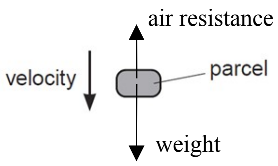
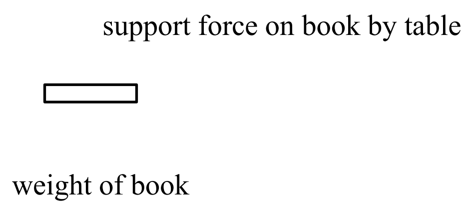
Anderson Serangoon Junior College 2021 H2 Physics Prelim Mark Scheme

Paper 3 (80 marks)

1a	Taking right as positive, $s = ut$ $4.40 = 5.40 \times t$ $t = 0.8148$ s Taking downwards as positive, $s = ut + ½at^2$ $h = ½ \times 9.81 \times 0.8148^2$ $= 3.2565 \approx 3.26$ m	 C1 A1
1bi	 downward pointing arrow labelled weight upward pointing arrow labelled air resistance no credit if magnitude of air resistance exceeds that of weight	B1
1bii	Air resistance increases (as velocity increases) Weight (or mass) is constant, so resultant force decreases Hence, acceleration decreases	B1 B1 B1
1biii	At terminal velocity, air resistance equals weight With larger mass, weight is larger. (Greater air resistance), so greater terminal velocity	B1 B1
1biv 1.	gravitational potential energy to kinetic energy and thermal/internal energy	B1
1biv 2.	gravitational potential energy to thermal/internal energy	B1

2ai	 Either The support force on book by table and the weight of book are both acting on the book. (N3L states that forces act on different bodies.) They are different types of forces, gravitational and electromagnetic/contact forces. (N3L states that forces must be of the same type.) (So, they are not a pair of action-reaction forces.) Or Reaction force of contact force by table on book is contact force that book exerts on table. Reaction force of weight of book is gravitational force that book exerts on Earth.	 B1 B1 B1 B1

	(So, weight of book and contact force by table on book are not a pair of action-reaction forces.) Credit 1 mark only if student did not mention type of force.	
2aii	Since book is resting on table, there is no net force on the book, so the two forces are equal and opposite.	B1
2b	Suppose two colliding bodies A and B (where A and B is an isolated system), By Newton's third law, force A exert on B, F_{AB} is equal in magnitude and opposite in direction to force B exert on A, F_{BA}. $F_{AB} = - F_{BA}$ Duration of collision is the same for A and B. By Newton's second law, net force on A, F_{BA} is equal to rate of change of momentum of A. Net force on B, F_{AB} is equal to rate of change of momentum of B. Hence, total (rate of) change of momentum is 0.	B1 B1 B1
2c	By Conservation of Linear Momentum Sum of initial momentum = Sum of final momentum $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (28)(88) + (17)(53) = (28)(67)+ (17)v_2 v_2 = 87.6 m s^{-1} Loss in kinetic energy = total initial kinetic energy – total final kinetic energy = ½ (28)$(88)^2$ + ½ (17)$(53)^2$ – (½ (28)$(67)^2$ + ½ (17)$(87.6)^2$) = 4200 J	C1 C1 A1
2d	 Correct shape – smooth curves for both lines. Line for steel objects has larger peak and smaller duration than line for rubber, with approximately equal area under the two lines.	B1 B1

3a	base units: kg m s^{-2} × m = kg m^2 s^{-2}	A1
3bi	distance of COG from P (= GP) = 17 cos 45° – 4.0 = 8.02 cm (or using Pythagoras Theorem: $\sqrt{144.5} - 4.0 = 8.02$) moment = 0.15 × 8.02 × 10^{-2}	C1 A1

	$= 1.2 \times 10^{-2}$ N m	
3bii	(line of action of) weight acts through pivot/P **or** distance between (line of action of) weight and pivot/P is zero (so) weight does not have a moment about pivot/P	M1 A1
3ci	upthrust = 6.20 – 5.60 = 0.60 N	C1 A1
3cii	$\Delta p = \Delta F / A$ $= 0.60 / 1.2 \times 10^{-3}$ = 500 Pa	 C1 A1
3ciii	upthrust increases when density increases and since upthrust + force on spring = weight of cylinder so extension decreases	M1 A1

4a	The heat input is used to <u>break intermolecular bonds between water molecules</u>/ <u>increasing the potential energy of molecules</u>, and <u>do work against the atmosphere</u> as it expands when it changes phase. The <u>average kinetic energy of molecules remains unchanged</u>, and hence <u>no change in temperature</u>.	B1 B1 B1
4b	As light passes two slits instead of one, the <u>total power that passes through the slits is doubled</u>. (Intensity of central bright fringe increases by four times due to constructive interference as waves from both slits arrive in phase.) At dark fringes, <u>destructive interference</u> as waves from both slits arrive with a phase difference of 180°, so the <u>intensity of dark fringes becomes zero</u>. Th<u>e total power / average intensity delivered onto the screen is hence doubled</u>, so that energy is conserved.	B1 B1 B1

5a	weight provides the centripetal force (or acceleration of free fall is centripetal acceleration) $9.81 = 0.130 \times \omega^2$ $\omega = 8.687 = 8.7$ rad s^{-1}	B1 M1 A0
5b	force in cord – weight = centripetal force $T - W = mr\omega^2$ force constant k = 5.0/0.018 $(L - 0.013) \times 5.0/0.018 - 5.0 = 5.0/9.81 \times L \times 8.7^2$ $L = 0.172$ m $= 17.2$ cm	 C1 C1 A1

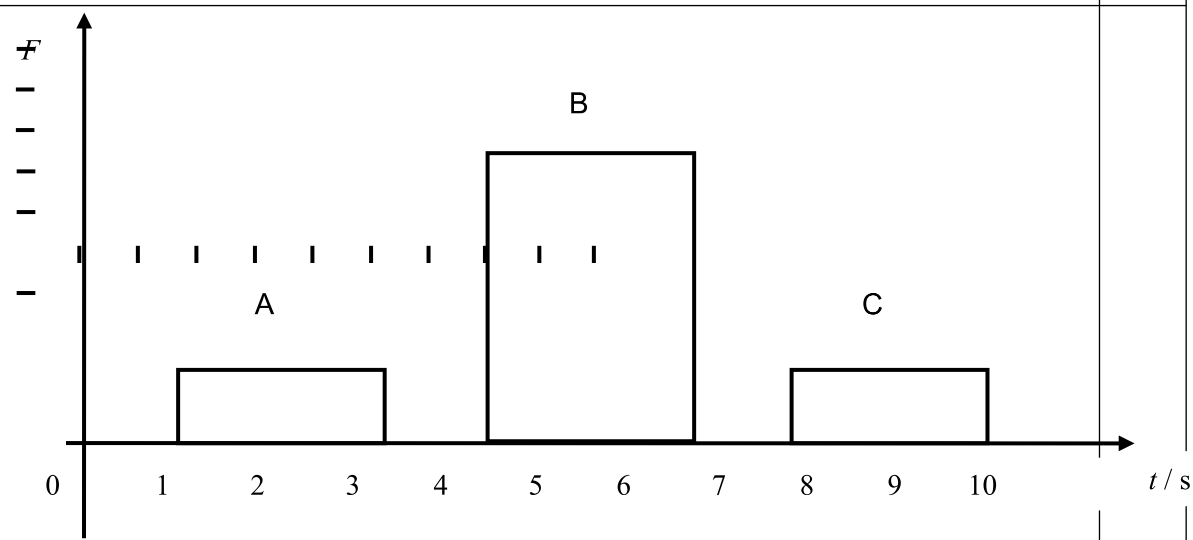
6ai	When light intensity is maximum, resistance of LDR = 1200 Ω	C1

	Total resistance = $\dfrac{1}{\left(\dfrac{1}{1200}\right)+\left(\dfrac{1}{600}\right)}$ = 400 Ω	A1
6aii	For minimum p.d. across R_2, R_1 = 400 Ω total parallel resistance (R_2 + LDR) is lower than R_2 (minimum) p.d. across R_2 in Fig. 6.1 is lower than that in Fig. 6.2	M1 M1 A1
6bi	At balance length, no current in E_1 or r, so $E_1 = V_{XY}$ (Balance length XY = 100.0 - 37.5 = 62.5 cm) (Using potential divider principle,) $V_{XZ} = \left(\dfrac{R_{XZ}}{R_{XZ}+R_1}\right)E = \left(\dfrac{10.0}{10.0+15.0}\right)(2.0) = 0.80\text{ V}$ $V_{XY} = \dfrac{L_{XY}}{L_{XZ}}(V_{XZ}) = \left(\dfrac{62.5}{100.0}\right)(0.80) = 0.50\text{ V}$ Therefore $E_1 = V_{XY} = 0.50$ V	M1 M1 M1 A0
6bii	$V_{XY} = V_{R_2}$ $\dfrac{10.0}{100.0}\times 2.0 = \dfrac{R_2}{R_2+r}E_1$ $= \dfrac{5.0}{5.0+r}\times 0.50$ $0.20(5.0+r) = 2.5$ $r = \dfrac{2.5}{0.20} - 5.0 = 12.5 - 5.0 = 7.5\ \Omega$	 C1 C1 A1

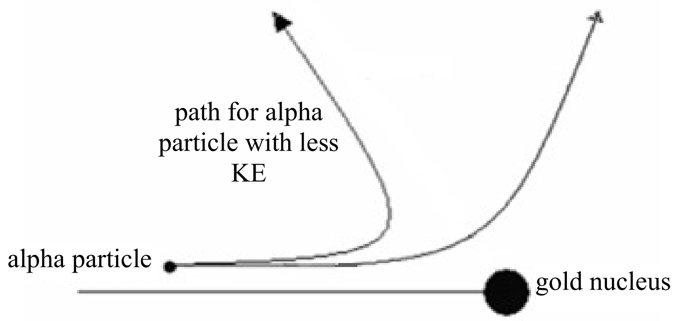
7ai	$V_{r.m.s.} = \dfrac{9.0}{\sqrt{2}} = 6.4\text{ V}$	A1
7aii	$T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{20}$ $= 0.31\text{ s}$	A1
7b	the r.m.s. voltages are different, so no same power dissipated. (Explanation: the r.m.s. voltage for Fig 7.1 is $\dfrac{V_o}{\sqrt{2}}$ but for Fig. 7.2 it is V_o)	B1
7ci	output power, $P = V_{r.m.s.} \times I_{r.m.s.}$ $= 120 \times 0.64$ $= 76.8$ W efficiency = (76.8/80) × 100%	 C1

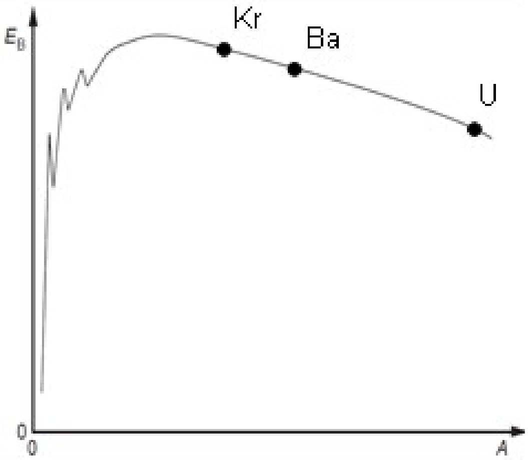
	= 0.96 or 96%	A1
7cii	Any one from: • heat losses due to resistance of windings / coils • heat losses in magnetising and demagnetising core / hysteresis losses in core • heat losses due to eddy currents in (iron) core • loss of flux in the (iron) core	B1

8ai	By Fleming's Left Hand Rule, the force acting on the wire is out of the plane of paper. By Newton's Third Law, the force on the magnet is into the plane of paper.	B1 B1
8aii	Force decreases by half / to half of its original value. OR from a maximum value at θ = 0° to a half its maximum value at θ = 60°.	M1 A1
8bi	Magnetic force = Bqv = 0.45 $(1.60 \times 10^{-19})(5.0)$ = 3.6×10^{-19} N	 M1 A0
8bii	By Fleming's Right Hand Rule, there is rate of cutting of flux which induced current to flow from B to A through the wire. OR By Fleming's Left Hand Rule, magnetic force acting on electron is directed towards B. Electrons accumulate at end B leaving excess positive charges at end A. End A has a higher potential.	M1 A1
8biii1.	Potential difference across the two ends of wire produces an electric field. Electrons in the wire experience an electric force of equal magnitude but directed oppositely to the magnetic force. Hence, equilibrium is achieved.	B1 B1
8biii2.	Electron in equilibrium, $F_B = Bqv = qE$, so $E = F_B / q$ $E = 3.6 \times 10^{-19} / 1.60 \times 10^{-19}$ $= 2.25 = 2.3$ N C^{-1}	 C1 A1
8biii3.	$E = \Delta V/d$ don't accept using e.m.f. = BLv $2.25 = \Delta V / 0.20$ $\Delta V = 0.45$ V	 A1
8ci	The frame experiences an increase in flux linkage. By Faraday's law, an emf is induced across XY. By Lenz's Law, a current is induced in the frame and flows clockwise (X → Y→ Z → W), resulting in a magnetic force on XY to the left / against its motion. To maintain constant speed, there should be no net force. Hence, an external force needs to be applied to the right. **OR**	M1 M1 A1

	The frame experiences <u>an increase in flux linkage</u>. By Faraday's law, an <u>emf is induced</u> across XY. A <u>current is induced</u> in the frame, **if** <u>no external force</u> is applied, <u>kinetic energy of the frame **will be**</u> <u>transformed to thermal energy</u> To maintain constant speed, <u>work has to be done by an external force</u> so that the <u>kinetic energy is maintained</u>.	M1 M1 A1
8cii	Induced emf = BLv = (1.0)(0.020)(0.010) = 2.0×10^{-4} V $F = BIL$ = $(1.0)\left[\frac{(2.0\times10^{-4})}{8.0\times10^{-4}}\right](0.020)$ = 5.0×10^{-3} N **OR** Induced emf = BLv = (1.0)(0.020)(0.010) = 2.0×10^{-4} V Heat dissipated per unit time = $\frac{V^2}{R}$ = $\frac{(2.0\times10^{-4})^2}{8.0\times10^{-4}}$ = 5.0×10^{-5} J $F = \frac{P}{v} = \frac{5.0\times10^{-5}}{1.0\times10^{-2}}$ = 5.0×10^{-3} N	C1 C1 A1 C1 C1 A1
8ciii	 B1 – Correct shape for B (magnitude of F around 4.0 times higher than A) B1 – Correct shape for C (magnitude of F same as A)	

	Detailed explanation From t = 1 s to t = 3 s, only one side of the frame (XY) experiences a force to the left as the induced current in XY is perpendicular to the magnetic field. From t = 3 s to t = 4 s, the entire frame is inside region A. The frame experiences no change in magnetic flux linkage, so no emf is induced. Hence no induced current and magnetic force experienced. From t = 4 s to t = 6 s, there is induced emf of equal magnitude but opposite polarity at both WZ and XY. Hence the magnitude of induced emf doubles to 4.0 x 10^{-4} V. Both WZ and XY experience a force of twice the magnitude to the left. Therefore the magnitude of F increases by 4 times (2.0 x 10^{-2} N). From t = 6 s to t = 7 s, the entire frame is inside region B. The frame experiences no change in magnetic flux linkage, so no emf is induced. From t = 7 s to t = 9 s, only one side of the frame (WZ) experiences a force to the left as the induced current in XY is perpendicular to the magnetic field. The magnitude of emf induced = $\frac{\Delta\Phi}{t}=\frac{B\Delta A}{t}=\frac{Bl\,\Delta s}{t}=Blv$, which is the same magnitude of emf induced from t = 1 s to t = 3 s, since v and magnitude of B are unchanged.	

9ai	1. nucleus has positive charge, so repels alpha particle. alpha particle gains momentum at right angles to the initial momentum. 2. greater deflection of final path (path cannot be parallel to original dir) final path has greater distance of closest approach 	 B1 B1 B1 B1
9aii	β-particles have a range of energies β-particles deviated by (orbital) electrons / attracted by nucleus β-particle has (very) small mass (any two sensible suggestions, 1 each, max 2)	B1 B1
9bi	1. as alpha particle approaches nucleus, KE is converted to EPE, at this distance of closest approach, alpha particle must possess a certain amount of EPE hence alpha particle must possess minimum energy to be this close to Li 2. E = $1/4\pi\varepsilon_0\, Q_1\, Q_2 / r$ = $9\times10^{9} \times 3.2\times10^{-19} \times 4.8\times10^{-19} / 4.2\times10^{-15}$ = 3.3 x 10^{-13} J	B1 B1 M1 M1 A0
9bii	1. mass change = 10.0011 + 1.0087 - 7.0144- 4.0015 = -6.1×10^{-3} u	M1

	mass loss = $6.1\times10^{-3} \times 1.66\times10^{-27} = 1.01\times10^{-29}$ kg 2. $E = mc^2$ $= 1.0\times10^{-29} \times 9\times10^{16} = 9.0\times10^{-13}$ J Energy of neutron = $9.0\times10^{-13} + 3.3\times10^{-13}$ $= 1.2\times10^{-12}$ J	M1 C1 C1 A1
9ci	Refer to summary notes.	B1
9cii	 U labelled near right-hand end of line Ba and Kr in approximate relative positions	B1 B1
9ciii	The binding energy of a particular nucleus = A x E_B The process is possible because the binding energy of U < the combined binding energy of (Ba + Kr)	B1 B1