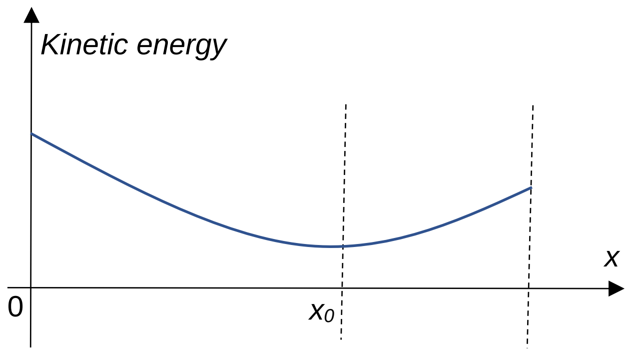
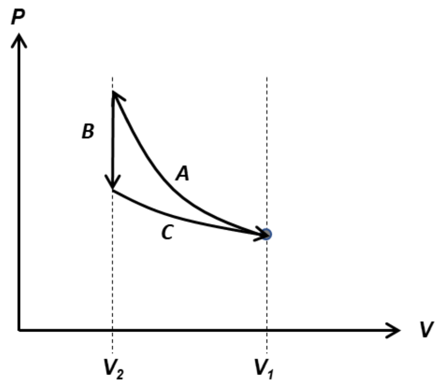
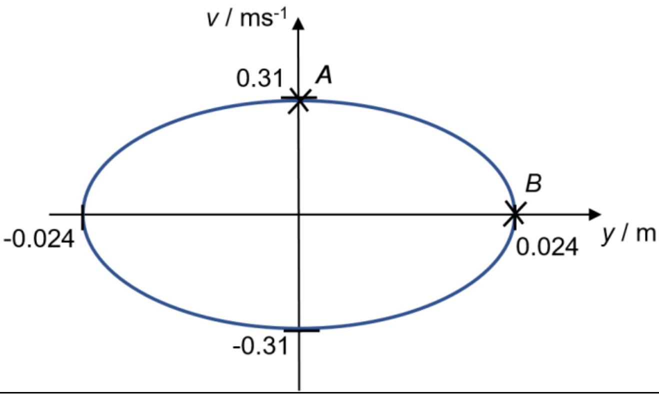
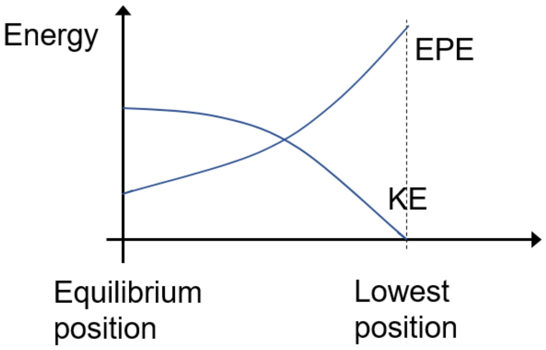
2022 C2 Prelim H2 Physics Paper 3 Suggested Solutions

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, $\Delta U = Q + W$ 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, $\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{0.25 \times 10^2}{150 \times 10^{-3}}} = 12.9099 = 12.9 \text{ rad s}^{-1}$	**A1**
3b(ii)	From **(b)(i)**, we have $\omega = 12.9099 \text{ rad s}^{-1}$ Using $v_0 = \omega y_0$, we have $y_0 = \frac{v_0}{\omega} = \frac{0.31}{12.9099} = 0.0240$ 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 $\Delta A = A_i - A_f = (3.00)^2 - 4[\tfrac{1}{2}(1.00)(2.83)] = 3.34$ m² The average induced e.m.f. is $\varepsilon = \frac{\Delta\varphi}{\Delta t} = B\frac{\Delta A}{\Delta t} = \frac{(0.100)(3.34)}{0.100} = 3.34$ V	**B1** **B1** **B1** **A1**
5(b)(ii)	The induced current in the loop, $I = \frac{\varepsilon}{R} = \frac{3.34}{10.0} = 0.334$ A	**A1**
	Max Marks	**10**

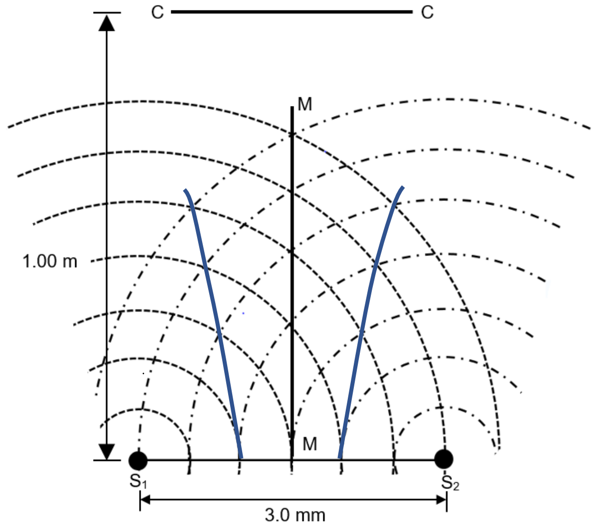
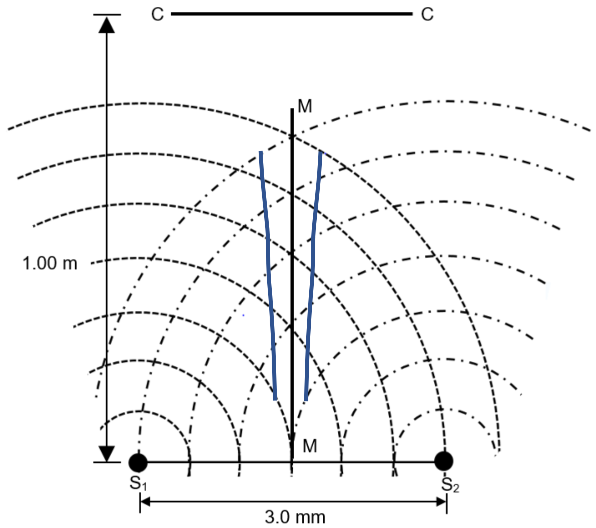
Setter: Jit Ning Marker:		
Question	**Answer**	**Marks**
6(a)	Frequency = 50 Hz Peak Voltage = 340 V Root-mean-square voltage = 240 V	**A1** **A1** **A1**
6(b)(i)	Voltage = 240/20 = 12 V	**A1**
6(b)(i)	Power consumed by 6.0 resistor, $P = \frac{V^2}{R} = \frac{12.0^2}{6.0} = 24.0\ W$ Power generated by primary circuit, $P = \frac{24.0}{0.95} = 25.263\ W$ Current in the primary circuit, $I = \frac{P}{V} = \frac{25.263}{240} = 0.10526 \approx 0.105$ 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 $\Delta y = \frac{\lambda L}{a}$ $\Delta y = \frac{(0.5 \times 10^{-3})(1.0)}{3.0 \times 10^{-3}}$ $\Delta y = 0.167$ 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, λ_{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)	<u>De Broglie wavelength associated with the moon (=9 x 10^{-60} m) << radius of its orbit</u> and hence the <u>wave nature of moon is insignificant.</u> 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 <u>the electrical force due to the parallel plate is about 10^5 times the force between two charged mineral grains</u> and hence, the electrical forces between the grains can be ignored.	 **M1** **A1** **A1**

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