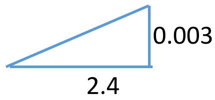
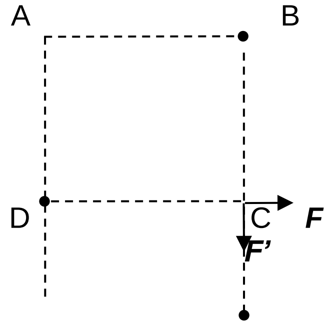
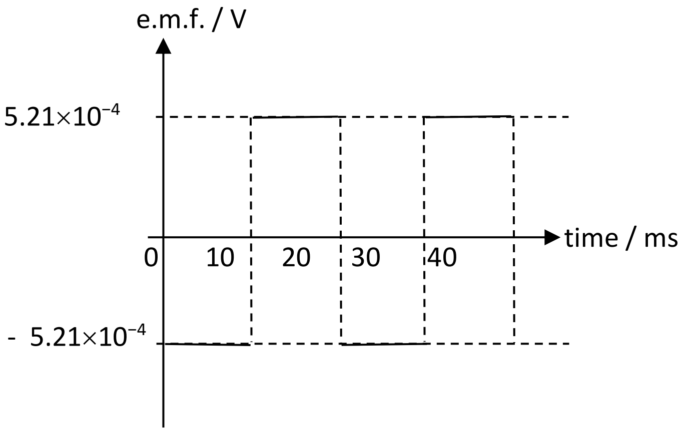
2024 PU3 Preliminary Examinations H2 Physics Paper 3 Suggested Answers

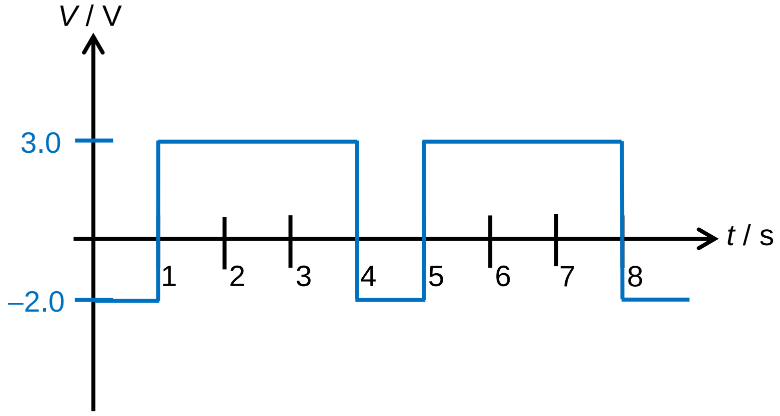
Section A

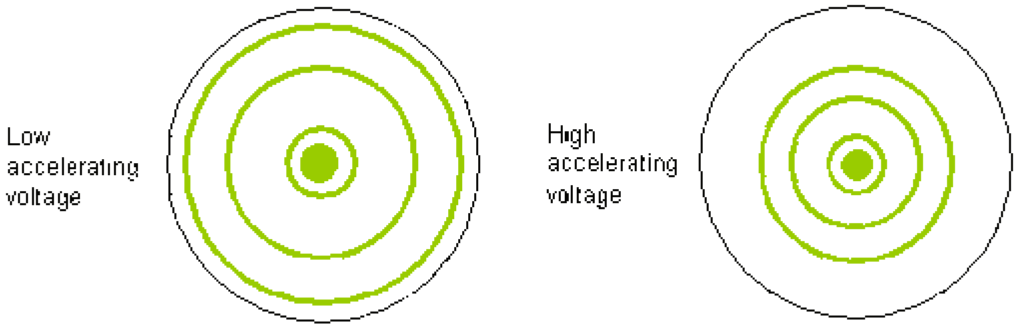
1	**(a)(i)**	Period = 0.80 s Frequency = 1/T = 1/0.80 = 1.25 Hz	**C1** **A1**
	(a)(ii)	Magnitude of induced emf is proportional to the rate of change of flux linkage	**A1**
	(a)(iii)	1. As magnet oscillates in the coil, the flux linkage with the coil changes and emf is induced in the coil, from Faraday's Law. 2. This causes an induced current to flow when the switch is closed. 3. The oscillating system loses energy as there is heat loss in the resistor. 4. Since energy of the system is proportional to the square of amplitude, amplitude decreases. OR 3. From Lenz Law, the flow of induced current produces a magnetic field which results in a force opposing the motion of the magnet. [B1] 4. The maximum resultant force on the magnet decreases and since amplitude is proportional to the maximum resultant force, amplitude decreases. [B1]	**B1** **B1** **B1** **B1** **OR** **B1** **B1**
	(b)(i)	0.50 Hz	**A1**
	(b)(ii)	Amplitude increases then decreases Amplitude is maximum at 1.25 Hz when resonance occurs. (Amplitude of oscillation increases as freq increases from 0.5 Hz to 1.25 Hz. At 1.25 Hz, resonance occurs. As frequency increases beyond 1.25 Hz to 5.0 Hz, the maximum amplitude decreases)	**B1** **B1**

2	**(a)(i)**	Single slit: sin θ= λ/b using small angle approximation sin $\theta \approx$tan θ  $sin\theta = \frac{0.003}{2.4} = \frac{\lambda}{b}$ (Accept 0.0325) $b = 5.04 \times 10^{-4}\, m$ (accept 4.65 x 10^{-4}m)	**C1** **A1**
	(a)(ii)1.	(When B decreases↓ , then sinθ increases ↑, and hence θ increases↑, therefore) this results in <u>increase in width of central maximum</u> and the maxima are further apart. The central maximum is also <u>lower in intensity</u>.	**B1** **B1**
	(a)(ii)2.	(When wavelength ***λ*** decreases↓, sinθ decreases↓, and hence θ decreases↓) Therefore there is <u>reduced width of central maximum</u> and the maxima are closer. <u>Intensity of the central maximum is unchanged</u> (bright and dark regions)	**B1** **B1**
	(b)(i)	$\theta = \frac{1}{2}(188 - 160) = 14°$ $d \sin\theta = n\lambda \rightarrow d \sin(14°) = 2(633 \times 10^{-9})$ $d = 5.23 \times 10^{-6}$ m $d = \frac{1}{N} \rightarrow N = \frac{1}{d} = 1.91 \times 10^{5}$	**C1** **M1** **C1** **A1**

3	**(a)**	Electric potential at a point is the <u>work done per unit positive charge in bringing a charge from infinity to that point.</u>	**B1**
	(b)(i)	 Two arrows of equal length, correct direction with labels (i.e. Force on C by B, Force on C by D) – 1 Mark	**B1**
	(b)(ii)	$F = \frac{Q^2}{4\pi\varepsilon_o r^2}$ = (9 × 10^9) $\frac{(1.2\times10^{-6})^2}{(2.0\times10^{-2})^2}$ = 32.4 N Resultant force = $\sqrt{(F^2 + F^2)}$ = $F\sqrt{2}$ = 32.4$\sqrt{2}$ = **45.8 N** Direction: Along A to C (ecf (i))	**C1** **A1** **A1**
	(b)(iii)	Distance from corner to centre, $r = \sqrt{2}$ cm $V = \frac{Q}{4\pi\varepsilon_o r}$ = (9 × 10^9) $\frac{-1.2\times10^{-6}}{\sqrt{2}\times10^{-2}}$ = –7.64 × 10^5 V Electric potential due to the three charges = 3V = 3 (–7.64 × 10^5) = **–2.29 × 10^6 V**	**C1** **C1** **A1**
	(b)(iv)	*At 100m away, potential due to the 3 charges is negligible* $W = q\Delta V$ = (1.2 × 10^{-6})(–2.29 × 10^6 - 0) = **–2.75 J**	**C1** **A1**

4	**(a)**	Any of 2 of the following: Increase current flowing through the solenoid Increase the number of turns per unit length in the solenoid Insert a ferrous core into the solenoid	 **B1** **B1** **B1** **(Max 2)**
	(b)(i)	C to D	**B1**
	(b)(ii)	By POM, F x 0.106 = 5.7x10^{-4} x 0.077 And F = BIL = B(4.9)(0.025) B = 3.38 x 10^{-3} T Tesla	 **C1** **C1** **A1** **B1**
	(c)(i)	$E = \left\lvert -\frac{d\Phi}{dt} \right\rvert$ $= \frac{d(NBA)}{dt}$ $= NA\frac{dB}{dt}$ $= NA\frac{d(\mu_o nI)}{dt}$ $= NA\mu_o n\frac{dI}{dt}$ $= (9)(0.010 \times 0.018)(4\pi \times 10^{-7})(\frac{400}{0.50})(\frac{3.2}{10 \times 10^{-3}})$ $= 5.21 \times 10^{-4}$ V	**C1** **A1**
	(c)(ii)	 Horizontal lie of constant e.m.f. with correct values (allow for e.c.f.) Correct sign of V	 **B1** **B1**

5	**(a)(i)**	$\langle V^2 \rangle = [(3^2 \times 3) + (6^2 \times 1)] / 4$ $= 15.75\ V^2$ Vrms = $(15.75)^{0.5}$ = 4.0 V	**C1** **A1**
	(a)(ii)	 Shape (not rectified) with correct period – 1m Correct values either (3.0 V, -2.0 V) Or (-6.0 V, 1.0 V) – 1m	**B1** **B1**
	(b)(i)	Turns ratio = 4.50 :500 = 9:1000 = 0.009 (allow for 500:4.50 = 111)	**A1**
	(b)(ii)	transmission line resistance = $6.44 \times 10^5 \times 4.50 \times 10^{-4} = 289.8\ \Omega$ Given the voltage is stepped up to 500 kV at the output of the transformer, The current flowing in the tx line = $5 \times 10^6 / 500 \times 10^3 = 10$ A Power loss = $10^2(289.8) = 2.9 \times 10^4$ W	**C1** **C1** **A1**
	(b)(iii)	By stepping up the voltage, the current in the transmission line will be lowered and hence the amount of power loss in the transmission line will be lowered.	**A1**

6	**(a)(i)**	The spread of the electron beam to form bright rings due to diffraction, The presence of dark regions between bright rings indicate that destructive interference is taking place	**B1** **B1**
	(a)(ii)1.	$KE = eV = p^2/2m$ $\lambda = \frac{h}{p}$ $= \frac{h}{\sqrt{2meV}}$	**M1** **M1** **A0**
	(a)(ii)2.	$\lambda = \frac{h}{\sqrt{2meV}}$ $= \frac{6.63\times10^{-34}}{\sqrt{2(9.11\times10^{-31})(1.60\times10^{-19})(250)}}$ $= 7.77 \times 10^{-12}$ m	 **C1** **A1**
	(a)(iii)	As potential difference V increases, the de Broglie wavelength decreases since $\lambda \, \alpha \frac{1}{\sqrt{V}}$. Since $d\sin\theta = n\lambda$, the angles at which the maxima are produced decrease. The rings become smaller/closer together.  	**B1** **B1**
	(b)	$\Delta p \, \Delta x \gtrsim h$ $\Delta p \, (1.2) \gtrsim 6.63 \times 10^{-34}$ $\Delta p \gtrsim 5.53 \times 10^{-34}$ kg m s^{-1} p = 80 x 2.0 = 160 kg m s^{-1} Hence, the uncertainty in his momentum is negligible as compared to his linear momentum. OR $\tan\theta = \frac{\Delta p}{p} = \frac{5.53\times10^{-34}}{160} = 3.46\times10^{-36} \approx 0$ Hence, the angle of deflection is negligible.	 **M1** **B1**

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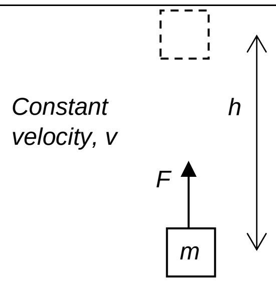
Section B

7	**(a)**	The moment of a force about a pivot is the product of that force and the perpendicular distance between the line of action of the force and the pivot. The torque of a couple between two forces is the product of one of the forces and the perpendicular distance between their lines of action. One force for moment & two forces for torque OR about a pivot for moment & no need for pivot for torque	**B1** **B1** **B1**
	(b)(i)	The anti-clockwise moment due to the weight of the hook is balanced by the total clockwise moments due to the weight of the sliding weights. OR c.g of the weighing machine is at the pivot	**B1**
	(b)(ii)	For the same load on the hook, a smaller perpendicular distance from the hook to the pivot will result in smaller anti-clockwise moment to be balanced by the sliding weights. A longer rigid rod will allow for smaller sliding weights to be used. OR A longer rigid rod will give a better precision to the reading**.** OR With the same sliding weights, a bigger range of loads can be measured**.**	**B1** **B1**
	(b)(iii)	Weight of sack of flour = mg $mg \times 4.8 = (12 \times 84) + (2.5 \times 72)$ $m = 25.2$ kg	 **C1** **A1**
	(b)(iv)	The movement of the sliding weights will be much smaller for such a small load hence the corresponding fractional uncertainty of the weight of the object will be higher.	**B1** **B1**
	(c)(i)	A force F acts on a mass m to move it vertically upwards at constant speed (so that no change in E_k) by a displacement h in the direction of the force.  Since the object moves at constant speed, the upward force, F, must be equal to the weight of the object, mg. (no resultant force). Using Work done on object = $Fh = (mg)h$ Since Fh is the work done on the object and is equal to the increase in potential energy, $E_p = mgh$	**B1** **B1** **B1**
	(c)(ii)1.	Power = $\frac{n \times mgh}{t} = \frac{60 \times (55)(9.81)(15)}{1 \times 30}$ $= 1.62 \times 10^4$ W	**C1** **A1**

	(c)(ii)2.	v (in direction parallel to escalator) = $\dfrac{15}{\sin 30^o} \div 30$ = 1.0 m s^{-1} Power = Fv = 1.0 x 10^4 x 1.0 = 1.0 x 10^4 W	**C1** **C1** **A1**
	(c)(ii)3.	To maintain constant speed, the escalator has to supply <u>more power</u> to <u>overcome the (downward) force exerted on escalator steps by users</u> moving up. OR higher rate of increase of GPE of the users	**B1** **B1**

8	**(a)(i)**	A spontaneous radioactive decay is one whereby it is not triggered by external stimuli such as chemical composition and physical environment (temperature, pressure, electric fields, magnetic fields, luminosity, etc.)	B1 B1
	(a)(ii)	${}^{238}_{94}\text{Pu} \rightarrow {}^{234}_{92}\text{U} + {}^{4}_{2}\text{He}$ correct symbols correct mass and atomic number	 B1 B1
	(a)(iii)1.	Conservation of mass-energy K.E of products = $(m_{Pu} - m_u - m_\alpha)\, c^2$ $(5.649\times10^{6})(1.6\times10^{-19}) = (238.0496 - m_u - 4.0026)(1.66\times10^{-27})(3\times10^{8})^2$ m_u = 234.0409 u	 C1 C1 A1
	(a)(iii)2.	By the principle of conservation of momentum, $0 = m_u v_u + m_\alpha v_\alpha$ $\frac{v_\alpha}{v_u} = -\frac{m_u}{m_\alpha}$ $\frac{T_\alpha}{T_u} = \frac{\frac{1}{2}m_\alpha v_\alpha^2}{\frac{1}{2}m_u v_u^2} = \frac{m_\alpha}{m_u}\left(-\frac{m_u}{m_\alpha}\right)^2 = \frac{m_u}{m_\alpha} = \frac{234.0409}{4.0026} = 58.47$ = 58.5	 C1 C1 A1
	(a)(iii)3.	$T_\alpha + T_u = 5.649$ MeV $T_\alpha \left(1 + \frac{1}{58.47}\right) = 5.649$ MeV T_α = 5.55 MeV	 C1 A1
	(b)(i)	α-particles are highly ionising due to their charge and relatively large mass. Due to its ionising ability, an α-particle has very short range as it loses its energy rather rapidly. γ-rays are very weakly ionising because they are electromagnetic waves and carry no charge and no rest mass. Hence, they are most penetrating.	B1 B1
	(b)(ii)	Alpha particles are highly ionizing and will not penetrate further than 10 cm of air. Thus emission of α-particles will not be detected.	A1

	(b)(iii)	True count = observed count – background count t / hour | True count-rate / min^{-1} 0 | 6,409 6.0 | 801 $\frac{C'}{C_0} = \frac{801}{6409} = \left(\frac{1}{2}\right)^n$ $\lg\left(\frac{801}{6409}\right) = n\ \lg\frac{1}{2}$ $\Rightarrow n = 3.0$ $\Rightarrow 6.0\,\text{hrs} = 3.0\, t_{1/2}$ $\therefore\ t_{1/2} = 2.0\,\text{hrs}$	C1 C1 A1
	(b)(iv)	Short-term effect: Ionizing radiation can cause immediate damage to human tissue and could be accompanied by radiation burns, radiation sickness, etc. Long-term effect: Delayed effects such as cataracts, hair loss, leukaemia, cancer, etc. could appear years after the exposure. Hereditary defects may also occur in succeeding generations as a result of gene damage.	B1 B1