2022 C2 H2 Physics Prelim Exams Paper 1 Suggested Solutions

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

1 **D** 550 GHz = 5.50×10^{11} Hz

This corresponds to radiation with wavelength $\lambda = 3.0 \times 10^8/(5.50 \times 10^{11}) \approx 10^{-3}$ m

Wavelength of green light is of order of magnitude 10^{-7} m.

2 **B** Conceptual Question. Mean value should be close to the true value, while experimental values should have a large spread.

3 **B** The gradient of v-t graph give the acceleration, and initial gradient must be ½ of the original.

The area under the v-t graph gives the distance between the two train stations, so it must the same for the second train.

4 **B** By Newton's first law, the objects can continue at the state of constant velocity.

5 **B** $M_b u_b + 0 = M_b v_b + M_p v_p$

$(5)u_b + 0 = (5)v_b + (1)v_p$ (1)

$u_b - 0 = v_p - v_b$

$u_b = 3.33 - v_b$ (2)

Using (1) and (2) to solve for $u_b = 1.998\ m\,s^{-1}$

6 **B** Take moments about the pivot.

Torque = 5.0(2)(0.5 sin 40°) = 3.2 N m

7 **A** Consider the vertical component of the tension, and letting the angle that the cord makes with the metal sheet be θ,

2Tsin(θ) = 10 → sin(θ)=0.25 → θ = 14.5°

Length of cord required = 2(10/cos(θ)) = 20.7 = 21 cm

8 **C** Option A and D have the wrong units and can be ruled out immediately. Option B is wrong as *vt* does not give the total distance traveled as the object is not moving at constant speed.

9 **B** $a = \omega^2 r = \left(2\pi \times \frac{3000}{60}\right)^2 \left(\frac{8.0}{100}\right) = 7897 \approx 7900\ m\,s^{-2}$

10 **A** As the Earth is taken to be a uniform sphere, the gravitational potential at any point on the Earth's surface is the same (as $\phi = -\frac{GM}{R}$, where M is the mass of the Earth and R is the radius of the Earth), hence the gravitational potential energy of the Earth-rocket system is the same whether the rocket is near Equator or near the North Pole. As such the escape speed is the same whether the launch is near the Equator or near the North Pole.

11 **B** Those who chose C or D did not know that gravitational potential energy is negative. Those who chose A or C did not know that orbital radius is the sum of the radius of planet and altitude of the satellite.

12 **D** If both gases are at the same temperature, their average microscopic kinetic energy and root-mean-square speed will be the same.

Since the volume of container B is larger than that of A, the gas pressure and density will be smaller in B.

13 **B** Net work done on the gas = $-$ |area enclosed| = $-$ |area of circle| = $-\pi$ = $-$3.14 J

By the first law of thermodynamics, there is a net heat transfer of 3.14 J into the system.

14 **B** The frequency of the driver determines the oscillating frequency.

So, f = 1/2 = 0.50 Hz

15 **C** Intensity of beam after passing Polaroid Q = $I\cos^2(30°)$

Intensity of beam after passing Polaroid R = $I\cos^2(30°) \times \cos^2(60°-30°)$ = 0.56 I (2 s.f)

16 **D** $Intensity\ I = \frac{P_{source}}{Area} = \frac{P_{source}}{4\pi x^2}$ (As the source is a point source, the Area through which energy pass through is the surface area of a sphere with radius x.)

As P_{source} is constant, $I \propto \frac{1}{x^2}$

$$\frac{I_1}{I_2} = \left(\frac{x_2}{x_1}\right)^2 \Rightarrow \frac{I}{I_2} = \left(\frac{0.5x}{x}\right)^2 \Rightarrow I_2 = 4I$$

As $I = \frac{P_{received}}{Area_{reciever}}$

$P = IC$

$$P_{received\ 2} = I_2 \times Area_{reciever\ 2} = 4I \times 2C = 8P$$

17 **D** Using Rayleigh's Criterion

$$\theta_{min} = \frac{\lambda}{a}$$

If angular seperation of light sources θ is greater than θ_{min}, the two images will be resolved (distinguished on the screen).

To reduce θ_{min}, one can reduce λ or increase a so options A and C will help to distinguish the two images.

For option C, by reducing distance *D,* the actual angular separation of the light sources θ gets larger so it is larger than θ_{min}. This change also helps to improve the ability to distinguish the two images.

For option D, changing *L* has no impact on θ or θ_{min} so it is the correct answer.

18 **C** Note that the vertical nylon lines result in the horizontal diffraction images while the horizontal nylon lines results in the vertical diffraction images.

From the equation for diffraction grating, $d\sin\theta = n\lambda$

For monochromatic light of fixed λ, For the same order of maxima, when *d* is larger, $\sin\theta$ is smaller and hence θ is smaller. This means that the separation of the straight through image and the image of the particular order is closer together.

Since the separation of the straight through image and the vertical images are smaller compared to the separation of the straight through image and the horizontal images, the *d* (slit separation) for the horizontal lines must be larger than the *d* for the vertical lines.

19 **C**

Option A : $F = \frac{q^2}{4\pi\varepsilon_0 r^2}$. *r* decreases and hence, force increase. Option A is incorrect.

Option B : Electric field strength is a vector quantity. Sketching the individual *E* due to each charge at O and summing vectorially to find the resultant shows the *E* has decreased. Option B is incorrect.

Option D: Electric potential is a scalar quantity and hence resultant potential at O remains zero even when the change is made. Hence option D is incorrect.

Option C : $U = -\frac{q^2}{4\pi\varepsilon_0 r}$. *r decrease, U becomes more negative. Hence U decreases.* Option C is correct.

(Alternatively you can think of the fact that the charges being closer now experience a stronger attractive force and hence will be at lower potential energy and will require a greater amount of energy to separate them to infinity.)

20 A $E = -\frac{dV}{dx} = -(\text{gradient of } V - x \text{ graph})$

Arrangement 1 : E-field is uniform and hence the gradient of *V-x* graph should be constant.

Arrangement 2 : E-field decreases as we move from P to Q, hence the gradient of *V-x* graph should be become gentler as we move from P to Q.

21 C Bulb X : $R_x = 10^2 / 20 = 5.0\ \Omega$

Bulb Y : $R_y = 5^2 / 2 = 12.5\ \Omega$

p.d. across X = 5.0 / (12.5 + 5.0) x 15.0 V = 4.3 V

power dissipated in X < 20 W

p.d. across Y = 12.0 / (12.5 + 5.0) x 15.0 V = 10.7 V

power dissipated in Y > 2 W

22 A **Note:** Question 22 has been made void due to ambiguity in phrasing of the question. All students will be awarded 1 mark regardless of choice.

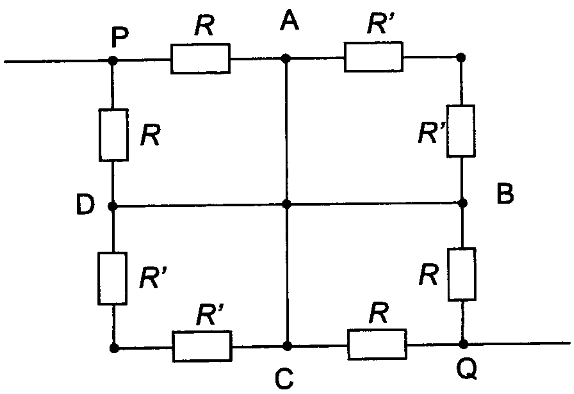
The Paper 1 question with question 22 updated to be clearer has been uploaded for your reference.

The solution for the updated question is shown below.

$R = \frac{\rho l}{A}$ and $l\,A$ = constant

$R = \rho l^2$ / constant
As *R* is plotted against *l*, the graph is quadratic.

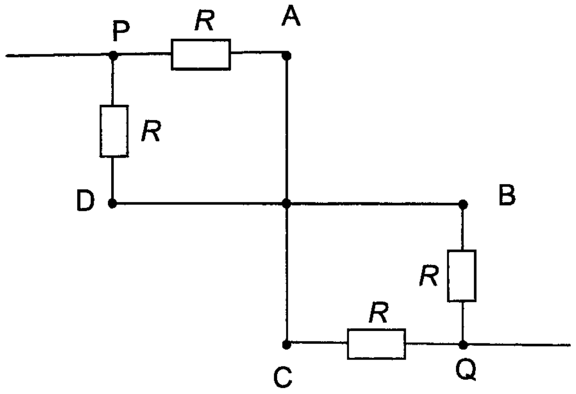
23 C



Points A, B, C and D have the same potentials.

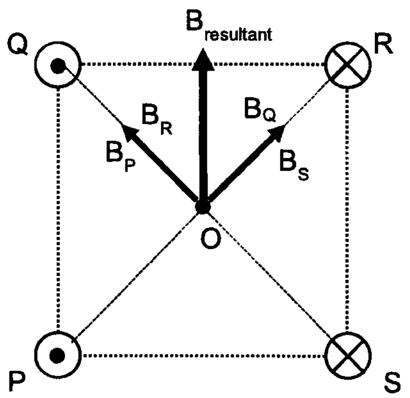
Thus, no current flows through all 4 R' resistors.

The above circuit can be re-drawn as shown below.



The effective resistance between P and Q is the twice of the net resistance of two resistors (across points P & D and P & A) in parallel. The effective resistance between P and Q = R.

24 **A** Apply RHGR to determine the direction of B-field at O due to the current flowing in a straight wire at P, Q, R and S respectively.



25 **D** Using a high direct current supply to coil X will result in high flux linkage in coil Y. But the flux linkage is not changing. Thus no e.m.f. will be induced in coil Y to produce a reading.

26 **C** For Loop 3 and loop 4, as the loops did not experience any change in magnetic flux linkage, there were no e.m.f. induced in loop 3 and loop 4. Thus no induced currents flow in loop 3 and loop 4 so the loops did not experience any magnetic force.

Loop 2 experienced a ***decreasing magnetic flux linkage*** through the loop, thus an e.m.f. is induced in the loop. As the loop is closed, an induced current flowed in loop 2. By Lenz's Law, the induced current in loop 2 flow in an anticlockwise direction to produce an effect to oppose the decreasing magnetic flux linkage. Thus by FLHR, there is a downward force on loop 2. (Or By Lenz's Law, there will be a downward force on loop 2 such as to produce an effect to oppose the decreasing magnetic flux linkage)

Loop 1 experienced an ***increasing magnetic flux linkage*** through the loop, thus an e.m.f. is induced in the loop. As the loop is closed, an induced current flowed in loop 1. By Lenz's Law, the induced current in loop 1 flow in a clockwise direction to produce an effect oppose the increasing magnetic flux linkage. Thus by FLHR, there is an upward force on loop 1. (Or By Lenz's Law, there will be a upward force on loop 2 such as to produce an effect to oppose the increasing magnetic flux linkage)

27 B When current is forward bias for the single diode, the total resistance is 1 kΩ. The peak current = peak voltage / 1 kΩ.
When current is forward bias for the single diode in series with the 5 kΩ resistor, the total resistance is 6 kΩ. The peak current = peak voltage / 6 kΩ. This is smaller than the previous case and the direction is opposite.

28 D Largest x-ray photon energy released $E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(0.02 \times 10^{-9})} = 9.945 \times 10^{-15}\,J$

For the electron to release this photon energy, it need to get eV amount of energy from the accelerating field.

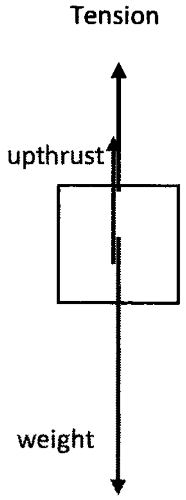
$(1.6 \times 10^{-19})V = 9.945 \times 10^{-15}$

$V = 62\,000$ volt

29 B $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{90}_{36}Z + 2\left(^{1}_{0}n\right)$
Proton number = 36
Number of neutrons = 90 - 36 = 54

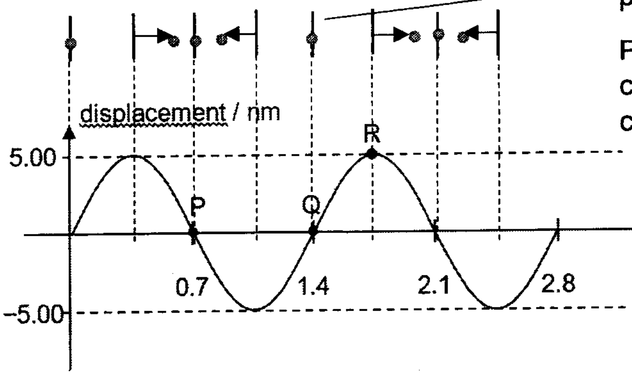
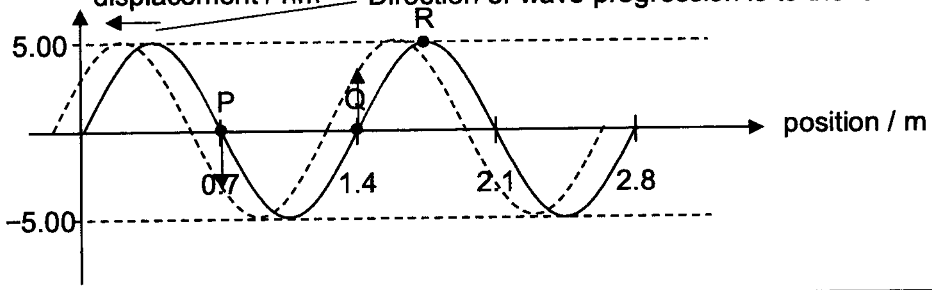
30 D Count rate for 10 g of living wood = 200 per minute
The count rate will be 50 after 2 half-lives.

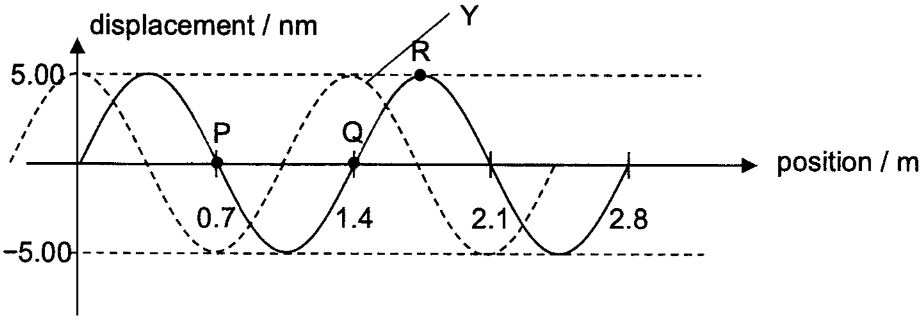
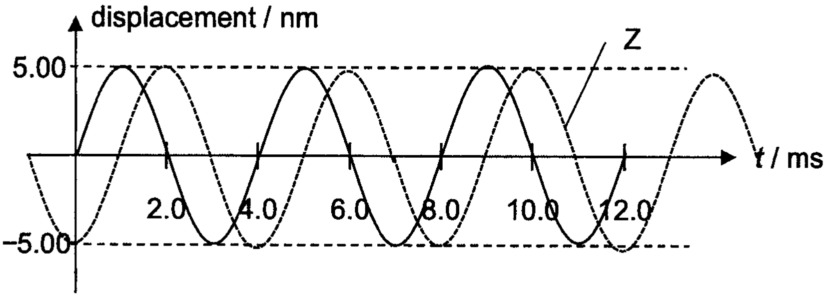
2022 Preliminary Examination Paper 2 Suggested Solution

Qn 1	Answer	Marks
(a) (i)	When mass *M* is placed on the spring, the spring extends by a length of $(L_2 - L_1)$. $mg = k(L_2 - L_1)$ $k = \dfrac{mg}{L_2 - L_1}$ $= \dfrac{(0.0985)(9.81)}{0.037 - 0.013} = 40.3 \text{ N m}^{-1}$	C1 M1
(a) (ii)	$\dfrac{\Delta k}{k} = \dfrac{\Delta m}{m} + \dfrac{\Delta(L_2 - L_1)}{L_2 - L_1} = \dfrac{0.2}{98.5} + \dfrac{0.2 + 0.1}{3.7 - 1.3} = 0.127$ Thus $\Delta k = k \times \dfrac{\Delta k}{k} = 40.3(\dfrac{0.2}{98.5} + \dfrac{0.2 + 0.1}{3.7 - 1.3}) = 5 \text{ N m}^{-1}$ (Do not penalise if Δk is left to a value that is greater than 1 s.f. – this mark will be marked in (a)(iii))	M1 A1
(a)(iii)	$k = (40 \pm 5) \text{ N m}^{-1}$ Δk expressed to 1 s.f. and k expressed to the same place value as Δk. Allow ecf from **(a)(ii)** and **(a)(iii)**.	A1
(b)(i)	 Marking Guidance: **B1** – 3 forces drawn with correct direction **B1** – Relative lengths of forces show T+U = W [-1] – Missing labels/legend Note that first B1 mark must be obtained before the second B1 mark can be given. [Point of action is not marked here. But in general, students should know that the upthrust is acting at the centre of buoyancy – c.g. of the liquid displaced and weight is at the c.g. of the cube.]	B2
(b)(ii)	Initially (Fig. 1.2), P is inequilibrum, net force on it is zero. Weight = upthrust $W = (0.7V)\rho g$	M1
(b)(iii)	After cube Q was connected (Fig. 1.3), at new equilibrium, net force on P is zero. Weight of P = Tension due to string + new upthrust	

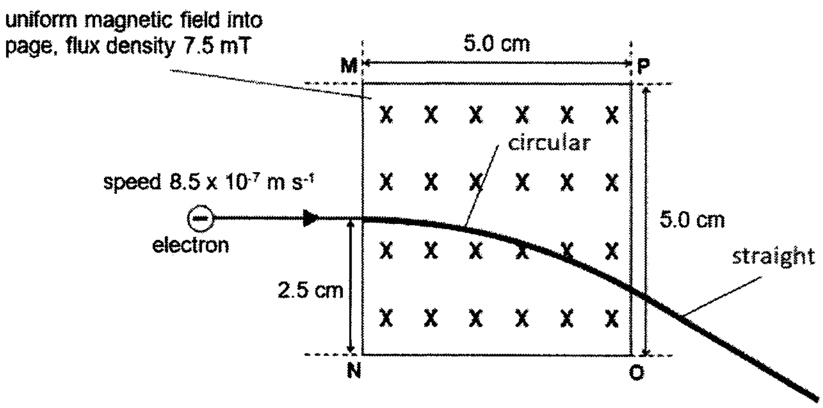
	$W = T + U' = T + 0.4V\rho g$ Solving the two equations above gives $T = W - 0.4V\rho g = W - \frac{0.4W}{0.7} = \frac{3}{7}W$ (Shown)	M1 M1
(b)(iii)	Consider the forces acting on cube Q. Resolving the weight of cube Q along the slope, and since it is in equilibrium, $T = (3/7)\,W = W\sin(\theta)$ $\Rightarrow$ Solving, $\theta = 25.4°$	A1
	[Total : 11 marks]	

Qn 2	Answer	Marks
(a) (i)	For circular motion, centripetal force is provided by the gravitational force, $$\frac{GM_J m}{R^2} = mR\omega^2$$ $$G\frac{M_J m}{R^2} = mR(\frac{2\pi}{T})^2 \Rightarrow T = \sqrt{\frac{4\pi^2 R^3}{GM_J}}$$	M1 A1
(a) (ii)	Since $T^2 \propto R^3$, $$\left(\frac{T_{Th}}{T_{Am}}\right)^2 = \left(\frac{R_{Th}}{R_{Am}}\right)^3 \Rightarrow \left(\frac{0.676}{T_{Am}}\right)^2 = \left(\frac{3.18}{2.62}\right)^3$$ T_{Am} = 0.506 Earth-days	M1 A1
(b)(i)	$$v = \frac{2\pi R}{T} = \sqrt{\frac{GM_J}{R}}$$ <u>OR</u> Since the orbit is circular, centripetal force is provided by gravitational force, hence $$\frac{GM_J m}{R^2} = \frac{mv^2}{R} \Rightarrow v = \sqrt{\frac{GM_J}{R}}$$ A1	A1
(b)(ii)	When the mass of the moon decreases, although the gravitational force and centripetal force required both decreases, the condition for orbit, that the gravitational force is **equal** to the centripetal force, is still true. Hence the moon will stay in orbit.	B1
(c)(i)	Read off graph with orbital period equal to one Jupiter-day = 0.417 Earth-days Orbital radius of geostationary orbit is <u>2.30 R_J</u>. (Allow : ± ½ smallest div)	A1
(c)(ii)	Able to <u>continuously observe</u> the <u>same area</u> on Jupiter for an extended period of time.	B1
	[Total : 8 marks]	

Qn 3	Answer	Marks
(a)	Using $v = f\lambda$ $v = \frac{1}{4.0\times10^{-3}}\times1.4$ $= 350$ m s^{-1}	M1 A1
(b)(i)	**Particle R** (As the particle is undergoing SHM, at the amplitude, the instantaneous velocity of the particle is zero).	A1
(b)(ii)	**Particle Q** .  Vertical lines represent equilibrium position of particle along the wave. Particle P is at the centre of compression and particle Q is at the centre of rarefaction	A1
(b)(iii)	**Particle Q.** (As the Fig. 3.2 shows a particle that is initially at equilibrium and is moving up in the next instant. Particle P and Q are both at equilibrium at t = 0. To determine which particle is presented above, the subsequent displacement-position graph in the next instant needs to be used. As seen below, since the wave is travelling towards the left, it is clear that particle P will be displaced in the negative direction and particle Q in the positive direction. Hence particle Q is depicted in Fig. 3.2).  Direction of wave progression is to the left.	A1
(c)(i)	Using equation . $\Delta\phi = \frac{\Delta x}{\lambda}\times360° = \frac{0.7}{1.4}\times360°$ $=180°$ Accept working with radians. And answer as π radians	M1 A1

(c)(ii)	Distance travelled by wave in 1 ms = vt = (350)(1 x 10^{-3}) = 0.35 m The graph should have shifted to the left by 0.35 m.  Award mark as long as one full wavelength is drawn with displacement at 5.00 nm at initial position.	C1 A1
(c)(iii)	 At t = 0, Particle R is at +5.00 nm displacement so Particle S should be at -5.00 nm displacement (phase difference of π rad).	A1
	[Total : 10 marks]	

Qn 4	Answer	Marks
(a)(i)	Power supplied by battery = Energy / time = (11.3 J) /(10 x 60 s) = 0.0188 W	M1 A1
(a)(ii)	From graph, resistance of thermistor = 3.1 kΩ Power dissipated through the resistor and thermistor = Power supplied by battery ⇒ 0.0188 = E^2 /(3100+1200) E = 8.99 V	B1 M1 A1
(b)	From graph, New resistance of thermistor = 2.0 kΩ Since the power delivered is the same, Total resistance before =total resistance after ⇒ 3100+1200 = R +2000 ⇒ R = 2 300 Ω	B1 M1 A1
	[Total : 8 marks]	

Qn 5	Answer	Marks
(a)	(Using Fleming's Left hand Rule), the magnetic force will **always be perpendicular to the direction of motion of the charge**. This force will provide the centripetal force for circular motion. Since the **magnitude of the magnetic force is constant**, the **magnitude of the centripetal force is constant**. The electron will describe a uniform circular path. **Or** since the force is always perpendicular to the motion, no work is done by the force on the system and there is no gain in kinetic energy of the electron and hence the electron is in uniform circular motion (or moving at constant speed). B1 – for explaining why the motion is that of a circular one. B1 – for explaining why the motion is uniform	B1 B1
(b)(i)	The magnetic force provides for the centripetal force, $Bqv = \frac{mv^2}{r}$ $r = \frac{mv}{Bq} = \frac{(9.11\times10^{-31})(8.5\times10^{7})}{(7.5\times10^{-3})(1.60\times10^{-19})}$ $= 6.45\times10^{-2}\text{m} = 6.5\,\text{cm}$	M1 A1
(b)(ii)	 B1- circular path curving downwards in B-field B1 - emerging at side PO (allow e.c.f.) B1 – straight path after leaving the B-field	B3
(b)(iii)	The magnetic force on electron provides the required centripetal force to keep the electron in circular motion. If m is the mass of the electron and ω is the angular velocity of the electron. $Bev = mr\omega^2 = mr\left(\frac{2\pi}{T}\right)^2 \Rightarrow T = \frac{2\pi m}{Be}$ Hence, T is independent of v and r.	M1
(b)(iv)	Since period T is independent of the speed and radius of the path taken, the period of both electrons are the same. Hence, the time spent by each electron in the magnetic field simply	B1

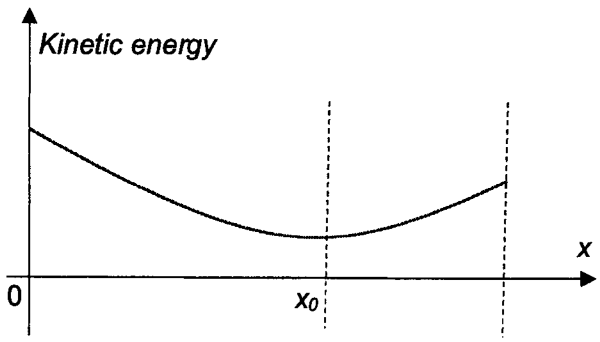
	depends **on the fraction of the circular path traveled by each electron** within the magnetic field. Electron e_1 travels for less than ¼ of a period in the field, while electron e_2 travels for ½ a period. Hence, **electron e_2 spends a longer time in the magnetic field.**	A1
	[Total : 10 marks]	

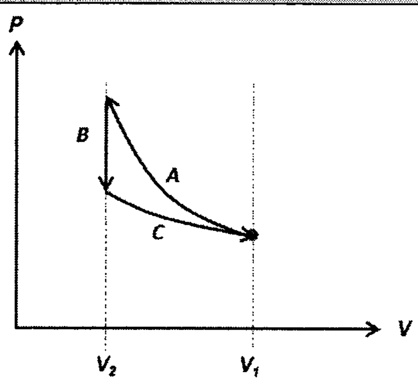
Qn 6	Answer	Marks
(a)	The activity of a radioactive source is the rate at which a source of unstable nuclei decays or the number of disintegrations per unit time.	A1
(b)(i)	$N = (2.40\times10^{-6})\left(\dfrac{6.02\times10^{23}}{235}\right)$ $= 6.148\times10^{15}$	M1 A1
(b)(ii)	Decay constant $\lambda = \dfrac{A}{N} = \dfrac{0.1919}{6.148\times10^{15}}$ $= 3.1213\times10^{-17} = 3.12\times10^{-17}\ s^{-1}$ (to 3 s.f.)	M1 A1
(c)(i)	${}^{42}_{19}K \rightarrow {}^{42}_{20}Ca + {}^{0}_{-1}e + antineutrino$ beta particles are emitted. Accept electrons. Accept: beta with (anti-)neutrino	A1
(c)(ii)	Half-life = 12.5 h	A1
(c)(iii)	Correct Shape B1 sum of Calcium-42 and Potassium-42 equals 1.0 N_o at $t = 0$, $t=t_{1/2}$ and $t = 40$ h	B1 B1
(c)(iv)	Four parts Calcium-42 and one part Potassium-42. From the graph, we get 0.8 N_o for Calcium-42 and 0.2 N_o for Potassium-42 giving the age as 29 hours. Alternatively, Ratio of Calcium-42 to Potassium is 4:1 Hence, for K-42, $N = N_o e^{-\lambda t} \Rightarrow t = -\dfrac{t_{1/2}}{\ln 2}\ln(\dfrac{N}{N_o}) = -\dfrac{12.5\text{ h}}{\ln 2}\ln(\dfrac{1}{5})$ M1 $= 29.0$ h A1	M1 A1
	[Total : 11 marks]	

Qn 7	Answer	Marks
(a)(i)	At level flight, there is no resultant vertical force. Hence, lift = weight of aircraft = 1.5×10^6 N At constant velocity, the resultant force horizontally is zero. Hence, drag = thrust = 0.60×10^6 N	 A1 A1
(a)(ii)	Taking moments about the intersection between the weight and thrust, Torque generated by the lift-weight couple = Torque generated by the thrust-drag couple ⇒ $1.5 \times 10^6 \times 0.75 = 0.60 \times 10^6 \times d$ ⇒ vertical separation d = 1.9 m	 M1 A1
(a)(iii)	The horizontal stabiliser with its vertical downward force acting on it and (its long distance from the CG), would provide a (clockwise) moment about the CG to enable the plane to rotate against the downward pitch.	B1 B1
(b)(i)	Air gains momentum when it passes through the jet engine and hence by Newton's 2nd law, there is a force acting on the air by the jet engine. By Newton's 3rd Law, there is an equal in magnitude and opposite in direction force on the jet engine to move the jet engine forward. That is the thrust.	B1 B1
(b)(ii)	|Force on jet engine by air | = |Force on air by the jet engine| = rate of change of momentum of the air = $210 \text{ kg s}^{-1} \times 580 \text{ m s}^{-1} = 1.22 \times 10^5$ N	 M1 A1
(b)(iii)	Possible reasons include. • Combusted fuel is mixed with the gas before ejection and hence the actual momentum gain is larger. • Pressure difference between the air in front of engine and back of engine can contribute to an additional thrust • The engine needs to exert a forward force on the air to reduce the speed of the air before it is combusted and pressurized, the air exerts a backward force in return and this reduces the thrust. Do not accept : That there is some initial speed of the air as the question in (b)(ii) gives the speed gained.	B1

(c)	Each wing has to provide sufficient lift to support half of the weight. $(P_L - P_U)A = \frac{mg}{2}$ $\Rightarrow \quad P_U = P_L - \frac{mg}{2A} = 7.00\times10^4\text{Pa} - \frac{(2.85\times10^5)(9.81)}{2(360)}$ $= 6.61\times10^4\text{Pa}$ [Only deduct one mark if *mg* is used instead.]	**M1** **A1**
(d)(i)	From the Lift Equation: $L = \frac{1}{2}C_L\rho v^2 S \quad \Rightarrow \quad C_L = \frac{2L}{\rho v^2 S}$ Units of $C_L = \frac{(\text{kg m s}^{-2})}{(\text{kg m}^{-3})(\text{m}^2\text{ s}^{-2})(\text{m}^2)}$ $= 1$ Hence, C_L is a dimensionless quantity.	**M1** **A1**
(d)(ii)	The aircraft tilts so that the horizontal component of the lift force can provide for the (centripetal) force needed to make the turn. It needs to increase in speed for a larger the lift force ($L = \frac{1}{2}C_L\rho v^2 S$) so that the vertical component of the lift force can support the weight.	**B1** **B1**
(e)(i)	$\frac{L}{D} = \frac{\frac{1}{2}C_L\rho v^2 S}{\frac{1}{2}C_D\rho v^2} = \frac{C_L}{C_D}$	**M1**
(e)(ii)	At maximum lift to drag ratio, most lift is generated (to support the weight) at minimum drag (<u>or</u> per unit drag). Hence, less fuel is wasted to overcome the drag force.	**B1**
(e)(iii) 1.	For angle of attack $\alpha = 4°$, $C_L = 0.45$ and $C_D = 0.0275$ $L/D = C_L/C_D = 0.45 / 0.0275 = 16.36$ Other possible combinations: <table><tr><th>C_L</th><th>C_D</th><th>L/D</th></tr><tr><td>0.45</td><td>0.03</td><td>15.00</td></tr><tr><td>0.425</td><td>0.0275</td><td>15.45</td></tr><tr><td>0.425</td><td>0.03</td><td>14.20</td></tr></table>	**M1**
(e)(ii)2.	Correct plot B1 A smooth best fit line through the plots with maximum at $\alpha = 4°$ B1	**B2**
	[Total : 22 marks]	

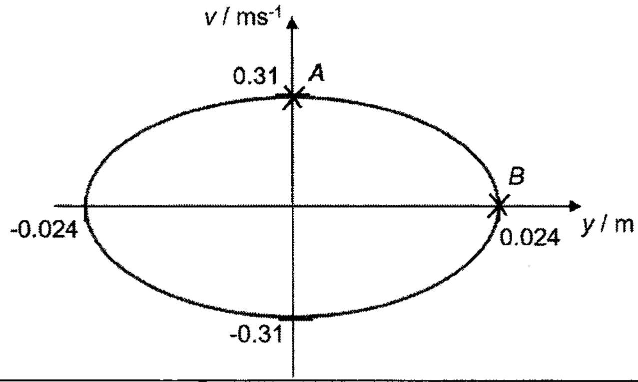
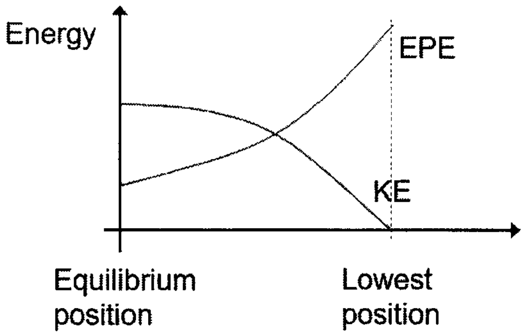
2022 C2 Prelim H2 Physics Paper 3 Suggested Solutions

Setter: Wei Hong Marker:		
Question	**Answer**	**Marks**
1(a)(i)	The gravitational potential at a point in a gravitational field is the work done per unit mass by an external agent in bringing a small point mass from infinity to that point in the field at constant speed.	A2
1(a)(ii)	Gravitational force is **attractive** in nature and the **potential is set to be zero at infinity**. To move a mass from infinity to a point in the field (of the source mass), **the force exerted on the mass by the external agent will be in opposite direction to the displacement of the mass**. Thus negative work is done by the external force (agent).	A1 A1
1(b)(i)	During the path AC, the gravitational force is directed towards A and is **weakening**. Gravitational force is **zero at C.**	A1 A1
1(b)(ii)	 1m for $KE_B < KE_A$ 1m for minimum point at C	A2
	Max Marks	**8**

Setter: Soo Yen Marker:		
Question	**Answer**	**Marks**
2(a)	Arrows drawn Processes are labelled A is a curve (steeper than C at common point) B is a vertical line C is a curve 	A3

2(b)	Isovolumetric/ isochoric	**A1**
2(c)	Net heat transfer out of cylinder	**A1**
2(d)	zero	**A1**
2(e)	Process B and C offers heat transfer out of the cylinder to the bath. This results in the melting of ice in the bath. Net heat transfer out = (100)(334) = 33400 J Applying 1st Law of Thermodynamics to process ABC, ΔU = Q + W For one cycle, there is no internal change in energy. Hence net work done on the gas = + 33400J	**M1** **A1**
	Max Marks	**8**

Setter: BiaoJin Marker:		
Question	**Answer**	**Marks**
3(a)	Since the acceleration of the object can be written in the form $a=\alpha y$, where α is a constant, the **acceleration** of the object is **directly proportional** to its **displacement** from its equilibrium point. The **negative sign** in the equation $a=-\frac{k}{m}y$ shows that this **acceleration** is always directed in the **opposite direction to the displacement**.	**B1** **B1**
3b(i)	Reading off directly from the given equation, $\omega=\sqrt{\frac{k}{M}}$. Substituting in values from the table and converting to SI units, $\omega=\sqrt{\frac{k}{m}}=\sqrt{\frac{0.25\times10^{2}}{150\times10^{-3}}}=12.9099=12.9\text{rads}^{-1}$	**A1**
3b(ii)	From **(b)(i)**, we have $\omega=12.9099\text{rads}^{-1}$ Using $v_0=\omega y_0$, we have $y_0=\frac{v_0}{\omega}=\frac{0.31}{12.9099}=0.0240\text{ m}$	**A1**

3(b)(iii)	 1m for drawing an ellipse 1m for indicating correctly the intercepts 1m for correctly indicating both points A and B.	**B1** **B1** **B1**
3(b)(iv)	 Marking points: 1m for correct shape of KE graph, with maximum at equilibrium position and 0 KE at lowest position. 1m for correct shape of EPE graph, with positive EPE at equilibrium position and EPE at lowest position greater than the value of KE at the equilibrium position.	**B2**
	Max Marks	**9**

Setter: Lih Juinn Marker:		
Question	**Answer**	**Marks**
4(a)	The e.m.f. of accumulator is the sum of p.d.s across the external resistor and the resistance wire. e.m.f. = 8.00 V.	**A1**
4(b)	Null deflection means the no current flows through the unknown cell. Thus, terminal p.d across unknown cell = p.d. across AB terminal p.d. across unknown cell = 4.00 V e.m.f. of unknown cell = terminal p.d across unknown cell = 4.00 V	**M1** **A1**
4(c)(i)	p.d. across AC = (e.m.f. of accumulator) [(72.0/120.0) R_1 / (72.0/120.0) R_1 + R_1] = 3.00 V	**M1** **A1**
4(c)(ii)	p.d. across R_2 = (p.d. across AC) = 3.00 V	**A1**
4(c)(iii)	4.00 X 12.0 / (r + 12.0) = 3.00 r = 4.0 Ω	**M1** **A1**
	Max Marks	**8**

Setter: Koon Loon Marker:	

Question	Answer	Marks
5(a)(i)	Square loop rotate about axis CD.	A1
5(a)(ii)	Square loop will rotate clockwise when viewed from C. The current in sides ab and bc of square loop interact with the components of the magnetic flux density that is perpendicular to the respective sides and hence experience a force. By Fleming's Left Hand Rule, the forces acting on sides ab and bc acts *in the direction out of the paper*. Similarly, the forces acting on sides cd and da can be determined to act *in the direction into the paper.* Thus, *there is a couple* resulting in clockwise torque (viewed from C) about the axis CD.	A1 B1 B1 B1
5(b)(i)	When a and c are 2.00 m apart, the area enclosed by the loop consists of four triangular sections, each having hypotenuse of 3.00 m, height of 1.00 m, and base of $\sqrt{3.00^2 - 1.00^2}$ = 2.83 m The decrease in the enclosed area is $\Delta A = A_i - A_f = (3.00)^2 - 4[\frac{1}{2}(1.00)(2.83)] = 3.34\ \text{m}^2$ The average induced e.m.f. is $\varepsilon = \frac{\Delta\varphi}{\Delta t} = B\frac{\Delta A}{\Delta t} = \frac{(0.100)(3.34)}{0.100} = 3.34\text{ V}$	B1 B1 B1 A1
5(b)(ii)	The induced current in the loop, $I = \frac{\varepsilon}{R} = \frac{3.34}{10.0} = 0.334\text{ A}$	A1
	Max Marks	10

Setter: Jit Ning Marker:	

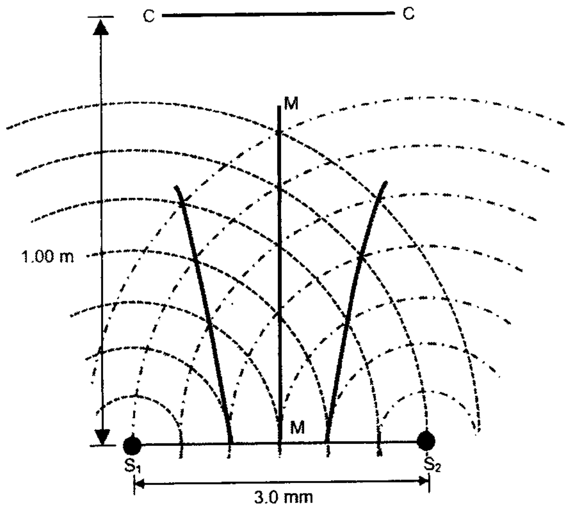
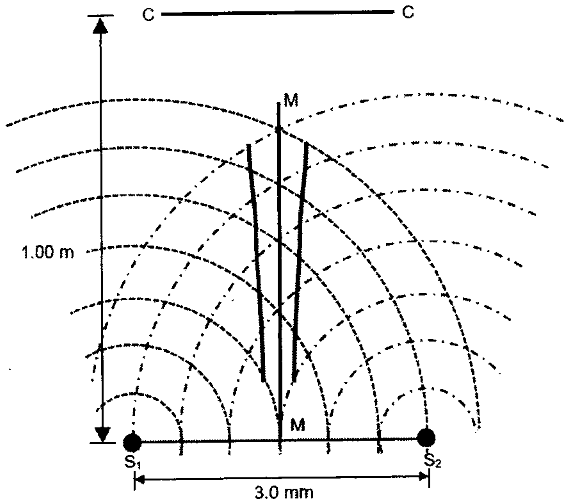
Question	Answer	Marks
6(a)	Frequency = 50 Hz Peak Voltage = 340 V Root-mean-square voltage = 240 V	A1 A1 A1
6(b)(i)	Voltage = 240/20 = 12 V	A1
6(b)(i)	Power consumed by 6.0 resistor, $P = \frac{V^2}{R} = \frac{12.0^2}{6.0} = 24.0\ W$ Power generated by primary circuit, $P = \frac{24.0}{0.95} = 25.263\ W$ Current in the primary circuit, $I = \frac{P}{V} = \frac{25.263}{240} = 0.10526 \approx 0.105\text{ A}$	A1 A1 A1

		Max Marks	7

Setter: Soo Yen Marker:		
Question	**Answer**	**Marks**
7(a)	Photoelectric Effect	A1
7(b)	$\frac{hc}{\lambda} = \phi + K$ $\frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(500 \times 10^{-9})} = (1.6 \times 10^{-19})(1.0) + K$ $K = 2.38 \times 10^{-19} J = 1.49\,eV$	M1 A1
7(c)	$p = \sqrt{2mK}$ $p = \sqrt{2(9.11 \times 10^{-31})(2.38 \times 10^{-19})} = 6.58 \times 10^{-25}\,Ns$	M1 A1
7(d)	$P = \frac{N\left(\frac{hc}{\lambda}\right)}{t}$ $25 \times 10^{-6} = \left(\frac{N}{t}\right)\frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(500 \times 10^{-9})}$ Number of incoming photons per unit time, $\frac{N}{t} = 6.285 \times 10^{13}$ Number of electron ejected per unit time = $(0.2)\left(\frac{N}{t}\right) = 1.257 \times 10^{13}$ Electron current, $I = (1.6 \times 10^{-19})(1.257 \times 10^{13}) = 2.01 \times 10^{-6}$ A	M1 M1 A1
7(e)	The metal must able to at least eject electrons from the least energetic photons. $\phi = \frac{hc}{\lambda}$ $\phi = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(700 \times 10^{-9})} = 2.84 \times 10^{-19} = 1.78\,eV$	M1 A1
	Max Marks	10

Section B

Setter: Caleb Marker:		
Question	**Answer**	**Marks**
8(a)(i)	When two or more waves overlap (meet) The resultant displacement at any point and instance is the vector sum of the displacements caused by the individual waves at that point at that instance.	B1 A1

8(a)(ii)	The two waves must be of the same type (i.e both waves must be electromagnetic/sound waves) The two waves must be coherent. The two waves must have similar amplitudes. If the two waves are transverse waves, they must either be unpolarised or polarized in the same plane. (1 mark for each correct condition. Maximum of 3 marks)	**B3**
8(b)(i)	180° (The two sources are in antiphase.) (As the waves that arrive at line MM have a path difference of 0, since a minima is detected, the sources must be in antiphase).	**A1**
8(b)(ii)1.	 The lines above are possible EE lines. (Drawn line should be at least 2 wavelengths long).	**A1**
8(b)(ii)2.	 The lines above are possible FF lines. (Drawn line should be at least 2 wavelengths long.)	**A1**
8(b)(iii)	Line FF: Antinodal line	**B1**
8(b)(iv)	A stationary wave/ standing wave. (As the interference pattern is produced by two coherent sources of waves meeting along a line).	**A1**
8(b)(v)	Number of wavefronts between S_1 and S_2 is 6. Distance between S_1 and S_2 = 6 λ = 3.0 mm λ = 3.0 / 6 = 0.5 mm (Shown)	**M1**

8(b)(vi)	As a stationary wave is formed, the distance between each minima = ½ λ = 0.25 mm Number of half-wavelengths in 3.0 mm = 3.0/0.25 = 12 Number of minimas detected (not inclusive of the sources) = 11 (Draw out a diagram if you are uncertain. If the sources are counted, there will be a total of 13 minimas)	M1 M1 A1
8(b)(vii)	(As the distance of the sources to line CC is much greater than the distance between both sources, the equation $\Delta y = \frac{\lambda L}{a}$ suitable) Using equation $\Delta y = \frac{\lambda L}{a}$ $\Delta y = \frac{(0.5\times10^{-3})(1.0)}{3.0\times10^{-3}}$ $\Delta y = 0.167$ m	M1 A1
8b(viii)1.	For CC: The distance between maximas (or minimas) will reduce. (Based on $\Delta y = \frac{\lambda L}{a}$, as a reduces, Δy increases.) For S_1S_2: There is no change to the distance between maximas. (The interference pattern is that of a stationary wave, distance between antinodes is half a wavelength).	A1 A1
8b(viii)2.	For CC: The contrast between the maximas and minimas will be reduced. (Due to incomplete cancellation at minima and the reduced amplitude at maximas). For S_1S_2: The contrast between the maximas and minimas will be reduced. (Due to incomplete cancellation at minima and the reduced amplitude at maximas).	A1 A1
	Max Marks	**20**

Setter: Yen Ling Marker:		
Qn 9	**Answer**	**Marks**
9(a)	The magnitude of the electrical force acting between two point charges is proportional to the product of the magnitude of the charges and inversely proportional to the square of the distance between them.	A1
(b)(i)	The electrical force between the electron and proton provides for the centripetal force. $\frac{e^2}{4\pi\varepsilon_0 r^2} = \frac{mv^2}{r} \Rightarrow v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$	B1 A1

(b)(ii)	$E_P = -\frac{e}{4\pi\varepsilon_0 r}$ $E_T = E_P + E_K = -\frac{e^2}{4\pi\varepsilon_0 r} + \frac{1}{2}\cdot\frac{e^2}{4\pi\varepsilon_0 r} = -\frac{e^2}{8\pi\varepsilon_0 r}$	M1 A1
(b)(iii)	Energy E = -13.6 eV = -13.6 x 1.6 x 10^{-19} = 2.18 x 10^{-18} J Radius, $r = -\frac{e^2}{8\pi\varepsilon_0 E} = -\frac{(1.60\times10^{-19})^2}{8\pi(8.85\times10^{-12})(2.18\times10^{-18})} = 5.29\times10^{-11}\text{m} \sim 5\times10^{-11}$ m	M1 A1
(c)	Any similarity from : Both are conservative fields Both have a potential Forces between point charges / point masses obey an inverse square law	A1
	Any difference from : - gravitational field act on mass but electric fields act on charge - electric fields can be shielded but gravitational field cannot be shielded - force of attraction between masses, but attraction and repulsion between charges	A1
(d)(i)1.	de Broglie wavelength of the Moon, $\lambda_{moon} = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(7\times10^{22})(1\times10^{3})} = 9.47\times10^{-60} = 9\times10^{-60}$m	A1
(d)(i)2.	de Broglie wavelength of the electron, $\lambda_{electron} = \frac{h}{mv} = \frac{6.63\times10^{-34}}{(9\times10^{-31})(2\times10^{7})} = 3.68\times10^{-11}$ m = 4×10^{-11} m	A1
(d)(ii)	De Broglie wavelength associated with the moon (=9 x 10^{-60} m) << radius of its orbit and hence the wave nature of moon is insignificant. OR the de Broglie associated with the electron (=4 x 10^{-11} m) comparable to radius of orbit and hence the wave nature is significant.	A1
(e)(i)	As $E = -\frac{dV}{dx}$ Magnitude of electric field strength between parallel plates E, $E = \frac{\Delta V}{\Delta x} = \frac{(100\times10^{3})}{(15\times10^{-2})} = 6.67\times10^{5}$ N C^{-1} Electrical force on a charged grain due to the parallel plate $F_p = qE = (1.60\times10^{-17})(6.67\times10^{5})$ $= 1.07\times10^{-11}$ N	M1 A1
(e)(ii)	The electrical force between two charged mineral grains which are adjacent to each other. (The distance between the centres of the two grains is equal to the diameter of a single grain.) $F_E = \frac{q^2}{4\pi\varepsilon_0 r^2} = \frac{(1.60\times10^{-17})^2}{4\pi(8.85\times10^{-12})(100\times10^{-6})^2}$ $= 2.30\times10^{-16}$ N From the calculation, we see that the electrical force due to the parallel plate is about 10^5 times the force between two charged mineral grains and hence, the electrical forces between the grains can be ignored.	M1 A1 A1

(e)(iii)	Horizontal acceleration, $a_x = \dfrac{F_x}{m} = \dfrac{q\Delta V}{m\Delta x} = \dfrac{(2.00\times10^{-6})(100\times10^{3})}{15.0\times10^{-2}} = 1.33\ \text{m s}^{-2}$	**A1**
(e)(iv)	$(\rightarrow)$ $s_x = 5.0$ cm, $u_x = 0$ m s^{-1}, $a_x = 1.33$ m s^{-2} Using $s_x = u_x t + \dfrac{1}{2}a_x t^2$, $\Rightarrow \quad t = \sqrt{\dfrac{2s_x}{a_x}} = \sqrt{\dfrac{2(5.0\times10^{-2})}{(1.33)}}$ $= 0.274$ s	**M1** **A1**
	Max Marks	**20**

2022 Prelim H2 Physics Paper 4 Mark Scheme and Markers' Comments
Question 1

Part	Marking Point	Mark	Marking Guidance and Markers' Comments
(a)	8 sets of readings	[1]	Mark not awarded if students data does not show a decreasing temperature with increasing time. If the trend shows temperature rising before falling, it is likely because students did not stir the water with the stirrer while heating.
	Correct precision for raw data (θ to 0.1 °C and t to 1 s, 0.1 s or 0.01 s)	[1]	Mark not awarded if d.p is not consistent throughout.
(b)	All point within the axes scale are plotted correctly	[1]	Check 4 points.
	Best-fit curve – Smooth curve. Judge by balance of all points on the grid about the candidate's curve. There must be an even distribution of points either side of the curve along the full length. If there are 6 or more points, allow one anomalous point only if clearly indicated by the candidate.	[1]	
(c)	Tangent line drawn at θ = 70 °C	[1]	

(d)	Identifies $\frac{d\theta}{dt}$ from gradient of tangent line drawn in (c).	[1]	
	Correct calculation of *P*.	[1]	

Question 2

Part	Marking Point	Mark	Marking Guidance
(a)	Value of R_A in the range 0.147 to 0.181 Ω cm^{-1} with correct units.	[1]	Ignore s.f
	Value of R_B in the range 0.263 to 0.323 Ω cm^{-1} with correct units	[1]	Deduct a maximum of 1 mark for incorrect units.
(b)	*L* approximately 50.0 cm		
	Value of *x* greater than *L*	[1]	
	Value of *I* recorded to 0.1 mA	[1]	Ignore precision of *x* as it will be graded in (c).
(c)	6 sets of readings	[1]	

	Column headings: Each column heading must contain a quantity, a unit and a separating mark where appropriate. The presentation of quantity and unit must conform to accepted scientific convention Correct precision for raw data	[1] [1]	For mistakes in conversion, penalize under precision of raw data.
(d)	Correct identification of graph to be plotted. (Graph of *1/l* vs *x* graph plotted.)	[1]	e.c.f awarded (allow for 1/l to have 2 s.f for the case of l being a 1 s.f raw data)
	Correct calculation and s.f. of 1/l or equivalent in table	[1]	
	Axes: Sensible scales must be used, no awkward scales (e.g. 3:10). Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scale markings should be no more than three large squares apart	[1]	Ignore wrong units for labels. If points are not plotted but the axes is labelled, markers to check if the scale is sensible based on data.
	Plotting of points: All observations in the table must be plotted on the grid. Points must be plotted to an accuracy of half a small square.	[1]	Check only 3 points.
	Line of best fit: Judge by balance of all points on the grid about the candidate's line (at least 5 points). There must be an even distribution of points either side of the line along the full length. If there are 6 or more points, allow one anomalous point only if clearly indicated by the candidate.	[1]	
	Gradient: The hypotenuse of the triangle used must be greater than half the length of the drawn line. The method of calculation must be correct. Do not allow $\Delta x / \Delta y$. Both read-offs must be accurate to half a small square in both the x and y directions.	[1]	Do not mark down for incorrect precision of up to half the smallest division when writing the gradient coordinates.

	Or Correct reading/calculation of y-intercept *E* calculated correctly from gradient or y-intercept	[1]	Once linearisation is wrong, this mark cannot be awarded. Ecf may be awarded for incorrect calculation of gradient.
(e)	Mark is awarded based on the graph which is drawn by student. Three possible forms are shown below for reference. The list is not exhaustive. For 1/I vs x graph, Line W must have a gentler (positive) gradient and a larger (positive) y-intercept compared to the original graph. For I vs Ix graph, Line W must have a gentler (negative) gradient and a lower (positive) y-intercept compared to original graph. For x vs 1/I graph, Line W must have a steeper (positive) gradient and a lower (more negative) y-intercept compared to the original graph	[1]	

Question 3

Q3	Marking point	Mark	Remark
(a) (i)	Final value of *d* in range 38.0 cm to 42.0 cm (inclusive). Evidence of repeated readings. Correct rounding up and calculation for average. Answers to nearest 0.1 cm. Correct unit quoted.	[1]	
(a) (ii)	Percentage uncertainty in *d*, based on an absolute uncertainty of 0.2 cm to 0.5 cm (inclusive). Final answer given to 1 or 2 sf.	[1]	
(a) (iii)	Final value of *l* in range 25.0 cm to 28.0 cm (inclusive). Evidence of repeated readings. Correct calculation for average. Answers to nearest 0.1 cm. Correct unit quoted.	[1]	
(a) (iv)	Percentage uncertainty in *l*, based on an absolute uncertainty of 0.2 cm to 0.5 cm (inclusive). Final answer given to 1 or 2 sf.	[1]	
(b)	Final value of *T* in range 0.6s to 0.9s (inclusive). time for N oscillations ε 20 s Evidence of repeated readings Correct calculation for average. Precision is as calculated or at least 3 d.p. Correct unit quoted.	[1]	

(c)	Value of *d* smaller than **(a)(i)** Value of *l* larger than **(a)(iii)** Precision of 0.1 cm for both *d* and *l*	**[1]**	
	Value of *T* larger than **(b)** Time for N oscillations > 20 s Evidence of repeated readings Correct calculation for average. Precision is as calculated or at least 3 d.p. Correct unit quoted.	**[1]**	
(d) (i)	Values of *k* calculated correctly with correct units (e.g. s^2 cm).	**[1]**	
	Values of *k* given to appropriate number of s.f. (3 s.f.) or 4 s.f. (one more than least is allowed by Cambridge)	**[1]**	
(d) (ii)	Percentage difference (using either value of *k* or average value of the two *k*) calculated correctly. <u>And compared</u> to either - percentage uncertainty in *d* only, - percentage uncertainty in *l* only, - sum of percentage uncertainty in *d* and *l*, (or twice for d) - % uncertainty in *k* obtained via other reasonable error propagation method. <u>Alternatively</u>	**[1]**	

	Correctly calculate absolute uncertainty of either one of the k using uncertainties in *d* and *l*. No need to mark for the uncertainty for *T*. And check that the other values of *k* falls within the range of the value of the first *k*. If reject hypothesis, must show that % difference is greater than % uncertainty in *k* obtained via <u>correct error propagation method</u>.		
(e)	Recorded values of *d, N, t and T* with correct headings and units	**[1]**	·
	At least 3 sets of data for varying *d*.	**[1]**	
	Data for 'with mass' and 'without mass' recorded and clearly indicated	**[1]**	
	Reasonably deduced value of *d* consistent with recorded data	**[1]**	
(f)	Recorded values of *m, N, t, T* with correct headings and units.	**[1]**	
	At least 2 sets of data at the extreme range (where m = 50g and m = 200g)	**[1]**	
	Reasonable trend identified (e.g. when mass *m* added increases, period *T* decreases)	**[1]**	

(g)	R	Measure length of plank, *L* using ruler.	**[1]**	

		Find the period of oscillation *T* via collecting the time (using stopwatch) of *N* oscillation. Vary *L* to find new *T*.		
	S	Graph to be plotted: *T* against *L*. Straight line obtained Graph goes through the origin.	[1]	
	T	Any one of the control variables - length of the string loop (or value of *l*) - separation of the two strings (*d*) - width of the plank - thickness of the plank - material of the plank	[1]	
	U	1 reasonable difficulty for very small length: <u>Very small length/Small period</u> - Hard to estimate where to start and stop timing	[1]	
	V	1 reasonable difficulty for very long lengths: <u>Slow oscillation</u> - May not get enough number of oscillations <u>Challenging to balance the plank especially for small value of *d*.</u>	[1]	

Question 4

/ 11 Marks

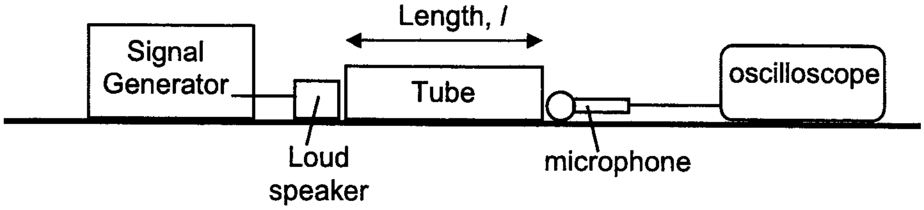
	Marks		**Marking Points**
Diagram	2	D1	Clear, labelled diagram showing tube and source of sound that can generate a range of frequencies.
			Sound must be able to produce a continuous variation of frequencies. Possible sources of sound: 1. Signal Generator and loudspeaker 2. Mobile phone accept in diagram - but details on how to use the mobile phone to generate a continuous variation of frequencies will be marked in V1. **Do not accept :** - <u>tuning fork</u> as it cannot produce a continuous frequency range - tuner, unless it is clear that the type stated can produce a continuous range of frequencies.
		D2	All apparatus must be supported by retort stands or placed on the table.
Variables	4	V1	Method to identify fundamental frequency Example: Identify fundamental frequency by increasing frequency from a low value until the maximum amplitude is detected.
			V1 point is marked for how the apparatus can be used to locate the fundamental frequency
		V2	Method and apparatus to measure fundamental frequency

			V2 point is about where the fundamental frequency value can be read from. For example : - Reading of the value from the signal generator, or - Reading the period and hence frequency from the CRO (CRO needs to be connected microphone and use the microphone as pick up.)
		V3	Method and apparatus to measure length L and diameter d
			Acceptable Apparatus for - L : Metre Rule - d : micrometer screw gauge, vernier callipers, and Metre Rule CIE Method requires blocks to be used with metre rule for measurement for L to ensure that the largest length across the cylinder is diameter. But will give BOD for our internal marking
		V4	At least 6 sets of valid data
			Advise to collect more than 6 sets of data (especially if a non-linear trend is expected).
Analysis	2	A1	• Plot appropriate graph(s) • Explain how the graph(s) would confirm the relationship. For example, "relationship is valid if a straight line is obtained"

			For this point to be awarded the student must specifically mention a "**straight line**" graph will be obtained if relationship is valid. Possible methods : (1) Fix d and vary L. Plot graph of 1/f vs. L. And repeat but fixing L and varying d. Plot graph of 1/f vs. d. <u>OR</u> (2) Fix d and vary L. Plot graph of 1/f vs. L. Then substitute the d value into y-intercept later in A2. <u>OR</u> (3) Fix L and vary d. Plot graph of 1/f vs d. Then substitute the L value into y-intercept later in A2
		A2	Describe how a and b are obtained. For example, "the constant a is given by the gradient of the graph."
			Mark is given for correct description from the graph plotted to get value. Graph plotted must be sensible in the first place.
Reliability	Max 2	R1	Repeating the measurement at <u>different points</u> along the tube to obtain a mean value for the diameter d.
		R2	Using microphone and oscilloscope to measure frequency
			Student must mention that they use the microphone and oscilloscope to measure the fundamental frequency in procedure for awarding of R2. If they further give details on how to get the frequency from the CRO they will be further awarded the R4 mark.
		R3	Method to reduce/remove ambient noise
			Accept use of a quiet room. Do not accept dark room - dark room may not necessarily be a sound proof room.

		R4	Additional details to explain how to measure frequency using microphone and oscilloscope. Period = number of divisions x time-base. Frequency=1/period
		R5	Use of blocks with ruler (if ruler is used measure diameter of tube) to ensure that the diameter of the tube is measured.
Safety	1	S1	Wear earplugs or other protective devices to prevent damage to ears when using loud sounds.
			Students must mention specifically to prevent damage due to "Loud sound" Accept ear protection to prevent damage due to loud sounds Do not accept - damage due to high frequencies.

Question 4
Suggested Solution



Variables
- Length of tube, *l*. Measured using a metre rule
- Diameter of tube, *d*. Measured using a Vernier Calliper
- Frequency of standing wave, *f*. Detected using a microphone. Period measured using an oscilloscope

Procedure
1. Setup the apparatus as shown above.
2. Conduct the experiment in a quiet room

Vary length *l*, keep diameter *d* constant to obtain *a*:

3. Measure the length *l* of the tube using a metre rule.
4. Measure the diameter *d* at different points along the tube using a Vernier calliper to obtain a mean value for *d*.
5. Turn on the signal generator and increase its frequency, starting from a low value until the oscilloscope detects the first maximum amplitude.
6. The oscilloscope shows the period of the sound wave.
7. Calculate the period *T* = number of divisions x time-base.
8. Calculate the frequency $f = 1 / T$
9. Repeat 3 to 8 for ten sets of data, each time using a tube with a different *l* but same *d*.
10. Plot the graph of $1/f$ against *l*.
11. The relationship is valid if a straight line is obtained.
12. The constant *a* is given by the gradient of the graph.

Vary *d*, keep *l* constant to obtain *b*:

13. Repeat 4 to 8 for ten sets of data, each time using a tube with different *d* but same *l*.
14. Plot the graph of $1/f$ against *d*.
15. The relationship is valid if a straight line is obtained.
16. The constant *b* is given by the gradient of the graph.

Safety precaution
Wear earplugs to prevent damage to ears in case of loud sounds.

Stationary Waves in an Open Pipe
Demo https://youtu.be/pGVhPEIX8VI
Theory https://youtu.be/BhQUW9s-R8M