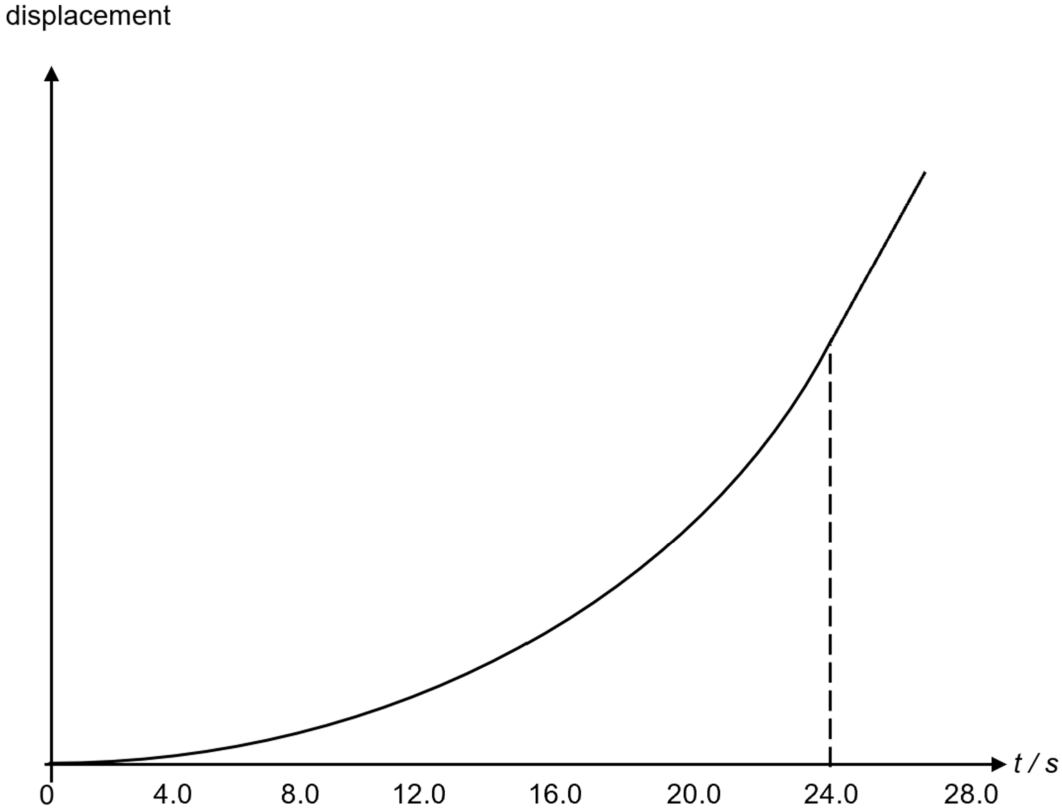
Anderson Serangoon Junior College 2024 JC2 H1 Physics Preliminary Examination Mark Scheme

Paper 2 (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	$g = \frac{(4\pi^2 \times 1.50)}{2.48^2}$ $= 9.63 \text{ m s}^{-2}$ Absolute uncertainty = 0.08 x 9.63 = 0.8 m s^{-2} *g* = 9.6 ± 0.8 m s^{-2}	 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 <u>no air resistance initially</u>, hence his initial acceleration is equal to 9.81 m s^{-2}.	M1 A1
2c	Before 24.0 s, <u>speed increases with decreasing rate</u> After 24.0 s, falling with <u>constant velocity</u>	B1 B1
2d	Find the area under the graph by using trapezium rule/counting squares	B1 B1
2e	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, $(W \times 0.25) + (12 \times 0.35) = (17 \sin 50° \times 0.50)$ $W = 9.246$ $= 9.2$ 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 $F = \sqrt{(8.177^2 + 10.93^2)} = 13.7$N	 C1 C1 A1
3d	By taking the 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

4a

If *R* is inversely proportional to *θ* then product of *R* and *θ* is a constant. **C1**

R / Ω	*θ* / °C	*Rθ* / Ω °C
1700	60	102000
800	100	80000
280	140	39200

As can be seen from the table, *Rθ* is not a constant in the range 50 °C to 150 °C. **A1**

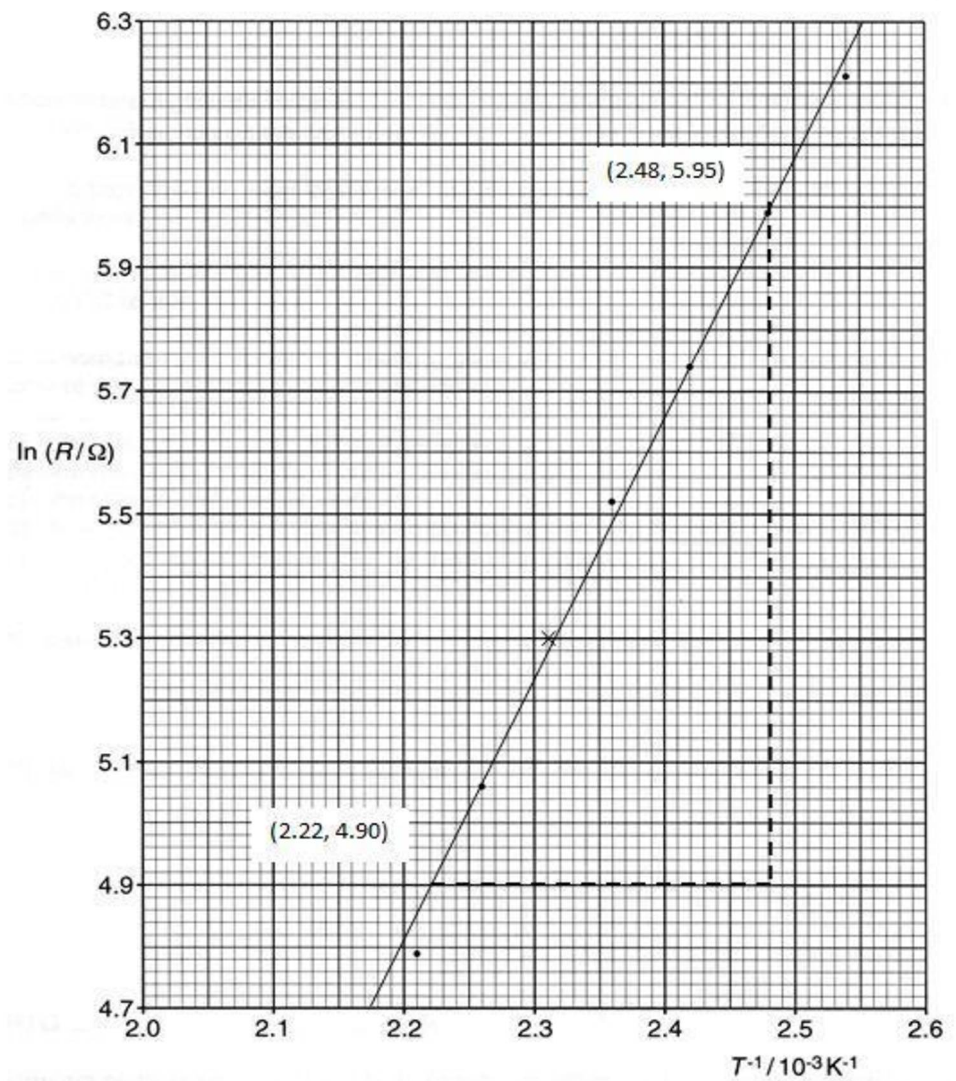
4bi **A1**

R / Ω	θ / °C	T^{-1} / 10^{-3} K^{-1}	ln(R / Ω)
200	160	2.31	5.30

Correct values for *R*, T^{-1} and ln *R*.

4bii

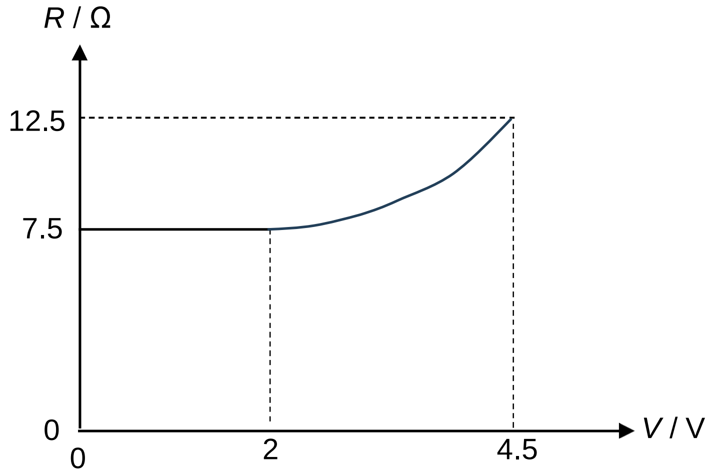
Plot point accurately to half small square. **A1**



4ci

$R = Ae^{E_g/2kT}$ **M1**

[Turn Over

	$\ln R = \ln A + E_g/2kT = (\frac{E_g}{2k})(\frac{1}{T}) + \ln A$ As seen from relationship, <u>when ln *R* is plotted against 1/*T*, a straight line should be obtained</u> with gradient = $\frac{E_g}{2k}$ and y-intercept = ln*A*. Since a straight line is seen in Fig. 7.3, it supports the proposal.	A1
4cii	Gradient = $E_g/2k$ $\frac{E_g}{2k} = \frac{5.95-4.90}{(2.48-2.22)\times10^{-3}} = 4038$ $E_g = 2(1.38\times10^{-23})(4038) = 1.11\times10^{-19}$ J	M1 M1 A1
4d	Parallel combination of resistance $=(\frac{1}{90}+\frac{1}{120})^{-1}$ $=51.43\Omega$ Using potential divider, $V_{out} = \frac{51.43}{51.43+243}\times9.0$ $=1.57$ V	C1 C1 A1
4e	For metal, as temperature increases, <u>the increase in lattice-electron collisions is more significant than the increase in charge carriers</u>, thus the resistance of metal <u>increases with temperature</u>.	A1
4f	 Correct shape – constant resistance then increasing (allow straight line) Include at least one set of correct resistance value, e.g. 7.5 Ω, 12.5 Ω or any correct value.	B1 B1
5a	electric field strength at a point is defined as the electric force exerted <u>per</u> unit positive charge placed at that point. OR	A1

	electric field strength at a point is defined as electric force <u>per</u> unit positive charge acting on a small stationary charge placed at that point.	
5b	$F = qE$ $ma = qE$ $a = \frac{qE}{m} = \frac{1.6 \times 10^{-19}(4.0 \times 10^{4})}{9.11 \times 10^{-31}}$ $= 7.0 \times 10^{15}$ m s^{-2}	C1 A1
5ci	magnetic force on ion in path B provides for centripetal force By N2L, $Bqv = m\frac{v^2}{r}$ $m = \frac{rBq}{v} = \frac{\frac{12.3}{2}\times10^{-2} \times 640\times10^{-3} \times 1.6\times10^{-19}}{9.6\times10^{4}}$ $= 6.56 \times 10^{-26}$ kg $= \frac{6.56\times10^{-26}}{1.66\times10^{-27}}$ = 40 u (or 39.5 u)	B1 C1 A1
5cii	Since the ions are of the same isotope, they all have the same mass regardless of the paths undertaken. Using the equation in answer to **(b)(i)**, the radius of the path is inversely proportional to *q* (or state equation for *r*) Hence, the ions in path A have thrice the charge compared to ions in path B.	B1 B1 B1
6a	two nuclei of low nucleon number join / combine together to form one larger nucleus with release of energy.	M1 A1
6b	Energy released = Binding energy of products – Binding energy of reactants binding energy of Z = [(1.25 + 1.81) × 10^{-10}] – 2.94 × 10^{-11} (= 2.77 × 10^{-10} J) nucleon number of Z = 93 + 139 + 2 – 1 (= 233) Binding energy per nucleon of Z = (2.77 × 10^{-10}) / (233 × 1.60 × 10^{-13}) = 7.43 MeV	C1 C1 C1 A1
6ci	sketch: line with negative gradient starting at (0, 1.0 N_0) and extending to t = 30 days exponential curve, extending from t = 0 to t = 30 days, with gradient of steadily decreasing magnitude line passing through (0, 1.0 N_0), (10, 0.5 N_0) and (20, 0.25 N_0)	B1 B1 B1
6cii	Short range in tissue / high ionisation energy.	B1
7ai	By Newton's 2nd Law, rotating blades pushes air and causes it to undergo a rate of <u>change in momentum downwards</u> giving rise to a <u>downward force</u>. From Newton's 3rd Law, the <u>air exerts an upward force of the same magnitude on the blades/helicopter</u>.	B1 B1

	When this upward force equals the weight of the helicopter, resultant force (of helicopter) is zero (and hence it can remain stationary vertically)	B1
7aii1	Area = $\pi r^2 = \pi(0.70)^2$ = 1.539 m^2 Volume of air per second = 1.539 x 4.0 = 6.156 $m^3\ s^{-1}$ Mass per second = volume per second x density = 6.156 x 1.2 = 7.387 kg s^{-1} = 7.4 kg s^{-1}	C1 C1 M1 A0
7aii2	Rate of change of momentum = dm/dt x velocity = 7.4 x 4.0 = 29.6 ≈ 30 N	C1 A1
7aiii	F_{net} = 0 *Mg* – Force on helicopter by air = 0 *Mg* = Force on helicopter by air = 29.6 N *M* = 29.6 / 9.81 = 3.0 kg	 C1 A1
7bi	Drag forces/ air resistance/ resistive forces increases with speed of the car At higher constant speed, there is greater work done against drag forces/ air resistance/ resistive forces hence, higher power is required	B1 B1 A0
7bii	v = 60 × (1000 / 3600) = 16.67 m s^{-1} Effective power = $F_{driving}$ × v $22 \times 10^3 = F_{driving} \times 16.67$ $F_{driving}$ = 1320 N Since the car is at constant speed, total resistive force = $F_{driving}$ = 1320 N	 C1 A1 B1
7biii 1.	Total momentum before = total momentum after *m* x 60 – 2m x 60 = (*m* + 2*m*) *V* *V* = – 20 km h^{-1} Speed = 20 km h^{-1}	 C1 A1
2.	During collision, force on car and truck is the same (by Newton's 3rd Law) but since car has smaller mass, acceleration of car is greater than the acceleration of the truck. (For the same mass), force by seatbelt on car driver is greater.	B1 B1 B1
8ai	Horizontal component of tension / spring force provides centripetal acceleration 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	$k = \frac{\Delta F_{spring}}{\Delta x} = \frac{3.2 - (0.29 \times 9.81)}{(10.8 - 8.5)}$ $k = 0.15 \text{ N cm}^{-1}$	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	$a_c = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2$ $T = 2\pi \times \sqrt{(0.049 / 5.0)} = 0.62 \text{ s}$	C1 A1
8bi	The <u>gravitational force</u> acting on the stars (which provides centripetal force) is <u>always perpendicular</u> to the velocity of the stars.	A1
8bii	The <u>gravitational force</u> between the stars provides/is the centripetal force By <u>Newton's third law</u>, the gravitational force acting on the stars have the same magnitude.	M1 A1
8biii	Centripetal acceleration changes the direction but not the speed/magnitude of velocity OR Work done by the centripetal force is zero	B1
8biv	$v = \frac{2\pi r}{T} = \frac{2\pi}{T}\left(\frac{d}{2}\right)$ $v = \frac{2\pi}{4.0 \times 365 \times 24 \times 60 \times 60}\left(\frac{2.8 \times 10^8 \times 10^3}{2}\right)$ v = 6973 ≈ 7.0 x 10^3 m s^{-1}	C1 A1
8bv	(Gravitational force provides centripetal force) $\frac{G \times M \times M}{d^2} = \frac{Mv^2}{\left(d/2\right)}$ $M = \frac{2v^2 d}{G} = \frac{2 \times 6973^2 \times 2.8 \times 10^8 \times 10^3}{6.67 \times 10^{-11}}$ M = 4.1 x 10^{29} kg	C1 A1