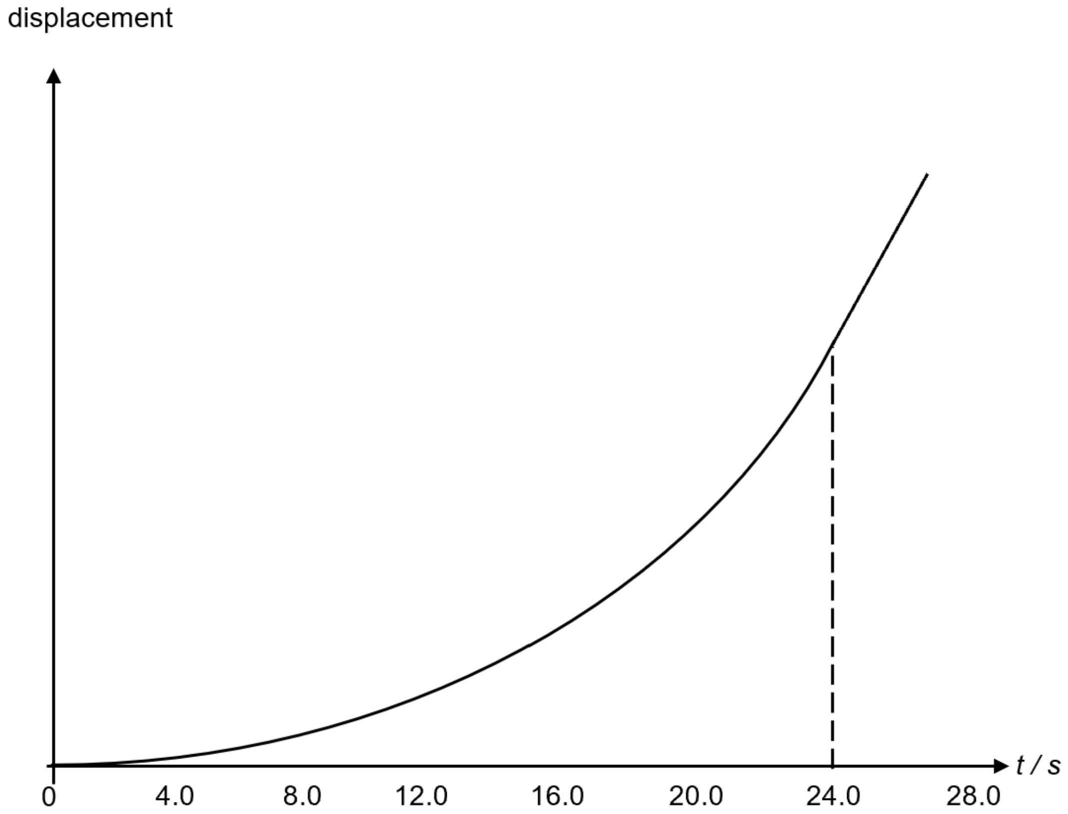
Anderson Serangoon Junior College 2024 H2 Physics Preliminary Examination Mark Scheme

Paper 3 (80 marks)

1ai	Any two of time, temperature, current, (luminous intensity)	B2
1aii	Any derived quantity, e.g. energy, force, power, velocity, acceleration, pressure, density, etc	B1
1bi	Percentage uncertainty = 2 + (3x2) = 8%	 A1
1bii	$g = \dfrac{(4\pi^2 \times 1.50)}{2.48^2}$ $= 9.63 \text{ m s}^{-2}$ Absolute uncertainty = 0.08 x 9.63 = 0.8 m s^{-2} g = 9.6 ± 0.8 m s^{-2} (*Note: g must have same place value as Δg)*	 C1 C1 A1

2a	As the sky-diver picks up speed, air resistance increases, the resultant force decreases and hence the acceleration decreases.	B1 B1
2b	(Since the sky-diver starts from rest), there is no air resistance initially / the only force he experiences is his weight, hence his initial acceleration is equal to 9.81 m s^{-2}.	M1 A1
2c	Terminal velocity is the area under the *a-t* graph (by using trapezium rule/counting squares)	A1
2d	Correct shape start with zero gradient and ends with constant gradient from about t = 24.0 s	M1 A1

3a	Resultant/net force (in any direction) on the object must be zero and Resultant/net moment / torque on the object about any point / axis must be zero.	B1 B1
3b	Taking moments about end A, (W × 0.25) + (12 × 0.35) = (17 sin 50° × 0.50) W = 9.246 = 9.2 N	 C1 A1
3c	Consider vertical equilibrium, taking upwards as positive Sum of forces in vertical direction = 0 F_y + 17 sin 50° − 9.2 − 12 = 0 F_y = 8.177 N Consider horizontal equilibrium, taking rightwards as positive Sum of forces in horizontal direction = 0 17 cos 50° − F_x = 0 F_x = 10.93 N $F = \sqrt{(8.177^2 + 10.93^2)}$ = 13.7N	 C1 C1 A1
3d	By taking moments about end A, The moment due to the force by the block on the beam decreases, , the tension in the string decreases. When the tension in the string deceases at the same angle, by considering horizontal equilibrium, the horizontal component of the force exerted on the beam by the hinge decreases.	M1 A1

4ai	reduction in energy / amplitude (of the oscillations) due to force opposing motion / resistive forces / dissipative forces	B1 B1
4aii	amplitude is decreasing (very) gradually / oscillations would continue for a long time / many complete oscillations hence light damping	M1 A1
4bi	frequency = 1 / 0.3 = 3.3 Hz	 A1
4bii	energy = ½ mv^2 and $v = \omega x_o$ $= \frac{1}{2} \times 0.065 \times (2\pi/0.3)^2 \times (1.5 \times 10^{-2})^2$ = 0.00321 J = 3.2 mJ	B1 B1 A0
4c	amplitude reduces exponentially / amplitude decreases by a smaller amount (for each oscillation) / does not decrease linearly / decrease at a decreasing rate so amplitude will not be 0.7 cm	M1 A1
4d	Relevant examples e.g. pointer in ammeter, car suspension system etc. where critical damping is used	A1

5ai	Using potential divider rule, $V_{BD} = \left(\frac{R_{BD}}{R_{BD}+1.0}\right) \times 2.0$ $V_{BD} = \left(\frac{4.0}{4.0+1.0}\right) \times 2.0 = 1.6$ V	 C1 A1
5aii	Since current in Cell Y is zero, V_{BC} = e.m.f. of cell Y $l = \left(\frac{1.5}{1.6}\right) \times 100 = 94$ cm	C1 A1
5b	Replace cell X with another cell with lower internal resistance OR Use a resistance wire of higher resistivity, keeping cross-sectional area and length unchanged OR Use a resistance wire of smaller cross-sectional area, keeping resistivity and length unchanged. OR Use resistance wire with a higher resistance per unit length By potential divider rule, this increases the p.d. across BD and allows a smaller value of l (while keeping current in cell Z zero).	M1 A1

5c	(When current is zero,) V_{BC} = e.m.f. of cell Z p.d. across internal resistance is zero hence terminal p.d. = e.m.f. Distance l remains unchanged.	M1 A1

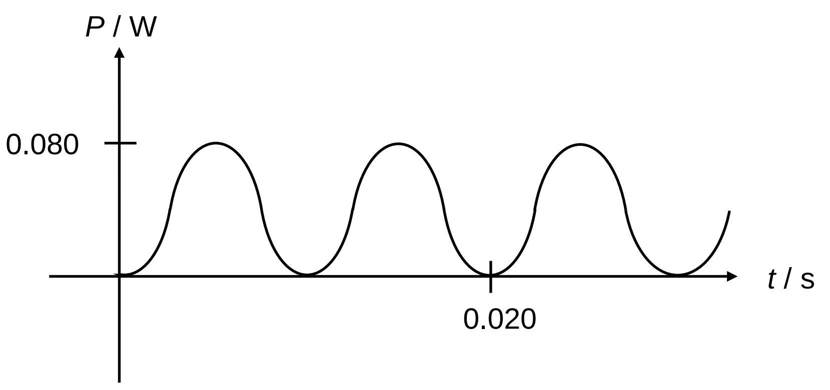
6a	electric and magnetic fields <u>normal</u> to each other <u>in the same region</u> *either* charged particles <u>enters region normal</u> to both fields *or* <u>correct *B* direction wrt *E*</u> for zero deflection (in drawing) For <u>no deflection</u>, <u>$v = E/B$</u> *or* <u>no net force</u>.	M1 A1 A1
6bi	magnetic force on ion in path B provides for centripetal force By N2L, $Bqv = m\frac{v^2}{r}$ $m = \frac{rBq}{v} = \frac{\frac{12.3}{2}\times10^{-2}\times640\times10^{-3}\times1.6\times10^{-19}}{9.6\times10^{4}}$ $= 6.56\times10^{-26}$ kg $= \frac{6.56\times10^{-26}}{1.66\times10^{-27}}$ = 40 u (or 39.5 u)	B1 C1 A1
6bii	Since the ions are of the <u>same isotope</u>, they all have the <u>same mass</u> regardless of the paths undertaken. Using the equation in answer to **(b)(i)**, the <u>radius of the path is inversely proportional to *q*</u> (or state equation for r) Hence, the ions in path A have <u>thrice</u> the charge compared to ions in path B.	B1 B1 B1

7a	energy from 1 nucleus = $(1.77\times10^{13}) / (6.02\times10^{23})$ $(= 2.94\times10^{-11}$ J) Energy released = Binding energy of products – Binding energy of reactants binding energy of Z = $[(1.25 + 1.81)\times10^{-10}] - 2.94\times10^{-11}$ □ $(= 2.77\times10^{-10}$ J) nucleon number of Z = 93 + 139 + 2 – 1 (= 233) Binding energy per nucleon of Z = $(2.77\times10^{-10}) / (233\times1.60\times10^{-13})$ = 7.43 MeV (3 s.f.)	C1 C1 C1 A1
7bi	$N_0 = 0.874 / (238\times1.66\times10^{-27}) = 2.212\times10^{24}$ $= 2.21\times10^{24}$	A1
7bii	$A = \lambda N = \frac{\ln 2}{t_{\frac{1}{2}}}N$ $= \frac{\ln 2}{87.7\times365\times24\times3600}\times2.21\times10^{24}$ $= 5.54\times10^{14}$ Bq	 C1

		A1
7biii	$A = A_0 e^{-\lambda t}$ $\ln 0.653 = -(\frac{\ln 2}{87.7})t$ $t = 53.9$ years	 C1 A1
7biv	half-life shorter, will not provide power for long enough / require frequent replacement of probe	B1

8ai	Horizontal component of tension / spring force provides centripetal force Weight of sphere is (now) equal to the vertical component of tension / spring force OR horizontal and vertical components of tension / spring force combine to give a greater tension in spring Greater tension/spring force so greater extension / since extension is proportional to spring force	B1 M1 A1
8aii1	Radius, r = 10.8 sin 27° = = 4.903 cm ≈ 4.9 cm	A1
8aii2	F_{spring} cos θ = mg OR sum of vertical forces = 0 $F_{spring} = \frac{mg}{\cos\theta} = \frac{0.29 \times 9.81}{\cos 27°} = 3.19$ N F_{spring} ≈ 3.2 N (shown)	B1 A1 A0
8aii3	$k = \frac{\Delta F_{spring}}{\Delta x} = \frac{3.2 - (0.29 \times 9.81)}{(10.8 - 8.5)}$ $k = 0.15$ N cm^{-1}	C1 A1
8aiii 1	$a_c = \frac{F_{spring} \sin\theta}{m} = \frac{3.2 \times \sin 27°}{0.29}$ a_c = 5.0 m s^{-2}	C1 A1
8aiii 2	$a_c = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2$ $T = 2\pi \times \sqrt{(0.049 / 5.0)} = 0.62$ s	C1 A1
8bi	From $g = -\frac{d\phi}{dr}$, when the gravitational field strength is zero, the potential gradient at that point would be zero. (Thus the point will be a turning point, which is a maximum point.) Thus, x is 0.52 x 10^{12} m Accepted range of x : 0.50 x 10^{12} m − 0.54 x 10^{12} m	M1 A1

8bii1	$\Delta U = m\Delta\phi = 180\times\left[-14-\left(-10\right)\right]\times10^{8}$ $= -7.2 \times 10^{10}$ J Change = 7.2×10^{10} J The change in kinetic energy is an <u>increase.</u>	C1 A1 A1
8bii2	energy required (to reach maximum point) = 180 × (10 – 4.4) × 10^8 or energy per unit mass (to reach maximum point) = (10 – 4.4) × 10^8 ½ × 180 × v^2 = 180 × (10 – 4.4) × 10^8 or ½ × v^2 = (10 – 4.4) × 10^8 v = 3.3 × 10^4 m s^{-1}	C1 C1 A1

9a	$V_{r.m.s.} = \sqrt{\dfrac{2^2(0.002)+1^2(0.002)}{0.01}}$ $= 1.0$ V	M1 A1
9b	Transmission of electrical energy at high voltage means that the <u>current is low</u> (according to $P = IV$) for the same power. Power <u>loss</u> through joule heating (I^2R) is hence lowered as less electrical energy is dissipated as <u>heat/thermal energy</u> in the cables of resistance R.	M1 A1
9ci	$\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$ $V_s = 71 \times 6.5 \times 10^{-3} = 0.46$ V	 A1
9cii	 Correct shape: sine squared or cosine squared. Correct labelling of values: period of 0.02 s and peak power of 0.080 W. <u>Explanation:</u> Power dissipated in the resistor, $P = I^2R$ (square of a sine function)	 B1 B1

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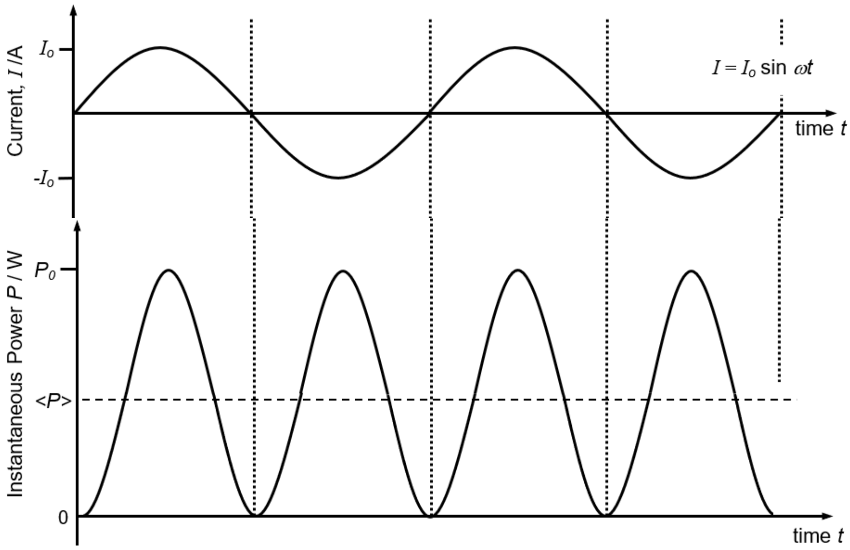

The average power of 0.040 W is half that of peak power. Hence, peak power is 0.080 W. Also, the period T = 1/f = 1/50 = 0.020 s.</td><td></td></tr>
<tr><td>9ciii</td><td>The current flow direction alternates between downwards through R and no current flow

with equal time intervals of 0.01 s / for half a period.</td><td>B1

B1</td></tr>
<tr><td>9civ</td><td>Since each sheet is insulated from the others, lamination <u>decreases</u> the size of <u>eddy/induced currents</u>.

With the same induced emf, the <u>heat/thermal energy</u> <u>losses</u> in the iron core will be <u>reduced</u>.</td><td>M1

A1</td></tr>
<tr><td>9di</td><td>An ideal gas is one which obeys the equation of state <u>pV = nRT at all pressures, volumes and temperatures</u>.</td><td>A1</td></tr>
<tr><td>9dii</td><td>
<table>
<tr><td></td><td>work done on gas / J</td><td>heat supplied to gas / J</td><td>increase in internal energy of gas / J</td></tr>
<tr><td>A to B</td><td>+360</td><td>0</td><td>+360 &</td></tr>
<tr><td>B to C</td><td>0 $</td><td>+670</td><td>+670 $</td></tr>
<tr><td>C to D</td><td>−810 &</td><td>0</td><td>−810</td></tr>
<tr><td>D to A</td><td>0 @</td><td>-220 @</td><td>−220 #</td></tr>
</table>

&: first and third line correct
increase in internal energy = work done on gas + heat supplied to gas

$: second line correct
work done on gas (B to C at constant volume) = 0 J
increase in internal energy = 0 + 670 = 670 J

#: −220 correct in right hand column
total change in internal energy = 0 J (cyclical process)
thus increase in internal energy (D to A) = 810 – 360 – 670 = – 220

@: other two figures correct in last line
work done on gas (D to A at constant volume) = 0 J
thus heat supplied to gas (D to A) = – 220 J</td><td>B1

B1

B1

B1</td></tr>
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9diii	Consider the process D to A, Since the gas is ideal, $\Delta U = \frac{3}{2} nR\Delta T$ From the ideal gas equation, since V is constant, $V\Delta p = nR\Delta T$ For the process D to A, $\Delta U = \frac{3}{2} V\Delta p$ ➔ − 220 = $\frac{3}{2}(750\times10^{-6})(1\times10^{5} - p_D)$ ➔ p_D = 2.955×10^{5} Pa Using $p_D V_D = nRT_D$ $n = \frac{p_D V_D}{RT_D} = \frac{2.955\times10^{5}\times750\times10^{-6}}{8.31\times888} = 0.030$ mole	 C1 A1
9div	the <u>gas molecules bounce off the receding/outward moving piston</u> hence a <u>decrease in kinetic energy /</u> <u>lower speeds</u> of the gas molecules, leading to lower temperature	B1 B1