}$$

24 1 period is 5 ms



area under I^2 graph $=(9)(2)+(1)(2)$

$$=20\text{ A}^2\text{ ms}^2$$

mean square $I=\frac{20}{T}=\frac{20}{5}$

$$=4\text{ A}^2$$
$$I_{rms}=2\text{ A}$$
$$\langle P\rangle=I_{rms}^2R=52\text{ W}$$

25 low intensity high freq can result in photoelectric effect, eliminate **A**

$$\left.\begin{aligned}hf-\Phi&=eV_s\\ h(2f)-\Phi&\neq e(2V_s)\end{aligned}\right\}\text{eliminate } \mathbf{B}$$

statement is correct for **min frequency** so should have been *max* wavelength, eliminate **C**

intensity can mean increased energy per photon or more photons

26 electron KE converted to photon:

$$eV=\frac{hc}{\lambda}$$
$$V=(\lambda^{-1})$$
$$\lg V=\lg\frac{hc}{e}+(-1)\lg\lambda$$

straight line with negative gradient

27 by Heisenberg's uncertainty principle, $\Delta p\Delta x\geq h$

$$\Delta p=\left(\frac{0.20}{100}\right)m_e v$$
$$\Delta x=\frac{h}{\Delta p}=\frac{h}{\left(\frac{0.20}{100}\right)m_e v}$$
$$=\frac{6.63\times10^{-34}}{\left(\frac{0.20}{100}\right)(9.11\times10^{-31})(1.5\times10^{6})}$$
$$=2.4\times10^{-7}\text{ m}$$

28 $C=(C_0)\exp(-\lambda t)+C_{bg}$

$$=(77.3-8.3)\exp\left(-\frac{\ln 2}{752}(280)\right)+8.3$$
$$=61.6\text{ s}^{-1}$$

29 energy needed in reaction

$$=(m_H+m_O-m_N-m_\alpha)uc^2$$
$$=\begin{pmatrix}1.007825+16.999130\\-14.003074-4.002604\end{pmatrix}uc^2$$
$$=0.001277(1.66\times10^{-27})(3\times10^{8})^2$$
$$=1.91\times10^{-13}\text{ J}=1.19\times10^{6}\text{ eV}$$

30 Isotope P could be formed from isotope Y after 2 successive alpha decays.

Isotope R could be formed from isotope Y after an alpha decay followed by a beta decay (or a beta decay followed by an alpha decay).

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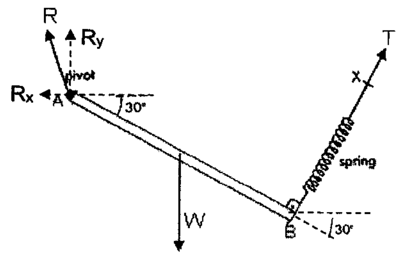
August/September 2022

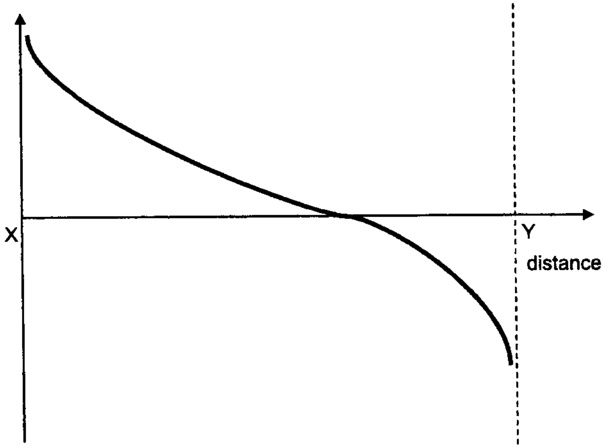
Paper 2
Structured Questions

Qn	Answer	Marks
1(a)	Forces must be labelled forces clearly in full – Weight, Reaction Force, Tension Lines of action forces (including intersection of the 3 lines) must be clearly shown.	1
(b)	Let T be the tension in the spring. Taking moments about A, Sum of clockwise moment = Sum of anticlockwise moment mg (0.20 cos30°) = T (0.40) 1.2(9.81) (0.20 cos30°) = T (0.40) T = 5.10 N	1 1

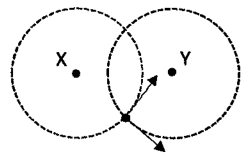
Qn	Answer	Marks
(c)	 Let R_x and R_y be the horizontal and vertical components of the reaction force R. Resolving forces horizontally, $R_x = T\cos 60°$ $= 5.10\cos 60°$ $= 2.55$ N Resolving forces vertically, $R_y + T\sin 60° = W$ $R_y + 5.10\sin 60° = (1.2)(9.81)$ $R_y = 7.36$ N magnitude of reaction force $R = \sqrt{R_x^2 + R_y^2}$ $= \sqrt{2.55^2 + 7.36^2}$ $= 7.79$ N	1 1 1
(c)	increase (stiffer spring so a smaller extension needed for the same elastic force, resulting in larger angle)	1

BP-471

2(a)(i)	Total momentum of an isolated system of interacting bodies before and after collision remains constant if no net external force acts on the system.	1
(a)(ii)	Presence of external force like weight / force from the ground	1
(b)	By Conservation of Energy, loss of gravitational potential energy = gain in kinetic energy $\not{m}gh = \frac{1}{2}\not{m}v^2$ $v = \sqrt{2gh}$ $= \sqrt{2(9.81)(2.0)}$ $= 6.26$ m s^{-1}	1
(c)	collision is elastic, total KE before and after bounce conserved $\frac{1}{2}(0.8)(6.26)^2 = \frac{1}{2}(0.3)(v^2) + \frac{1}{2}(0.5)(3.2)^2$ $v = 9.35$ m s^{-1}	1 1

3(a)(i)	Since the direction of field strength is directed upwards at point O, the horizontal component of the electric field strength due to the 2 charges at O are equal in magnitude and opposite in direction. $\frac{q_1}{4\pi\varepsilon_o r^2}\sin 30° = \frac{q_2}{4\pi\varepsilon_o r^2}\sin 60°$ $\frac{q_1}{q_2} = \frac{\sin 60°}{\sin 30°} = 1.73$ $= 1.7$	1
3(a)(ii)	 correct shape, graph does not touch the y-axis or dotted line (else max 1) $E = 0$ at position nearer to Y Relative field strength at X larger in magnitude than at Y	1 1
3(b)(i)	electric field strength is a vector quantity Since the resultant field strength at point O is directed upwards, the resultant electric field strength is the vector sum of the vertical component of the electric field strength due to the 2 charges. $E_{resultant} = E_1 + E_2$ $= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r^2}\right)\cos 30° + \frac{1}{4\pi\varepsilon_0}\left(\frac{q_2}{r^2}\right)\cos 60°$ $= \frac{q_2}{4\pi\varepsilon_0 r^2}\left[(1.7)\cos 30° + \cos 60°\right]$ $= \frac{200\times10^{-9}}{4\pi(8.85\times10^{-12})(0.50)^2}\left[(1.7)\cos 30° + \cos 60°\right]$ $= 1.42\times10^4$ V m^{-1}	1 1

Qn	Answer	Marks
(b)(ii)	electric potential is a scalar quantity total electric potential at point O is <u>sum</u> of <u>electric potential at that point due to the 2 charges</u>. $V_{resultant} = V_1 + V_2$ $= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r}\right) + \frac{1}{4\pi\varepsilon_0}\left(\frac{q_2}{r}\right)$ $= \frac{q_2}{4\pi\varepsilon_0 r}\left[(1.7)+1\right] = \frac{200\times10^{-9}}{4\pi(8.85\times10^{-12})(0.50)}(2.7)$ $= 9710 \text{ V}$	1
(b)(iii)	work done $W = q\Delta V$ $= (-2q_2)(V_{final} - V_{initial})$ $= (-2)(200\times10^{-9})(9710-0)$ $= -0.00388 \text{ J}$ $= -2.43\times10^{16} \text{ eV}$	1 1

Qn	Answer	Marks
4(a)	Force per unit current unit length of wire Carrying a wire that is normal to the magnetic field.	1
(b)(i)1.	direction (dots above current, crosses below current) field strength stronger when nearer wire (higher density of dots/crosses nearer the current)	1 1
(b)(i)2.	positive	1
(b)(ii)	Force is always perpendicular to the velocity of the particle <u>No displacement in the direction of force</u>, so <u>work done</u> by the force is <u>zero</u>, no change in kinetic energy so no change in speed.	1 1
(b)(iii)	Done in vacuum, so no loss of kinetic energy due to no collision with air particles, so no change in speed. OR Weight of the particle is negligible compared to the magnetic force.	1
(c)	Observe that 3 cm, 4 cm and 5 cm form a right-angle triangle. So the magnetic flux density at point Z due to currents in X and Y are perpendicular to one another.  The magnetic flux density at Z is the <u>vector sum</u> of <u>magnetic flux densities</u> due to X and Y. $B = \frac{\mu_0 I}{2\pi d}$ $B_{resultant} = \sqrt{B_X^2 + B_Y^2}$ $= \sqrt{\left[\frac{(4\pi\times10^{-7})(7.0)}{2\pi(3.0\times10^{-2})}\right]^2 + \left[\frac{(4\pi\times10^{-7})(8.0)}{2\pi(4.0\times10^{-2})}\right]^2}$ $= 6.15\times10^{-5} \text{ T}$	1 1

BP-473

Qns	Answer	Marks
5(a)(i)	At 22.5 °C, R_T = 1.6 kΩ (read from graph) Total resistance = $\left(\frac{1}{1600}+\frac{1}{1600}\right)^{-1}$ = 800 Ω	1 1
(a)(ii)	Using potential divider principle, $\frac{V}{9.0}=\frac{800}{800+1200}$ $V = 3.6$ V	1 1
(b)(i)	Using potential divider principle, $\frac{1200}{R_{AB}}=\frac{5}{4}$ $R_{AB} = 960\ \Omega$	1 1
(b)(ii)	$\frac{1}{960}=\frac{1}{1600}+\frac{1}{R_T}$ $R_T = 2400\ \Omega$ From graph, temperature = 10.5 °C **OR** 10.75 °C (read to half the smallest division) **OR** 11 °C	1 1
(c)	From graph, no calibration data available between 24°C to 25°C (accept "at 25 °C"O). Since graph is non-linear, hence cannot extrapolate to get values of temperature. Based on temperature range of 0 – 25 °C, V_{AB} has a range of 0.48 V to 3.5 V. Since only a small part of the voltage scale is used, the measurement of temperature will be less sensitive.	1 1

Qns	Answer	Marks
6(a)(i)	Progressive wave is one where energy is transferred in the direction of propagation of the wave. Transverse wave is one where the direction of oscillations is normal to the direction of energy propagation.	1 1
6(a)(i)	Polarisation is where oscillations of a wave to one direction only, in the plane normal to the direction of energy propagation. Since the oscillations in a longitudinal wave is parallel to the direction of energy propagation, longitudinal wave cannot be polarised.	1 1
6(b)(i)	Based on the amplitudes of the electricity field strength graphs, $A = A_o \cos\theta$ $16 = 9\cos\theta$ $\theta = 56°$	1 1
6(b)(ii)	$I \propto A^2$ $I = \cos^2(\theta)$ $\frac{I}{I_0} = \cos^2(\theta) = \left(\frac{9}{16}\right)^2 = 0.316$	1 1

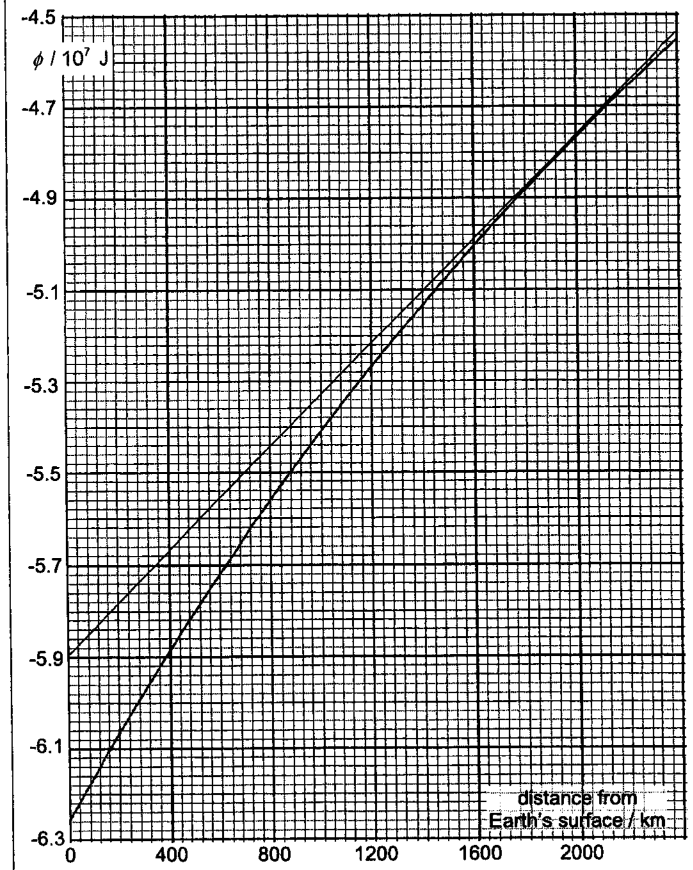
Qn	Answer	Marks
7(a)(i)	Loss in electric potential energy = gain in kinetic energy $\frac{1}{2}m_e v^2 = eV$ $\frac{1}{2}(9.11\times10^{-31})v^2 = (1.60\times10^{-19})(45)$ $v = 3.98\times10^6$ $\approx 4.0\times10^6$ m s^{-1}	1
(ii)	$p = m_e v$ $= (9.11\times10^{-31})(4.0\times10^6)$ $= 3.644\times10^{-24}$ kg m s^{-1} $\lambda = \frac{h}{p}$ $= \frac{6.63\times10^{-34}}{3.644\times10^{-24}}$ $= 1.82\times10^{-10}$ m •	1 1
(b)(i)	Spacing between the crystals is of the same order of magnitude as the de Broglie wavelength of electron (so diffraction effect is significant). The crystal acts as a diffraction grating for the beam of electrons. Bright spots observed when constructive interference takes place.	1 1 1
(ii)	As the accelerating potential increase, the **de Broglie wavelength of the electron decreases.** Hence, the **angle of diffraction decreases** so **spacing between bright spots decrease** •	1 1

Qn	Answer	Marks
8(a)(i)	$v_y = v\cos\theta$ $= (536)\cos(90° - 86.7°)$ $= 535$ m s^{-1}	1 A0
(a)(ii)	$s = ut + \frac{1}{2}at^2$ $-50.4 = (535)t + \frac{1}{2}(-9.81)t^2$ $t = 109$ s	1 1
(a)(iii)	$v^2 = u^2 + 2as$ $0 = 535^2 + 2(-9.81)s_{max}$ $s_{max} = 14588$ m height $= 14588 + 50.4$ ≈ 14600 m	1 1
(b)(i)	$\frac{\cancel{mg}h_{actual}}{\cancel{mg}h_{ideal}} = \frac{9300}{14600} = 0.637$	1
(b)(ii)	Larger Drag force increases with larger relative velocity. Traditional rockets start off stationary and hence experience less drag across the ascend process	1 1
(c)(i)	$\omega = \frac{2\pi}{T} = \frac{2\pi}{24\times60\times60} = 7.27\times10^{-5}$ rad s^{-1}	1
(c)(ii)	Towards east. Launching projectile in the same direction as Earth's rotation reduces the amount of kinetic energy that the accelerator has to transfer to the projectile for the projective to achieve the desired speed.	1 1
(d)(i)	$v = r\omega = r\left(\frac{\theta}{t}\right)$ $= (50.0)\left(\frac{2\pi(450)}{60}\right)$ $= 2356$ $= 2360$ m s^{-1}	1

BP-475

BP~476

Qn	Answer	Marks
(d)(ii)	$v_{\text{at launch}} = \frac{8000 \times 10^3}{60 \times 60} = 2220 \text{ m s}^{-1}$ $\text{ratio} = \frac{\frac{1}{2} m v_{\text{at launch}}^2}{\frac{1}{2} m v_{\text{before}}^2} = \left(\frac{2220}{2360}\right)^2 = 0.880$ (accept 0.890)	1
(d)(iii)	**Minimise loss of** (kinetic) **energy** as heat due to work done against **air resistance**	1
(e)(i)	KE just before launch $= \frac{1}{2} m v^2$ $= \frac{1}{2}(200)(2360)^2$ $= 5.57 \times 10^8$ J time needed $= \frac{5.57 \times 10^8}{100 \times 10^3} = 5570 \text{ s} = 92.8 \text{ min}$	
(e)(ii)	$\frac{a_c}{g} = \frac{r\omega^2}{g}$ $= (50.0)\left(\frac{450(2\pi)}{60}\right)^2 \frac{1}{9.81}$ $= 11300$ No. They were subject to more than 10 000 *g* for more than an hour.	1 1
(f)(i)	**Work by per unit mass** in bringing **a small test mass** from **infinity to that point**	1

[redacted]		
(f)(ii)	 $g = -\frac{d\phi}{dr} \approx \frac{[(-4.54)-(-5.9)] \times 10^7}{(2400-0) \times 10^3} = 5.67 \text{ N kg}^{-1}$	1 1
(f)(iii)	The astronauts experience the **same acceleration towards centre of the Earth** as the space craft. Hence there is **no contact force by space craft on the astronaut.**	1 1
(f)(iv)	$\Delta U = m_{\text{projectile}}(\Delta\phi) = m_{\text{projectile}}(\phi_{\text{final}} - \phi_{\text{initial}})$ $= (200)((-5.89-(-6.25)) \times 10^7)$ $= 7.20 \times 10^8$ J	1 1

Paper 3
Longer Structured Questions

Qn	Answer	Marks
1(a)(i)	gravitational force of attraction per unit mass acting on (OR experienced by) a small test mass placed at that point (in the gravitational field)	1
1(a)(ii)	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**	1
	Let m be the mass of an object distance R away from Mass M	1
	field strength is gravitational force of attraction per unit mass experienced by **small test mass** placed at that point $\frac{F}{m} = \frac{1}{m}\frac{GMm}{r^2} = \frac{GM}{r^2}$	1
1(b)(i)	volume of star $= \frac{4}{3}\pi r^3$ $= \frac{4}{3}\pi\left(2.7\times10^4\right)^3$ $= 8.245\times10^{13}\ \text{m}^3$	1
	$\rho = \frac{m}{V} = \frac{6.2\times10^{30}}{\frac{4}{3}\pi\left(2.7\times10^4\right)^3} = 7.52\times10^{16}\ \text{kg m}^{-3}$	1
1(b)(ii)	(words to effect of) density increase closer to centre	1
	(words to effect of) outer layers compress inner layers	1

Qn	Answer	Marks
1(b)(iii)	By conservation of energy: loss in KE = gain in GPE $\frac{1}{2}mv^2 - 0 = 0 - \left(-\frac{GMm}{r}\right)$	1
	$v = \sqrt{\frac{2Gm}{r}} = \sqrt{\frac{2\left(6.67\times10^{-11}\right)\left(6.2\times10^{30}\right)}{2.7\times10^4}}$ $= 1.75\times10^8\ \text{m s}^{-1}$	1

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	Answer	Marks
2(a)	oscillatory motion where acceleration is directly proportional to displacement from equilibrium position and directed opposite to displacement	1
2(b)(i)	amplitude $x_0 = 0.7$ m $\lvert v \rvert = \omega\sqrt{x_0^2 - x^2} = \left(\frac{2\pi}{T}\right)\sqrt{x_0^2 - x^2}$ $= \left(\frac{2\pi}{4.0}\right)\sqrt{0.7^2 - 0.2^2}$ $= 1.05$ m s^{-1}	1 1
2(b)(ii)	relative to equilibrium $x = -0.15$ m $x = x_0 \sin \omega t$ $= x_0 \sin\left[\left(\frac{2\pi}{T}\right)t\right]$ OR relative to ground $x = 0.55$ m $x = x_0 \sin \omega t + 0.7$ $0.55 = x_0 \sin\left[\left(\frac{2\pi}{T}\right)t\right] + 0.7$ $-0.15 = (0.7) \sin\left[\left(\frac{2\pi}{4.0}\right)t\right]$ duration $= 2.13748 - (-0.13748)$ $= 2.27$ s (can be by GC)	 1 1

	Answer	Marks
3(a)(i)	$E = mL_v + h_{loss} = Pt$ $P = \left(\frac{m}{t}\right)L_v + \frac{h_{loss}}{t}$ $P_1 = \left(\frac{m}{t}\right)_1 L_v + \left(\frac{h_{loss}}{t}\right)_1$ ——(1) $P_2 = \left(\frac{m}{t}\right)_2 L_v + \left(\frac{h_{loss}}{t}\right)_2$ ——(2) (1)−(2) $P_1 - P_2 = \left[\left(\frac{m}{t}\right)_1 - \left(\frac{m}{t}\right)_2\right]L_v$ $L_v = \frac{P_1 - P_2}{\left(\frac{m}{t}\right)_1 - \left(\frac{m}{t}\right)_2} = \frac{I_1V_1 - I_2V_2}{\left(\frac{m}{t}\right)_1 - \left(\frac{m}{t}\right)_2}$ $= \frac{(5.0)(78) - (4.0)(60)}{\frac{16\times10^{-3}}{1.5\times60} - \frac{10\times10^{-3}}{1.5\times60}}$ $= 2.25\times10^6$ J kg^{-1}	1 1 A0
3(a)(ii)	pure substances undergo phase change at constant temperature (words to that effect) so temperature difference with surrounding kept constant	1
3(b)(i)	$Q = mL$ $= (1.0)(2.25\times10^6)$ $= 2.25\times10^6$ J	 1 1
3(b)(ii)	$W_{on} = -p\Delta V = -p(V_{final} - V_{initial})$ $= -(1.0\times10^5)(1.67 - 1.04\times10^{-3})$ $= -(1.0\times10^5)(1.66896)$ $W_{by} = +1.67\times10^5$ J	1 1
3(b)(iii)	$\Delta U = Q + W$ $= 2.25\times10^6 + (-1.67\times10^5)$ $= 2.08\times10^6$ J	 1
3(b)(iv)	$\Delta PE = PE_{gas} - PE_{liquid}$ $PE_{gas} = \Delta PE + PE_{liquid}$ $= 2.08\times10^6 + 3.41\times10^5$ $= 2.42\times10^6$ J	 1 1

Qn	Answer	Marks
3(b)(v)	pure substances undergo phase change at constant temperature so total translational kinetic energy of particles remain constant	B0
	large increase in volume for phase change from liquid to gas so separation between molecules instead	1
	intermolecular bonds are complete broken as potential energy between particles increases	1
	work is done against atmosphere	1

Qn	Answer	Marks
4(a)(i)	current in solenoid produces magnetic field with field lines parallel to axis of solenoid	1
	radii of copper disc cuts magnetic flux as it rotates,	1
	(by Faraday's law) rate of change of magnetic flux linkage results in emf	1
4(a)(ii)	consider a radial strip of copper: by faraday's law: $\lvert E\rvert = \frac{d}{dt}(N\phi) = \frac{d}{dt}(NBA)$ $= (1)(B)\frac{d}{dt}\left(\frac{1}{2}R^2\theta\right)$ $= \frac{1}{2}BR^2\omega$ $= \frac{1}{2}BR^2(2\pi f)$ $= BAf$	1 1
4(b)(i)	at null deflection, p.d. across resistor = induced e.m.f. $V_R = E$ $IR = BAf$ $= (\mu_0 nI)Af$ same current in solenoid and resistor BUT NOT COPPER (disc/axle) $R = \mu_0 nAf$	1
4(b)(ii)	no electrical quantities needed so not dependent on accuracy of any voltmeter, ammeter or ohmmeter used	1
4(c)	$BAf = (\mu_0 nI)Af$ __(1) $R = \mu_0 nAf$ __(2) take $\frac{(1)}{(2)}$: $\frac{BAf}{R} = \frac{(\mu_0 nI)Af}{\mu_0 nAf}$ $B = \frac{IR}{AF} = \frac{(1.0\times10^{-3})(10)}{(\pi(0.20^2))(5.0)}$ $= 0.0159$ T	1

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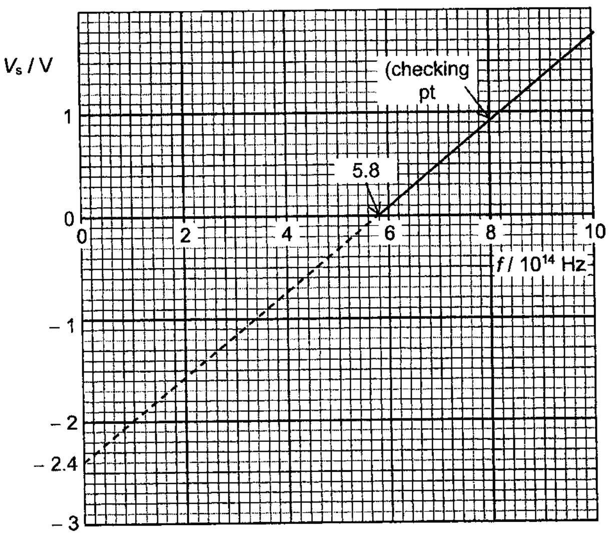
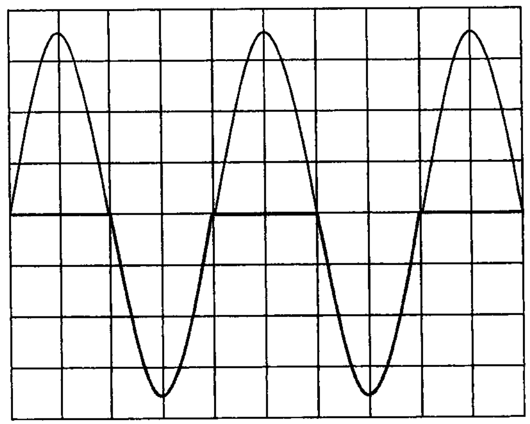
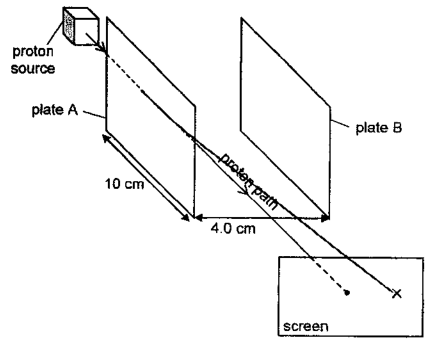
Qns	Answer	Marks
5(a)	$hf = \Phi + \frac{1}{2}mv_{max}^2$ $= \Phi + eV_s$ $V_s = \left(\frac{h}{e}\right)f - \frac{\Phi}{e}$ when $V_s = 0$, $f = \frac{\Phi}{h}$ $= \frac{2.4(1.6\times10^{-19})}{6.63\times10^{-34}} = 5.79\times10^{14}$ Hz when $f = 0$, $V_s = -\frac{\Phi}{e}$ $= -\frac{2.4\text{ eV}}{e} = -2.4$ V (extrapolated)	**1** cut x-axis at (5.8, 0) **1** dotted line to (0, –2.4) **OR** pass through (8, 0.9)



Qns	Answer	Marks
5(b)	$V_{peak,\ supply} = \sqrt{2}\,V_{supply,\ rms}$ $= \sqrt{2}(4.6) = 6.5$ V $V_{peak,\ diode} = V_{peak,\ supply}$ $= 6.5$ V	**1**

Qns	Answer	Marks
5(c)		**1**

Qn	Answer	Marks
6(a)(i)	time spent between plates: $t=\frac{L}{v}=\frac{10\times10^{-2}}{6.5\times10^{5}}=1.54\times10^{-7}$ s	1
	$F=qE=ma$ $a=\frac{qE}{m}=\frac{q\Delta V}{md}=\frac{(1.6\times10^{-19})(500)}{(1.67\times10^{-27})(4.0\times10^{-2})}=1.20\times10^{12}$ m s^{-2}	1
	$v_{\perp}=u+at=0+at$ $=1.84\times10^{5}$ m s^{-1}	1
	speed $=\sqrt{v_{\perp}^2+v_{initial}^2}$ $=6.76\times10^{5}$ m s^{-1} (accept 6.8×10^{5} m s^{-1})	1
6(a)(ii)	consider potential change from 0V equipotential line: $W=q\Delta V$ $\Delta V=\frac{\frac{1}{2}m_p v_{\perp}^2}{e}=177$ V Potential is – 177 V as protons will displace towards region of lower potential	1
	OR	
	consider displacement from 0V equipotential line: $s_{\perp}=ut+\frac{1}{2}at^2$ $=0+\frac{1}{2}\left(\frac{(1.6\times10^{-19})(500)}{(1.67\times10^{-27})(4.0\times10^{-2})}\right)\left(\frac{10\times10^{-2}}{6.5\times10^{5}}\right)^2$ $=0.0141$ m	1 1
	$V=\frac{s_{\perp}}{2.0\text{ cm}}(250)=177$ V Potential is – 177 V as protons will displace towards region of lower potential	

Qn	Answer	Marks
6(b)		
6(c)	uniform magnetic field (where field lines) pointing upwards	1
	no deviation for particles with velocity that result in equal **magnitudes** of electric and magnetic force	1
	acting in opposite **directions**	1

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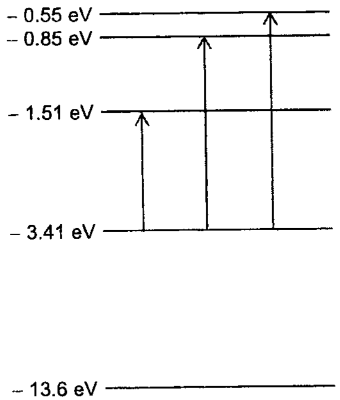
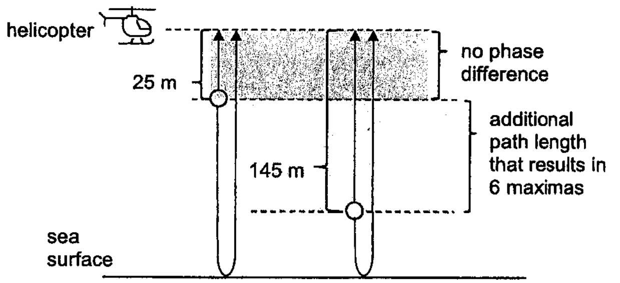
Qn	Answer	Marks
7(a)	a photon is a discrete packet of energy of electromagnetic radiation the energy of one photon is directly proportional to the frequency of electromagnetic radiation, $E = hf$	1
7(b)(i)	$E_{max} = \frac{hc}{\lambda_{min}} = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(400\times10^{-9})(1.60\times10^{-19})} = 3.11$ eV $E_{min} = \frac{hc}{\lambda_{max}} = \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(700\times10^{-9})(1.60\times10^{-19})} = 1.78$ eV	1
7(b)(ii)	The absorbed wavelengths are remitted in all directions; only part of the absorbed wavelengths is in the direction of the beam. These wavelengths appeared as dark lines with very much reduced intensities in the observed spectrum.	1
7(b)(iii)	 • Correct identification of the 3 possible transitions in the visible light range and nothing else (possible for electrons to start from n = 2 since question did not state cool gas) $E_{2\to3}$: 1.89 eV $E_{2\to4}$: 2.55 eV $E_{2\to5}$: 2.86 eV • Arrows pointing UP (absorption spectrum)	1 1
7(c)(i)	photons of visible light has <u>insufficient energy</u> to cause any transition of the electron from the lowest energy level. no dark band observed	1 1

Qn	Answer	Marks
7(c)(ii)1.	The 3 transitions for the 3 bright lines observed are: $E_{3\to2}$:1.89 eV $E_{4\to2}$:2.55 eV $E_{5\to2}$:2.86 eV Hence energy given to the electron must be from $E_{1\to5}$ so that the 3 transitions within the visible light spectrum can take place. $E_{1\to5} = 13.6 - 0.54 = 13.1$ eV Hence V = 13.1 V	1 1
7(c)(ii)2.	$\lambda = \frac{hc}{E_{5\to2}}$ $= \frac{(6.63\times10^{-34})(3.00\times10^{8})}{(2.86)(1.60\times10^{-19})}$ $= 4.35\times10^{-7}$ m	1

Qn	Answer	Marks
8(a)(i)	when two or more waves meet and overlap, resultant displacement is vector sum of displacement of each individual wave	1
8(a)(ii)1.	waves from emitter directly and after reflecting off the sea surface meet and overlap at receiver/helicopter different path lengths as emitter drops so waves arrive at receiver/helicopter changing phase difference maxima when waves arrive in phase and undergo constructive interference minima when waves arrives in anti-phase and undergo destructive interference	1 1 1
8(a)(ii)2.	(words to effect of) attenuation of waves increase with distance from emitter / waves have lower intensity at greater distance from emitter / are of lower amplitude at greater distance from emitter (words to effect of) when emitter is near helicopter, amplitude/intensity of reflected wave is lower OR reflected wave is more attenuated than wave reaching directly so incomplete destructive interference OR (words to effect of) when emitter is near water surface, path length of both waves reaching helicopter directly and reflected wave is similar. so waves reach helicopter with similar intensity / amplitude / attenuation, resulting in more complete destructive interference	1 1
8(a)(iii)	(words to effect of) 6 maximas between d = 25 m and d = 145m (words to effect of) distance between adjacent maxima is half wavelength $6\left(\frac{\lambda}{2}\right)=145-25$ $\lambda = 40$ m 	1 1 1
8(b)(i)	splitting of a single heavy nucleus when bombarded by neutrons to form two or more lighter nuclei of approximately same mass with neutrons emitted	1
8(b)(ii)	spontaneous and random emission of ionizing radiation in the form of alpha particles, beta particles or gamma ray photons from unstable nucleus to become a more stable nucleus	1

Qn	Answer	Marks
8(b)(iii)	combining of two or more light nuclei under very high temperatures to form a single, more massive nucleus	1
8(c)(i)	allows values of different orders of magnitude to be shown on one graph / along one axis	1
8(c)(ii)	answer deals with conservation of mass in the form of nucleon number fission results in two daughter nuclei and two neutrons of <u>total nucleon number 236</u> $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{117+x}_{92-y}A + ^{117-x}_{y}B + 2^{1}_{0}n$ if same mass, each product has nucleon number of 117 $\left(=\frac{1}{2}(236-2)\right)$ if one fission product has a nucleon number less than 117, the other fission product have the same difference in nucleon number above 117 therefore symmetrical about 117	1 1 1 A0
8(d)(i)	$^{140}_{53}I \rightarrow ^{139}_{53}I + ^{1}_{0}n$	1
8(d)(ii)	$^{140}_{53}I \rightarrow ^{140}_{54}Xe + ^{0}_{-1}e \; (+\bar{\nu})$	1
8(d)(i)	energy released = [(total mass of reactant) – (total mass of product)] uc^2 $=[139.9019-(138.8969+1.0087)]uc^2$ $=-0.0037uc^2$ OR -5.58×10^{-13} J OR -3.49×10^{6} eV not feasible	1
8(d)(i)	energy released = [(total mass of reactant) – (total mass of product)] uc^2 $=[139.9019-(139.8919+0.0006)]uc^2$ $=0.0094uc^2$ OR 1.40×10^{-12} J OR 8.75×10^{6} eV feasible	1

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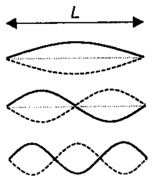
9(a)(i)	[source of force] wire experiences magnetic force directed normal to both current and magnetic field [property of vibration] alternating current so direction of force oscillates between vertically upwards and downwards	1 1
9(a)(ii)1.	$v = f\lambda = (50)\left(2\times\left(40\times10^{-2}\right)\right) = 40 \text{ m s}^{-1}$	1
9(a)(ii)2.	wave of same type, same frequency, same speed, (same amplitude) are reflected off fixed ends X and P and travel towards each other in opposite directions waves superpose along length XP speed is that (of energy transfer) of individual/constituent incident / reflected wave in wire	1 1 1 1
9(a)(ii)3.	natural frequency of wire changes and no longer matches driving frequency from alternating current wire no longer in resonance so amplitude decrease	1 1
9(a)(ii)4.	$L = \lambda_1$ $f_1 = \frac{v}{\lambda_1} = \frac{40}{40\times10^{-2}} = 100 \text{ Hz}$ $L = \frac{3}{2}\lambda_2$ $f_2 = \frac{v}{\lambda_2} = \frac{40}{\left(\frac{2}{3}\right)40\times10^{-2}} = 150 \text{ Hz}$ 	1
9(b)(i)	$A = A_o \exp(-\lambda t)$ $\ln A = \ln A_o - \lambda t$ The gradient of the ln (A /s^{-1}) against t graph will give the value for -λ. ln (A /s^{-1}) in 1990 = 16.80; ln (A /s^{-1}) in 1997 = 16.20 gradient $= \frac{y_1 - y_2}{x_1 - x_2} = \frac{16.20 - 16.80}{7} = -0.0857 \text{ y}^{-1}$ $\lambda = 2.72\times10^{-9} \text{ s}^{-1}$	 1 1
9(b)(ii)	$T_{½} = \frac{\ln 2}{\lambda}$ $T_{½} = \frac{\ln 2}{2.72\times10^{-9}} = 2.55\times10^{8} \text{ s}$ $= 8.1 \text{ yr}$	1 1

9(b)(iii)	At year 1997, ln (A / s^{-1}) = 16.20 $A = e^{16.20} = 1.10 \times 10^{7} \text{ s}^{-1}$. The number of nuclei which ought to be present is $N_1 = \frac{A}{\lambda} = \frac{1.10\times10^{7}}{2.718\times10^{-9}}$ $= 4.00\times10^{15}$	1 1
9(b)(iv)	The number of nuclei left after the theft is $N_2 = \frac{A}{\lambda} = \frac{e^{15.92}}{2.718\times10^{-9}} = 3.02\times10^{15}$ The number of nuclei stolen is given by $4.00\times10^{15} - 3.02\times10^{15} = 0.975\times10^{15}$	1 1
9(b)(v)	gradient corresponds to the (magnitude of) decay constant decay constant is <u>not dependent on the number of radioactive nuclei</u> but is <u>characteristic/unique</u> to a particular nuclide	 1 1

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2022
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749

MARK SCHEME

August/September 2022

Paper 4
Practical

Qns	Marking Instructions	Mark
1(a)(i)	Raw values of x and L_1 to the nearest 0.1 cm Mean (need to show repeat) of x and L_1 in range of 23.0 – 27.0 cm	1
1(a)(ii)	$\Delta L_1 \approx 0.2$ cm to 0.5 cm correct calculation of percentage uncertainty to 2 s.f. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown AND the uncertainty is greater than instrument precision 0.1 cm.	1
1(b)(i)	Raw values of L_2 to the nearest 0.1 cm. Repeated values of L_2 in range of 28.3 cm to 38.3 cm	1
1(b)(ii)	absolute uncertainty in L_2 > absolute uncertainty in L_1 Correct method of calculation to obtain percentage uncertainty.	1
1(b)(iii)	Correct calculation of $\frac{L_1}{L_2}$ to correct s.f.	1
1(c)(i) /(ii)	Mean (need to show repeat) of x in range of 28.0 cm to 32.0 cm and L_1 in range of 18.0 cm to 22.0 cm and L_2 in range of 13.5 cm to 23.5 cm Quality: Second value of L_2 < first value of L_2.	1 1 1
1(d)(i)	Evidence of averaging across two sets of data and correct units of cm / mm / m	1

Qns	Marking Instructions	Mark
1(d)(ii)	correct plot of variable against another variable (need **not** strictly be dependent vs independent) correct identification of gradient and y-intercept eg $L_2 = \left(\frac{l^2}{3}\right)\left(\frac{L_1}{x^2}\right)$, plot L_2 against $\left(\frac{L_1}{x^2}\right)$, gradient is $\left(\frac{l^2}{3}\right)$, y-intercept is zero MUST make explicit l be subject of equation eg $l = \sqrt{3(\text{gradient})}$	1 1
1(e)(i)	•Difficult to get same lengths with reason e.g. judging the strip horizontal, checking the strings vertical, adjusting the setup. •Difficult to determine lengths with reason e.g. cannot place rule alongside strings, difficult to hold the ruler still, holding ruler with hands, parallax error, difficult to locate centre of bob. •Difficulty with oscillations of rule e.g. have small amplitude, unwanted modes, strings move along during oscillation, stands move, oscillations die away quickly. •Difficult to see when both oscillations match their periods. •Releasing bob and rule simultaneously is difficult/uneven force applied.	1
1(e)(ii)	•Detailed use of spirit level/plumb line/set squares. •Mark strings **or** use a clamped rule/pointer on rule with detail. Clamp stand to bench/method of attaching string to strip. •Use longer dimensions to increase period. •Use a video to identify when in phase/use a timer and check individually. •Use a card for a gate for both to release together.	1

Total: 13 marks

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Qns	Marking Instructions	Mark
2(a)	Quality: value of y in range 45 - 50 cm Repeat, and to correct precision of 0.1 cm / 1 mm	1
2(b)	6 sets of readings of R and y independently (zero otherwise)	1
	column headings each contain a quantity, a unit and a separating mark where appropriate	1
	Consistency: All values of raw y must be given to the nearest mm.	1
	Significant figures: All values of 1 / y should have the same number of s.f. as (or one more than) its corresponding raw y value. (if no table, deduct 1 mark)	1
2(c)(ii)	All points in table plotted to half-square accuracy	1
	Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. Allow one anomalous point only if clearly indicated (i.e. circled or labelled) by the candidate. There must be at least five points left after the anomalous point is disregarded. Lines must not be kinked or thicker than half a small square.	1
	Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. All observations must be plotted. Awkward scales (e.g. 3:10) are not allowed. Accept only 1, 2, 5 only (every 10 small sq) Scales to be labelled no more than 4 cm apart. Axes must be labelled with the quantity (and units) which is being plotted.	1
	Values for a and gradient triangle	1
	and b correctly calculated to 3 s.f. with consistent units (If no linearising statement, max 1 mark.)	1
2(d)(ii)	Quality: value of P in range 90 – 110 Ω and with unit	1
2(e)	steeper gradient, larger y-intercept so consistently higher than original line (no credit if no label 'S')	1

Total: 12 marks

Qns	Marking Instructions	Mark
3(c)(ii)	Value of θ to nearest degree with unit. Repeated readings shown.	1
3(c)(iii)	Percentage uncertainty in θ based on absolute uncertainty of 2 - 5°. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown AND the uncertainty is greater than instrument precision (nearest degree). Correct method of calculation to obtain percentage uncertainty. Percentage uncertainty to 2 s.f.	1
3(c)(iv)	Correct calculation of $\tan^2\frac{\theta}{2}$ with working. s.f. same as θ or 1 more. (Zero if units are given as output from tangent function is dimensionless)	1
3(d)(ii)	Quality: value of θ smaller than 3(c)(ii) Adherence to marking instructions in 3(c)(ii), and 3(c)(iv).	1
3(e)(i)	Correct units of both k (grams or kilograms)	1
	Correct calculation for both k, to appropriate s.f.	1
3(e)(ii)	Justification of s.f. in k linked to significant figures in m and θ.	1
3(e)(iii)	Correct calculation of percentage difference in k, to appropriate s.f.	1
	Sensible comment relating to percentage difference in k, testing against percentage uncertainty of θ from 3(c)(iii). Values calculated must be explicitly stated.	1
3(f)	Choose 100 g over 200 g because larger angle measured so lower percentage error in $\frac{\Delta\theta}{\theta}\times 100\%$	1
	Clear evidence of method to measure length of rubber band	1
	Table of values with correct column headings. Length values repeated and average found, to 1 d.p. in cm. θ values repeated and average found, to nearest degree.	1
	Clear trend that is described in words	1
	Two readings insufficient to show trend so take more readings and plot suitable graph.	1

Qns	Marking Instructions	Mark
3(g)(i)	Clear method of measuring <u>mass of rubber band</u> (e.g. using mass balance). Correct method of calculating linear density λ.	1
	Repeat procedure of measuring angle using protractor with same mass hung (differentiate clearly between mass of rubber band and load) using different rubber bands of different cross-sectional area/ thickness/density. Correct method of calculating k using equation in (e).	1
	Either $\lambda = ck^3$, c being a constant. If valid, plotting λ against k^3 should yield a straight-line graph passing through the origin. Or $\lambda = ck^3 \rightarrow \ln \lambda = 3(\ln k) + \ln c$ If valid, plotting $(\ln \lambda)$ against $(\ln k)$ should yield a straight-line graph having gradient of value (close to) 3.	1
	small λ: easy to snap / break	1
	large λ: large percentage error due to less noticeable change in angle θ	1

Total: 19 marks

Qns 4

Marking Instructions	Mark
Diagram • sealed container • vacuum pump for changing pressure • set up containing salt solution inside sealed container and clearly labelled	V
Feasible method for **heating** salt solution within sealed container e.g. electric heater connected to power supply / hotplate. Can be in clearly labelled in diagram.	H
Feasible method for measuring variable **pressure surrounding solution**. Description or clearly labelled pressure gauge / manometer / pressure sensor connected to data logger. Can be in clearly labelled in diagram.	P
Feasible method for measuring **temperature** of salt solution with type of thermometer specified. Must state how to identify "starts to boil". Cannot be "constant temperature" because salt solution is not pure liquid.	T
Method for measuring **density** of salt solution (e.g. mass balance and measuring cylinder, equation for determining density). expected. Beaker not accepted, insufficient precision.	D
Control variable (what to keep constant) Room temperature at which density is determined (e.g. measure room temperature and mixture temperature, leave sitting out for sufficiently long duration for thermal equilibrium)	C
Linearised equation $\ln \theta = \ln k + n \ln \sigma + q \ln P$	Q
Analysis Run 1 Keep density same by using same solution Vary air pressure [redacted] Repeat relevant procedure at minimal 6 pressure values Plot $\ln \theta$ against $\ln P$ q = gradient	R2
Analysis Run 2 Keep using same pressure e.g. room/atmospheric pressure Vary density by dissolving different masses of salt in same volume of water [redacted] Repeat relevant procedure at minimal 6 density values Plot $\ln \theta$ against $\ln \sigma$ n = gradient	
Safety (max 1) Safety screen in case implosion of sealed container Wear <u>heat insulating</u> gloves / Do not touch hot objects.	S
Other details (max 1) Use of a shut-off/pressure valve to keep the pressure inside the sealed container constant during the heating process. Use pure distilled water to avoid contamination from other solutes Clear mention of dissolving <u>all</u> salt in water Description of taring / measuring mass of dry empty measuring cylinder	E