## Anderson Serangoon Junior College 2025 JC2 H2 Physics P1 Prelim Mark Scheme
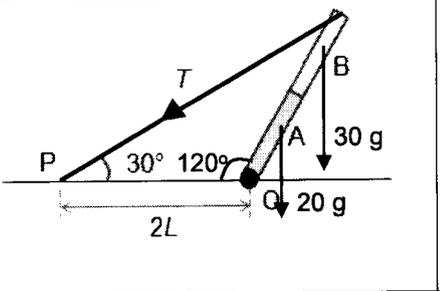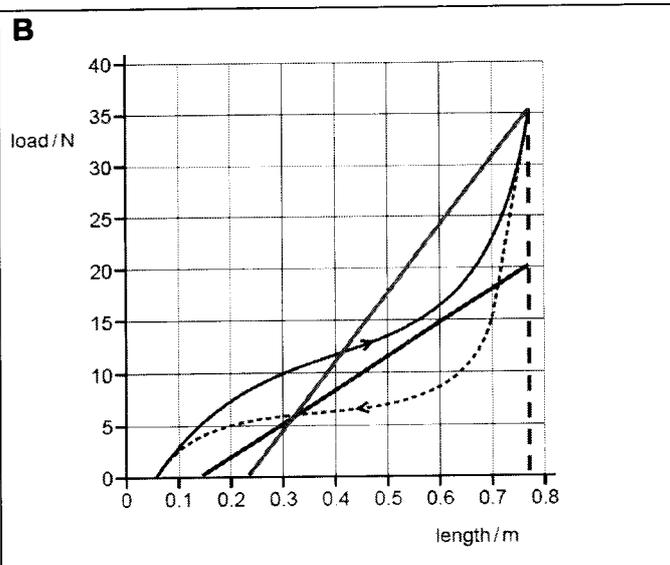
Paper 1 (30 marks) **E – Easy, A – Average, D – Difficult**

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

1	C	E
	Typical mass of a small car = 1500 kg Average KE of car = ½ (1500) (30²) = 0.68 × 10⁶ = 1 × 10⁶ J (1 s.f.)	

$$\text{Average KE of car} = \tfrac{1}{2}(1500)(30^2) = 0.68 \times 10^6 = 1 \times 10^6 \text{ J (1 s.f.)}$$

2	B	E
	For a fixed resistor, R = constant or ratio of V/I is a constant. The presence of a non-zero y-intercept indicates a systematic error. There is no random error as all points lie on the best fit line	

3	B	A
	Using $s = ut + 0.5at^2$, as $u = 0$ and a = constant, Hence, $s \propto t^2$ $\dfrac{x}{L} = \dfrac{(0.5T)^2}{T^2}$ $x = 0.25L$	
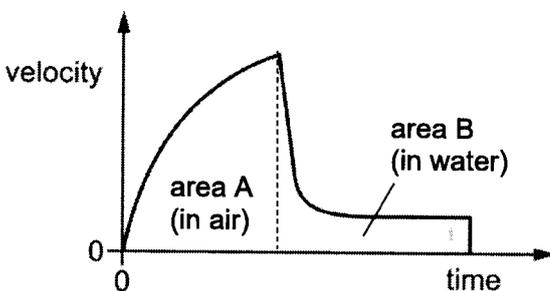
4	C	A
	 Terminal velocity was reached in water as shown by the horizontal line. Area A (distance travelled in air) > Area B (distance travelled in water). Rate of change of velocity in air (gradient of curve) is decreasing.	

5	C	A
	Forces must be of the same type, opposite in direction and acts on different body.	
6	**A** 90 kg min^{-1} = 1.5 kg s^{-1} $F = \dfrac{\Delta(mv)}{t} = v\dfrac{\Delta m}{t} = 20 \times 1.5 = 30\,N$	A
7	**D** Since the rod is in equilibrium, $\Sigma\tau = 0$ Taking moment about O, $T(2L\sin 30°) = 20g(\dfrac{L}{2}\cos 60°) + 30g(\dfrac{3L}{2}\cos 60°)$ $\qquad T = 269.78 = 270\,N$	D
8	**B** WD to stretch = ½ × 0.5 × 35 = 9 J Energy recovered = ½ × 0.6 × 20 = 6 J Total WD in 1 cycle = Energy remaining in 1 cycle = 9 – 6 = 3 J Or by counting the no of squares in the area between the two curves Energy remaining = (5 × 0.1) × 6 = 3 J	D
9	**B** Constant force: Acceleration, a = constant Initial speed, u = 0 Therefore v = u + at = at P = Fv = Fat $P \propto t$	A

10	D	E
	The vertical component of the acceleration is the centripetal acceleration which is present since the particle is performing circular motion. The horizontal component of the acceleration causes the speed of the object to increase.	
11	B	E
	On P, Since weight of mass is 1.0 N, g = weight/mass = 1.0 / 1.0 = 1.0 m s^{-2} On Q, Mass of 1.0 kg remains unchanged on Q. g = 1.0 x 10 = 10 m s^{-2} Weight of mass = 1.0 x 10 = 10 N	
12	B $$P = \frac{1}{3}\frac{Nm}{V} < c^2 >$$ $$P = \frac{1}{3}\rho < c^2 >$$ $$1.0 \times 10^5 = \frac{1}{3} \times 1.2 \times < c^2 >$$ $$\sqrt{< c^2 >} = 500 \text{ ms}^{-1}$$	E
13	C For full cycle processes, the net change in internal energy is zero. $$\Delta U = Q + W$$ $$0 = Q + [(-4.2) + (1.0 \times 10^5 \times (20.0 - 5.0) \times 10^{-6})]$$ $$Q = 2.7 \text{ J}$$	E
14	A at equilibrium position, x = 0 mm amplitude = 50 mm period = 2.0 s Time shutter remained open t, from x = 0 s to x = 25 mm, $$25 = 50\sin\frac{2\pi t}{2.0}$$ t = 0.17 s	D

15	**B** Air molecules undergo simple harmonic motion. As intensity is proportional to square of amplitude, amplitude of vibration of air molecules increases. Since $v_0 = \omega x_0 = (2\pi f)x_0$, maximum speed increases. Speed of wave travel of sound depends on the medium (density, temperature etc), not intensity.	**A**
16	**A** $\text{phase difference} = \dfrac{\text{path difference}}{\text{wavelength}} \times 2\pi + (\text{phase difference between sources})$ As light intensity at P is zero, the waves from R and S meet at P with phase difference of $n\pi$, where n = 1, 3, 5, 7.... A: phase difference at P = $2\pi + \pi = 3\pi$ (correct) B: phase difference at P = $\frac{1}{2} \times 2\pi + \pi = 2\pi$ (incorrect) C: phase difference at P = $2\pi + \frac{1}{2}\pi = 5/2\ \pi$ (incorrect) D: phase difference at P = $2\pi + 0 = 2\pi$ (incorrect)	**A**
17	**A** $d \sin\theta = n\lambda$ For the same d and θ, $3\lambda_x = 2\lambda_{red}$ $3\lambda_x = 2 \times 720 \times 10^{-9}$ $\lambda_x = 480$ nm	**A**
18	**D** $F = qE$ $ma = qE$ $a = qE/m$ $\Rightarrow$ Since q, E, m are constants, a is constant $v^2 = u^2 + 2ax$ $u = 0$, $v^2 = 2ax$ $KE = \frac{1}{2}mv^2 = \frac{1}{2}m(2ax)$ $\Rightarrow$ KE is proportional to x.	**A**
19	**D** From definition, $V = \dfrac{W}{Q}$ From definition, $V = \dfrac{W/t}{Q/t} = \dfrac{P}{I}$, and $R = \dfrac{V}{I}$, hence $P = IV = I^2R = \dfrac{V^2}{R} = \dfrac{W^2}{Q^2R}$	**E**
20	**A** When S is closed, effective external resistance decreases, hence current (ammeter reading) increases, and cause voltmeter reading to decrease as p.d across internal resistance increases.	**A**

21	D	A
	$V_{out} = \dfrac{4}{2+4} \times E$	
	$\dfrac{V_{out}}{E} = \dfrac{2}{3}$	

22	A	D
	Potential gradient $k = \dfrac{\Delta V}{\Delta \ell} = \dfrac{V_{xy}}{\ell_{xy}} = \dfrac{\left(\dfrac{0.50}{0.50+0.50}\right) \times 1.5}{0.96} = 0.781$	
	$E = k\, l_{xz} = (0.781)(0.64) = 0.50$ V	

23	B	A
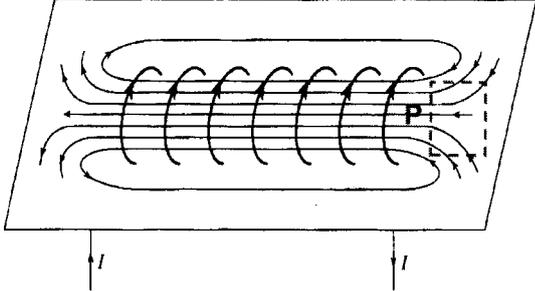
24	A	A
	By Fleming's Left Hand Rule, force is directed out of the page. As θ tends to 0°, force becomes maximum, as wire becomes perpendicular to flux density (or as θ tends to 90°, force becomes minimum). Hence the force is a cosine function.	
	$F = BIL$ where B and L are perpendicular to each other $= BI\,(2)\,(L/2 \cos \theta)$ $= BIL \cos \theta$	

25	D	A
	The wire segment can be split into 2 portions, the triangular segment and a rectangular segment.	
	The magnitude of the rate of change of magnetic flux when triangle is entering or leaving the field, is increasing as the rate of change of area in field increases. Induced e.m.f. and hence induced current is increasing.	
	At the rectangular segment, rate of change of flux is constant, thus induced emf and induced current is a constant.	

26	A	A
	$\sqrt{\dfrac{2(I_o^2)+(2I_o)^2}{3}} == \sqrt{2}\,I_o$	
27	**D** Frequency of violet light $f = 7 \times 10^{14}$Hz (or wavelength of violet light $\lambda = 400$ nm) Estimated energy of a photon of violet light, $E = hf$ $\quad = (6.63 \times 10^{-34})\,(7 \times 10^{14}) = 5 \times 10^{-19}$ J	A
28	**C** Based on HUP, $\Delta x\,\Delta p \geq h$ $(1.00 \times 10^{-20})\,(\Delta p) \geq 6.63 \times 10^{-34}$ $\Delta p \geq 6.63 \times 10^{-14}$ Percentage change in uncertainty of momentum $= \dfrac{6.63 \times 10^{-14} - 4.00 \times 10^{-14}}{4.00 \times 10^{-14}} \times 100\%$ $= 66\%$	D
29	**C** Since half-life of sample (33 years) is much greater than duration of decay (2 days), the activity of the sample is approximately constant during the duration of decay. From A = -dN/dt The number of decayed nuclei (dN) = A(dt) $\qquad\qquad\qquad\qquad\qquad = 4.0 \times 10^5\,(2 \times 24 \times 3600)$ $\qquad\qquad\qquad\qquad\qquad = 6.9 \times 10^{10}$ OR $A = \lambda N$ $A_O = \left[\dfrac{ln2}{t_{0.5}}\right] N_O$ $4 \times 10^5 = \dfrac{N_O\,ln2}{33 \times 365 \times 24 \times 60 \times 60}$ $N_O = 6.00558 \times 10^{14}$ $N = N_O e^{-\lambda t}$ $N = N_O e^{-\left[\frac{ln2}{t_{0.5}}\right]t}$ $\quad = (6.00558 \times 10^{14}) e^{-\left[\frac{ln2}{33 \times 365 \times 24 \times 60 \times 60}\right](2 \times 24 \times 60 \times 60)}$ $\quad = 6.004889 \times 10^{14}$ Thus, $N_O - N = 6.91160 \times 10^{10} = 6.9 \times 10^{10}$ (2 s.f.)	A

30	C	E
	$^a_b X \rightarrow \; ^{a-4}_b Y + ^4_2 He + 2 \; ^0_{-1}e$ Between X and Y, the number of neutrons differ, and the number of protons are the same. Hence, nucleus Y is an isotope of nucleus X.	

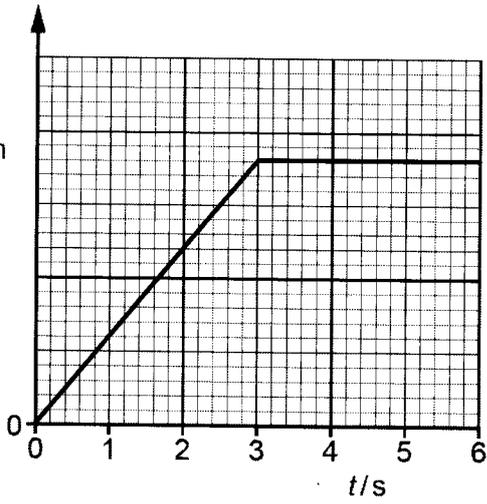**Paper 2 (60 marks)**   **E – Easy, A – Average, D – Difficult**

ECF	Error carried forward	SF	Significant figures error	M0	No A marks awarded
AE	Arithmetic error	BOD	Benefit of doubt	^	More is needed in answer
POT	Power of ten error	CON	Contradictory response	XP	Wrong physics
TE	Transcription error	IR	Irrelevant (part) response		

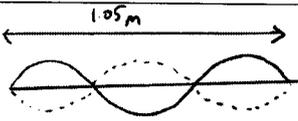|			
1ai	$g = (4\pi^2 \times 1.50) / (2.48^2)$ $= 9.63$ m s^{-2} _Examiner's comments:_ Most answers were correct. A small number of students incorrectly left the answer in 1 or 2 s.f. though the least s.f. of data in the question is 3.	E	A1
1aii	percentage uncertainty = 2 + (3 $\times$ 2), OR fraction uncertainty = 0.02 + (0.03 $\times$ 2) actual uncertainty = 0.08 $\times$ 9.63 = 0.8 m s^{-2} _Examiner's comments:_ Many answers showed lack of understanding/familiarity of use of percentage uncertainty.	A	C1 A1
1bi	$\omega = 2\pi / T$ $\quad = 2\pi / 4.0$ $\quad = 1.57$ rad s^{-1} $v_0 = \omega x_0$ $\quad = 1.57 \times 5.0$ $\quad = 7.9$ cm s^{-1} (2 s.f.) _Examiner's comments:_ Period and amplitude have to be read to half the smallest square. Some answers were obtained through the gradient approach, but since the tangent was not accurately drawn, their answers did not fall within the acceptable range. Hence, in this case the calculation approach is preferred.	A	B1 B1
1bii	• initial pull was to the right/initial motion is toward the left • distance from X to trolley at equilibrium is 20 cm • initial motion undamped, then motion becomes (lightly) damped at/from 12 s • maximum speed at 1 s, 3 s, etc. / stationary at 2 s, 4 s, etc. _Any two points, 1 mark each_ _Examiner's comments:_ Since this question refers to the given graph, quantities must be quoted where relevant (e.g. time when damping begins), except if the quantities had been determined in part (b)(i), as per instruction of the question. The key word "exponentially" is often missing when describing decrease in amplitude (e.g. amplitude decreases <u>exponentially</u>".	A	B2

1biii		D	

sketch:
minimum L shown as 15 cm and maximum L shown as 25 cm

B1

minimum v shown as −7.9 cm s⁻¹ and maximum v shown as +7.9 cm s⁻¹

B1

Examiner's comments:
Many did not draw the ellipse shape properly, which resulted in mark deduction.

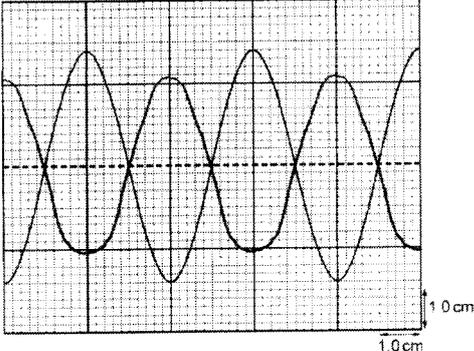| 2ai	change in momentum = (1.40 − 0.40 − 0.80 sin 30°) x 3.0 = 1.80 kg m s⁻¹ _Examiner's comments:_ Unable to determine the net force acting on the block for the specified time interval. Working for net force and the concept of Ft was not clearly demonstrated to meet the demand of a "Show" question. Many did not read graph to half smallest division. Need to indicate the smallest division even if the last digit is a "zero".	A	M2 A0
2aii	resultant force (on block) is zero (so) velocity is constant _Examiner's comments:_ Those who were unable to determine the net force in earlier part often encountered difficulty in this part. Some concluded the velocity wrongly with the correct net force.	D	B1 B1
2aiii	0 to 3.0 s: upward sloping straight line from the origin. 3.0 to 6.0s: horizontal line at non-zero value of momentum with no 'step change' in momentum at 3.0 s	A	B1 B1

Examiner's comments:
Many could obtain the correct answer for 0 to 3 s only. Common mistakes seen for 3 to 6 s included a step changed at 3 s and a non-linear line drawn.

2bi	total initial momentum is not zero (in the absence of an external force,) the total momentum can never be zero, hence stopping at different times. **or** force on each nucleus is equal in magnitude (by N3L) with different mass, they have different magnitudes of deceleration and hence stopping at different times. Examiner's comments: Many students merely define COLM or stated "by COLM" without applying COM into the context of the question. Students need to state explicitly that the **total** initial momentum value is **non-zero** and to recognize that **total** final **cannot be zero**. By stating "total final momentum must be non-zero" merely regurgitated COLM and did not contextualize to the event when the nuclei stop at the same instant. Many students were not sensitive/clear with their choice of words used in explanations which could bring about different understanding, eg. "initial momentum is zero" is not the same as "total initial momentum is zero".	D	M1 A1 A0 (M1) (A1) (A0)
2bii	curve with positive final speed same change in momentum **or** total momentum remains constant **or** same force (N3L) since mass of P > mass of Q, **change** in velocity of Q > **change** in velocity of P **or** curve with positive final speed (Speed of approach = speed of separation) Speed of approach or speed of separation is positive value Hence, speed of Q > speed of P	D	B1 M1 A1 (B1) (M1) (A1)

	Examiner's comments: Many students merely stated COLM or RSS = RSA without applying them into the context of the question.	E	

3ai	(tangent to) line gives direction of force on a (small test) mass	E	B1
3aii	(tangent to) line gives direction of force on a (small test) <u>positive charge</u> Examiner's comments: This recall-type question was generally not answered well.	E	B1
3b	similarity: lines are radial / greater separation of lines with increased distance from the sphere/ lines normal to the surface difference: gravitational lines directed towards sphere and electric lines directed away from sphere Examiner's comments: The answer must take into account relevance to the "positively charged sphere" context. Some answers showed that candidates lack of use of proper terms such as "radial", or incorrectly use the term "uniform".	A	B1 B1
3ci	$E = Q / 4\pi\varepsilon_0 r^2$ or $E = kQ / r^2$ with k defined / substituted in $4.1 \times 10^{-5} = [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.025^2)] - [Q / (4\pi \times 8.85 \times 10^{-12} \times 0.075^2)]$ $Q = 3.2 \times 10^{-18}$ C Examiner's comments: This question was mostly answered well.	A	C1 C1 A1

3cii		A	

smooth curve with gradient decreasing starting at (0, 4.1 × 10⁻⁵) to *d*-axis at (2.5, 0) **B1**

smooth curve with gradient increasing from (2.5, 0) ending at (5, − 4.1 × 10⁻⁵) **B1**

Examiner's comments:
The start and end of curve must be plotted to half the smallest square.

3ciii	acceleration decreases (to zero at mid-point)	D	B1
	then acceleration increases in the opposite direction / increasing negative acceleration		B1

Examiner's comments:
Many answers used as the verb "accelerated" which resulted in inaccurate descriptions. It is better to use the <u>noun "acceleration"</u> accompanied by its increase/decrease and its direction. (Note: deceleration is not always negative acceleration, as it depends on positive direction.)

4ai1 4ai2	total volume of molecules negligible compared to that of containing vessel	E	B1
	molecules in random (and rapid) motion time of collision small compared with the time between collisions large number of (identical) molecules (any two of above, 1 mark each)		B1

Examiner's Comments:
Many students did not read the question carefully and stated assumptions that are already implied in the question such as elastic collisions and no intermolecular forces between molecules.

			E	B1
	Students to take note that for assumption on comparing the volume of the molecules with the volume of the container, it must be the total volume of the molecules, not the volume of a molecule. Volume of the gas is also not accepted as the volume of gas is the same as the volume of the container.			
4aii	(random) kinetic energy increases with temperature no potential energy (so increase in temperature increases internal energy) _Examiner's Comments:_ For this part, students need to be explicit in mentioning that there is no potential energy for idea gas to gain credit. Many students went on to give irrelevant or incorrect details about the movement of the molecules, pressure, volume of the gas when temperature increases. Students are to take note that the relationship between kinetic energy and temperature must be clear to gain credit.		E	B1 B1 A0
4aiii	Horizontal straight line passing through (P, u) The gas remains in thermal equilibrium with the surroundings, the temperature of the gas remains constant during compression. Since the r.m.s. speed depends on temperature, and temperature is constant, the r.m.s. speed of the oxygen molecules will also remain constant as the pressure increases. r.m.s. speed u ───────────────── 0 ─── P ──────────── pressure _Examiner's Comments:_ Many students were not able to gain credit. Many thought that the r.m.s speed will increase which is incorrect as the temperature remains constant.		D	B1
4b	gas expands so work done by gas (against atmosphere) <u>no time</u> for thermal energy Q to enter or leave the gas (Since $\Delta U = Q + W_{on\,gas}$ and hence ΔU is negative) U decreases _Examiner's Comments:_ Many students were able to gain credit on recognizing work is done by the gas during expansion. Some were confused and wrongly described work done by gas increases instead of work done by gas is positive. The concept of positive or negative work done is not the same as work done increase or decreases. Many were not able to gain full credit as they were not able to deduce and explain that Q=0. A handful of students did not seem to know 1st law of thermodynamics.		D	M1 M1 A1
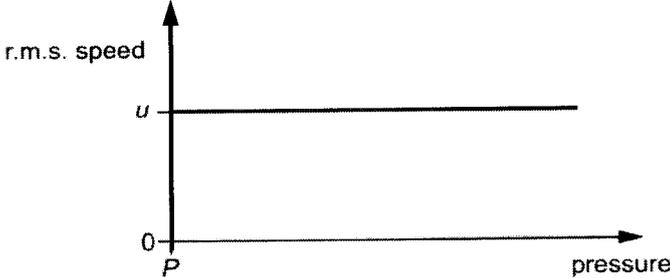
5a	1. Stationary <u>does not advance</u> while progressive wave <u>advances in the direction of energy transfer</u> of the wave. 2. For stationary wave, no energy is carried along the wave and the energy is <u>stored</u> as the kinetic and potential energy of the vibrating particles while energy is <u>carried along in the direction of wave propagation</u> for progressive wave.	E	B2

	3. For stationary wave, the amplitude of oscillations of the particles varies according to their positions, particles at the <u>antinodes</u> oscillate with <u>maximum amplitude</u> and particles at the <u>nodes</u> do not oscillate and have <u>zero amplitude</u> while for progressive wave, the amplitude of oscillations are the <u>same for all particles</u> in the wave regardless of position (assuming no energy loss), equal to the amplitude of the wave. 4. For stationary wave, all particles have the <u>same phase within 2 adjacent nodes</u> and particles in adjacent segments are π radians out of phase while for progressive wave, particles have <u>different phases (0 to 2π) within a wavelength</u>. Any 2 of the above. *Examiner's Comments:* • Some students went to describe the conditions to form stationary wave – NAQ. • Some students attributed the properties of transverse waves to stationary/progressive waves, and attributed the properties of longitudinal waves to the other. This is a misconception. Both stationary and progressive waves can be either transverse and longitudinal waves. • Poor phrasing from some students e.g. the particles have different phases for the entire wave in a progressive wave. This is only correct if the wave has exactly one wavelength.		
5bi	The incident sound wave travels towards the metal sheet and get <u>reflected off the sheet</u>. The <u>incident and reflected waves</u> travelling in <u>opposite</u> directions towards each another <u>superpose</u>, resulting in the formation of stationary wave *Examiner's comments:* The explanation of which waves formed the stationary wave was not always clear. E1: Used two waves instead of <u>incident and reflected waves</u> travelling in <u>opposite</u> directions or did not used 'superpose'; used wrong word (interfere, superimpose(everyday English)) or gave general answers about how standing waves are formed rather than relating to the situation described.	**A**	B1 B1
5bii	Microphone passes through 3 node-to-node separations Node-to-node separation is $\lambda/2$ $d = 1.5\,\lambda$ Any of the above line $\lambda = 1.05 / 1.5 = 0.70$ m *Examiner's comments:* Some students misunderstood the question, and some unaware that the distance between successive nodes = $\lambda/2$.	**A**	C1 A1
5ci	Intensity $\propto \dfrac{1}{\text{distance}^2} \propto$ amplitude^2 $A \propto \dfrac{1}{r}$ So $\dfrac{A_2}{A_1} = \dfrac{r_1}{r_2}$ $A_2 = \dfrac{1.05}{1.40} \times 2.8 = 2.1$ cm *Examiner's comments:* E1: many did not show their working, even though the question asked for it.	**A**	B1 A1

5cii		period same as original, with amplitude 2.1 cm Phase difference of 180° from original	D	B1 B1

Examiner's comments:
E1: wrong amplitude given
E2: wrong phase difference
E3: phase difference does not match wavelength given in b(ii)

6ai	energy <u>required</u> to separate nucleons of nucleus **to infinity**	E	A1
	Examiner's Comments: • One of the above definitions will suffice. • Note whether it is <u>released</u> or <u>required</u>, depending on the definition written. • Important to mention "constituent particles" or nucleons. • Note that the definition deals with nucleus, not atoms nor element.		
6aii	binding energy per nucleon is a maximum at around A = 56	D	B1
	products (of splitting a ^{56}Fe nucleus) must have a lower (total) binding energy		B1
	(reaction would require) a net input of energy		B1
	Marking points: 1st B1: Binding energy per nucleon is maximum for Fe 2nd B1: Compare BE or stability or mass between reactants and products 3rd B1: Indicate that energy input is needed Examiner's Comments: • Many added that "binding energy is equivalent mass defect" which is incorrect. Binding energy is the "<u>energy equivalent</u> of mass defect" or "mass defect × c^2". • This question was poorly done due to many incorrect understandings e.g. equal mass before and after reaction hence no net energy released.		
6bi	mass defect of uranium, Δm = 236.909 u – 235.044 u $\qquad\qquad$ = 1.865 u	A	C1
	given that energy equivalent to a mass of 1.00 u is 934 MeV, binding energy of uranium = 1.865 u $\times$ 934 = 1.742 MeV		C1
	binding energy per nucleon of uranium = 1.742 / 235 = 7.412 MeV		A1

	Examiner's comments: Some students did not use the given relationship "1u is equivalent to 934 MeV" to simplify their calculations. Students wrongly used mass of nucleus as nucleon number. Not all substitutions were clearly shown in the workings.		
6bii	energy = {(1.219 + 0.859) − 1.865)} × 934 **or** energy = (95 × 8.443) + (139 × 8.189) − (235 × 7.412) = 199 MeV *Examiner's comments:* E1: Some students obtained negative energy but did not explain why omit the negative sign in final their answer. E2: did not multiply nucleon number to find BE of each nucleus. E3: made assumption on the mass of neutron.	**A**	C1 A1
6biii	number of reactions = 1.2 × 10^{-7} × 6.02 × 10^{23} = 7.22 × 10^{16} energy release (for one reaction) = 199 × 1.60 × 10^{-13} (= 3.18 × 10^{-11} J) power = (7.22 × 10^{16} × 3.18 × 10^{-11}) / (25 × 10^{-3}) = 9.2 × 10^{7} W *Examiner's comments:* E1: did not find the number of molecules. E2: did not convert energy to joules.	**A**	C1 C1 A1

7ai	Electrical energy to sound energy OR Sound energy to electrical energy *Examiner's comments:* Kinetic energy refers to motion of crystal, not the emitted ultrasound energy in the medium. Be careful with terms: use 'electric potential energy' for a charge in a field and 'electrical energy' for energy supplied or stored by a device. For example: the battery supplies electrical energy; moving a charge through a potential difference changes its electric potential energy.	**E**	A1
7aii	Ultrasound is a wave in which the displacements of the particles in the wave are <u>along</u> the direction of transfer of energy of the wave and Light is a wave in which the directions of the oscillations of electric field and magnetic field are perpendicular to each other and at right angles to the direction of transfer of energy of the wave. Or ultrasound is longitudinal and light is transverse Or ultrasound needs medium for propagation but light can propagation in vacuum Or ultrasound cannot be polarised and light can be polarised.	**A**	B1

	Examiner's comments: E1: • comparison is incomplete. Examples of complete comparison are: 'ultrasound is mechanical wave and light is electromagnetic wave', 'ultrasound is longitudinal and light is transverse' • avoid negatives – state properties positively. E.g: ultrasound needs a **medium** for propagation but light can propagation in **vacuum.** • misconception: 'there are <u>no</u> particle displacements in Light' is wrong; should be ' the electric and magnetic fields oscillate perpendicular to the direction of propagation. • 'speed/frequency of light is larger than that of ultrasound' is vague; should be 'speed of light is many orders of magnitude greater than that of ultrasound'.		
7aiii	$v = f\lambda$ distance $d = vt$ $= (5.0 \times 10^6)(3.1 \times 10^{-4}) \times \dfrac{(52.0 \times 10^{-6})}{2}$ $= 0.040\ (0.0403)\ \text{m}$ *Examiner's comments:* *This question was mostly answered well.*	E	C1 C1 A1
7b	Exposure time $= \dfrac{\text{absorbed dose}}{\text{dose-rate}} = \dfrac{240 \times 10^3}{200}$ $\qquad\qquad = 1200\ \text{s}$ *Examiner's comments:* Some students missed key information in the passage.	A	C1 A1
7ci	The range of *SF* values is too large to be accommodated on a graph paper for the various absorbed doses. *Examiner's comments:* Many students could not explain why the survival fraction is plotted on a logarithmic scale.	D	A1
7cii	more time for heat to conduct away Or more time for cell to repair damage *Examiner's comments:* Many students described what a lower dose rate is instead of explaining why it leads to higher cell survival.	A	B1
7ciii	(table below)	E	

absorbed dose / kJ kg^{-1}	$\log_{10}(SF)$
50	– 0.65
100	–0.90
160	–1.20
240	–1.58
340	–2.15
450	–2.85
560	–3.75 OR –3.78

Examiner's comments:
Some did not read to half the smallest division. Smallest division for $\log_{10}(SF)$-axis is 0.05.

(A1)

7d

absorbed dose / kJ kg⁻¹ graph with $\log_{10}(SF)$ on the vertical axis

			A	
Point plotted correctly (accuracy up to half of a small square)			E	B1
best fit curve/ straight line drawn (number of points on either side of curve differ by 1)				B1

Examiner's comments:
E1: in <u>each half of the line</u> the number of points above and below differ by more than 1 (instead of same number or differ by 1).
E2: number of points on either side of curve/straight line differ by more than 1(instead of same number or differ by 1).
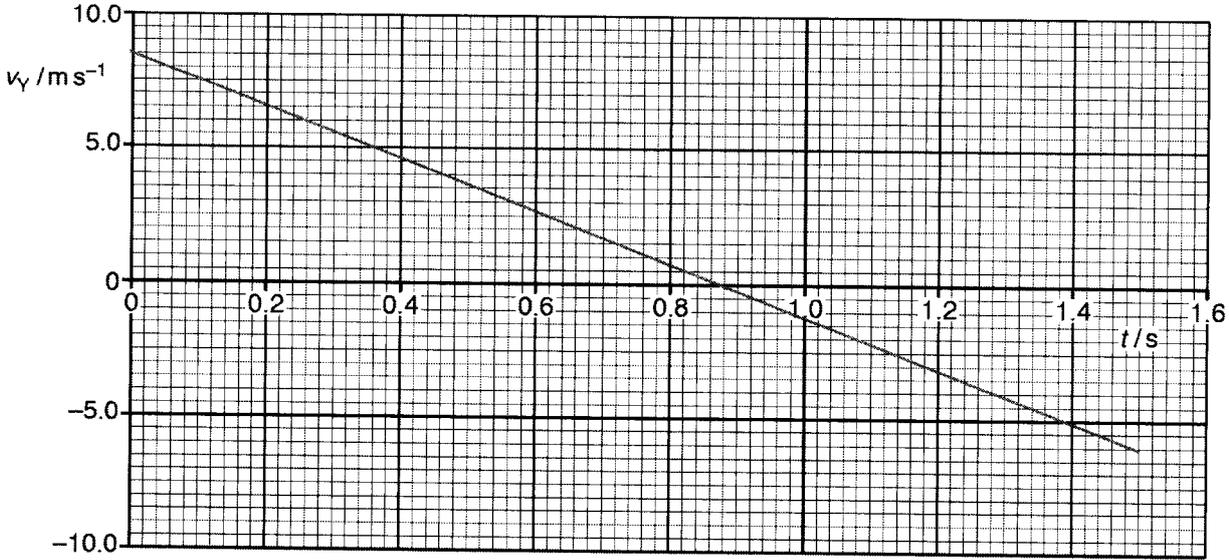
7ei	There <u>are dips in the curves at (about) 200 W kg⁻¹</u> for the <u>higher</u> absorbed doses.	A	A1

Examiner's comments:
Incorrect term — this is a dip (decrease), not a spike (increase).

[Turn Over

7eii	The curve is almost linear at low doses, and the gradient of the curve decreases at higher doses (the magnitude of the gradient of the curve increases at higher doses) _Examiner's comments:_ Some students did not provide sufficient evidence to support their answers.	D	B1 B1
7f	diagnostic imaging: dose-rate: <1 W kg^{-1} Explanation: In order not to damage tissues, survival fraction needs to be high / close to 1. (for info, realistic values range from 10^{-4} to 10^{-2} W kg^{-1}) therapeutic ablation: dose-rate of 200 W kg^{-1} explanation: lower survival fraction _Examiner's comments:_ Many students gave dose-rate of 35 W kg^{-1} for diagnostic imaging without realising that SF is still very high. When dose-rate of 35 W kg^{-1}, log SF is -0.48. $10^{(-0.48)} = 0.33$, it means only 33% of cells surviving after exposure. In order not to damage tissues, survival fraction needs to be high / close to 1.	A	B1 (B1) B1 B1

Anderson Serangoon Junior College 2025 H2 Physics Prelim P3 Mark Scheme

Paper 3 (80 marks)   **E – Easy, A – Average, D – Difficult**

ECF	Error carried forward	SF	Significant figures error	M0	No A marks awarded
AE	Arithmetic error	BOD	Benefit of doubt	^	More is needed in answer
POT	Power of ten error	CON	Contradictory response	XP	Wrong physics
TE	Transcription error	IR	Irrelevant (part) response		

|			
1a	$s_x = v_x t$ $v_x = 24 / 1.5 = 16$ m s^{-1} $\tan 28° = v_Y / v_X$ or $v_X = v \cos 28°$ **and** $v_Y = v \sin 28°$ $v_Y = 16 \tan 28°$ or $v_Y = 16 \times (\sin 28° / \cos 28°)$ so $v_Y = 8.507 = 8.5$ m s^{-1} <u>Examiner's comments:</u> Most students were able to solve. Some workings did not show complete substitution of values to meet the demand of a "Show" question. There were still some students who did not show more s.f. before final answer which was required in a "Show" question.	**A**	C1 C1 A0
1b	Taking upwards as positive $v_Y = u_Y + at$ $t = (0 - 8.5) / (- 9.81)$ $= 0.87$ s <u>Examiner's comments:</u> Students did not substitute the sign of the direction correctly in their Kinematics questions which resulted in wrong answer. Some students wrongly assumed initial velocity as zero.		C1 A1
1c	straight line from positive v_Y at t = 0 to negative v_Y at t =1.5 s line starts at (0, 8.5) and crosses t-axis at (0.87, 0) and does not go beyond t = 1.5 s.		M1 A1

	Examiner's comments: Those who drew a straight line graph often did not ensure the x-intercept was within half smallest square and extended line beyond t = 1.5 s.		
1d	acceleration (of freefall) is unchanged / not dependent on mass, and so no effect (on maximum height and time taken) Examiner's comments: Many did not pinpoint acceleration as the quantity that was unchanged / independent of mass. Even though net force (= weight) was larger, the acceleration of free fall remained as *g*, so this showed it was independent of mass.	E	B1
1e	Since air resistance acts downwards, net downward force is larger hence, shorter time taken Examiner's comments: Students need to be explicit about the direction of the net force / net deceleration as **downwards**. Stating AR is directed opposite to the motion of the object was too generic and not contextualizing. Students need to illustrate their awareness about the net deceleration or net force is **greater** than before. Many students used inappropriate term such as "increases" to illustrate greater / larger. Some did not conclude for the time taken.	D	M1 A1

2ai	Use $R = \dfrac{\rho l}{A}$ $= \dfrac{(5.5 \times 10^{-8})(2.0)}{\left(\dfrac{\pi(0.020 \times 10^{-3})^2}{4}\right)}$ $= 350 \; \Omega$ power dissipated $= I^2R = (0.42)^2(350) = 62$ W *Examiner's comments:* Most students performed the correct calculation and obtained the correct answer.	A	C1 A1
2aii1	**Mthd 1** Common current in both wires, so *nAv* for tungsten= *nAv* for copper. $v_{tungsten} = \dfrac{n_{copper} A_{copper} v_{copper}}{n_{tungsten} A_{tungsten}}$ $= \dfrac{(8.0)(1.4^2)(0.021 \times 10^{-3})}{(3.4)(0.02^2)}$ $= 0.24$ m s^{-1} **Mthd 2** Use $I = nAve$ $v_{tungsten} = \dfrac{I}{n_{tungsten} A_{tungsten} e}$ $= \dfrac{0.42}{(3.4 \times 10^{28})(\pi \dfrac{(0.02 \times 10^{-3})^2}{4})(1.60 \times 10^{-19})}$ $= 0.25$ m s^{-1} *Note that v is the drift speed and not the actual speed of the electrons.* *Examiner's comments:* This was commonly correct.	A	C1 A1

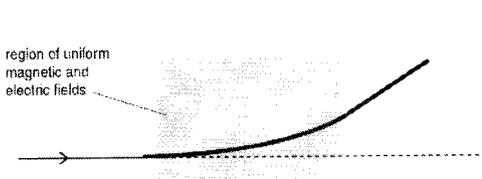| 2aii2	The higher speed of the electrons in tungsten means that they have <u>a much greater kinetic energy</u> than those in copper. As the electrons <u>collide</u> with the fixed atoms, energy is <u>lost</u> to these atoms, resulting in a rise in temperature. <u>Examiner's comments:</u> This question proved challenging. Many students did not use the values of drift speed calculated from the previous part. E1: did not explain in microscopic terms; diameter/current/power is macroscopic E2: did not associate kinetic energy of an electron with its drift speed. E3: did not mention electrons transfer energy to lattice during collisions. E4: misconception, e.g: higher drift speed does not, by itself, mean electrons collide more often. The collision rate is set mainly by the material, impurities, and temperature, not by the small drift speed.	D	M1 A1
2bi	resistance of thermistor at 0 °C = 3900 Ω using potential divider, $\left(\dfrac{R}{R+3900}\right)$x1.50 = 1.00 R = 7800 Ω resistance of thermistor at 30 °C = 1250 Ω using potential divider, voltmeter reading = $\left(\dfrac{7800}{7800+1250}\right)$x1.50 = 1.29 V <u>OR</u> p.d. across thermistor = 1.50 − 1.00 = 0.50 V resistance of thermistor at 0 °C = 3900 Ω common current in circuit = $\dfrac{1.00}{R}=\dfrac{0.50}{3900}$ R = 7800 Ω resistance of thermistor at 30 °C = 1250 Ω common current, I in circuit = $\dfrac{1.50}{R+1250}=\dfrac{1.50}{7800+1250}=\dfrac{1.50}{9050}$ voltmeter reading = IR = 1.29 V <u>Examiner's comments:</u> It is advisable to use potential divider method instead of using current method which is longer. The current in the circuit is not the same when temperature changes.	A	C1 A1
2bii	resistance of thermistor at 0 °C = 3900 Ω effective resistance of R and voltmeter, X = 7800/2 = 3900 Ω (same as thermistor's) voltmeter reading = p.d. across X = 1.50/2 = 0.750 V <u>Examiner's comments:</u> The answer should be written to 3 s.f. because all data are given as 3 or more s.f.	A	C1 A1

3ai	gravitational force provides the centripetal force	A	B1
	$GMm / R^2 = mv^2 / R$		M1
	$E_K = \frac{1}{2}mv^2$ and clear algebra leading to $E_K = GMm / 2R$		A1
	Examiner's comments: *Answers need to be clear in presentation flow, since this is a "show" question. Any symbols that are not found in the question must be defined.*		
3aii	$E_T = E_K + E_P$ $= GMm / 2R - GMm / R$ $= - GMm / 2R$	A	M1 M1 A0
	Examiner's comments: *The concept of total energy must be shown, as this is a "show" question.*		
3b	As the satellite gradually loses energy, i.e. its <u>total energy E_T decreases</u> (i.e. more negative), its <u>radius of orbit R decreases.</u>	D	B1
	As the satellite radius of orbit R decreases, its <u>kinetic energy E_k increases</u>, i.e. its <u>speed v increases</u>, and it would also move nearer or into the Earth's atmosphere.		B1
	The satellite's increasing speed gives rise to <u>increase of resistive forces</u> which results in <u>increasing</u> rate of conversion of its energy to <u>thermal energy</u>, and so the satellite could eventually 'burn up'.		B1
	Examiner's comments: *The question started with "small resistive forces". Good answers need to show how this transitioned into increasing severity of the satellite eventually "burning up".*		
3c	advantage: • Continuous coverage: They orbit at the same speed as the Earth's rotation, appearing stationary over one location, providing constant monitoring of a specific area. • Ideal for communications: They are well-suited for broadcasting and communication services due to their fixed position. • Weather monitoring: They can provide continuous weather observations and imagery of a particular region. • **Surveillance:** Their constant visibility makes them useful for surveillance applications. Any 1 of the points above or other suitable advantages.	D	B1
	disadvantage: • Their high altitude (about 35,786 km above Earth's surface) leads to longer signal transmission times. • Limited polar coverage: Due to the curvature of the Earth, they have limited coverage of the polar regions. • Lower detail: Their high altitude results in lower-resolution images compared to polar-orbiting satellites. Any 1 of the points above or other suitable disadvantages.		B1
	Examiner's comments: *Good answers require not only the characteristics of a geostationary satellite, but how that characteristic leads to an advantage/disadvantage.*		

4a	directed vertically upwards, line of action passing through centre of sphere from centre of submerged part of sphere.	A	B1 B1
	sphere sea water, density 1050 kg m^{-3} centre of sphere *Examiner's comments:* *Candidates need to use a ruler to properly draw a straight line.*		
4b	Due to pressure difference at varying depths of seawater. *Examiner's comments:* *This question was generally answered well.*	A	B1
4c	Equal in magnitude but opposite in direction to the weight of sphere. It acts through the c.g of the sphere. *Examiner's comments:* *Most answers missed out on the rotational equilibrium part (acting through the c.g.). A few erroneously thought upthrust as action-reaction pair of weight.*	A	B1 B1
4d	weight of fluid displaced = weight of sphere $\rho_w g V_w = \rho_s g V_s$ 1050 x 9.81 x 0.21V = ρ_s x 9.81 x V ρ_s = 220.5 kg m^{-3} = 220 kg m^{-3} *Examiner's comments:* *Many correctly answered this part.*	A	C1 A1
4e	F = Upthrust - weight of sphere $2000 = (1050 - 220.5) \times 9.81 \times \frac{4}{3}\pi(\frac{d}{2})^3$ d = 0.777m = 0.78 m *Examiner's comments:* *While many started with the correct concept, fewer successfully calculated the final answer. Others incorrectly omitted the value of g in the calculation.*	A	C1 A1

5a	E = ½kx^2 or E= ½Fx and F = kx E = ½ x 29 x (8.0 x10^{-2})^2 or E = ½ x 2.32 x 8.0 x 10^{-2} E = 9.3 x 10^{-2} J	E	C1 A1

	Examiner's comments: Many answer were correct except a significant number of students omitted the factor half or power square.		
5b	$(\Delta)E_p = mg(\Delta)h$ $= 4.5 \times 10^{-2} \times 9.81 \times 8.0 \times 10^{-2} \sin 15°$ $= 9.1 \times 10^{-3}$ J Loss in EPE = gain in KE + gain in GPE and $E_k = \frac{1}{2}mv^2$ $(9.3 \times 10^{-2} - 9.1 \times 10^{-3}) = \frac{1}{2} \times 4.5 \times 10^{-2} \times v^2$ $v = (2 \times 8.4 \times 10^{-2} / 4.5 \times 10^{-2})^{0.5}$ $\quad = 1.9$ m s^{-1} *Examiner's comments:* Many did not consider the ball had gained GPE.	**D**	C1 C1 A1
5c	The speed will be <u>lower</u>, as the <u>spring will possess some KE</u> (or GPE). *Examiner's comments:* There was a need be clear about the **spring** possessed some KE or GPE. Often, students missed out stating the spring possessing some of the energy.	**D**	B1

6ai	$V_s/V_p = N_s/N_p$, $V_s/9.0 = 20/1$ $V_s = 20 \times 9.0 = 180$ V (r.m.s.) *Examiner's comments:* *This question was generally answered well.*	**E**	A1
6aii	$I_p V_p = P_{mean}$ $I_p \times 9.0 = 30$, $I_p = 30/9.0 = 3.33$ A (r.m.s) *Examiner's comments:* *Some students did not read the question carefully and calculated the output current.*	**A**	A1
6aiii	From graph, T = 20 ms, $w = 2\pi/T = 314 = 310$ Hz $V_{rms} = \dfrac{V_0}{\sqrt{2}}$, $V_0 = 180\sqrt{2} = 254.6$ V = 250 V $V = V_o \sin (2\pi/T)t$ $\quad = 250 \sin 310t$ Examiner's comments: Many students were not able to determine the period correctly from the graph given. Some who determined the period correctly made POT error. Some confused peak output voltage with input voltage or confused between peak and rms value.	**A**	 C1 A1
6bi	Peak power = 2 x mean power = 60 W *Examiner's comments:* A significant number of students were not able to gain credit. Many did not realise the peak power is the same for the input and output.	**E**	A1

6bii	Input mean P = output mean P = 30 W (ideal transformer) Diode reduces the power by half Mean power in R = 30/2 = 15 W _Examiner's comments:_ _Many students were not able to do this part. Some managed to get the answer but presented wrong concept._	A	A1
6ci	Magnetic flux in the core is changing, causing <u>induced</u> e.m.f. or current in the core. <u>Current in core</u> causes heating effect. _Examiner's comments:_ _E1: Did not clearly state the cause (changing magnetic flux) or effect (induced e.m.f or current in the core)_ _E2: Referred to the coils rather than the core, ie explaining changing magnetic flux linkage and induced e.m.f. in the coils. The term 'linkage' (Nϕ) is for coils, for the core we should just use the term 'magnetic flux' (ϕ)._ _E3: Wrong understanding of operation of transformer, eg current flow from primary coil to secondary coil through the core. The core doesn't conduct current between the coils._	A	B1 B1
6cii	The iron core is made of laminated sheets to reduce power loss due to induced current. _Examiner's comments:_ _E1: Many students did not include "sheets"._	E	B1

7a	Diffraction is the <u>spreading</u> of waves when they pass through an <u>opening</u> or round an obstacle. Diffraction effects are the greatest when the <u>width</u> of the opening is **comparable** with <u>the wavelength</u> of the waves. _Examiner's comments:_ _Students who memorized the definition well would score full marks. Some unacceptable terms used to illustrate "comparable" included "equal", "similar", "identical"._	A	B1 B1
7bi	The <u>two stars</u> are considered <u>just distinguishable</u> when the <u>central maximum of the diffraction pattern</u> (of one star) <u>coincides</u> with the <u>first minimum of the diffraction pattern of the other (star)</u>. _Examiner's comments:_ _Need to contextualize Rayleigh Criterion to the context of the question by relating the objects to stars. Note that those underlined words in the answer were important._ _Students are strongly discouraged to use the word "resolved" in their explanation as this had been given in the context of the question as "resolution". Instead use "distinguishable" to replace the word "resolved"._	D	B1 B1 B1 B1
7bii	With smaller aperture, θ (the angular separation of objects when their images are just resolved) increases (since $\theta = \lambda/b$), resulting in decrease in resolving power. _Examiner's comments:_ _Many were unable to appreciate that having a greater angular separation meant the need to have a bigger angle to tell the objects apart from one another. This would mean that the resolving power is poor._	D	B1

7biii	$\theta \approx \dfrac{\lambda}{b} = \dfrac{550 \times 10^{-9}}{0.120}$ = 4.58 × 10⁻⁶ rad Examiner's comments: Many were able to solve this part. Some made POT error. Note: Those students who used sin θ in your equation, you need to use radian mode in your calculator.	E	C1 A1
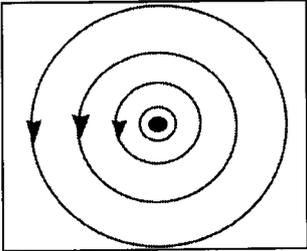
8ai	 • concentric circles (min 3 lines) centred on the wire • separation of lines increasing with distance from wire • arrows show anti-clockwise direction Examiner's comments: Good answers need to indicate proper concentric circles, else mark was deducted for shape/spacing.	A	B2
8aii1	Current in each wire creates a magnetic field at the other wire Current (in wire) at 90° to magnetic field causes a force Examiner's comments: Some answers did not answer why there is a force.	A	B1 B1
8aii2	By Newton's third law, the pair of forces are equal in magnitude. or The force is proportional to product of both currents so they are equal in magnitude Examiner's comments: Correct answers indicate an understanding that the force is a product of both currents.	A	B1
8bi	The force acting per unit current per unit length on a conductor placed perpendicular to the magnetic field. Examiner's comments: Prepared students were able to score full credit.	E	B2
8bii	Into the page Examiner's comments: Most answered correctly.	E	B1
8biii	Magnetic force is always normal to direction of motion of electrons (and force / KE / speed of particle is constant) Magnetic force provides centripetal force Examiner's comments: If this is a 3-mark question, the second line in brackets will be credited.	A	B1 B1

	"Magnetic force is normal to current" is not accepted as the focus is on the charged particle (electron) and its motion in a magnetic field. E1: Dropping the term 'always' in the first point (not penalised). This is essential in explaining how magnetic force is able to provide centripetal force.		
8biv	$Bqv = mv^2/r$, (so $Bq = mv/r$) $4.80 \times 10^{-3} \times 1.60 \times 10^{-19} = 9.11 \times 10^{-31} \times 1.70 \times 10^7 / r$ $r = 0.02017$ m $d = 2r = 0.04033$ m ≈ 0.0403 m $= 4.03$ cm *Examiner's comments:* Many answers were correct.	**A**	C1 C1 A1
8bv	$t =$ distance / speed $= \pi d/2v = \pi \times 0.0403 / (2 \times 1.70 \times 10^7) = 3.723 \times 10^{-9}$ s *Examiner's comments:* Some responses did not include the pre-rounded values, which is required for all 'show' questions. Many used a longer method.	**A**	B1
8bvi	(Due to electric field directed into the page, electron experiences electric force out of the page.) In the direction out of the page: $F_{out} = ma_{out} = qE$, so $a_{out} = qE/m$ $v_{out} = a_{out}t = qEt/m$ $\quad\quad = 1.60 \times 10^{-19} \times 18000 \times 3.723 \times 10^{-9} / 9.11 \times 10^{-31} = 1.177 \times 10^7$ m s^{-1} $v^2 = v_x^2 + v_{out}^2$ (since resultant v now has 2 components, directed leftwards and out of the page) $\quad = (1.70 \times 10^7)^2 + (1.177 \times 10^7)^2$ $v = 2.068$ m s$^{-1} \approx 2.07$ m s^{-1} *Examiner's comments:* Only a minority were able to answer correctly. Due to the uniform electric field, the electron experiences a constant electric force directed out of the page, resulting in uniform acceleration out of the page. Hence, the circular motion due to magnetic field, coupled with increasing velocity out of the page, will result in a helical motion of the electron. The electron will spend the same amount of time inside the fields, completing half a circle. Upon exiting, its velocity will have a leftward component (same magnitude as before) and component out of the page.	**D**	 C1 C1 C1 A1

Wrong approach	Why it is wrong
F_E provides F_C or $(F_E + F_B)$ provides F_C	A force (or sum of forces) can only provide the centripetal force if it is directed towards the centre of the circular motion. F_E is directed out of the page, not towards the centre of the circular motion.
$F_E = F_B$	Electric force $= qE$, magnitude force $= Bqv$. They are due to different fields. In the scenario of crossed fields velocity selector, electric force acts opposite in direction to magnetic force, so when the charged particle moves undeflected, the electric force and magnitude force are equal in magnitude. However, this question is unlike the scenario for crossed fields velocity selector.
$v = u + at$, substituting $u = 1.70 \times 10^7$ m s^{-1}	This equation applies for uniform accelerated motion, which is the case for the direction out of the page. However, the initial velocity (upon entry) for this direction is 0. The velocity 1.70×10^7 m s^{-1} is directed rightwards upon the electron's entry into the fields.

[Turn Over

| 8c | region of uniform magnetic and electric fields | smooth curve, deviated upwards
straight path after leaving the field | A | B1
B1 |

Magnetic force on electron is downwards based on Fig 8.4, so magnetic force on proton (Bqv) is upwards. Electric force on proton (qE) is downwards. With higher entry speed, Bqv > qE, so net force upwards.

Examiner's comments:
E1: Not drawing the path of the electron after it exits the fields, or drawing a path that is not straight, or the path is too short to for marker to assess if it is straight. It is advisable to label the path 'straight'.
E2: The curve is not smooth.
E3: The deflection is too large, eg more than 90 degrees. Some drew a semi circle showing the proton exiting from the same side where it entered. As the proton has a significantly larger mass compared to the electron, it will have a much larger radius (see equation in part iv), so any deflection here should not be too large.

| 9ai | e.g. no time delay between illumination and emission
      max. (kinetic) energy of electron dependent on frequency
      max. (kinetic) energy of electron independent of intensity

(any two separate statements, one mark each, maximum 2)

Examiner's comments:
All observations needed to be stated precisely. For example, it is not enough to say that "kinetic energy depends on frequency" when the precise statement is that "the maximum kinetic energy of the emitted electrons depends on the frequency". Similarly, it is not enough to say that "no time delay" when the precise statement is that "no time delay between the illumination of the metal and the emission of electrons". | E | B2 |

| 9aii1 |

$E_{max} = hf - hf_o$

$$= h\frac{c}{\lambda} - h\frac{c}{\lambda_o}$$
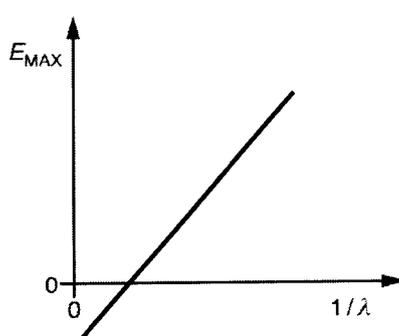
positive intercept on $(1/\lambda)$-axis (when extrapolated)
straight line with positive gradient | A |

B1
B1 |

	Examiner's comments: The most common graph was drawn as a straight line through the origin.		
9aii2	gradient = hc where c is the speed of light Examiner's comments: Students did not relate the gradient to the Planck constant. The most common response was to simply state the equation for the energy of a photon.	A	B1
9aii3	each photon has more energy fewer photons per unit time fewer electrons per unit time / less current Examiner's comments: Some students tried to apply the fact that the intensity affect the number of photons and hence number of electrons emitted.	D	M1 M1 A1
9bi	• change in electron energy level emits a single photon / photon energy = difference in energy levels • energy of photon has a corresponding frequency • discrete frequencies (not continuous) must have come from discrete energy levels Examiner's comments: This was a question where many students answered a different question from that which was asked. There were many responses that gave answers to questions asking either for a description of the appearance of an emission spectrum or for an explanation of how an emission spectrum is formed, but where students did not make a connection between the emission spectrum and the idea of discrete energy levels. There was much confusion between the concepts of photon energy, energy transitions and energy levels, with many responses lacking accuracy in the way these technical terms were used.	A	B3
9bii	transition (to – 3.400 eV) from X corresponds to 658 nm line $E_2 - E_1 = hc/\lambda$ $E_2 - (-3.400) = \dfrac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{658 \times 10^{-9} \times 1.60 \times 10^{-19}}$ $= 1.889$ $E_2 = 1.889 - 3.400$ $= -1.511$ $= -1.51$ eV Examiner's comments: Most students were able to identify the correct starting equation and the correct wavelength of the line that corresponds to the transition from level X to the –3.400 eV energy level but a few students were a little confused, and with many random attempts to add and subtract the other energy levels to somehow arrive at a value for X.	D	C1 C1 C1 A0
9ci	Electron energy = photon energy $eV = \dfrac{hc}{\lambda}$ $\lambda = \dfrac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{1.60 \times 10^{-19} \times 15000}$ $= 8.3 \times 10^{-11}$ m	A	C1 A1

	Examiner's comments: This calculation was generally done well by those who identified the correct starting equation. Common errors included using the accelerating p.d. in place of the electron energy or finding the de Broglie wavelength of the electron rather than the wavelength of the emitted photon.		
9cii	The intensity of entire x-ray will increase, because more energetic electrons produce more x-ray photons The wavelength of highest energy x-ray photon decreases, because the energy of each electron increases when the accelerating potential increases The positions of the k lines remain unchanged (but their intensity increase) because the target metal is not changed Examiner's comments: Candidates were unclear of the difference between the deceleration of the electrons on hitting the target and their acceleration through the applied potential difference. Also all changes needed to be stated precisely. For example, it is not enough to say that "wavelength decreases" when the precise statement is that "the wavelength of highest energy x-ray photon decreases". Similarly, it is not enough to say that "k lines remain changed" when the precise statement is that "the positions of the k lines remain unchanged".	**D**	B1 B1 B1 B1 (B1 B1)