Millennia Institute 2022 Preliminary Examinations

H2 Physics Paper 1 Suggested Solutions

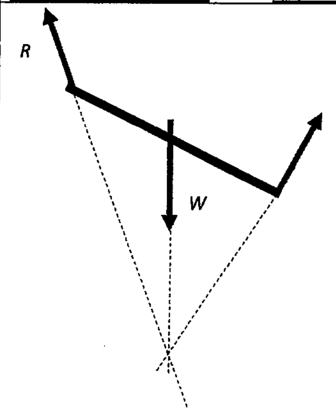
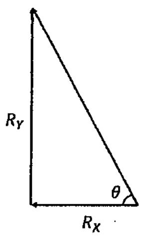
S/N	Answer	Suggested Solutions
1	D	1st measurement is recorded to a different precision. The measurements vary above and below the average value, hence random errors may be present. The calculated value of acceleration is close to actual value of 9.81 m s^{-2}, hence accurate.
2	A	With constant acceleration while there is fuel, the rocket gains velocity at a constant rate. When the fuel is used up, the rocket experience gravitational acceleration downwards, hence slowing down till it reaches the maximum height with zero vertical velocity, before falling back down with gravitational acceleration towards the ground. Area under the v-t graph above and below the horizontal axis should be about the same.
3	A	$v_y = u_y + a_y t = 0 + gt$ $t = \frac{v_y}{g}$ $s_x = u_x t = u\left(\frac{v_y}{g}\right) = \frac{uv}{g}$
4	B	3 forces must intersect at the same point for the system to be in static equilibrium.
5	C	From Fig A, 1.0 g = 1.2 a_A From Fig B, 0.2 g = 1.2 a_B $a_A : a_B$ = 1.0: 0.2 = 5: 1
6	A	A: Gravitational pull depends on mass of object and gravitational acceleration due to Earth. B: The cube is already fully submerged in the water hence upthrust will not increase. C: The balance reading considers weight of the cube as well. D: Upthrust is a result of the pressure difference at the top and bottom of the cube.
7	B	Assume that the force on top hinge F is pointing horizontally to the right. Taking moments about the bottom hinge, 1.8(200 cos 30°) + 3(200 sin 30°) = 1.8 F + 1.5(40)(9.81) F = 12.87 = 13 N (to the right)
8	B	Total output power = power in doing work against friction + power in gaining gravitational potential energy $P = Fv \rightarrow resistive\ force = \frac{P}{v} = \frac{1.0}{0.10} = 10N$ Power in overcoming friction = $Fv = 10 \times 0.20 = 2W$ Power in gaining gravitational potential energy $= mg \times vertical\ component\ of\ speed = 0.500 \times 9.81 \times 0.20 \times sin30° = 0.49W$ Total output power = 2.5W
9	D	Power from generator = VI = 32 x 230 = 7360 W Power from water wheel = rate of change of gravitational potential energy = (200)(9.81)(8) = 15696 W % efficiency = (useful power/ output power) x 100% = (7360/15696) x 100% = 47%
10	B	N cos 40° = mg -----eqn (1) N sin 40° = mv^2/r ----- eqn (2) Eqn (2)/ eqn (1), tan 40° = v^2/rg r = 34^2/ (tan 40°)(9.81) = 140.43 m d = r/ cos 40° = 183.32 = 183 m
11	D	A: $g = -\frac{d\varphi}{dr}$, while g = 0 at Z, it only means that potential is either a minimum or maximum at point Z. B: Since Q has a smaller magnitude of g, it has a smaller mass. C: Gravitational force is an attractive force. D: Since g = 0 and F = mg, net force at Z is zero hence the forces due to P and Q are equal in magnitude and opposite in direction

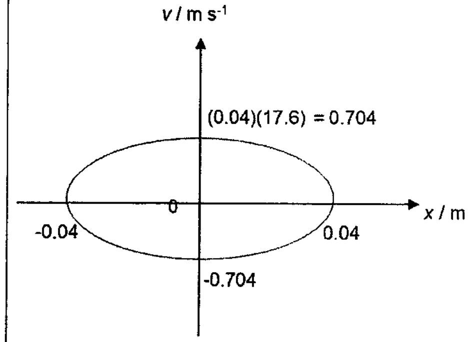
S/N	Answer	Suggested Solutions
12	D	For a satellite at Earth's surface, $mg = mr\omega^2 = mr(\frac{2\pi}{T_E})^2$ $(T_E)^2 = \frac{4\pi^2 R}{g}$ For a satellite at Moon's surface $(T_M)^2 = \frac{4\pi^2\left(\frac{R}{4}\right)}{\frac{g}{6}} = \frac{6}{4}\left(\frac{4\pi^2 R}{g}\right) = \frac{3}{2}(T_E)^2$ $T_M = \sqrt{\left(\frac{3}{2}\right)}\,T$
13	B	PV = nRT At the bottom of the lake, P(1.00 x 10^{-6}) = nR (273.15 + 15) = nR(288.15) At the top water surface, (1.00 x 10^5)(5.00 x 10^{-6}) = nR (273.15 + 30) = nR(303.15) P = (1.00 x 10^5)(5.00 x 10^{-6}) (288.15)/ (303.15) = 4.75 x 10^5 Pa Change in pressure = (4.75 – 1.00) x 10^5 = 3.75 x 10^5 Pa = 375 kPa
14	B	Higher specific heat capacity means that more energy will be needed to cool down or heat up the material. Hence, the temperature of gold will be higher than that of iron. Mc(20+T) = 0.100c_W (40 – T)
15	D	A: Internal energy of an ideal gas is made of sum of random distribution of KE. B: With isothermal change, there is no change in temperature (hence KE), therefore no change in internal energy. C: When an ideal gas is compressed, work is gone on the system. D: The First Law of Thermodynamics states that the <u>increase</u> in internal energy of a system is the sum of heat supplied to the system and the work done on the system.
16	C	Maximum force = 8 N, amplitude = 0.5m $F = ma_0 = m\omega^2 x_0 \rightarrow \omega = \sqrt{8}\,rads^{-1}$ maximum velocity $=\omega x_0 = \sqrt{8} \times 0.5 = 1.41ms^{-1}$
17	D	$I = \frac{P}{4\pi r^2}$ At 3.0 m, $P = 0.18 \times 4\pi \times 9 = 6.48\pi$ Power is now tripled, new P = 19.44π At 4.5 m, $I = \frac{P}{4\pi r^2} = \frac{19.44\pi}{4\pi 4.5^2} = 0.24Wm^{-2}$
18	C	For stationary wave, a displacement node corresponds to a pressure antinode hence the pressure value will fluctuate from high to low.
19	B	d sin 45° = 3λ d sin 90° = nλ n = 3(sin 90°)/ sin 45° = 4.24 Hence the highest order which can be viewed on the screen is the 4th order.
20	A	Electric potential = $\frac{Q}{4\pi\varepsilon_0(\frac{1}{3}r)} + \frac{2Q}{4\pi\varepsilon_0(\frac{2}{3}r)} = \frac{3Q}{2\pi\varepsilon_0 r}$ Electric field strength = $\frac{Q}{4\pi\varepsilon_0(\frac{1}{3}r)^2} - \frac{2Q}{4\pi\varepsilon_0(\frac{2}{3}r)^2} = \frac{9Q}{8\pi\varepsilon_0 r^2}$
21	D	Using Fleming's Left Hand Rule, the magnetic force on the protons is upwards. Hence, the electric force needs to be applied such that there is a force on the proton downwards so that the protons will not be deflected. Since protons are positive, the direction of the E-field should be downwards, towards the lower plate. Bqv = qE ⊠ E = Bv = (1.5)(2 x 10^7) = 3 x 10^7 N C^{-1}
22	A	E = W/Q = (2500+1500) / 2000 = 2 V
23	A	Effective resistance across the 6Ω, 10Ω and 4Ω resistors = $[(\frac{1}{6}) + (\frac{1}{10}) + (\frac{1}{4})]^{-1} = 1.935\Omega$ By potential divider rule, voltage across the 10 Ω resistor = (12.0)(1.935)/(2+1.935) = 5.9V Current through the 10 Ω resistor = 5.9/10 = 0.59 A

BP~807

24	B	Using right hand grip rule, the magnetic field on Y due to X and Z is into the plane of paper. Using Fleming's Left-Hand Rule, both X and Z will cause a magnetic force on Y that points towards X.
25	B	Use Fleming's Right-Hand Rule, the induced current will flow from O outwards to the rim.
26	D	Secondary r.m.s voltage = $\frac{1000}{200}20 = 100V$ Secondary r.m.s current = $\frac{100}{100} = 1.00A$ Primary r.m.s. current = $\frac{1000}{200}1.00 = 5.00A$ Primary peak current = $5 \times \sqrt{2} = 7.07V$
27	C	A: A higher work function should lead to a photoelectron with lower kinetic energy. B: Stopping potential is not a energy quantity. C: Once an electron at the metal surface absorbs a photon with energy higher than the work function of the metal it will be emitted immediately. D: Emission of a photoelectron only depends on the energy of the incident photon.
28	B	The diagram shows that there is a range of frequencies for emitted photon, hence there is a range of energies for the emitted photon. The energy-time uncertainty principle best accounts for this phenomenon.
29	C	β-particles have a negative charge and is affected by magnetic and electric fields unlike X-rays which are photon particles. β-particles will be stopped by a few mm of Al, will X-rays will not be stopped by Al or container of cargo truck. Both have energy that can ionize air particles.
30	B	Reading off the log graph, when $A/A_o = 0.5$, the time pass is 160 years.

2022 PU3 Prelim Examinations H2 Physics PAPER 2 Solution

Qn	Answers	Marks
1 (a)	Resultant/ net force is zero Resultant/ net moment about any axis/point is zero	B1 B1
(b)(i)	 • T and W correctly labelled with full name, T and W in correct direction. • All 3 forces intersect to meet at a common point (clearly shown with dotted lines!) and R correctly labelled & in correct direction *W* is the weight of the rod, *T* is the tension acting on the rod, *R* is the force acting on the rod by the hinge/ contact force	M1 A1
(b)(ii)	Take moments about the hinge, $30\times9.81\times\cos30°(\frac{L}{2})=T\times L$ $T=127.4\approx127N$	B2
(b)(iii)	$(\leftarrow+)$ $R_X=T\sin30°=127.4\sin30°=63.7N$ $(\uparrow+)$ $R_Y=30\times9.81-T\cos30°=184N$ $R=\sqrt{R_X^2+R_Y^2}=\sqrt{63.7^2+184^2}=194.7\approx195N$ ecf allow  $\tan\theta=\frac{184}{63.7}\Rightarrow$ $\theta=70.9°$ above the horizontal as shown in Fig. 1 ecf allow	C1 C1 A1 A1

2(a)(i)	$\omega=2\pi/T$ (where T = 10/28 s) = 17.6 rad s^{-1} (accept if T is read off graph)	B1
aii	 correct shape x_0 and v_0 labelled	M1 A1
(a)(iii)	At t = 0, *x* = its max positive value → eqn of motion is of the form $x=x_o\cos\omega t$ rather than $x=x_o\sin\omega t$ From Fig 3.2, x_o = 0.04 m. → *x* = 0.04 cos (17.6 *t*) (accept if T is read off graph)	B1 B1
a)(iv)	Graph showing amplitude decreasing with time (must be consistent for **all** that peaks both above and below the t axis) Period remains unchanged or slightly larger.	B1 B1
(b)(i)	$T=2\pi\sqrt{\frac{m}{k}}=2\pi\sqrt{\frac{0.20}{6.0}}=1.15\approx1.2\ s$	B1
(b)(ii)	Max speed $v_{max}=\omega x_o$, where x_o = 0.05 m , $\omega=\frac{2\pi}{T}$ = 0.27 m s^{-1}	C1 A1
(b)(iii)	Total energy = ½ mv_{max}^2 = ½ (0.200)(0.273)^2 = 7.5 × 10^{-3} J	C1 A1

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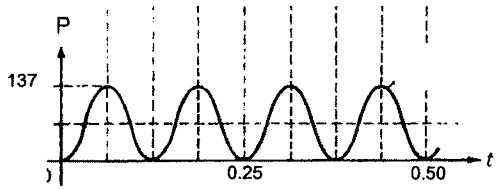
3(a)(i)	The electric force per *unit* ***positive*** charge placed at that point.	B1
(a)(ii)	Electric field strength at a point is equal to the negative potential gradient at that point {Accept use of eqn, E = $-\frac{dV}{dx}$, as symbols are already defined in qn; cannot use '*r*' in place of '*x*'}	B1
(a)(iii)	From the graph, at x = 15.0 cm, the gradient is positive. The electric field strength is thus negative, which means that it is pointing leftwards/towards sphere A.	B1
(b)	At x = 15.0 cm, the potential due to both spheres is zero. $V_A + V_B = 0$ $\frac{Q_A}{4\pi\varepsilon_o x} + \frac{Q_B}{4\pi\varepsilon_o (d-x)} = 0$ $\frac{Q_A}{0.15} = \frac{-0.48 \times 10^{-9}}{(0.60-0.15)}$ $Q_A = -1.6 \times 10^{-10}$ C	C1 C1 A1
(c)	loss in electric potential energy = gain in kinetic energy $U_i - U_f = K.E._f - K.E._i$ $-1.60\times10^{-19}\times(0-140) = \frac{1}{2}\times9.11\times10^{-31}\times\left[v_f^2-(4.0\times10^6)^2\right]$ $v_f \approx 8.1\times10^6$ m s^{-1}	C1 C1 A1

4(a)(i)	Resistance is the ratio of the potential difference across the component to the current passing through it	B1
(b)	$R = \frac{\rho l}{A} = \frac{1.7\times10^{-8}\times1.5}{3.2\times10^{-9}}$ = 8.0 Ω	**C1** **A1**
(c)	$E = IR$ 12 = I × (1.0 + 2.0 + 8.0) I = 1.091 A $I = nAqv$ 1.091 = (8.5 × 10^{28}) (3.2 × 10^{-9})(1.6 × 10^{-19}) v v = 0.025 m s^{-1}	C1 A1
(d)(i)	$V_{PQ} = I_{PQ}R_{PQ}$ = (1.091)(8.0) = 8.7 V	M1 **A0**
(ii)	terminal pd of B = $\frac{R}{R+r}\times E = \frac{4.0}{4.0+3.0}\times1.5$ = 0.857 V $\frac{V_{PJ}}{V_{PQ}} = \frac{l_{PJ}}{l_{PQ}}$ Since terminal pd of B = V_{PJ} $\frac{0.857}{8.7} = \frac{l_{PJ}}{1.5}$ l_{PJ} = 0.148 m	C1 C1 A1
(iii)	To improve accuracy, the modification is either to: replace cell A with one of lower emf or reducing the resistance of the wire through replacing the copper wire with one of higher cross-sectional area, or lower resistivity or replace the 2.0 Ω resistor with one of higher resistance or add in another resistor in series with cell A. Explanation: To reduce the fractional/ percentage error in the determination of balance length. (do not accept: "longer balance length" alone)	B1 B1

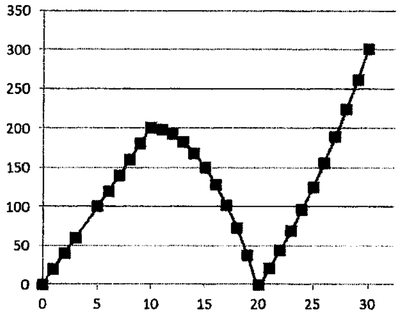
5a(i)	(by Fleming's left hand) magnetic force is right So electric force is left and so left plate is lower potential	**M1** **A1**
a(ii)	Bqv = qE => v = E/B = $1.50 \times 10^4 / 0.020$ = 7.5×10^5 m s^{-1}	**C1** **A1**
a(iii)	The ions of other speeds are deflected. Faster ions experience larger magnetic force and are deflected to the right, slower ions are deflected to the left. Only ions of certain "chosen" velocity experience equal magnetic and electric force, then remain undeflected and emerge from the slit.	B1 B1
b(i)	Bqv = mv^2/r => r = mv/Bq = $(35)(1.66 \times 10^{-27})(7.5 \times 10^5) / [(0.020)(1.60 \times 10^{-19})]$ = 13.6 m	**C1** **A1**
b(ii)	1. no effect. No effect. 2. no effect, radius is halved	**B1** **B1**
6 (a)	Root-mean-square value of an alternating current is defined as the value of an alternating current which would dissipate heat at the same average heating effect /rate in a given resistance as a steady direct current of that value.	B1
(b)(i)	For e.m.f. to be maximum, $\sin(\omega t) = 1$. Hence, max e.m.f. $E_o = NBA(2\pi f)$ = $(800)(0.50)(5.0\times10^{-2} \times 8.0\times10^{-2})(2\pi)(240/60)$ = 40.2 V	C1 A1
(ii)	$I_o = \frac{V_o}{R} = \frac{40.2}{0.60 + 11} = 3.4655 \approx 3.47\ A$ $I_{rms} = \frac{I_0}{\sqrt{2}} = 2.45\ A$	C1 A1
(iii)	 Correct shape with 2 cycles drawn. Label $P_{max} = I_o^2 R = (3.4655^2)(11.4) = 137$ W Label period $T = \frac{60}{240} = 0.25\ s$	B1 B1 B1

7 (a) **1.** **2.**	vibration / oscillation parallel to energy transmission / wave vibration / oscillation perpendicular to energy transmission / wave energy transferred	B1 B1
(b)(i)	7.98(t – 170) = 4.75t t = 420 s OR 7.98t = 4.75(t + 170) t = 250 s 250s+170s = 420s t = 7.0 min	C1 A1
(ii)	420 × 4.75 = 2000 km	B1
(c)(i)	(From Fig 7.3) S-wave velocity is 0/ has no velocity in outer core (and inner core)/ from a depth of 3000km to the center of the Earth S-waves cannot travel through (outer) core Because the (outer) core is liquid/ S-waves cannot travel though liquid	B1 B1 B1
(ii)	These regions are on the other side of the Earth with respect to the epicenter/earthquake	B1
(d)(i)	Speed increases Because (*any 2 from*): density increases; elastic moduli increases; pressure increases;	M1 B1 B1
(ii)	path curves OR refracted away from centre of earth OR towards surface	M1 A1
(e)(i)	waves that just enter the outer core and those that just scrape/curve across its surface are travelling/separated/ "bent"/"curved" in opposite directions as seen in Fig 6.4. leads to a gap/"region where no seismic waves are detected" between these two positions	B1 B1
(ii) **1.**	(From Fig 7.3), Radius of Earth = 6500 km (accept: 6250 km to 6750 km) {do not accept: 6000 km}	B1
2.	(From Fig 7.4), Δ θ from the centre of the Earth = 143° – 103°) = 40° = 0.698 rad s = r($\Delta\theta$) = (6250 km to 6750 km)(0.698) = 4360 to 4710 km (or 4000 to 5000 km)(1 sf)	C1 A1
(f)	Any one from the following, from any "category": social: locate earthquakes locate landslides warn about tsunamis / volcanoes rush assistance quickly	B1

BP-811

	identify archaeological sites save lives / evacuate area academic curiosity identify erosion technological: design buildings that resist earthquakes locate gas / oil reserves locate mineral reserves locate water locate sunken treasure / aeroplane Black boxes / oil tanks predict / understand earthquakes / tsunamis / volcanoes economic: cheaper resources no need to replace destroyed buildings discover contamination harness geothermal energy	

2022 PU3 H2 Physics Prelim Paper 3 Suggested Solution

1a	Assumption: g is constant as h is very small compared to the radius of the earth. Work done by external agent (me) in moving a mass upward goes to the gain in GPE of the object Hence, GPE gain = Work Done = Force by external agent x Distance moved = mgh	M1 M1 A0
1b	 Rate of work done = P = Fv. Correct shape and value for each of the segment For 0 m s^{-1} to 10 m s^{-1} For 10 m s^{-1} to 20 m s^{-1} For 20 m s^{-1} to 30 m s^{-1}	 B1 B1 B1
2ai	From the graph, at 4.0×10^{-8}m, g = 0.8 N kg^{-1} gravitational force, F = mg = $(5.5\times10^{13})(0.8) = 4.4\times10^{13}$ N [accept range g = 0.5 N kg^{-1} to 0.9 N kg^{-1} and F between 2.75. $\times10^{13}$ N to 4.95×10^{13} N]	 A1
2aii	Area under graph from 2.0×10^{8} m to 4.0×10^{8} m = (7.5 squares)$(0.5\times10^{8})(1) = 3.75\times10^{8}$ N kg^{-1} m [Accept range 7.5 squares to 8.5 squares, 3.75×10^{8} to 4.25×10^{8} N kg^{-1} m] By Conservation of energy, KE gained=GPE lost = 5.5×10^{13} (area under g-distance graph) = $5.5\times10^{13}(3.75\times10^{8})$ = 2.06×10^{22} J **Or** use the point values from the graph for calculations.	 M1 A1
2bi	Period of rotation of geostationary satellite = 24x3600=8.64×10^{4} s Gravitational force provides centripetal force for satellite to orbit around earth. $\frac{GMm}{{r_{geo}}^2} = mr_{geo}(\frac{2\pi}{T})^2$ $r_{geo} = [\frac{(6.67\times10^{-11})(6.0\times10^{24})(8.64\times10^{4})^2}{(2\pi)^2}]^{\frac{1}{3}}$ $r_{geo} = 4.23\times10^{7}m \approx 4.23x10^{4}km$	 M1 A0

2bii	Kinetic energy of satellite at the equator = ½ mv^2 = ½ $(1000)((6.39\times10^{6})\frac{2\pi}{8.64x10^4})^2$ = 1.08×10^{8} J Total energy of satellite at the equator = KE + GPE = $1.08\times10^{8} + (-\frac{6.67x10^{-11}(1000)(6.0x10^{24})}{6.39x10^{6}})$ = -6.2521×10^{10} J Note: Total energy of satellite in a geostationary orbit $= -\frac{GMm}{2r} = = -(\frac{1}{2})(6.67\times10^{-11})(6.0\times10^{24})(1000)\left(\frac{1}{4.23\times10^{7}}\right) = -4.7305\times10^{9}$ J Min energy required = total energy of satellite in geostationary orbit – total energy of satellite at the surface of earth = -4.7305×10^{9} J $-(-6.2521\times10^{10})$ = 5.78×10^{10} J	M1 M1 A1
2biii	E_t becomes more negative radius of orbit r will decrease as magnitude of E_t will increase as <u>radius decrease</u>. Since $E_t = -E_k$ and E_t becomes more negative, $E_k = \frac{GMm}{2r}$ will increase and hence <u>speed of satellite v will increase.</u>	M1 A1 A1
3ai 1	Interference pattern of Black and White equally spaced stripes 	A1
3ai 2	Fringe separation of the interference pattern will double. The bright fringes will be less bright.	A1 A1
3bi	Distance from lower slit to P = $\sqrt{1+0.23^2}$ Distance from higher slit to P = $\sqrt{1+0.03^2}$ Path difference at point P = $\sqrt{1+0.23^2} - \sqrt{1+0.03^2}$ = 0.0257 m	 M1 M1 A0
3bii 1	Phase difference = 2.57 / 1.03 x 2 π = 5 π	M1 A1
3bii 2	**Destructive interference**, minima observed	A1

3biii

0π	Bright
1π	Dark
2π	Bright
3π	Dark
4π	Bright
5π	Dark

M1

3 low intensity regions (count from the table above). A1

Alternative Method

Fringe separation = λ D / a = 5.15 cm M1

Number of low intensity regions = 13 / 5.15 = 2.52 = 3 (rounded up) A1

3c

Central white fringe as all frequencies of light will overlap. A1

Continuous bright coloured spectrum and dark fringes on either side, A1
Due to different wavelengths of light having different fringe separations. M1

4ai

Maximum KE
= hf – 2.2eV M1
= 9.4×10^{-20} J A1

4aii

Stopping potential = 9.4×10^{-20} / e = 0.587V A1

4aiii

The values remain the same. A1

Intensity = Rate of Photons incident per unit area x Energy of 1 photon.
Since the wavelength of the incident radiation is kept constant, energy of the incident photon remains the same, hence KE and Stopping potential are not affected. Doubling the intensity will only double the rate of incident photons per unit area. M1

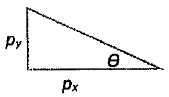
4bi

It is not possible to measure position or momentum (or energy and time interval during which an object is in that state) of an object precisely at the same time. A1

Note: Definition for Heisenberg position-momentum is if measurement of position is made with precision Δx and a simultaneous measurement of momentum in the x-direction is made with precision Δp, then the product of the two uncertainties can never be smaller than *h (Planck's constant)*.

4bii

Using De Broglie's relationship:
λ = h/p
= $6.63\times10^{-34}/9.11\times10^{-31}\times3.75\times10^{6}$
= 0.1942 nm M1



$\sin\theta = \dfrac{\lambda}{D} = 3.88\times10^{-5}$ M1

At small angles, $\sin\theta \approx \tan\theta$

Now $\tan\theta = \frac{p_y}{p_x} = 3.88 \times 10^{-5}$

$p_y = (9.11 \times 10^{-31})(3.75 \times 10^{6})(3.88 \times 10^{-5})$ M1
$= 1.33 \times 10^{-28}$ kg m s^{-1} A0

Therefore, maximum y-component of the momentum of an electron
= 1.33×10^{-28} kg m s^{-1}

4biii

$$\Delta y\, \Delta p_y \geq h$$
$$\Delta y \geq \frac{h}{\Delta p_y} = \frac{6.63 \times 10^{-34}}{1.33 \times 10^{-28}}$$ M1
$$\Delta y \geq 4.98 \times 10^{-6}\text{ m}$$ A1

4c

Applying de Broglie's wavelength,
$\lambda = \frac{h}{p} = \frac{(6.63 \times 10^{-34})}{(9.11 \times 10^{-31})(1.26 \times 10^{4})} = 5.78 \times 10^{-8} m$ M1
Applying nλ = d sin θ,

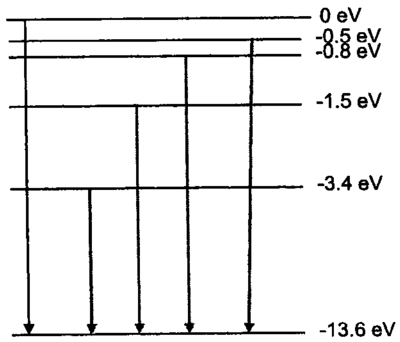
For 2nd order maximum, $(1.6\times10^{-6})\sin\theta_2 = 2\,(5.78\times10^{-8})$, θ = 0.0723 rad A1

4di

$E_{95.0} = \frac{hc}{(95.0\times10^{-9})(1.6\times10^{-19})} = 13.1$ eV
$E_{97.3} = \frac{hc}{(97.3\times10^{-9})(1.6\times10^{-19})} = 12.8$ eV
$E_{102.6} = \frac{hc}{(102.6\times10^{-9})(1.6\times10^{-19})} = 12.1$ eV
$E_{121.6} = \frac{hc}{(121.6\times10^{-9})(1.6\times10^{-19})} = 10.2$ eV

Values of energy level calculated correctly (2 marks for all correct, 1 mark if 2 wrong, 0 marks for more than 2 wrong) B2

4dii



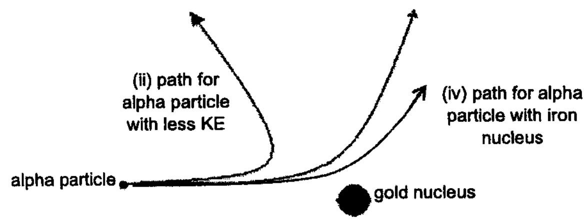
Arrows for emission lines to ground state drawn correctly. (2 marks for all correct, 1 mark if 2 wrong, 0 marks for more than 2 wrong). B2
Minus 1 mark if no labelled clearly.

5ai

Gold nucleus and alpha particle are positive charged. Thus, the gold nucleus repels the alpha particle. A1

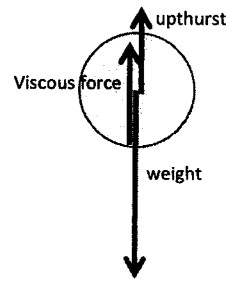
5aii

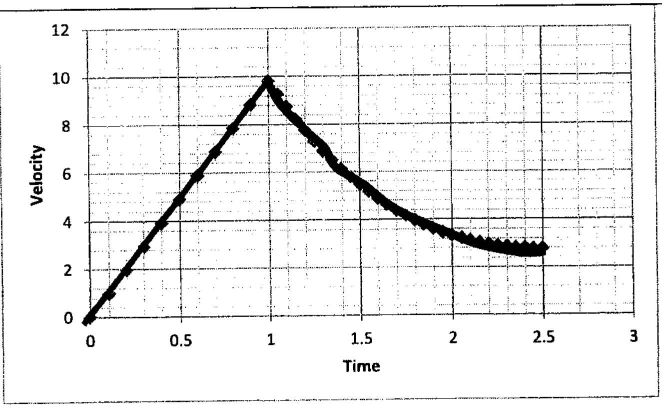
Greater deflection of final path and final path has smaller distance of closest approach A1



5aiii	A thin gold foil is required as to ensure one alpha particle to collide with a single gold nucleus or to avoid multiple collisions of one alpha particle with many gold nuclei.	A1
5aiv	Lesser deflection of final path and final path has greater distance of closest approach	A1
5bi	As alpha particle approaches nucleus, KE is converted to EPE, U. Hence alpha particle must possess minimum energy U to be this close to Li By conservation of energy, Loss in KE = Gain in EPE $U = (1/4\pi\varepsilon_0)(Q_1 Q_2 / r)$ $= (9\times10^9) \times [(2\times1.6\times10^{-19}) \times (3\times1.6\times10^{-19}) / (4.2\times10^{-15})$ $= 3.3 \times 10^{-13}$ J	 M1 M1 A0
5bii	Maximum possible energy of a neutron would occur when Boron does not have kinetic energy. Maximum Energy of neutron = (Rest mass energy of reactants)+(K.E. of alpha) – (Rest mass energy of products) $= (4.0015+7.0144)uc^2 + 3.3 \times 10^{-13} - (10.0011+1.0087)uc^2$ $= 1.24 \times 10^{-12}$ J	M1 M1 A1
5ci	Photoelectron is an electron emitted from a metal when light of certain frequency (or frequency higher than threshold frequency of metal / sufficient energy) is shone on the metal. β-particle is a fast-moving electron emitted from an unstable nucleus in radioactive decay.	B1 B1
5cii	$dN/dt = -\lambda N$	A1
5ciii	unit of $\lambda = s^{-1}$	A1
5civ	$A = A_0 e^{-\frac{\ln 2}{t_{1/2}} t}$ $2.8 \times 10^3 = A_0 e^{-\frac{\ln 2}{4.2\times10^4}(7.2\times10^4)}$ $A_0 = 9.19 \times 10^3$ Bq	 M1 A1

Section B

6ai	It is rate of change of velocity.	A1
6aii	The highest point of the motion when the ball is thrown vertically upwards/ object in simple harmonic motion at amplitude position OR any other reasonable scenario.	B1
6bi	Air resistance is negligible as the acceleration of the ball when it is falling through air during 0s to 1s is constant at 9.8 ms^{-2}, which shows that the net force acting on the ball is weight of ball only. Or Since acceleration is 9.8 m s^{-2} which is equal to the gravity acceleration, the net force acting on ball is weight only.)	A1
6bii	Zero acceleration at 2.5s does not mean that it had reach the bottom of the beaker, the ball could have reached terminal velocity where the drag force and upthrust balances the weight of the ball. Or At 2.5 s, the velocity of the ball is not zero (Area under acceleration-time graph gives us the change of velocity. Since area under the graph of acceleration time graph from t=0 to t=2.5s is not zero, velocity at 2.5 s is not zero). Hence, if the ball had reached the bottom of the beaker, there should be a large negative acceleration upon impact.	A1
6biii	Upward force: viscous force and upthrust, downward force: weight. Length of the forces should be balanced.  	A1
6biv	Highest velocity = area under acceleration-time graph for t between 0 to 1s, = (9.81)(1) = 9.81 ms^{-1}. Or using v = u+at where u=0 v = 0+9.81(1) M1 = 9.81 ms^{-1} A1	M1 A1
6bv	Terminal velocity occurs at t=2.5s. Terminal velocity = area under acceleration-time graph for t between 0 to 3s, = 9.81 - area under acceleration-time graph for t between 1 to 3s = 9.81 -73(1)(0.1) = 2.51 ms^{-1}	 M1 A1

6bvi	 Correct shape and value for each of the segment For 0 s to 1 s For 1 s to 2.5 s	 B1 B1
6ci	Speed of trolley after collision, v_f can be obtained from conservation of energy. [Gain in gravitational of potential energy of trolley with block and pellet equal to loss in Kinetic Energy of trolley with block and pellet after collision. i.e. $Mgh = ½ Mv_f^2$, $v_f = \sqrt{2gh}$] By conservation of linear momentum, initial momentum of pellet = final momentum of trolley with block and pellet, the speed of the pellet can be determined. [i.e. $mu = Mv_f$ ➔ Speed of pellet, $u = \frac{M}{m} v_f$]	B1 B1
6cii	u is calculated assuming all kinetic energy of trolley with block and pellet after collision is converted to gravitational potential energy. With presence of friction, some of the kinetic energy of trolley after collision is converted to work done against frictional force. Since h is a fixed measurement, u calculated is an underestimate.	 M1 A1
6di	When objects of a closed system interact, their sum of momentum before impact is equal to their sum of momentum after impact, if no net external force acts on the system. [Only need to mention either closed system or no net external force. Need not mention both.]	A1
6dii	By conservation of linear momentum, Pi =Pf 0.0020(u) = (0.5020)(0.4) u = 100.4 ms^{-1}=100 ms^{-1}	 M1 A1
6e	Kinetic Energy of pellet before hitting trolley with block = ½ (0.0020)(100^2) = 10.0 J Kinetic Energy of trolley with block and pellet after collision = ½ (0.5020)(0.4^2) = 0.0402 J	M1 (for 2 KE)

	Since Kinetic Energy before and after collision are not the same value, the collision between pellet and block is not inelastic. OR By relative speed of relation, speed of approach is non-zero while speed of separation is zero (as the bullet is embedded)	A1
7a	Temperature of a substance is directly proportional to the average kinetic energy of the molecules in the substance. As the temperature is the same for both ice and water, the average kinetic energy of their molecules would be the same.	B1 B1
7bi	Setup B helps to measure amount of melted ice due to heat gained by the ice from the surroundings.	A1
7bii	Thermal Energy from heater = Heat gained by ice (12.0)(10 x 60) = [(40.0-18.4)x10^{-3}]L_f L_f = 3.33 x 10^5 J kg^{-1}	M1 A1
7ci	$P = \frac{nRT}{V}$ $P = \frac{(0.200)(8.31)(27+273.15)}{5.00 \times 10^{-3}}$ = 9.98 x 10^4 Pa	 A1
7cii	New Pressure $P_{new} = \frac{(0.200)(8.31)(27+273.15)}{(5.00+3.00) \times 10^{-3}}$ = 6.2356 x 10^4 Pa = 6.24 x 10^4 Pa $n_B = \frac{P_{new}V}{RT}$ $n_B = \frac{(6.2356 \times 10^4)(3.00 \times 10^{-3})}{(8.31)(27+273.15)}$ = 0.0750 mol	 A1 A1
7ciii	With the valve open, the molecules will move between the two containers till the pressure is equalized. $n_A + n_B = \frac{PV_A}{RT_A} + \frac{PV_B}{RT_B}$ $0.200\ (8.31) = P\left(\frac{5.00 \times 10^{-3}}{27+273.15} + \frac{3.00 \times 10^{-3}}{100+273.15}\right)$ $1.662 = P\ (2.4698 \times 10^{-5})$ $P = 6.73 \times 10^4$ Pa	 M1 A1
7di	pV (= 170 J) evaluated correctly for 3 readings taken correctly from graph (2 marks for 3 readings, 1 marks for 2 readings) Conclude that since pV values are the same (or some slight variation) hence it is isothermal (or not isothermal)	M1, M1 A1

7dii	Process must be carried out (infinitely) slowly OR container must be a good conductor of heat so as to allow time for heat to enter into / exit from the system in surroundings of constant temperature maintained by a water bath (or equivalent)	B1 B1
7diii	At constant pressure, $V \propto T$: $\frac{1.7 \times 10^5}{T_A} = \frac{3.4 \times 10^5}{385}$ $T_A = 193$ K	M1 A1
7div	$w = -1.7 \times 10^5 \times 5 \times 10^{-4} = -85$ J $q + w = \Delta U$, therefore $\Delta U = 213 - 85$ $= 128$ J Students who use the method below to award max 2 marks Increase in internal energy of the gas $= \frac{3}{2} \times 1.7 \times 10^5 \times (5 \times 10^{-4})$ [M1] $= 127.5$ J [A1]	M1 M1 A1

Candidate Name: ____________________

Class	Adm No

millennia institute

2022 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749 / 04**

Paper 4 Practical **30 August**

Candidates answer on the Question Paper. **2 hours 30 minutes**

READ THESE INSTRUCTIONS FIRST

Write your name, class and admission number in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the papers.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided in this question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 12
2	/ 11
3	/ 20
4	/ 12
TOTAL	55

This document consists of **14** printed pages and **0** blank pages.

1 In this experiment, you will investigate the oscillations of a triangular-shaped object.

(a) You have been provided with a wire. Bend the wire to form a triangle shape so that the length of each side a is approximately 10 cm, as shown in Fig. 1.1.

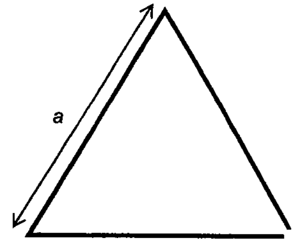


Fig. 1.1

Use the wire cutter to remove any excess wire.

(i) Measure and record a.

$a = (10.5 + 10.5) / 2$
$= 10.5$ cm

[1] correct d.p. of a (1 d.p. for cm and 3 d.p. for m); Repeated readings; and correct unit of a; Accepted range is 9.5 cm – 10.5 cm

a = ... [1]

(ii) Estimate the percentage uncertainty in your value of a.

$(0.1 + 0.1) / 10.5 \times 100\%$
$= 1.9\%$

Absolute uncertainty in the range of 0.2 cm to 0.5 cm (1.s.f.).
[-1] either percentage uncertainty more than 2 s.f.
[-1] either absolute uncertainty not 1 s.f.
[-1] either (Δd and d) differs in d.p.

percentage uncertainty in a = ... [1]

(b) Suspend the triangular-shaped wire as shown in Fig. 1.2. The pin should be held firmly in the clamp and the wire should be able to pivot about the pin freely.

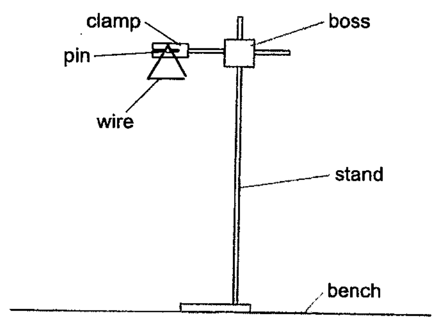


Fig. 1.2

BP~819

Gently displace the wire and release it so that it oscillates about the pin.

Take suitable measurements to determine T, the period of the oscillation.

$N = 35$, $t_1 = 21.8$ s, $t_2 = 21.8$ s

$T = (21.8 + 21.8) \div (2 \times 35) = 0.623$ s

> [1] $NT \geq 20$ s; correct d.p. of t (1 d.p.); correct s.f. and units of T.
>
> [1] Readings are recorded clearly; repeat readings taken.

T = ... [2]

(c) Remove the triangular-shaped wire from the pin. Form a new triangle shape from the wire so that a is approximately 8 cm.

Use the wire cutter to remove any excess wire.

Repeat **(a)(i)** and **(b)**.

a = (8.2 + 8.0) / 2
= 8.1 cm

$N = 40$, $t_1 = 20.8$ s, $t_2 = 21.0$ s

$T = (20.8 + 21.0) \div (2 \times 40) = 0.523$ s

> [1] correct d.p. of a (1 d.p. for cm and 3 d.p. for m); and correct unit of a; Accepted range is 7.5 cm – 8.5 cm
> AND
> $NT \geq 20$ s; correct d.p. of t (1 d.p.); correct s.f. and units of T / Repeated readings
>
> [1] 2nd T should be smaller than 1st T

a = ...

T = ... [2]

(d) It is suggested that

$$T^2 = \frac{a}{k}$$

where k is a constant.

Use your values from **(a)(i)**, **(b)** and **(c)** to determine the two values of k.

$k_1 = 10.5 / 0.623^2 = 0.271$ m s^{-2}

$k_2 = 8.1 / 0.523^2 = 0.296$ m s^{-2}

> [1] k values are calculated correctly
>
> [1] with correct s.f. (allow for plus 1) and units (e.g. m s^{-2} or cm s^{-2}).

first value of k = ...

second value of k = ... [2]

(e) Justify the number of significant figures given in your values of k.

[1] Values of k follows the least sf between T and a

[1]

(f) State whether the results of your experiment support the relationship suggested in **(d)**.

Justify your conclusion by referring to your answer in **(a)(ii)**.

(0.296 - 0.271) / [0.5 (0.296 + 0.271)] x 100%
= 8.82%

> [1] calculated correctly percentage difference;
>
> [1] compare with percentage uncertainty of a in (b)(ii); conclude

Since the percentage difference of 8.8% (e.g.) is less than the **percentage uncertainty of a** of 1.9% in **(a)(ii)**. Hence, the results do not support the suggested relationship. [2]

(g) The acceleration of free fall g near the surface of the Earth is given by

$$g = \frac{4\pi^2}{\sqrt{3}} k$$

Use your first value of k to calculate a value for g.

$g = (4\pi^2 / \sqrt{3}) \times 0.271$
$= 6.18$ m s^{-2}

> [1] g value is calculated correctly with correct s.f. (allow for plus 1) and units (e.g. m s^{-2} or cm s^{-2}).

g = ... [1]

[Total: 12]

2 In this experiment, you will investigate the forces acting on an object.

(a) Place the metre rule on a cylinder which is on top of the wooden block. Place some blue-tac at the base of the cylinder to ensure that it does not roll off the wooden block.

Hang the rubber bung on the metre rule 15.0 cm away from the pivot. Ensure that the metre rule is balanced by placing a 20.0 g mass on the other side of the pivot, as shown in Fig. 2.1.

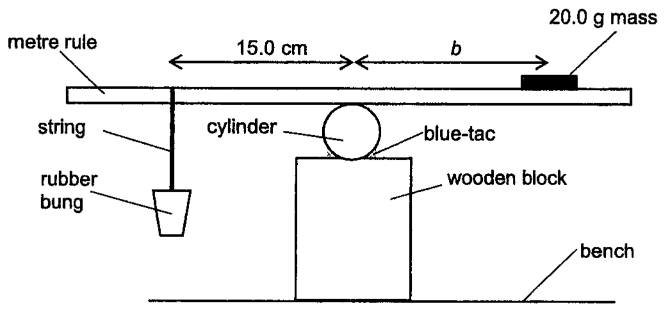


Fig. 2.1

b is the distance between the pivot and the centre of the 20.0 g mass.
Measure and record *b*.

$b = (46.4 + 46.6) / 2$
$= 46.5$ cm

[1] correct d.p. of *b* (1 d.p. for cm and 3 d.p. for m); Repeated readings; and correct unit of *b*

b = ... [1]

(b) Place a beaker under the rubber bung and pour approximately 250 cm^3 of liquid X into the beaker until the it is completely submerged. Adjust the position of the 20.0 g mass so that the metre rule remains balanced, as shown in Fig. 2.2.

c is the distance between the pivot and the centre of the 20.0 g mass when the rubber bung is completely immersed in liquid X.

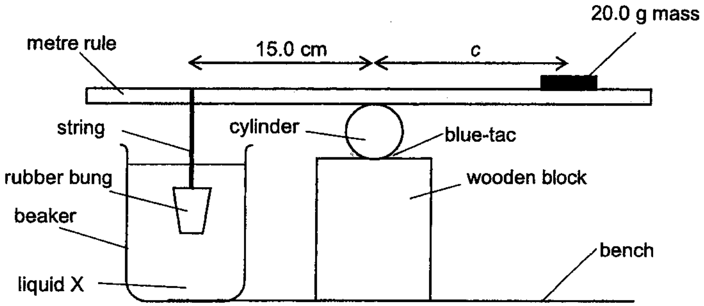


Fig. 2.2

(i) Measure and record *c*.

$c = (10.0 + 10.0) / 2$
$= 10.0$ cm

[1] correct d.p. of *c* (1 d.p. for cm and 3 d.p. for m); Repeated readings; and correct unit of *c*

c = ... [1]

(ii) Estimate the percentage uncertainty in your value of *c*.

$(0.1 + 0.1) / 10.0 \times 100\%$
$= 2.0\%$

Absolute uncertainty in the range of 0.2 cm to 0.5 cm (1.s.f.).
[-1] either percentage uncertainty more than 2 s.f.
[-1] either absolute uncertainty not 1 s.f.
[-1] either (Δd and d) differs in d.p.

percentage uncertainty in *c* = ... [1]

(iii) The density of liquid X, ρ_X, *b* and *c* are related by the expression

$$\rho_X = Z(b - c)$$

where $Z = 0.0296$ g cm^{-4}.

Calculate ρ_X.

$\rho_X = 0.0296 \times (46.5 - 10.0)$
$= 1.08$ g cm^{-3}

[1] ρ_X value is calculated correctly with correct s.f. (allow for plus 1) and units (e.g. g cm^{-3} or kg m^{-3}).

[1] $\rho_X > 1.00$ g cm^{-3}

ρ_X = ... [2]

(iv) Suggest one significant source of uncertainty in this experiment.

Any of the following:

1) It is difficult to balance the metre rule This affects the measurement of *b* and *c*.
2) It is difficult to measure *b* or *c* on the metre rule as the centre of the 20.0 g mass may not be easy to determined.

[1]

(v) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **(b)(iv)**.

You may suggest the use of other apparatus or a different procedure.

Corresponding improvement

1) Replace the cylinder with a (knife-edge) prism.
2) Tie a string to the 20.0 g mass and hang it on the ruler. [1]

BP~821

(c) The expression given in **(b)(iii)** suggests that the density of the liquid in the beaker in Fig. 2.2 has a linear relationship with c.

Explain how you would investigate this relationship.

You would be provided with liquids of different densities.

Your account should include:

- your experimental procedure
- control of variables
- how you would measure the densities of the liquids
- how you would use your results to show that the two variables are linearly related

Set up experiment similar to Fig. 2.2.

Measure the mass of 250 cm^3 of the liquid given using an **electronic balance. Divide its mass by 250 cm^3** to find the density of the liquid. [1]

Keeping the position of the rubber bung / 20.0 g mass constant. [1]
vary the density of liquid used by using different liquids given.

Measure c, distance between the pivot and the centre of the 20.0 g mass **by reading off the metre rule**. [1]

Plot **a graph of density of liquid against** c. If **a straight line is obtained**, then the two variables are **linearly related**. [1] [4]

[Total: 11]

3 In this experiment, you will investigate an electrical circuit.

(a) You have been provided with metre rule Y, with a resistance wire attached.

(i) Record the resistance per unit length of the wire attached to rule Y, r.

$r = 8.3\ \Omega\ m^{-1}$

r = ...

(ii) Take measurements to determine the cross-sectional area of the wire attached to rule Y, a_Y.

Zero error = 0.00 mm
d_1 = 0.28 mm
d_2 = 0.28 mm
d_{ave} = (0.28 + 0.28) / 2
= 0.28 mm

[1] d value: correct d.p. (2 d.p. for mm and 5 d.p. for m); Repeated readings; evidence of checking for zero error and correct unit

[1] a_Y value is calculated correctly with correct s.f. (allow for plus 1) and units (e.g. m^2 or cm^2).

$a_Y = (\pi/4) \times (0.28 \times 10^{-3})^2$
$= 6.16 \times 10^{-8}\ m^2$

a_Y = ... [2]

(iii) Calculate the resistivity of the wire attached to rule Y, ρ_Y

$\rho_Y = RA / l$
$= 6.16 \times 10^{-8} \times 8.3$
$= 5.11 \times 10^{-7}\ \Omega\ m$

[1] ρ_Y value is calculated correctly with correct s.f. (allow for plus 1) and units (e.g. Ω m or Ω cm).

ρ_Y = ... [1]

(b) Set up the circuit shown in Fig. 3.1

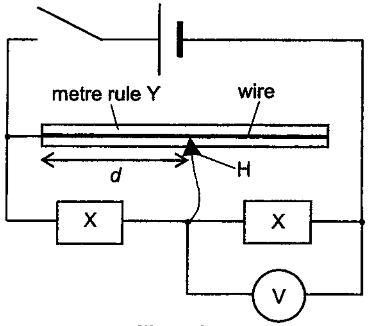


Fig. 3.1

H is a crocodile clip that is free to move along the wire.

The e.m.f. of the circuit is E. The value of the resistance of X is R_X.

d is the distance between the end of the rule and H, as shown in Fig. 3.1.

(i) Measure and record E.

E = 2.83 V

> [1] Value of E (to 2 dp), measured directly using voltmeter

E = ... [1]

(ii) Record R_X.

R_X = 10 Ω

R_X = ...

(iii) Close the switch. Adjust the position of H until d is 50.0 cm.

Record the voltmeter reading that measures the potential difference across X, V_X.

V_X = 1.93 V

> [1] correct d.p. of V (2 d.p.); correct unit of V

V_X = ... [1]

(iv) Calculate the resistance of length of the resistance wire that is connected in parallel with X, R_Y using information from **(a)(i)**, and the following expression:

$R_Y = r\,d$

R_Y = 8.3 x 0.500
= 4.2 Ω

> [1] R_Y value is calculated correctly with correct s.f. (allow for plus 1) and unit Ω.

R_Y = ... [1]

(v) Vary d, obtaining a suitable range of values, and repeat **(b)(ii)** and **(b)(iii)**.

Present your results clearly.

d / cm	V_X / V	R_Y / Ω	V_X (R_X + 2R_Y) / V Ω
50.0	1.89	4.15	34.6
60.0	1.84	4.98	36.7
70.0	1.80	5.81	38.9
80.0	1.78	6.64	41.4
40.0	1.94	3.32	32.3
30.0	2.00	2.49	30.0

> [1] 6 sets of readings obtained (without assistance)
> [-1] if the candidate has been unable to collect data without assistance/intervention.
>
> [1] Each column heading must contain a physical quantity and an appropriate unit.
>
> [1] Consistency in number of decimal places for raw data (d and V_X).
>
> [1] **R_Y and V_X (R_X + 2R_Y)** calculated correctly,
> [1] significant figures for each of the calculated value should reflect the number of significant figures in the raw data.

[5]

(vi) V_X, R_X and R_Y are related by the expression

$$V_x\,(R_X + 2R_Y) = pR_Y + q$$

where p and q are constants.

Plot a suitable graph to determine values for p and q.

Y-axis: ***V_X (R_X + 2R_Y)***
X-axis: ***R_Y***
Gradient: p
Y-intercept = y

p = 2.72 V

q = 23.3 V Ω

> [1] Linearising equation correctly
>
> [1] Determination of Gradient
> Recording of the 4 coordinates accurate to half a small square
> Hypotenuse of triangle > half length of li[ne] drawn
> correct calculation of p; unit of p
>
> [1] correct calculation of y intercept using a point on the line {not from the table} or read off the graph to accuracy within half a small square; Unit for q

p = ...

q = ... [6]

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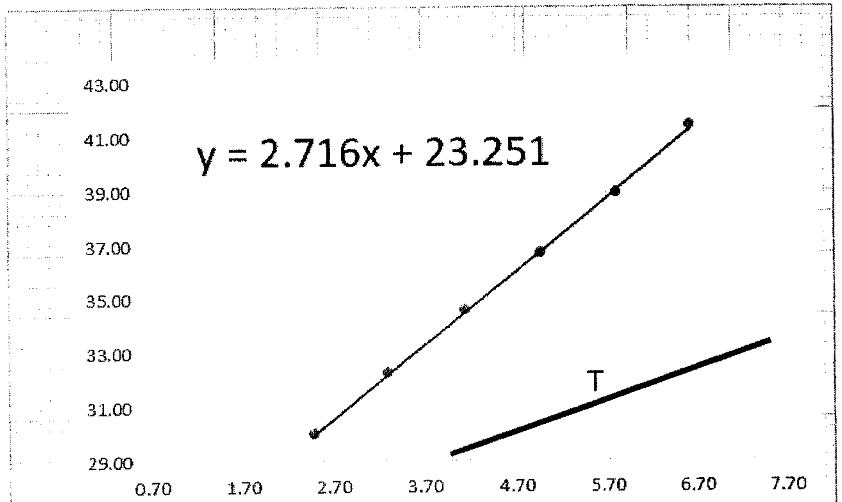


[1] Sensible scales must be used. No awkward scale allowed. Scales must be chosen such that the plotted points occupy more than half the grid in both x and y directions. Axes must be labelled with correct quantity and appropriate unit.

[1] All collected data points must be plotted correctly on the graph grid. (Accuracy up to half a small square in both the x and y directions).

[1] Assessed best fit line if and only if at least 5 out of 6 of the plotted points are non-anomalous. Judge by scatter of points about the plotted line. Fair scatter of points on either side of the line

(vii) Theory suggests that

$$q = R_X E$$

where E is the e.m.f. of the circuit.

State and explain whether the results of your experiment support the suggested relationship. Justify your answer by comparing your experimental results with the value of R_X recorded in **(b)(ii)**.

$23.3 = R_X \times 2.83$
$R_X = 8.23\ \Omega$

[1] R_X value is calculated correctly with correct s.f. (allow for plus 1) and unit Ω. Percentage difference correctly calculated.

Percentage difference in the two values of R_X obtained
= (10 – 8.23) / [0.5 (10 + 8.23)]
= 19%

Since the percentage difference of 19% in the two values of R_X is very large, the results of the experiment do not support the relationship.

[1] A reasonable conclusion is made based on the percentage difference calculated.

[2]

(viii) It is known that p decreases when E decreases.

Assuming that the relationship stated in **(b)(vi)** is true, sketch a new line on your graph grid to show the results you would expect if the experiment is repeated with a smaller E.

Label this line as T. [1]

[1] T has lower gradient and y-intercept as compared to the original line.

[Total: 20]

4 A typical dragon boat requires 20 paddlers, 1 drummer and 1 steerer. Every time a crew member steps onto the dragon boat, it experiences vertical oscillations in water.

The frequency f of the oscillations of an object (such as the dragon boat) with mass m in solution of density ρ is given by the equation

$$f = k\, m^x \rho^y$$

where k, x and y are constants.

Design an experiment to determine the values of x and y.

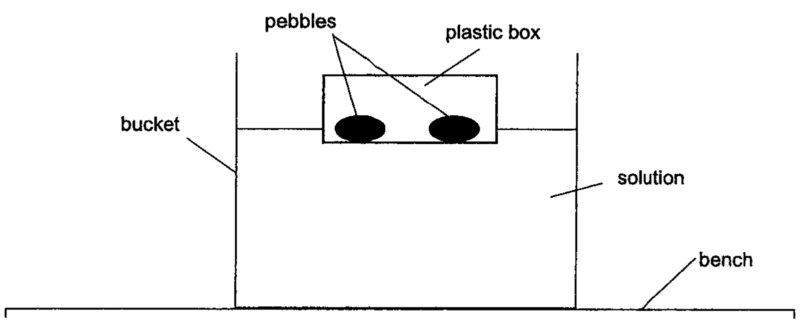
You are provided with a bucket, a small empty plastic box, sugar and some small pebbles.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

- the equipment you would use
- the procedure to be followed
- how the frequency of oscillations and density of solution is measured
- the control of variables
- any precautions that should be taken to improve the accuracy of the experiment

[Total: 12]

	Marks	Marking Points	
Diagram **D**	1	**D1**	Clear, labelled diagram showing a plastic box (with some pebbles) floating in a solution in a bucket.
Basic Procedure identifying the Variables **V**	2		Dependent variable is frequency of oscillation f
		V1	By varying Independent variables mass m, measure and record 6 sets of readings for frequency of oscillation f and m (with ρ constant)
		V2	Another 6 sets of readings for f and ρ (with m constant)
Control **C**	1	**C1**	Keep the volume of solution used in the bucket to be constant throughout.



Procedures **P**	4		Set up apparatus as shown.
		P1	Keeping density of solution ρ constant, vary mass m by adding different number of pebbles into the plastic container. Measure m using an electronic mass balance.
		P2	Keeping mass m constant, vary density of solution ρ by adding different amounts of sugar into solution in the bucket.
		P3	Measure the mass m_s of 100 cm^3 of the solution using a an electronic mass balance and measuring cylinder respectively. Calculate ρ using $\rho = m_s / 100$
		P4	Displace the plastic box vertically when it's floating on the water. Measure the time taken t for N number of oscillations with a stopwatch. Calculate f using N / t.
Analysis **A**	1	**A1**	$\lg f = x \lg m + \lg (k\rho^y)$ Plot a suitable graph of $\lg f$ vs $\lg m$ (keeping ρ constant). gradient = x; y-intercept = $\lg (k\rho^y)$ $\lg f = y \lg \rho + \lg (k m^x)$ Plot a suitable graph of $\lg f$ vs $\lg \rho$ (keeping m constant). gradient = y; y-intercept = $\lg (k m^x)$
Reliability **R**	2		Any **two** of the following design details to improve Accuracy of DV and IV:
		R1	Ensure that all of the sugar added has been completely dissolved.
		R2	Ensure that the pebbles in the plastic box are evenly spaced apart so as that the plastic box is stable when it is oscillating. Use a marker to mark the equilibrium position of the plastic box to aid in the counting of oscillations. Ensure that the amplitude of oscillations is kept small so there is little splash and waves reflected from the sides of the bucket. Ensure that the plastic container is placed in the middle of the bucket so that it will be less affected by the waves reflected from the sides of the bucket.
Safety **S**	1		Any **one** safety consideration.
		S1	Ensure that the bucket is placed in the middle of the table bench or on the floor. Be careful in moving the bucket of solution as it is heavy and can potentially injure someone.
Total	12		

BP~825