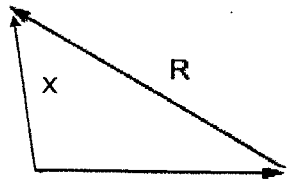
2022 YIJC Preliminary Examination H2Physics Physics Paper 1 Answer Key

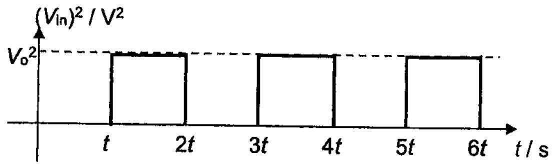
Question	Answer	Question	Answer	Question	Answer
1	C	11	C	21	A
2	A	12	D	22	A
3	C	13	B	23	A
4	D	14	C	24	C
5	D	15	A	25	D
6	D	16	B	26	B
7	C	17	C	27	A
8	B	18	D	28	C
9	A	19	B	29	A
10	A	20	C	30	C

S/N	Ans	Explanation
1	C	Units of $\mu = \frac{\text{C s}}{\text{kg}}$ = A s^2 kg^{-1}
2	A	X = P – R = P + (–R) Hence vector R needs to change to the opposite direction before adding to P 
3	C	Distance travelled during 0.20 m s^{-2} acceleration = $\frac{20^2}{2(0.20)}$ =1000 m Distance travelled for the 0.40 m s^{-2} deceleration = $\frac{20^2}{2(0.40)}$ = 500 m Total time travel = $\frac{20}{(0.20)} + \frac{1500}{20} + \frac{20}{(0.40)}$ = 225 s
4	D	Given that the reading is smaller than the person's mass, this means that the normal force is less than its weight. Thus, the resultant force at this instant is downwards. Hence, the person could be moving downwards with increasing speed or moving upwards with decreasing speed

S/N	Ans	Explanation
5	D	Taking all the masses as a system, F = 6a a = F/6 Applying F = ma for the 1kg mass F–Force by 2kg = a F–Force by 2kg = F/6 Force by 2kg = 5F/6
6	D	For elastic collision, momentum and total KE must be conserved. Only option D fulfilled both the conditions. For Option D: Initial total momentum = (0.50)(4.0) + (0.50)(1.0) = 2.5 N s^{-1} Final total momentum = (0.50)(1.0) + (0.50)(4.0) = 2.5 N s^{-1} Initial total KE = ½(0.50)(4.0)^2 + ½(0.50)(1.0)^2 = 4.25 J Final total KE = ½(0.50)(1.0)^2 + ½(0.50)(4.0)^2 = 4.25 J Extra knowledge: since the object has the same mass, and it is head on elastic collision, the object will swap their velocities before and after collision
7	C	Weight = (Tension)cos(30°) *F* = (Tension)sin(30°) Hence, *F*/Weight = tan(30°) *F* = 170 N
8	B	By conservation of energy, Loss in GPE = Gain in KE + W.D by resistive force (600)(80 – *h*)(9.81) = [½ (600)(12.0)^2 – 0] + (200)(1500) *h* = 22 m
9	A	Force by engine + (Weight)sin(6.0°) – resistive force = 0 Force by engine = 462 N Power output by engine = (462)(30) = 14 kW
10	A	Frictional force is the only horizontal force and hence it will be the only force that contributes to the centripetal force. Since centripetal force is towards the right at this instant, frictional force is rightwards.

11	C	$F_n = ma$ $mg = ma$ Since $g = -\frac{d\phi}{dr} = -\frac{\Delta\phi}{\Delta r}$ for a uniform gravitational field $\frac{m\Delta\phi}{\Delta r} = \frac{E}{x} = ma$ $a = \frac{E}{mx}$ The direction of F_n and g is from higher potential to lower potential, i.e. P to Q
12	D	For simple harmonic motion, $a = -\omega^2 x$. Hence the gradient of an a-x graph is $-\omega^2$ $\|\text{Gradient}\| = (\frac{2\pi}{T})^2 = \frac{4\pi^2}{T^2}$ When the period of oscillation is doubled, the gradient of the graph is one quarter of the original graph.
13	B	$v = f\lambda \Rightarrow 340 = (500)\lambda \Rightarrow \lambda = 0.68$ m $\frac{x}{\lambda} = \frac{\Delta\theta}{2\pi} \Rightarrow \frac{0.17}{0.68} = \frac{\Delta\theta}{2\pi} \Rightarrow \Delta\theta = \frac{\pi}{2} rad$
14	C	I_1 is the same regardless of the orientation. (Students to understand that I_1 is half the intensity of the incident unpolarized light) I_2 will change according to Malus' Law ($I_2 = I_1 \cos^2\theta$) where θ is the angle between the transmission axes of the polarisers.
15	A	There are effectively 6 loops spanned over a distance of 1.5 m Thus, length of one loop = $\frac{1}{2}\lambda = \frac{1.5}{6}$ $\lambda = 0.50$ m
16	B	$d\sin\theta = n\lambda$ $\left(\frac{10^{-3}}{1200}\right)\sin 35.0^0 = (1)\lambda$ $\lambda = 4.78\times10^{-7}$ m = 478 nm
17	C	Assuming that the rate of heat loss is constant, a longer time interval Q compared to time interval S means that more thermal energy is given out during the process of condensation than freezing. For the same mass, more thermal energy implies that the specific latent heat of vaporisation is greater than its specific latent heat of fusion.

18	D	With the reduction in the volume of gas, the distance between the walls of the container is reduced, leading to an increase in the frequency of the collisions of the gas molecules with the walls. Hence the rate of change of momentum and hence force that the gas molecules experience increased. According to Newton's third law, the force and pressure acting on the walls increases. With constant temperature, the kinetic energy and speed of the gas molecules remains unchanged.
19	B	$W_{on} = -p(V_f - V_i) = -1.3 \times 10^5 \times (3.6 - 1.3) \times 10^{-4}$ $= -29.9$ J (expansion) $\Delta U = Q_{to} + W_{on} = (+24) + (-29.9)$ $= -5.9 \approx -6$ J
20	C	With the electric field pointing downwards, the electric force acting on the +Q and −Q is downwards and upwards respectively. That would lead to a resultant force of zero and a resultant torque in the anti-clockwise direction.
21	A	Work done = $\Delta EPE = q\Delta V$ Since P and Q are at the same distance away from the positive point charge, the potential at P and Q are the same, i.e. $\Delta V = 0$ $W = 0$
22	A	$I = nAvq$ Thus the average drift velocity is directly proportional to the current and inversely proportional to the square of the diameter. When the current is doubled and the diameter is doubled, the average drift velocity is halved.
23	A	$P_{device} = I^2R$ $4.0 = I^2 \times 20$ $I_{device} = 0.447$ A $P_{device} = I V$ $4.0 = 0.447 V$ $V_{device} = 8.94$ V $V_{rheostat} = I R$ $16 - 8.94 = 0.447 R_{rheostat}$ $R_{rheostat} = 15.7 \approx 16\ \Omega$
24	C	Given that the ammeter reading is zero, the p.d. across the 100 Ω is the same as the p.d. across the 200 Ω, i.e. $V_{100\,\Omega} = V_{200\,\Omega}$ Using potential divider, $\frac{100}{100+50} \times 12 = \frac{200}{200+R} \times 24$ R = 400 Ω

25	D	$B = \mu_o n I$ As the number of turns is halved, solenoid length is also halved, hence n does not change. As $I = V/R$ where $R = \rho L/A$, since L is halved, R will be halved and I will be twice as before. Hence B_{centre} will be twice.
26	B	By Faraday's Law, the e.m.f. induced in the coil of wire rotating in a magnetic field is proportional to the rate of change of flux in the coil. $E = -\frac{d\phi}{dt} = -\frac{d(NBA)}{dt}$ Hence e.m.f. does not depend on resistance of coil.
27	A	By Fleming's Right Hand Rule, the induced current will flow from Y to X inside the rod, which makes X the end with higher potential. Using $\varepsilon = BLv$, we have $\varepsilon = 3.5 \times 0.80 \times 2.0 = 5.6$ V Thus, P = $\varepsilon^2 \div R = 5.6^2 / 6 = 5.23$ W
28	C	Half-wave rectification is achieved with one diode:  For the above graph, $V_{rms} = \sqrt{\frac{V_0^2}{2}} = 0.71\ V_o$
29	A	$(\Delta x)(\Delta mv) \geq h$ $\Delta v \geq h / (0.25 \times 10^{-3} \times 5.30 \times 10^{-26}) = 5.0 \times 10^{-5}$ m s^{-1}
30	C	An alpha decay reduces nucleon number by 4 and proton number by 2. A beta decay maintains value of the nucleon number and increases proton by 1. Thus new nucleon number = 217 – 4 – 4 – 0 = 209 And new proton = 85 – 2 – 2 + 1 = 82.

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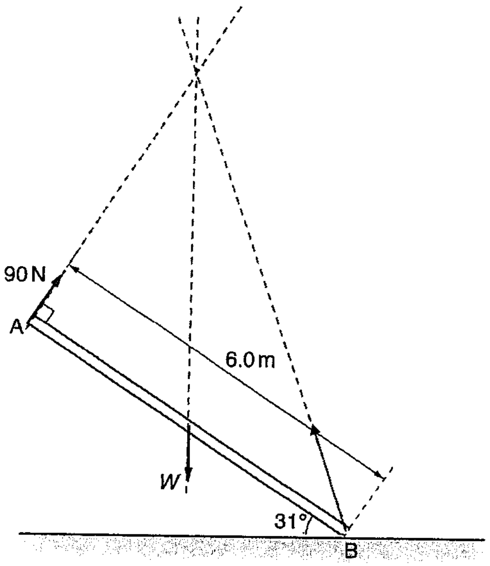
2022 Preliminary Examination H2Phy Paper 2 Suggested Solutions

1	(a)(i)	Using v = u + at for vertical motion, 5.5sin(33°) = −5.5sin(33°) + (9.81)t t = 0.61 s	C1 A1
	(a)(ii)	**Horizontal distance** = 5.5cos(33°) × 0.61 = 2.8 m	C1 A1
	(a)(iii)	Ratio = [5.5cos(33°)]²/[5.5]² = 0.70	C1 A1
		Marker's comment:	
	(b) (i)	 Students must show that the lines of action of all 3 lines intersect at a common point.	B1
	(b)(ii)	Taking moment about B, 90 × 6.0 = W × 3.0 cos(31°) W = 210 N	C1 A1
	(b)(iii)	Vertical component of F = 210 – 90 sin(59°) = 133 N Horizontal component of F = 90 cos(59°) = 46 N $F = (133^2 + 46^2)^{1/2} = 141$	C1 C1 A1

2	(a)	<u>Straight line passing through the origin</u> which shows that F and x is proportional	B1
	(b) (i)	Spring constant = 5.6/0.04 = 140 N m^{-1}	B1
	(b) (ii)	EPE = ½ (5.6)(0.04) = 0.11 J	B1
	(c) (i)	Upthrust = Weight – Tension = 6.2 – 5.6 = 0.60 N	A1
	(c) (ii)	Pressure difference = 0.60/(1.2 × 10^{-3}) = 500 Pa	C1 A1
	(d)	If the liquid has a greater density, then <u>the value of upthrust will increase</u>. Since upthrust + spring force = weight, the <u>value of spring force will decrease</u>. Hence the <u>extension will reduce</u>.	M1 A1
	(e)	Percentage uncertainty of h $= \left[\frac{0.4}{6.2} + 2\left(\frac{0.03}{1.95}\right) + \frac{300}{7800}\right] \times 100\%$ = 13%	C1 A1

3	(a)	The gravitational potential <u>at infinity is set at zero</u> (as there is negligible g-force).	B1
		Either of the following points, • The gravitational force is **attractive** and so the external force acting on the object is <u>opposite in direction</u> to the object's displacement as it moves from infinity to the point in question. • The celestial bodies are in a bound system. Work needs be given to separate them. Therefore, the system has negative potential. • At points that are less than infinity, the gravitation potential is negative as the test mass would lose gravitational potential energy when displaced from infinity (where GP is zero) to those points.	B1
		Hence, the work done by the external force is negative which results in the gravitational potential having a negative value. <u>Alternative</u> The gravitational potential at infinity is set at zero. In bringing a point mass from infinity to a point in the gravitational field, the work done per unit mass by an external agent is **negative** as the force exerted on the point mass is opposite to its displacement from infinity. Hence, the gravitational potential has a negative value.	A0
	(b) (i)	The (net) gravitational field strength is equal to the negative gradient of the (net) gravitational potential – distance graph.	B1
		Hence the direction of the net gravitational force is initially towards star A at $x = 0.1 \times 10^{12}$ m , zero at 0.52×10^{12} m and finally towards star B thereafter.	B1
	(b)(ii)	For the rock to reach the point where $x = 1.2 \times 10^{12}$ m, it must first be provided with a minimum amount of <u>energy to reach the point of maximum gravitational potential</u> (-4.4×10^8 J kg^{-1}). After that, the rock will be pulled towards star B. $GPE_A + KE_A = GPE_{max}$ (KE=0 at the peak of graph) $m\,\phi_A$ + min KE $= m\,\phi_{max}$	M1
		$(180)(-10 \times 10^8) + (½ \times 180 \times v^2) = (180)(-4.4 \times 10^8)$ $v = 3.3 \times 10^4$ m s^{-1}	A1

4	(a)	amplitude to amplitude = 2 x_0 = 9.8 cm x_0 = 4.9 cm	A1
	(a) (ii)	$f = \frac{2700}{60}$ f = 45 Hz	A1
	(a) (iii)	$v = \omega\sqrt{x_0^2 - x^2}$	C1
		$= 2\pi \times 45 \times \sqrt{0.049^2 - (0.049 - 0.023)^2}$ = 12 m s^{-1}	A1

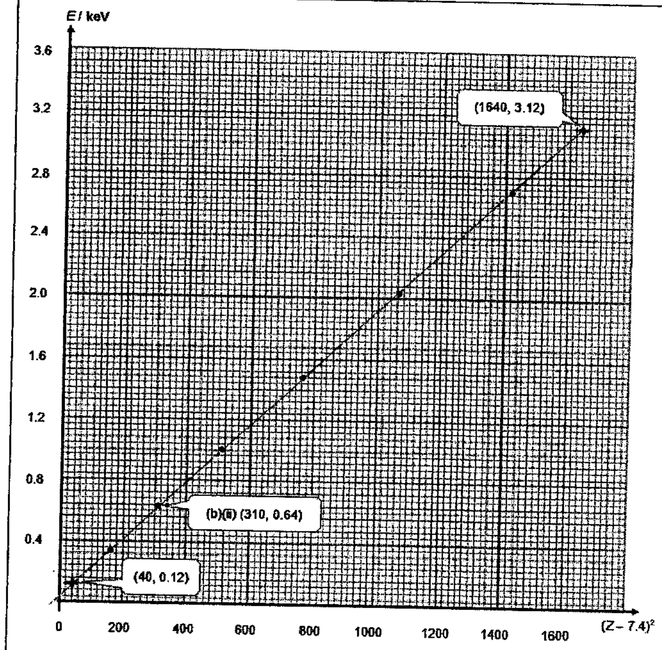
	(b)	$F_{max} = ma_{max} = m\omega^2 x_0$ $= 0.64 \times (2\pi \times 45)^2 \times 0.049$	C1
		= 2500 N	A1

5	(a)	First law of thermodynamics states that the increase in internal energy of a gas is the sum of the thermal energy supplied to the gas and the work done on the gas.	A1
	(b) (i)	Using the ideal gas equation, $P = \frac{nRT}{V}$ $P_i = \frac{nRT_i}{V_i} = \frac{nR(21.0+273.15)}{3.49\times10^{-6}} = nR(8.43\times10^4)$	B1
		$P_f = \frac{nRT_f}{V_f} = \frac{nR(53.0+273.15)}{3.87\times10^{-6}} = nR(8.43\times10^4)$	M1
		Since the mass of the gas (or number of moles) is constant, the final and initial pressures are the same. Or Since PV=nRT, and the number of moles is the same, the ratio of V/T must be constant. $\frac{V_1}{T_1} = \frac{3.49\times10^3\times10^{-6}}{21.0+273.15} = 1.19\times10^{-5}$ $\frac{V_2}{T_2} = \frac{3.87\times10^3\times10^{-6}}{53.0+273.15} = 1.19\times10^{-5}$ the pressure is also constant	A0
	(b) (ii)	Since pressure is constant, $W_{by} = p\Delta V$ $= 4.2 \times 10^5 \times (3.87 - 3.49) \times 10^3 \times 10^{-6}$	C1
		= 160 J (1 mark for students whose answer is – 160 J)	A1
	(b) (iii)	$\Delta U = Q_{to} + W_{on}$ = (+ 565) + (– 160)	C1
		= 405 J	A1
	(b) (iv)	The internal energy of a real gas is defined as the sum of the microscopic kinetic energy and potential energy of the gas molecules.	B1
		However, for an ideal gas, it is assumed that there are no intermolecular forces of attraction between the gas molecules.	B1
		This means that the gas molecules do not possess microscopic potential energy.	B1
		Hence, the the change in its internal energy is totally due to the change in the total microscopic kinetic energies of the gas molecules.	A0

6	(a)	Magnetic flux density is the force acting per unit current per unit length on a conductor placed at right angles to a magnetic field	B1
	(b)(i)	The particle has a velocity component (v_y) that is perpendicular to the *B*-field and another component (v_x) parallel to the *B*-field. Due to v_y always being perpendicular to the *B*-field, there is magnetic force that is always perpendicular to v_y, hence resulting in circular motion of the particle. Due to v_x always being parallel to the *B*-field, there is no magnetic force, hence resulting in linear motion of the particle. Combining the two motions, the resulting path is helical.	B1 B1
	(ii)	The component of the velocity involves in the circular motion is $v_y = v\sin\theta$. The magnetic force acting on the charge acts as its centripetal force. $Bqv_y = \frac{mv_y^2}{r}$ $r = \frac{mv_y}{Bq} = \frac{mv\sin\theta}{Bq}$	B1 B1 M1 A0
	(iii)	$v\sin\theta = r\omega$ Since $r = \frac{mv\sin\theta}{Bq}$ $v\sin\theta = \frac{mv\sin\theta}{Bq} \times \frac{2\pi}{T}$ $T = \frac{2\pi m}{Bq}$ Since the expression for period *T* does not contain θ, *T* is independent of θ.	M1 A1

7	(a)	The magnitude of the induced e.m.f. is directly proportional to the rate of change of magnetic flux linkage.	B1
	(b)(i)	Final flux linkage = $8.0 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$ = 4.8×10^{-5} Wb Initial flux linkage = $50 \times 10^{-3} \times 0.4 \times 10^{-4} \times 150$ = 3.0×10^{-4} Wb change = $\lvert(4.8 \times 10^{-5}) - (3.0 \times 10^{-4})\rvert$ = 2.52×10^{-4} Wb	M1 A1
	(ii)	Ave e.m.f. = $\lvert\frac{\Delta\phi}{\Delta t}\rvert$ = $\frac{2.52 \times 10^{-4}}{0.30}$ = 8.4×10^{-4} V	M1 A1
	(c)	The change in flux linkage over a given distance decreases when the coil is further from the magnet.	M1 M1

		For the induced emf to remain the same, the rate of change of flux linkage with respect to time must be constant. Thus, the speed of the coil should increase.	A1

8	(a) (i)	In photoelectric effect, EM radiation releases electrons. In X-ray production, the reverse happens whereby electrons' acceleration or deceleration releases EM radiation.	B1
	(ii)	Maximum $I = P/V = 4 \times 10^3 / 40 \times 10^3 = 0.10$ A = 100 mA Minimum $I = P/V = 4 \times 10^3 / 115 \times 10^3 = 0.0348$ A = 35 mA Range of currents = 35 – 100 mA	M1 A1
	(iii)	The rest of the kinetic energy of the electrons is transferred to the atoms (which causes the atoms to vibrate more vigorously). Or The rest of the kinetic energy is converted to heat.	B1 B1
	(b)(i)	310	B1
	(ii)	 Accurate plot (to half a small square) Best fit line	B1 B1

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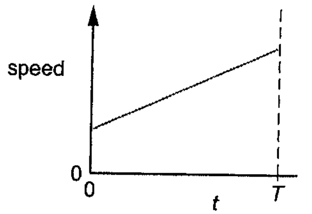
	(iii)	Gradient = $(3.12 - 0.12) / (1640 - 40) = 1.875 \times 10^{-3}$ keV $\approx 1.9 \times 10^{-3}$ keV Thus, $aE_1 = 1.9 \times 10^{-3}$ keV $\Rightarrow E_1 = 1.9 \times 10^{-3}$ keV / 0.139 = 13.7 eV Or $E_1 = 1.875 \times 10^{-3}$ keV / 0.139 = 13.5 eV	M1 A1
	(iv)	Finding y-intercept: $3.12 = (1.9 \times 10^{-3})(1640) + c \Rightarrow c = 0.0040$ keV Or $3.12 = (1.875 \times 10^{-3})(1640) + c \Rightarrow c = 0.045$ keV Since $c \approx 0$ keV, this is consistent with the mathematical expression of Moseley's law which does not have a y-intercept. (Alternatively, students can read off the y-intercept and comment on the consistency.)	M1 A1
	(v)	For the K_α line, $E = 0.75E_1(Z-1)^2 = 0.75(0.0137)(Z-1)^2$ Thus, $E = 0.75(0.0137)(74-1)^2 = 54.8$ keV	M1 A1
	(vi)	To show up on the X-ray spectrum of rhodium, the minimum energy of the incident electrons must be 2.70 keV. Thus, the minimum accelerating voltage must be 2.70 kV.	M1 A1
	(c)(i)1	$\frac{\text{Intensity of X-ray beam emerging from model}}{\text{Intensity of X-ray beam incident on model}} = \frac{I_o e^{-(0.3)(10)}}{I_o}$ = 0.0498	A1
	(i)2	$\frac{\text{Intensity of X-ray beam emerging from model}}{\text{Intensity of X-ray beam incident on model}} = \frac{I_o e^{-(0.3)(4)} e^{-(10)(6)}}{I_o}$ $= 2.64 \times 10^{-27}$	M1 A1
	(ii)	The ratio of the ratios in (i) and (ii) is very large. Thus, the images will have good contrast	M1 A1

2022 YIJC JC2 H2 Preliminary Examination Paper 3 Suggested Solutions

1	(a)	Using $v^2=u^2+2as$ $8.7^2 = u^2 + 2(9.81)(1.5)$ $u = 6.8$ m s^{-1}	 C1 A1
	(b)	 Linear line and when $t = 0$, speed is more than 0	B1
	(c)	When the ball hits the ground, it exerted a (normal) force on the ground. By Newton's third law, the ground exerts a (normal) force on the ball. The two forces are equal in magnitude but opposite in direction.	 B1 B1
	(d)(i)	Change in momentum = final momentum – initial momentum = (0.059)(5.4) – (0.059)(– 8.7) = 0.83 N s	 C1 A1
	(d)(ii)	Resultant force on the ball = 0.83/0.091 = 9.1 N Force by ground on ball = 9.1 + (0.059)(9.81) = 9.7 N	 C1 C1 A1
	(e)	The resultant force will be equal to weight – air resistance. Air resistance increases with speed. Therefore, the resultant force and acceleration will decrease with time. Thus, the gradient of the graph will decrease with time.	B1 B1

2	(a)	For an object to move in circular motion at constant speed, it only changes direction hence, the change in velocity must be perpendicular to the direction of its velocity. Thus, the acceleration needs to be perpendicular to its velocity which leads to the resultant force being perpendicular to the velocity Alternative: Since the object is moving at constant speed, its KE does not change. By Work-Energy Theorem, the work done by the resultant force must then be zero. Thus the resultant force must act perpendicular to its velocity.	B1 B1 B1 B1

	(b)(i)	$v = r\omega$ = (6.2)(2π/4.1) = 9.5 m s^{-1}	 C1 A1
	(b)(ii)	Acceleration = $r\omega^2$ = (6.2)(2π/4.1)^2 = 14.6 m s^{-2}	 C1 A1
	(b)(iii)	R_B – Weight = resultant force R_B – (75)(9.81) = (75)(14.6) R_B = 1830 N	 C1 A1
	(c)	$R_A = ma - mg$, $R_A > 0$ is required to remain contact so $v^2/r > g$, i.e. $v > \sqrt{rg}$, the minimum speed for a contact force to be required	B1 B1
	(d)	minimum speed is when $v^2/r = g$ $v^2/6.2 = 9.81$ $v = 7.8$ m s^{-1}	 C1 A1

3	(a)	There is no lost volts or energy in the internal resistance of the battery *OR* With no internal resistance, the potential difference between A and C which is the terminal p.d. across the battery is equal to the e.m.f. of the battery.	B1
	(b)	As R is increased, the current I from the battery and hence flowing through Y decreases. With resistance of Y being constant, the p.d. across Y decreases	M1 A1
	(c)(i)	**Method 1** When $R = 6.0\ \Omega$, $I = 2.4$ A Hence $V_{BC} = 2.4 \times 6.0 = 14.4$ V $V_{AC} = V_{AB} + V_{BC}$ $24 = V_{AB} + 14.4$ $V_{AB} = 9.6$ V **Method 2 (longer method)** When $R = 6.0\ \Omega$, $I = 2.4$ A Hence $E = I R_{total}$ $24 = 2.4 \times R_{total}$ $R_{total} = 10\ \Omega$ $R_{AB} + R_Y = R_{AB} + 6.0 = 10$ $R_{AB} = 4.0\ \Omega$ Using potential divider rule, $V_{AB} = \frac{R_{AB}}{R_{total}} \times E = \frac{4.0}{10} \times 24$ = 9.6 V	C1 M1 A0

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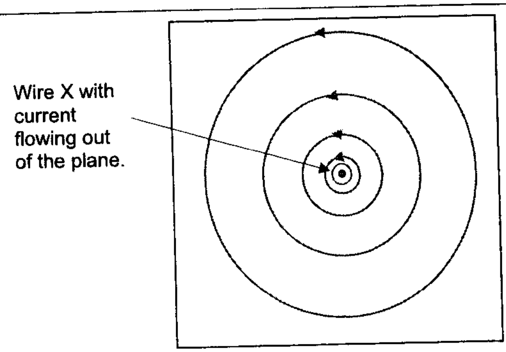
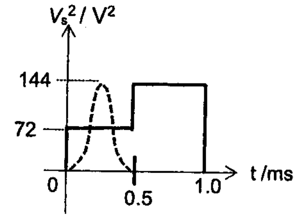
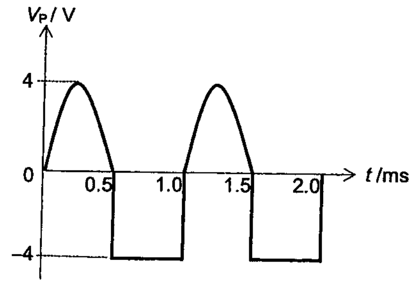
Q	Part	Answer	Marks
	(c)(ii)	**Method 1** $V_{AB} = I_{AB} \times R_{AB}$ $9.6 = 2.4 \times R_{AB}$ $R_{AB} = 4.0\ \Omega$ $\frac{1}{R_X} + \frac{1}{R} = \frac{1}{R_{AB}}$ $\frac{1}{R_X} + \frac{1}{6.0} = \frac{1}{4.0}$ $R_X = 12\ \Omega$ **Method 2** $V_R = I_R \times R$ $9.6 = I_R \times 6.0$ $I_R = 1.6$ A $I = I_R + I_X$ $2.4 = 1.6 + I_X$ $I_X = 0.8$ A $V_X = I_X \times R_X$ $9.6 = 0.8 \times R_X$ $R_X = 12\ \Omega$	C1 C1 A1
	(c)(iii)	$P = I E$ $= 2.4 \times 24$ $= 57.6$ W	A1
	(d)	With a constant e.m.f. and a decreasing current from battery OR With a constant e.m.f. and an increasing total resistance in the circuit the power provided by the battery decreases	A1 M0

Q	Part	Answer	Marks
4	(a)(i)	 Magnitude of magnetic field strength: Increasing width separation of the concentric circles from the centre at wire X Direction of magnetic field: Anticlockwise direction based on right hand grip rule	B1 B1
	(a) (ii)	Since the currents of the parallel current-carrying wires are the same in direction, the magnetic forces are attracting each other. Hence, the direction of the magnetic force is from Y towards X.	B1

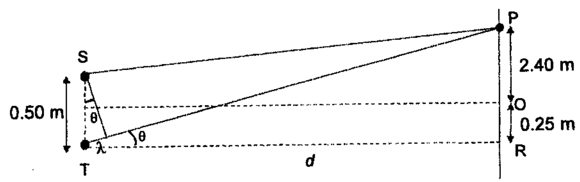
Q	Part	Answer	Marks
	(b)(i)	B at wire Y due to wire X, $B = \frac{\mu_0 I_X}{2\pi x}$ $B = \frac{4\pi \times 10^{-7} \times 5.0}{2\pi \times 2.5 \times 10^{-2}}$ $= 4.0 \times 10^{-5}$ T $F = B I_Y L \sin\theta$ $F = 4.0 \times 10^{-5} \times 7.0 \times L \sin 90°$ $\frac{F}{L} = 2.8 \times 10^{-4}$ N	C1 C1 A1
	(b)(ii)	The magnetic force acting on wire X due to wire Y and the magnetic force acting on wire Y due to wire X are a pair of action and reaction forces. According to Newton's 3rd law, the forces on the two wires are equal in magnitude. ***OR*** The magnitude of the magnetic force depends on the product of the currents in the two wires. Hence the forces on the two wires are equal in magnitude.	M1 A1 M1 A1
	(c)	$F_Y = B_Y I_x L \sin\theta$ $F_Y = \frac{\mu_0 I_X \sin\omega t}{2\pi x} \times I_Y \sin\omega t \times L \sin\theta$ $F_Y = \frac{\mu_0 L I_X I_Y}{2\pi x} \times \sin^2 \omega t$ Since F_Y is proportional to $\sin^2 \omega t$, the variation of the magnitude of the magnetic force is square of sinusoidal (or sinusoidal) OR the variation of the magnitude of the magnetic force is twice the frequency of the current. Since the currents are in phase, i.e. the currents in the two wires are always in the same direction, the magnetic forces acting on the wires are always attractive, (except when the currents in the wires are both zero). The direction of the magnetic force is always towards wire X (or leftwards or always in the same direction). (One mark to describe the magnitude and One mark to describe the direction)	B1 B1

5	(a)	The value of voltage that is <u>equivalent to that of a steady d.c. voltage</u> which will dissipate energy <u>in a given resistor at the same rate</u>.	B1 B1
	(b)(i)	Squaring the graphs and arranging the curved portion to a rectangle.  Mean-square-voltage = 108 V² Root-mean-square voltage = 10.39 V = 10.4 V	M1 M1 A1
	(b)(ii)	Diode 1 — Forward-biased Diode 2 — Reverse-biased Both correct – [1] One or zero correct – [0]	B1
	(b)(iii)	Effective resistance across resistors P and Q = 10/2 = 5 Ω Using potential divider rule, Max p.d. across P = $\frac{5}{10+5}(12) = 4.0$ V	B1 B1
	(b)(iv)	 Correct waveform (shape) for two cycles −12 V < V_P < 12 V Numerical values of V_P not assessed	B1 B1

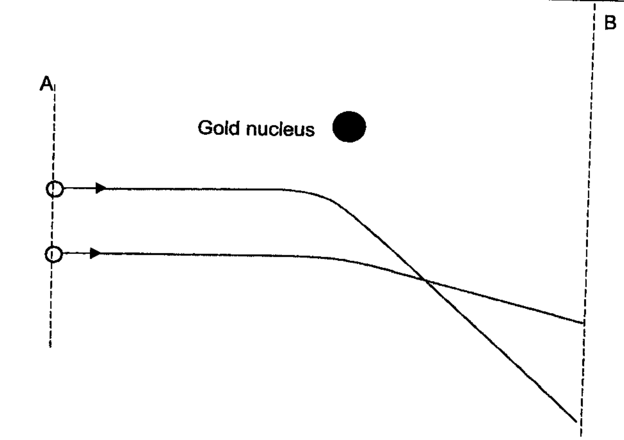
6	(a)(i)	either wavelength is longer than threshold wavelength or frequency is below the threshold frequency or photon energy is less than work function	B1
	(a)(ii)	$hc / \lambda = hf_o + E_k$ $(6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (240 \times 10^{-9}) = 6.63 \times 10^{-34} f_o + 4.44 \times 10^{-19}$ $f_o = 5.8 \times 10^{14}$ Hz	C1 A1
	(b)1.	photon energy larger so (maximum) kinetic energy is larger	B1
	(b)2.	fewer photons (per unit time) so (maximum) current is smaller	B1 B1

Section B

7	(a)	• The <u>direction of the oscillations</u> or vibrations is the key difference between longitudinal and transverse waves. • For longitudinal waves, the vibrations are <u>parallel</u> to the direction of wave (or energy) travel. • For transverse waves, the vibrations are <u>perpendicular</u> to the direction of wave (or energy) travel. (If student gave first point only, one mark is awarded. If student gave second and third points, full marks are awarded) Transverse wave can be polarised but longitudinal wave cannot. [B1]	B1 B1
	(b)(i)	$I = \frac{P}{4\pi D^2}$ Since intensity is proportional to the power of the sound source for fixed distance, the intensity is also halved when the power is halved Intensity is directly proportional to the square of the amplitude. $\Rightarrow I = kA^2$ $\Rightarrow \frac{I_2}{I_1} = \left(\frac{A_2}{A_1}\right)^2$ $\Rightarrow \frac{1}{2} = \left(\frac{A_{new}}{A}\right)^2$ $\Rightarrow A_{new} = \frac{A}{\sqrt{2}}$ or $0.71A$	C1 A1
	(b)(ii)	Intensity from a point source follows the inverse square law. The sound intensity $I = \frac{P}{4\pi D^2}$ For the intensity to be the same, $\frac{\frac{1}{2}P}{4\pi D'^2} = \frac{P}{4\pi D^2}$ $\Rightarrow D' = \frac{1}{\sqrt{2}}D = 0.71D$ To make the perceived intensity return back to its original intensity, one must move closer to the sound source.	C1 A1

	(c)(i)	The two waves are coherent because they have a <u>constant phase difference</u> (or constant phase relation) of π radian or 180°. or From Fig. 7.2, the periods of both waves are same at **ALL** times. (Value of phase difference is not necessary) (Reject the following notions - having same frequency, period, speed etc. Two independent sources may have the same frequency but are not coherent because their phase relation may not be the same at all times.)	B1
	(c)(ii)	The two waves arrive at P <u>in antiphase (180°) to each other</u> (crest of one meets the trough of the other wave) and <u>so destructive interference takes place</u>. However, it is only a partial cancellation as <u>their amplitudes are not the same (they do not cancel completely).</u> Hence, sound intensity at P is not zero but is a minimum.	B1 B1
	(c)(iii)	The resultant intensity is I. No explanation is required here. After superposition, the resultant amplitude is still that of S alone. Thus, the intensity is the same as S alone.	B1
	(c)(iv)	From Fig. 8.2, period T = 0.800 ms, $c = f\lambda$ $330 = (\frac{1}{0.800\times10^{-3}})\lambda$ λ = 0.264 m	M1 A1
	(d)(i)	P and O are successive minima and so the path difference must be one wavelength, λ = 0.264 m	B1
	(d)(ii) 1.	 Since P is the first minimum after O, the path difference (TP-SP) = λ Thus, $\sin\theta = \frac{\lambda}{a} = \frac{0.264}{0.50} = 0.528$ $\Rightarrow \theta = 31.9°$	C1 A1
	(d)(ii) 2.	Looking at triangle TPR, we have PR = PO + OR = (2.40 + 0.25) m = 2.65	C1

		$\tan\theta = \frac{x}{d} \Rightarrow \tan 31.9 = \frac{2.40+0.25}{d} = \frac{2.65}{d}$ $d = 4.3$ m • Note that sin 31.9° is not the same as tan 31.9° • Reject solving using $\lambda = \frac{ax}{D}$ (which yields d = 4.5 m). • The $\lambda = \frac{ax}{D}$ is valid only if $a << D$.	C1 A1
	(d)(iii)	The Young's double slit interference equation was derived based on the approximation that the wavelength λ is very small compared to the slit separation a, or that the slit separation a is much smaller than d In part (d)(ii)1, the angle θ (31.9°) is large. Here, we see that $\sin\theta = \frac{\lambda}{a} = \frac{0.264}{0.50} = 0.53$, and so the wavelength is not very small, compared to the source separation. In part (d)(ii)2, $\frac{a}{d} = \frac{0.50}{4.3} = 0.11$ Thus, the assumption does not satisfy the approximation condition where $\theta \approx \sin\theta \approx \tan\theta$ and so we cannot use the equation $\lambda = \frac{ax}{D}$.	M1 A1
	(e)	Polarisation is a phenomenon associated with transverse waves only. Sound is a longitudinal wave and as such is not affected by polarisation.	B1

8	(a)(i)	To remove air from the chamber, so that alpha particles can successfully travel from the source to the foil and to the screen.	B1 B1
	(a)(ii)	To detect the alpha particles, via scintillations / flashes of light, there must not be other significant sources of light in the room.	B1 B1
	(a)(iii)	Either Observation: A very small fraction of the α-particles was deflected through very large angles Implication: The nucleus has large mass and (positive) charge Or Observation: Most of the α-particles were hardly deflected Implication: The nucleus is very small in size / Most of the atom is empty space	B1 B1
	(a)(iv)	 Deflection is away from nucleus and the upper alpha particle has greater deflection angle Change in direction occurs before the point directly below nucleus Sharp deflection – max of [1]	B1 B1
	(b)(i)	$E = mc^2$ $= (1.0 \times 1.66 \times 10^{-27})(3.0 \times 10^8)^2$ $= 1.494 \times 10^{-10}$ J $= 1.494 \times 10^{-10} / 1.6 \times 10^{-19}$ eV = 934 MeV	M1 M1 A0

	(b)(ii)	Energy absorbed to separate a nucleus into its constituent free/unbound protons and neutrons Or Energy released to form a nucleus from its constituent free/unbound protons and neutrons	**B1** **B1**
	(b)(iii)	Mass defect of Zr = (40 × 1.0073) + (57 × 1.0087) – (97.0980) = 97.7879 – 97.0980 = 0.6899 u B.E. = 0.6899 × 934 = 644.37 MeV B.E. per nucleon = 644.37 / 97 = 6.64 MeV/nucleon	**C1** **C1** **A1**
	(c)(i)	Spontaneous decay means that the rate of decay is not affected by external factors such as pressure, temperature, etc. Or Decay occurs on its own, without external stimuli	**B1**
	(c)(ii)	The curve has local fluctuations / jagged edges	**B1**
	(c)(iii)	1. Gamma rays/photons 2. Alpha-particles 3. Gamma 4. Beta-particles **All four correct – [2]** **Subtract [1] for any wrong answer. Minimum is [0]**	
	(c)(iv)	The energy released is shared by the daughter nucleus, beta particle and a neutrino / anti-neutrino.	**B1**

YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CG

INDEX NO

PHYSICS

Marking Scheme

9749/04

Paper 4 Practical

25 Aug 2022

2 hours 30 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.

You may lose marks if you do not show your working, where appropriate, in the boxes provided.

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	/ 14
2	/ 6
3	/ 23
4	/12
Total	/ 55

This document consists of **17** printed pages and **3** blank pages.

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BP~871

BP~872

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

(a) Assemble the circuit as shown in Fig. 1.1.

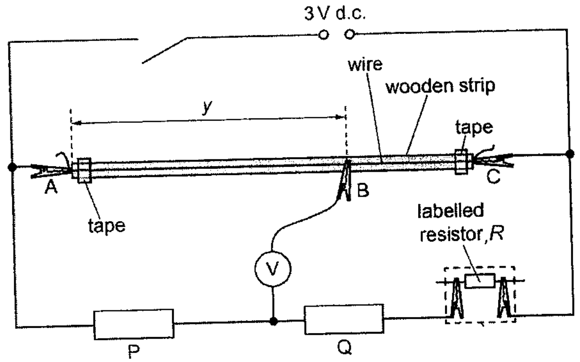


Fig. 1.1

Connect the resistor labelled 150 Ω and record it as resistance R.

R = 150 Ω

Close the switch. The voltmeter reading will be non-zero.

Adjust the position of B on the wire until the voltmeter reading is as close as possible to zero.

The distance between A and B is y, as shown in Fig. 1.1.

Measure and record y.

- Accuracy reading of y
- y recorded with correct unit and d.p [1]

(34.1 + 33.9)/2 = 34.0 cm

y = 34.0 cm [1]

Open the switch.

(b) Change the labelled resistor R and repeat **(a)**.

Present your results clearly.

R/Ω	y_1/cm	y_2/cm	y/cm	$\frac{1}{y}$ / cm^{-1}
150	34.1	33.9	34.0	0.0294
220	26.3	26.8	26.6	0.0376
330	19.6	20.2	19.9	0.0503
470	15.3	15.5	15.4	0.0649
680	10.7	11.1	10.9	0.0917
820	8.5	9.0	8.8	0.11

- Correct header with unit [1]
- 6 sets of data [1]
- Reading recorded with correct precision and values calculated to correct s.f

[3]

(c) It is suggested that the quantities y and R are related by the equation

$$\frac{1}{y} = a(R+b)$$

where a and b are constants.

Plot a suitable graph to determine a and b.

- Correct linearisation (look out for the linearisation statement) [1]
- Correct calculation of a with units and s.f [1]
- Correct calculation of b with units and s.f [1]

- Graph with appropriate scale [1]
- All data points correctly plotted [1]
- Appropriate best fit line drawn [1]

Plot $\frac{1}{y}$ against R with expected gradient a and vertical intercept ab

Gradient, $a = \frac{0.110-0.030}{840-160} = 1.18 \times 10^{-4}\text{cm}^{-1}\Omega^{-1}$

Vertical intercept = $0.110 - (1.18 \times 10^{-4})(840) = 1.09 \times 10^{-2}$

$b = (1.09 \times 10^{-2})/(1.18 \times 10^{-4}) = 92.4\ \Omega$

a = $1.18 \times 10^{-4}\text{cm}^{-1}\Omega^{-1}$

b = 92.4 Ω

[6]

(d) Measure and record the length W of the wire between the crocodile clips A and C.

- Measured to correct precision
- Check accuracy (87.5 to 92.5 cm)

W = 90.0 cm [1]

(e) The resistor P has resistance P.

Calculate the value of P using the relationship

$$a = \frac{1}{PW}$$

- P calculated to the correct s.f and unit
- Check accuracy (85 to 105 Ω)

$$1.18\times10^{-4} = \frac{1}{P(90.0)}$$

$$P = 94.2\ \Omega$$

P = 94.2 Ω [1]

(f) The experiment is repeated with a larger value of P.

Sketch a line on your graph grid on page 5 to show the expected result.

Label this line Z.

- Z plotted with appropriate change in gradient and y-intercept. (So larger P means smaller a, thus smaller gradient and y-intercept)

[1]

(g) Explain, without calculation, why the value of y is approximately equal to 0 cm when resistor P is replaced with a wire of negligible resistance.

After P is replaced, there is no potential drop across the new wire from the battery, hence point B is needed to be placed at position A (y = 0 cm) where there is no potential drop from the battery as well.

[1]

[Total: 14]

BP~873

2 In this experiment, you will investigate the result of a collision between two cylinders.

(a) The thicker wooden cylinder has diameter D.

Measure and record D.

- D measured to the correct precision (1 d.p in mm, 2 d.p in cm)
- Check accuracy of D
- Repeated reading for both D and d

½ (1.59 + 1.59) = 1.59 cm

D = ...1.59 cm...... [1]

(b) The thinner wooden cylinder has diameter d.

Measure and record d.

- d measured to the correct precision (1 d.p in mm, 2 d.p in cm)
- Check accuracy of d
- Repeated reading for d

½ (0.63 + 0.63) = 0.63 cm

d = ...0.63 cm...... [1]

(c) (i) You have been provided with a wooden ruler with a line drawn on the face without the scale.

Use the stand, boss and clamp to set up the ruler in the position shown in Fig. 2.1. The end near the line should touch the cork board and the other end should be approximately 7 cm above the bench.

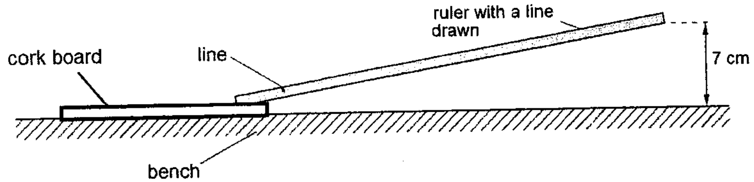


Fig 2.1

Place the cylinder with smaller diameter approximately 8 cm from the end of the wooden ruler.

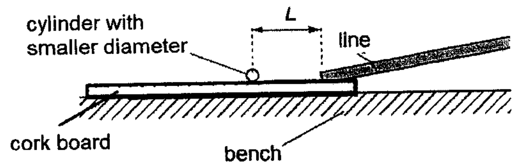


Fig 2.2

The distance between the end of the ruler and the cylinder is L, as shown in Fig. 2.2.

Measure and record L.

L = ...8.0 cm......

(ii) Place cylinder with smaller diameter on the line on the ruler is shown in Fig 2.3.

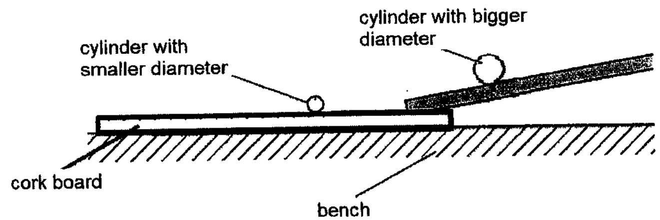


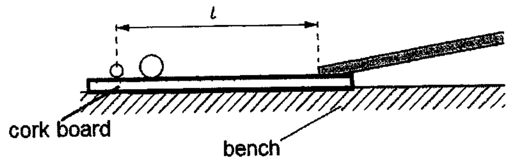
Fig 2.3

Release the cylinder of the bigger diameter.

It will roll down the ruler and on the cork board until it collides with the cylinder of the smaller diameter.

The cylinder of the smaller diameter will roll and then come to rest as shown in Fig. 2.4.

The distance between the cylinder of smaller diameter and the end of the ruler is l, as shown in Fig. 2.4.



Measure and record l.

- l is measured to the correct precision (1 d.p in cm)
- repeated reading
- l is more than L

½ (17.2 + 16.6) = 16.9 cm

l = ...16.9 cm...... [1]

(d) It is suggested that the relationship between l, L, D and d is

$$(l-L)^2 = z(D-d)^3$$

where z is a constant.

(i) Using your data, calculate z.

- z is calculated correctly and with the appropriate s.f
- z is reported with appropriate units [cm^{-1}]

$$z = \frac{(1.59-0.63)^3}{(16.9-8.0)^2} = 0.11\ cm^{-1}$$

z = 0.11 cm^{-1} [1]

(ii) If you were to repeat this experiment using a similar wooden ruler and cylinders but with different starting position of the cylinder with smaller diameter, describe the graph that you would plot and how can z be determined from the graph.

- *Plot l against L* [1]
- *z can then be determined from the vertical intercept as the vertical intercept will be $z^{1/2}(D-d)^{3/2}$* [1]

Any other logical linearisation can be accepted

[2]

[Total: 6]

3 In this experiment, you will investigate the motion of a loaded plastic ruler.

(a) Assemble the apparatus as shown in Fig. 3.1.

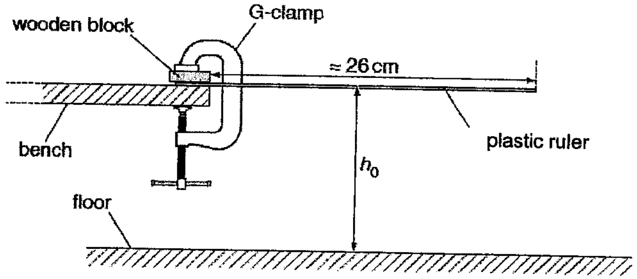


Fig. 3.1 (not to scale)

The vertical distance from the floor to the top surface of the plastic ruler is h_0, as shown in Fig. 3.1.

Measure and record h_0.

Value of h_0 with unit and to the nearest mm [1]

h_0 = 89.5 cm or 0.895 m [1]

(b) (i) Place the 50 g slotted mass on the plastic ruler with its centre approximately 19 cm from the bench and tape it in position.

When released, the plastic ruler will bend down, as shown in Fig. 3.2.

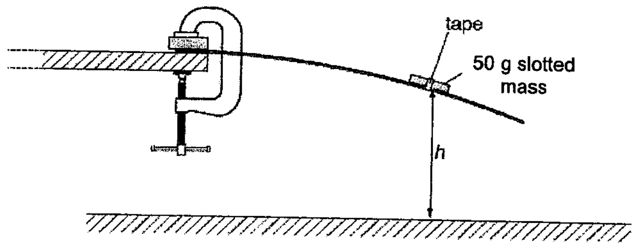


Fig. 3.2 (not to scale)

The vertical distance from the floor to the top surface of the plastic ruler at the centre of the mass is h.

Value of h with unit and value of h less than h_0

h = 80.8 cm or 0.808 m [1]

(ii) Calculate y, where $y = h_0 - h$.

$y = 0.895 - 0.808 = 0.087\ m$

Correct calculation of y with unit following the d.p. of h_0 and h

y = 8.7 cm or 0.087 m [1]

BP-875

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

$$\text{Percentage Uncertainty} = \frac{\Delta y}{y} \times 100\% = \frac{0.003}{0.087} \times 100\%$$

$$= 3.4\%$$

Absolute uncertainty in y of 3 to 6 mm Correct calculation and to 2.s.f.

percentage uncertainty = ...3.4%...... [1]

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

The metre rule may not be vertical (hence it is difficult to measure h_0 or h)

It is difficult to judge the position of the centre of mass (hence It is difficult to measure h)

The plastic rule is bent or is not horizontal (hence it is difficult to measure h)......... [1]

(iii) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **I(ii)**.

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

Use a set square on floor or plumb line or spirit level to check that metre rule is vertical.

Mark and measure *h* at the position for the centre of mass on the plastic ruler

Clamp the rule and use a set square as a pointer .... [1]

(d) Push the end of the plastic ruler down a small distance and then release it. The plastic ruler will oscillate.

Determine the period of *T* of the oscillations.

$$T = \frac{22.36 + 22.27}{2(40)} = 0.5579 \text{ s}$$

Evidence of repeat readings of time where $nT \geq 20$ s Value of *T* in range 0.5 s to 0.6 s *T* expressed in 4 s.f. based on raw data

T = ...0.5579 s...... [2]

(e) Move the slotted mass approximately 3 cm further from the bench and fix it with tape.

Measure and record *h*.

Second value of *h* which is smaller than the first value

h = ...78.0 cm or 0.780 m......

Repeat **(b)(ii)** and **(d)**.

$y = 0.895 - 0.780 = 0.115\ m$

y = ...11.5 cm or 0.115 m......

$$T = \frac{25.16 + 25.01}{2(40)} = 0.6271 \text{ s}$$

Second value of *T* with unit Second value of *T* is greater than the first value

0.6271 s [3]

(f) It is suggested that the relationship between T and y is

$$T = c\sqrt{y}$$

where *c* is a constant.

(i) Using your data, calculate two values of *c*.

1st value: $T = c\sqrt{y}$

$0.5579 = c\sqrt{0.087}$

$c = 1.891$

2nd value: $T = c\sqrt{y}$

$0.6271 = c\sqrt{0.115}$

$c = 1.894$

first value of *c* = ...1.9......

second value of *c* = ...1.89......

Correct calculation of two values of *c*

[1]

(ii) Justify the number of significant figures given for your values of *c*.

The number of significant figures for c follows the lowest significant figures for y and T.

Since y has the lowest s.f. of 2 or 3 s.f., c also has 2 or 3 s.f. respectively.......... [1]

(iii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your answers in **c(i)**.

$$\text{Percentage difference} = \frac{c_{bigger} - c_{smaller}}{c_{smaller}} \times 100\% = \frac{1.9 - 1.89}{1.89} \times 100\% = 0.53\%$$

$$\text{Percentage uncertainty} = \frac{1}{2}\frac{\Delta y}{y} \times 100\% = \frac{1}{2} \times 3.4\% = 1.7\%$$

Since the percentage difference is smaller than the calculated percentage uncertainty of c,

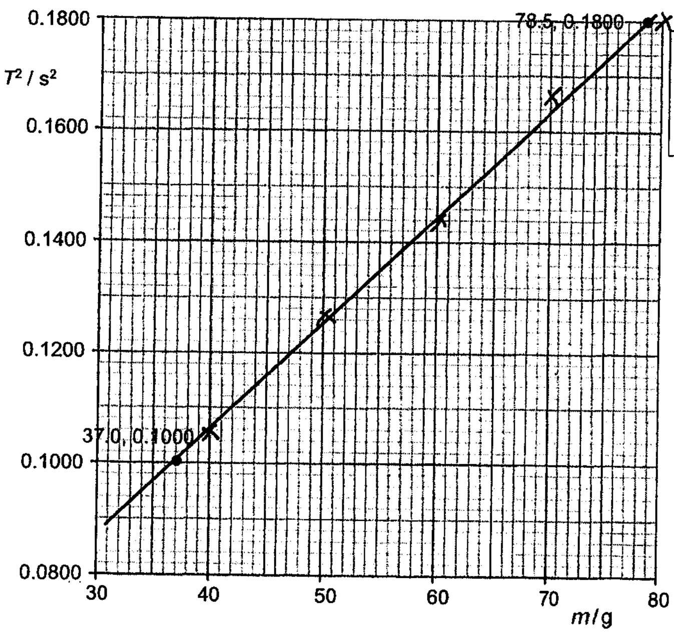
the results support the suggested relationship. .... [1]

(g) In an investigation, the mass m of the slotted mass attached to the centre of the plastic rule was varied.

The following results for m and T were recorded. The value of T^2 is then calculated.

m / g	40	50	60	70	80
T / s	0.3250	0.3555	0.3794	0.4074	0.4243
T^2 / s^2	0.1056	0.1264	0.1439	0.1660	0.1800

(i) Plot T^2 against m on the grid and draw the straight line of best fit. [2]



- Correct placement of data points
- Best fit line

(ii) Use your graph to determine the value of T when no mass is attached to the plastic rule.

$Gradient = \frac{y_2 - y_1}{x_2 - x_1} = \frac{0.1800 - 0.100}{78.5 - 37.0}$

$Gradient = 0.001928$

Correct calculation of gradient using gradient coordinates

$y = mx + c$ where $c = T^2$

$0.1800 = 0.001928 * 78.5 + T^2$

$T^2 = 0.02865$ (y-intercept)

$T = 0.169$ s

Correct calculation of y-intercept using gradient coordinates

Correct calculation of T using y-intercept

T = ... s [3]

 [Turn over

(h) The behaviour of the loaded plastic ruler depends on the thickness of the plastic ruler.

It is suggested that the square of the period T is inversely proportional to the cube of the thickness b of the plastic ruler.

Explain how you would investigate this relationship.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show inverse proportionality
- why you might have difficulties using very thin plastic rulers

1. The independent variable is the thickness b of the plastic ruler.
2. The dependent variable is the period T of the oscillating loaded plastic ruler.
3. The control variables are the mass of the slotted load attached, the breadth of to the plastic ruler, the position at which the mass is attached to the plastic ruler. [C1]
4. Set up the apparatus as shown in Fig. 3.1.
5. Measure the thickness b of the plastic ruler using a vernier calipers. [M]
6. Push the end of the ruler downwards and let it oscillate.
7. Measure the time taken t to complete n oscillations (such that t is greater than 20 s) using a stopwatch. [M]
8. Repeat step 6 and 7 and take the average of the two timings.
9. Calculate the period of the oscillating loaded plastic ruler using $T = (t_1 + t_2) / 2n$. [M]
10. Repeat steps 5 to 9 for another seven times with different thickness of the plastic ruler.
11. Plot a graph of T^2 against $1/b^3$. If the best fit line is a straight line passing through origin, T^2 is inversely proportional to b^3. [A1]
12. When the plastic ruler is too thin, the loaded plastic ruler may break easily. [D1]

[C1] Stating the two control variables.

[M1] Measurement of L and t and the calculation of T

[A1] Analysis of the results to prove the inverse proportional relationship of T^2 and b^3.

[D1] State any appropriate difficulty faced when using a thin plastic ruler.

[4]

[Total: 23]

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4 An aluminium ring is placed on a coil with the rod of a metal retort stand passing through their centres, as shown in Fig. 4.1.

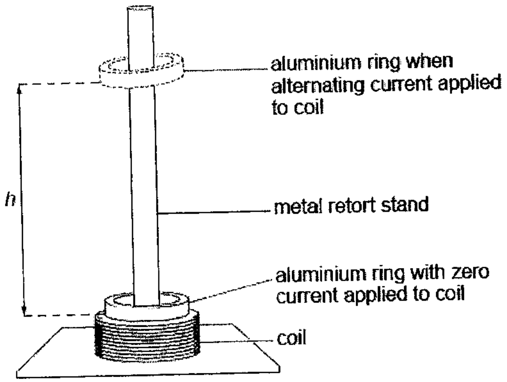


Fig. 4.1

The aluminium ring has a thickness b.

When an alternating current of frequency f is applied to the coil, the ring rises until it is in equilibrium at a height h above the coil.

The height h that the aluminium ring rises until it is in equilibrium is given by

$$h = k f^p b^q$$

where k, p and q are constants.

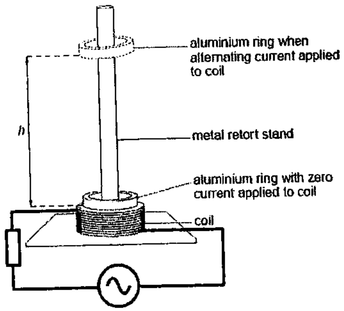
Design an experiment to determine the values of p and q.

You would be provided with several aluminium rings with different thickness.

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

(a) the equipment you would use
(b) the procedure to be followed
(c) how the frequency of the alternating current, thickness of ring and height risen are measured
(d) the control of variables
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram



Labelled diagram of apparatus: including working circuit with a.c. supply / signal generator, coil, stand and ring [M1]

 [Turn over

Defining the problem (2 marks)

1. The aim of the experiment is to find the unknown p and q in the relation $h = k f^p b^q$
2. The two independent variables are the frequency f of the alternating current and the thickness b of the aluminium ring.
3. The dependent variable is the height h that the aluminium ring rises. [D1]
4. The two sets of experiment are to be carried out
   (1) h and f with b kept constant
   (2) h and b with f kept constant
5. The control variables are the (rms) current in the coil, diameter of the aluminium ring, number of turns of the coil. (state at least 2 control variables) [C1]

Data Collection (X marks)

6. Set up the apparatus as shown earlier.

Expt 1

7. Close the switch.
8. Read off the frequency f of the alternating current stated in the signal generator or variable frequency power generator. Or The frequency f of the alternating current can be determined from the period T of the alternating current measured by an oscilloscope using the formula $f = 1/T$. [M2]
9. Measure the height h that the aluminium ring has risen using a rule. [M3]
10. Repeat the experiment with another 7 sets of frequency f by adjusting the frequency knob of the signal generator while keeping the thickness of the ring constant [M4]

Expt 2

11. Measure the thickness of the aluminium ring using a vernier caliper. [M3]
12. Close the switch.
13. Measure the height h that the aluminium ring has risen using a rule.
14. Repeat the experiment with another 7 sets of thickness b by using aluminium ring of different thickness while keeping the frequency of alternating current constant [M5]

Analysis (2 marks)

15. Plot a graph of lg h against lg f. If the best fit line is a best-fitted straight line, the gradient of best fit line is the value of p. [A1]
16. Plot a graph of lg h against lg b. If the best fit line is a best-fitted straight line, the gradient of best fit line is the value of q. [A2]

Safety consideration (1 Mark)

17. Switch off when not in use to prevent the coil from overheating. (Do not allow small current as the current needs to be large enough for the height to be measurable).
18. Do not touch the hot coil or Use gloves to prevent any injury from the hot coil. [S1]

 [Turn over

Additional details (2 marks)

19. Connect a variable resistor to the circuit so that the current flowing through the coil can be monitored to be constant (using an ammeter).
20. Use iron (or steel) rod to increase the change in magnetic field that the ring experiences to have measurable height.
21. Use coil of many turns or large current to have measurable height.
22. A set square is used to ensure metre rule is vertical when measuring *h*.

Any two of the additional details.

[Total: 12]