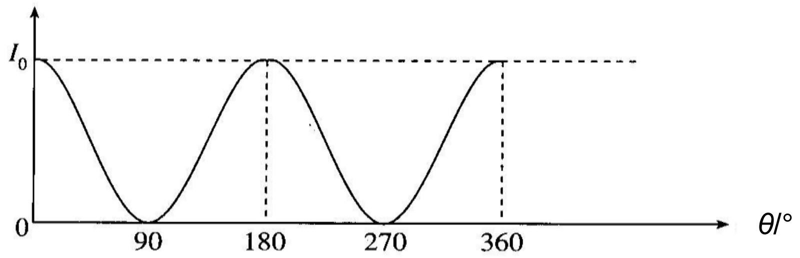
Anderson Serangoon Junior College 2024 H2 Physics Preliminary Examination Mark Scheme

Paper 2 (80 marks)

1a	The net momentum of a system remains constant provided no external resultant force acts on the system.	B1 B1
1bi	(total initial momentum in the direction at right−angles to the direction of the initial path of ball A = 0) (taking ↑ as positive) $0 = 4.0 \times 6.0 \sin\theta - 12 \times 3.5 \sin 30°$ $\theta = 61°$	 C1 A1
1bii	Considering momentum along the direction of the initial path of ball A: By Conservation of linear momentum, total initial momentum = total final momentum $4.0 \times v = 4.0 \times 6.0 \cos 61° + 12 \times 3.5 \cos 30°$ $v = 12\text{ m s}^{-1}$	 C1 A1
1biii	total initial k.e. = ½ $(4)(12)^2$ = 288 J total final k.e. = ½ $(4)(6.0)^2$ + ½ $(12)(3.5)^2$ = 145.5 J Since the total kinetic energy before and after collision is different, the collision is inelastic.	 M1 A1

2ai	take any two sets of coordinates to determine a constant value (F/x) F/x constant hence obeys Hooke's law	M1 A1
2aii	$k = \dfrac{4.5 - 1.5}{(1.8 - 0.6) \times 10^{-2}} = 250\text{ N m}^{-1}$ E_P = area under graph or ½Fx or ½kx^2 $= 0.5 \times 4.5 \times 1.8 \times 10^{-2}$ or $0.5 \times 250 \times (1.8 \times 10^{-2})^2$ = 0.041 J (0.0405 J)	 C1 A1
2b	Loss in KE of cart = Gain in EPE of spring KE = ½mv^2 = 0.0405 $v = (2 \times 0.0405 / 1.7)^{½} = 0.22\text{ m s}^{-1}$	 C1 A1

<table>
<tr>
<td>3a</td>
<td>
Intensity is proportional to (amplitude)^2
Since amplitude is $A \cos \theta$, the graph of amplitude is a cosine function.
Hence $I = kA^2 \cos^2 \theta$ (Malus' Law)



Shape: M1
Axes values: A1
</td>
<td>M1
A1</td>
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<tr>
<td>3bi</td>
<td>
$I = kA^2 \cos^2 \phi$, and $I_o = kA^2$

Intensity after passing through polaroid R = $I_o \cos^2 30° = 0.75\, I_o$
Intensity after passing through polaroid Q = $(0.75\, I_o) \cos^2 (90° - 30°) = 0.19\, I_o$
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<td>C1
A1</td>
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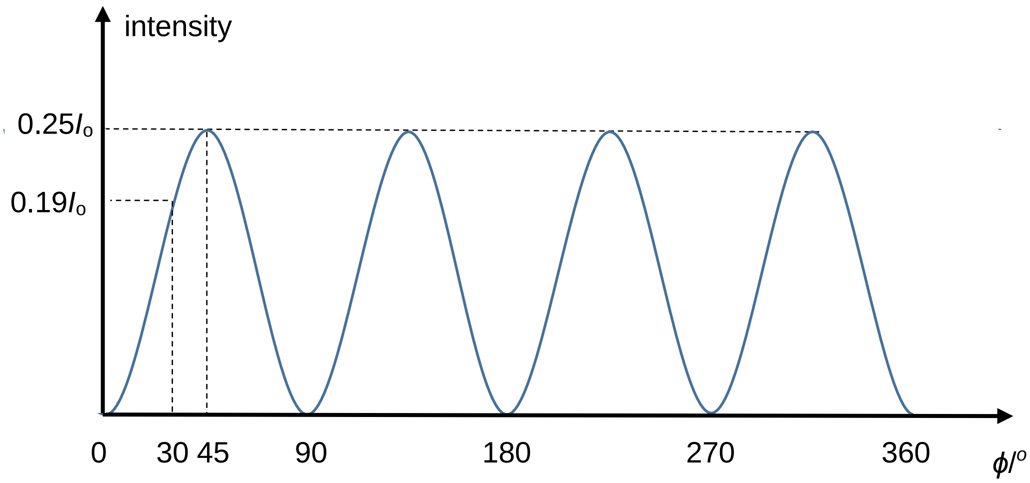
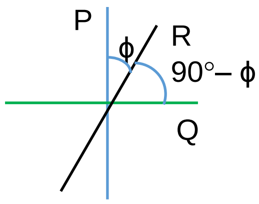
<tr>
<td>3bii</td>
<td>


<u>Working below is not required:</u>



Intensity after passing through polaroid R, $I_R = I_o \cos^2 \phi$
Intensity after passing through polaroid Q $= I_R \cos^2 (90° - \phi)$
$= I_o \cos^2 \phi \sin^2 \phi$
$= I_o (0.5 \sin 2\phi)^2$ where $\sin 2\theta = 2 \sin \theta \cos \theta$
$= 0.25\, I_o \sin^2 2\phi$

Shape: sine-square graph with 4 cycles, starting with zero
labelling of every 45°
correct maximum value – 0.25 I_o
</td>
<td>M1
A1
B1</td>
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<tr>
<td>3c</td>
<td>Longitudinal waves cannot be polarised because the <u>oscillation of particles</u> in the wave is parallel to its <u>direction of energy transfer</u>.</td>
<td>A1</td>
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</table>

4a	progressive waves transfer/propagate energy **and** energy in a stationary waves is localised/stored, *OR* <u>amplitude</u> constant for progressive wave **and** varies (from max/antinode to min/zero/node) for stationary wave, *OR* for stationary waves, particles within a loop/segment are in phase **and** for progressive wave particles within a wavelength are out of phase Any 2 of the above.	B2
4bi	wave/microwave from source/S <u>reflects</u> at reflector R reflected and (further) incident waves <u>overlap/meet/superpose</u> waves have same <u>frequency/wavelength/period</u>/<u>speed</u> and (amplitude), (so stationary waves are formed)	B1 B1 B1
4bii	detector/D is moved between reflector/R and source/S maximum and minimum/zero observed on <u>meter/readings/measurements/recordings</u>	B1 B1
4biii	<u>determine/measure</u> the distance between adjacent nodes/minima or maxima/antinodes or across <u>specific number</u> of nodes/antinodes wavelength is twice distance between <u>adjacent</u> nodes/minima or maxima/antinodes (or other correct method of calculation of wavelength from measurement)	B1 B1
4c	Waves from the two sources travel the same distance to the detector so the <u>path difference is zero</u>, <u>constructive interference</u> happens so the reading is <u>maximum.</u>	M1 A1

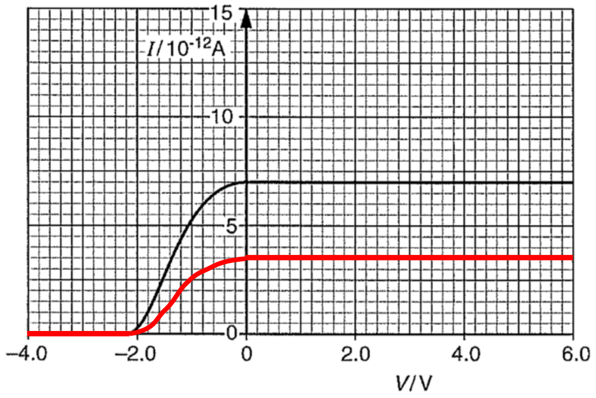
5ai	Since the <u>field strength is zero at a point between the spheres</u> / there are <u>two sections of the graph that are of opposite signs</u> hence <u>opposite direction of E-field</u> therefore the charges are the <u>same sign</u>.	M1 A1
5aii	At <u>x = 0.08 m,</u> the electric field strength due to sphere A cancels out the electric field strength due to sphere B OR net E is zero. $E_A = E_B$ $\frac{Q_A}{4\pi\varepsilon_o\ (0.080)^2} = \frac{Q_B}{4\pi\varepsilon_o\ (0.040)^2}$ $\frac{Q_A}{Q_B} = \left(\frac{0.080}{0.040}\right)^2 = 4.0$	M1 M1 A1

[Turn Over

5bi	E = V/d = 100 / 0.050 = 2000 N C^{-1} Direction of electric field strength is upwards (high to low potential)	B1 B1
5bii	$a = \dfrac{qE}{m}$ $= ((1.6 \times 10^{-19})(2000) / (9.11 \times 10^{-31})$ $= 3.5 \times 10^{14}$ m s^{-2}	 C1 A1
5biii	$\Delta U = q\Delta V$ $= (-1.6 \times 10^{-19})[(-100) - (-150)]$ $= -8.0 \times 10^{-18}$ J	 C1 A1

6a	change in magnetic flux density $\Delta B = 5 - 50 = -45$ mT (from graph, accept positive value) average induced e.m.f. = $\Delta\Phi / \Delta t = \Delta NBA / \Delta t = NA\, \Delta B / \Delta t$ $= 180 \times \pi\, (5.3\times10^{-3}/2)^2 \times(-45\times10^{-3}) / 0.30$ $= -5.957\times10^{-4} = -6.0\times10^{-4}$ V	B1 C1 A1
6b	As the coil moves away from the magnet, there is <u>a rate of change of magnetic flux linkage through the coil</u> due to the decreasing magnetic flux density <u>resulting in an induced e.m.f.</u> in the coil, according to Faraday's law. With the resistor connected in a closed loop with the coil, <u>a current is induced</u> in the <u>closed loop / coil</u> that opposes the motion of the coil, according to Lenz's law. As <u>work is done (by external force)/ energy is required to move the coil away</u> at constant speed, this gives rise to the heating effect of induced current (in resistor).	 B1 B1 B1

7ai	As p.d. becomes negative, there are photoelectrons that reach collector C, contributing to the photocurrent, as they have <u>kinetic energy greater than the work done against electric field</u> between the metal plates.(As the p.d. becomes more negative, only the more energetic photoelectrons reach the collector C) Hence, the sloping section of the graph shows that photoelectrons are emitted from metal plate E with <u>a range of kinetic energies</u>.	B1 B1
7aii	From Fig. 7.2, the stopping potential, $V = -2.2$ V (Since stopping potential stops the most energetic photoelectrons emitted from metal plate E, by conservation of energy) loss in kinetic energy of most energetic photoelectrons = work done against e−field $\frac{1}{2} m v_{max}^2 - 0 = qV$ $v_{max} = \sqrt{\dfrac{qV}{{}^1\!/_2\, m}} = \sqrt{\dfrac{(-1.60\times10^{-19})(-2.2)}{{}^1\!/_2 (9.11\times10^{-31})}}$ $= 8.79 \times 10^5$ m s^{-1}	B1 M1 A1

7aiii		frequency is constant ➔ stopping potential is the same intensity is halved ➔ rate of photons incident on metal plate E is halved ➔ rate of photoelectrons emitted is halved ➔ photocurrent is halved at every respective value of p.d.	B1 B1
7b	Since $E = hf$ or hc/λ, from work function energy, threshold wavelength = $\frac{hc}{\text{work function energy}} = \frac{(6.63 \times 10^{-34})(3.00 \times 10^{8})}{5.8 \times 10^{-19}}$ = 343 nm (For photoelectrons to be emitted, the wavelength of the radiation should be less than the threshold wavelength.) Since the wavelength of the radiation from the second lamp is longer than the threshold wavelength [appropriate comment comparing wavelengths/ energies/ frequencies], there will be no effect on photoelectric current (as this wavelength does not cause photoelectric effect of zinc). Note: Also accept analysis using threshold frequency or minimum energy for photoelectron emission.		C1 A1 A1

8a	Fast moving/ high speed/ high (kinetic) energy electrons moving towards the target metal (anode), undergo rapid/large deceleration/ acceleration as they interact with the lattice ions. The loss in energy of the electrons is emitted in the form of X-ray photons, and since the loss of energy can vary according to the interaction, they form the continuous X-ray spectrum.	B1 M1 A1
8b	tungsten is ductile so it can be made into thin wires tungsten has a high atomic number tungsten is a good thermionic emitter / good at emitting electrons tungsten has a very high melting point (any one relevant point)	A1
8ci1.	From Fig. 8.2, μ of muscle is 0.40 cm^{-1}. Using $\frac{I}{I_0} = e^{-\mu x}$, ratio along MM = $e^{-0.40(8.0)}$ = 0.041 or 0.0408	 C1 A1
8ci2.	From Fig. 8.2, μ of bone is 2.46 cm^{-1}. Using $\frac{I}{I_0} = e^{-\mu x}$,	

	ratio along BB = $\left(\frac{I}{I_0}\right)_{\text{muscle}} \times \left(\frac{I}{I_0}\right)_{\text{bone}}$ $= e^{-0.40(4.0)} \times e^{-2.46(4.0)}$ = 0.000011 or 0.0000108 or ratio along BB = $\left(\frac{I}{I_0}\right)_{\text{muscle, 2 cm}} \times \left(\frac{I}{I_0}\right)_{\text{bone}} \times \left(\frac{I}{I_0}\right)_{\text{muscle, 2 cm}}$ $= e^{-0.40(2.0)} \times e^{-2.46(4.0)} \times e^{-0.40(2.0)}$ = 0.000011 or 0.0000108	C1 C1 A1
8cii	Since the ratio along BB is <u>3 orders of magnitude smaller</u> than that along MM, the contrast is <u>good</u>.	M1 A1
8d	MRI is able to provide excellent contrast between the different parts of the brain (gray matter, white matter and blood) due to the distinct relaxation times in Fig. 8.5, whereas X-ray has poor contrast between blood and brain due to similar absorption coefficients. MRI is safer as it uses magnetic field and radio frequency waves unlike X-rays which is an ionising radiation and can cause tissue damage causing mutations which can lead to growth of cancerous tissues.	B1 B1
8e	• small space, not suitable for patient who are claustrophobic • strong magnetic field can cause ferromagnetic objects in the room to become projectile posing risk to patient and staff • metal implants (e.g. pacemaker, cochlear implants) / ferromagnetic implants in patients may malfunction / move in the strong magnetic field • (long scan time) patient needs to remain still for long duration and any reasonable challenges e.g. any movement may cause blurred image, children or patients who cannot lie down for long duration. • ineffective for bone imaging due to fast relaxation times • helium gas leaking during a quench resulting in suffocation or frostbite (any one relevant point)	A1
8f	For a solenoid, $B = \mu_0 n I$ $1.5 = (4\pi\times10^{-7}) \times n \times 750$ $n = 1591.55\ \text{m}^{-1}$ Hence, number of turns = n × 2.2 = 3500 turns	C1 A1
8g	Lamor frequency, $\omega = \gamma B_0$ $= (2.68\times10^{8}) \times 1.5 = 4.02\times10^{8}\ \text{rad s}^{-1}$ frequency of RF wave = $\omega/2\pi$ $= 4.02\times10^{8}/2\pi$ = 64 or 64.0 MHz	C1 A1
8h	assuming all electrical energy is used to vaporise liquid helium, rate of electrical heating = rate of vaporisation of liquid helium $I^2R = ml_v$ where m is the initial rate of vaporization $(750)^2(0.0045) = m\ (21\times10^{3})$ $m = 0.12$ or $0.121\ \text{kg s}^{-1}$	C1 A1