1. CGS: Mechanics (+ Thermal Physics) [GRILS/Practical Planning]

Qn	Part	Suggested Answers	Marks	Remarks
9	(a)	$Q = mc\Delta\theta$ Q = 0.0010 × 4200 × 1.0 = 4.2 J	 A1	
	(b)	Work done against weight = GPE gained = *mgh* = 50 × 10 × 201 = 100500 J = 1.0 × 10^5 J (2 s.f.)	 M1 A1	Accept answer to 2 or 3 s.f.
	(c)	Min amount of energy from carbohydrates = 60% × 100500 = 60300 J Min amount of calories provided = 60300 / 4.2 = 14357 Min mass of carbohydrates needed = 14357 / 4000 = 3.59 g	 M1 A1	Allow ECF from (b)
	(d)	Use calibrated electronic balance to measure his mass *m.* Use metre rule to measure the height of one step, *h*, of the staircase. Count the total number of steps, *n*, that he has to run up. The total height that he runs up to will be *H = nh.* Using a stopwatch, record the time taken *t* for him to reach *H.* His average power can then be calculated from P_{ave} = *mgH / t.* Repeat the above steps at least 2 more times. Take the mean of P_{ave} for a more accurate answer.	 B1 B1 B1 B1	1 m for stating the 3 main measuring instruments and their corresponding physical quantities 1 m for stating the formula for average power P_{ave} 1 m for describing a clear and sensible procedure 1 m for repeating and taking the mean of P_{ave}
	(e)	*t = E / P* = 100500 / 48 = 2.1 × 10^3 s	 A1	Allow ECF from (b)

2. HCI: Mechanics [GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
9	(a)	$KE = \frac{1}{2}mv^2$ = 0.5 (0.025) $(56)^2$ = 39.2 = 39 J	M1 A1	
	(b)(i)	$v = u + at$ $0 = 56 + a(0.020)$ $a = -2800$ m/s^2 deceleration = 2800 m/s^2	M1 A1	
	(ii)	$F_{net} = ma$ $f = (0.025)(2800)$ $f = 70$ N	M1 A1	
	(c)	Work done = fd = (70)(0.12) = 8.4 J	M1 A1	
	(d)	Loss in KE = WD against friction + Gain in GPE $39.2 = 8.4 + mgh$ $39.2 = 8.4 + (0.025 + 8.0)(10)\,h$ $h = 0.3838 = 0.38$ m (theoretical value) However, experimental value = 0.292 m, hence there is a discrepancy	M1 Aa1	

3. Nan Chiau: Mechanics (+ Thermal Physics + Magnetism and Electricity) [GRILS/PRC]

Qn	Part	Suggested Answers	Marks	Remarks
10	(a)	80 − 50 = 30 m	A1	
	(b)	Any possible reason: -To protect the wind turbine from damage due to its blades being ripped off / wear and tear / prevent turbulence or prevent the generator being burnt out or catastrophic failure -Stop working during hurricane -Current too high causing fuse to melt and open circuit so not working	B1	Note for student: "Suggest" question so you need to come up with an answer that may be based on or even beyond what is covered in the syllabus.
	(c)(i)	$E = 0.5\,\pi\ \times 50^2 \times 14^3 \times 1.25$ = 13469578.5 W = 13.5 MW (3 s.f.)	A1	
	(ii)	Efficiency = useful power / input power × 100% = (3034 / 13470) × 100% = 22.5% (3 s.f.)	M1 A1	
	(iii)	Any possible reason: -Due to the limited number of blades mounted, not all the KE of the wind is converted to electrical energy. -In any mechanical system due to friction among moving parts or resistance in the electrical components, some of the electrical energy is wasted as heating effect or thermal energy on the wiring and electrical components. -Work is done against air resistance. -Some energy is converted into sound energy.	B1	
	(d)	-Diagram showing cyclic arrows in anti-clockwise direction of movement of hot air rising from land and movement of cold air towards the land. -Due to higher specific heat capacity of water than land		B1 each, max 2 marks

		-The warm air over the land expands, becomes less dense and rises, creating a partial vacuum. -The heavier, denser, cooler air over the water flows in to take its place, creating sea breeze. -Higher air pressure above sea and lower air pressure above land causes air flow from sea to land. -Explanation of convection current formed.		
	(e)	Lightning conductors mounted at the highest point, reducing the probability of lightning striking due to the point action of the sharp points which produces positively charged ions below a highly negatively charged cloud. OR Earth wire connected to the metallic part of the wind tower or a network of strike termination devices (lightning rods); A network of conductors to move electrical energy from the strike termination devices toward earth; a network for ground terminations (ground rods), direct excess charges to the ground/earth.	B1 B1 B1 B1	

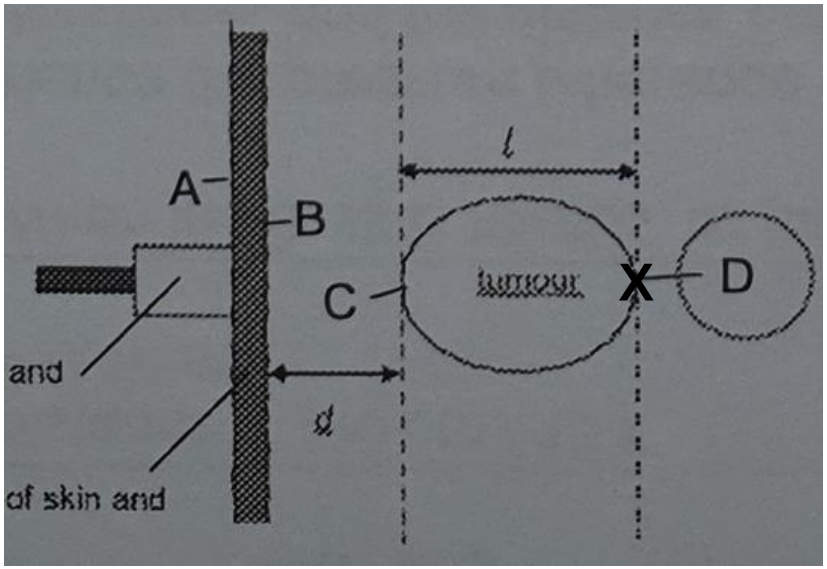
4. NYGH: Waves [PRC/AUSGAI]

Qn	Part	Suggested Answers	Marks	Remarks
13 E	(a)	Light from a wider range of directions can enter the light collector with less reflection, so more light can be captured	B1	
	(b)(i)	55° and 0°	A1	
	(ii)	Light ray laterally displaced for flat light collector Light ray passes through undeviated for hemispherical collector	B1 B1	1 m to be deducted from total mark for missing direction on rays
	(c)(i)	Incident angle and angle of reflection are equal Reflections constructed until ray exits the tube	B1 B1	
	(ii)	The greater the number of reflections, the smaller the amount of light transmitted. At each reflection, some light is absorbed and some light is refracted. OR Longer distance travelled when there are more reflections, hencegreater loss of light to surroundings.	B1 B1	
	(d)	Light hits the acrylic film at different angles of incidence due to the irregular surface. Hence the light is refracted out from the film at different angles.	B1 B1	

13 O	(a)	Less easily refracted / no significant loss of energy over long distances	B1	
	(b)(i)	170 ms	A1	
	(ii)	Time taken to receive reflected signal is long for vacant lots as the distance travelled by signal is longer. Amplitude of signal is smaller as there is greater energy loss for longer distance travelled for vacant lots	B1 B1	
	(iii)	Distance = speed x time = 340 m/s × (20 × 10^{-3} s) / 2 = 3.4 m	M1 A1	Note for student: 20 ms is the time difference between empty and occupied lot; so we need to divide by 2 because signal is reflected from top of vehicle (travelled twice the distance)
	(iv)	Reference value remains the same as frequency does not affect speed of the wave.	B1	
	(v)	Ultrasound travels faster in liquid Time taken between transmission and reception of signals is shorter. OR The amplitude is smaller as there is greater energy loss in liquid than in gas.	B1 B1	
	(c)	Presence of wind will carry away the wave and hence the wave cannot be detected by the receiver.	B1	

5. VS: Waves [AUSGAI/GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
10	(a)(i)	50 cm	A1	
	(ii)	$v = f\lambda$ = 2.0 (50) = 100 cm/s $d = st$ = 100 (0.06) = 6.0 cm	M1 A1	
	(iii)	Arrow pointing down	B1	
	(iv)	−9.0 cm	A1	Accept −8.0 cm to −11.0 cm Allow ECF from (a)(ii) Note for student: To estimate the displacement of P, draw the wave after it has travelled for 0.060 s
	(b)(i)	To ensure that no air is trapped between transmitter and skin, otherwise nearly all the transmitted pulse will be reflected at the surface of the skin.	B1	
	(ii)	The cross at the rightmost tip of the tumour	B1	Note for student: Pulse A: left surface of skin/fat layer Pulse B: right surface of skin/fat layer Pulse C: leftmost tip of tumour Pulse D: rightmost tip of tumour

				
	(iii)	Pulse takes 275 − 100 = 175 μs to travel 2l $2l = st$ = (1.5 × 10^3) (175 × 10^{-6}) l = 0.131 m	M1 A1	
	(iv)	Ultrasound is non-ionising, hence it is not dangerous compared to using X-rays as it does not damage human cells.	B1	

6. ACS(B): Thermal Physics [GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
11	(a)(i)	$Q = mc\Delta\theta$ $m = \frac{Q}{c\Delta\theta}$ $m = \frac{200 \times 10^6}{(4.2 \times 10^3)(45 - 25)}$ $m = 2380$ kg	M1 A1	Note for student: Convert MJ to J in substitution of *Q*
	(ii)	$Q = mc\Delta\theta$ $Q = 2380 \times (4.2 \times 10^3) \times (45 - 14)$ $Q = 3.10 \times 10^8$ J or 310 MJ	M1 A1	ECF allowed Use outdoor temperature of France
	(iii)	$Q = Pt$ $t = \frac{Q}{P} = \frac{3.10 \times 10^8}{12 \times 10^3}$ $t = 25800$s or 7.17 h (or 7.18 h)	M1 A1	ECF allowed Note for student: 1 h = 3600 s Giving answer in hours will help in (b)
	(b)	The temperature difference between warm water and outdoor temperature is 31 °C for France and 26 °C for Fiji. Hence, the amount of solar energy required to heat up water in Fiji is 0.84 of the amount required for France. Fiji will need (7.17 × 0.84) = 6 h of daily sunshine, but Fiji receives only 4 h of daily sunshine. Hence, it is unable to accumulate enough solar energy to maintain the indoor temperature of 25 °C.	B1 B1	Deduct 1 mark if no data Note for student: Refer to workings in (a)(ii) and (a)(iii) Compare data for France and Fiji in Fig. 11.3 Alternatively, repeat the calculations in (a)(ii) and (a)(iii) using Fiji data to conclude that Fiji will need 6 h of daily sunshine but only gets 4 h. Note that as this is an "explain" question, showing calculations without using the numbers to explain the reasoning will result in no credit.
	(c)	The water pipes can be made of metal as metal is a good conductor of heat.	B1 B1	

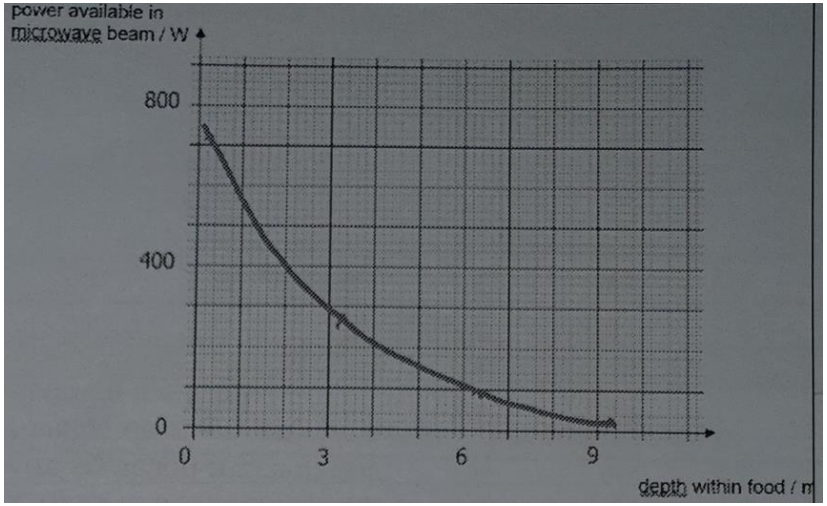
7. PLMGS: Thermal Physics [GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
11	(a)	Property: electrical voltage or electromotive force (e.m.f.) Assumption: the e.m.f. varies linearly with temperature	B1 B1	
	(b)	The amount of energy that is needed to raise the temperature of 1 kg of lead by 1 °C is 130 J.	B1	
	(c)(i)	Temperature rise = 8 / 10 = 0.8 °C	A1	
	(ii)	$Q = mc\Delta\theta$ $Q = (0.395)(130)(0.8)$ $Q = 4.11$ J	M1 A1	
	(d)(i)	Let x be the final temperature of the lead target. Heat lost by lead target with pellet & water = heat gain by ice $(mc\Delta\theta)_{lead} + (mc\Delta\theta)_{water} = (ml_f)_{ice} + (mc\Delta\theta)_{ice}$ $(39.5 + 0.5) \times 10^{-3} \times 130 \times (40.0 - x)$ $+100 \times 10^{-3} \times 4200 \times (25.0 - x)$ $= 20 \times 10^{-3} \times 3.4 \times 10^{5} + 20 \times 10^{-3} \times 4200 \times (x - 0)$ $x = 7.67$°C	M1 M1 A1	
	(ii)	No thermal energy lost to surroundings/container of icy water	B1	

8. PHS: Thermal Physics [GRILS/PRC]

Qn	Part	Suggested Answers	Marks	Remarks
9	(a)	The function of the resin is to cool the spacecraft. When the resin evaporates and boils, it takes away a large amount of heat energy, latent heat of vaporisation, from the surface of the aircraft, hence cooling the surface of the aircraft when the surface loses this energy.	B1 B1 B1	
	(b)(i)	A large amount of heat is generated due to friction as the spacecraft moves through the atmospheric layer. The black colour helps to dissipate heat away from the space shuttle since black colour is a good emitter of infra-red radiation. OR The white colour helps to reflect away heat generated externally due to friction since white is a good reflector/emitter of infra-red radiation.	B1	
	(ii)	The silica tiles should have a very high specific heat capacity so that it requires a very large amount of thermal energy to raise the temperature of unit mass of the silica tiles by 1 °C.This will keep the temperature of the surface lower.	B1 B1	
	(iii)	The silica tiles are poor conductors of thermal energy. This helps to insulate the inside of the space shuttle from the extreme temperature.	B1	
	(c)(i)	$\frac{1}{2}mv^2 = mc\Delta\theta$ 0.5 (1) $(5000)^2$ = (1) (900)$\Delta\theta$ $\Delta\theta$= 13888.89 °C = 13900 °C	 M1 A1	
	(ii)	The rise in temperature is much higher than the boiling point (2467 °C) of aluminium. Hence, the aluminium sections would have vaporised into the air.	B1	

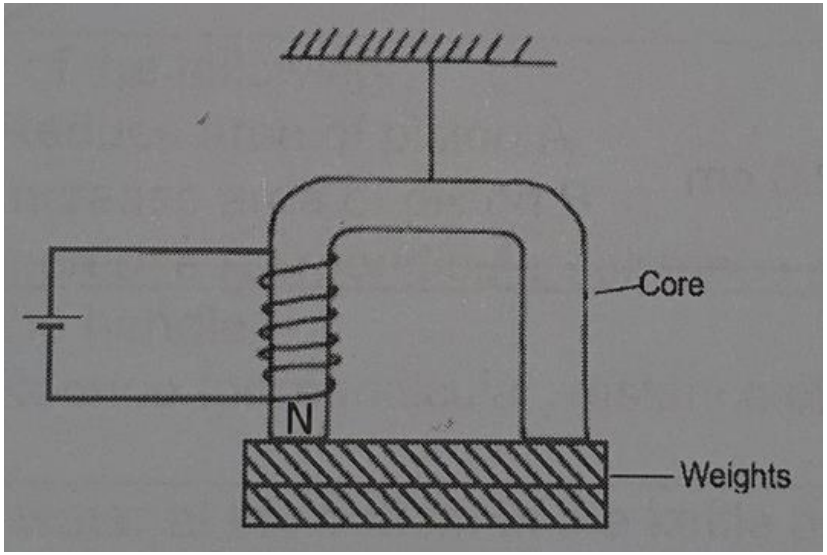
9. SCGS: Thermal Physics [GRILS]

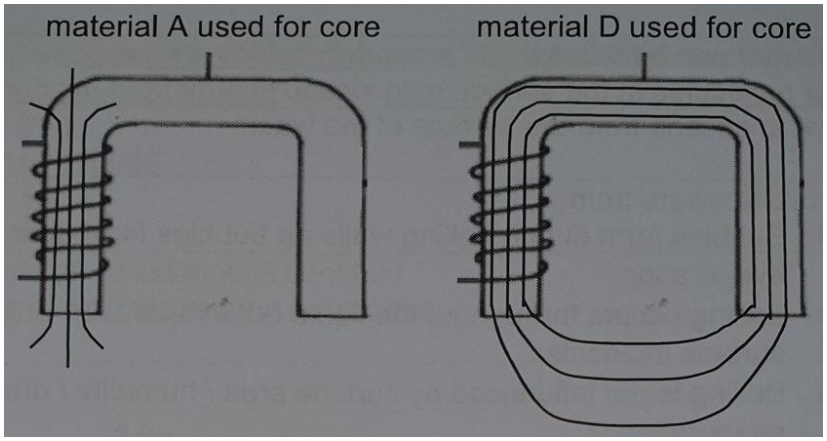
Qn	Part	Suggested Answers	Marks	Remarks
9	(a)	2.5×10^9 complete oscillations are being made in 1 s	B1	
	(b)	$v = f\lambda$ $\lambda 1 = v / f = 3.0 \times 10^8 / (2500 \times 10^6)$ $= 0.12$ m	M1 A1	
	(c)		B3	Best fit curve passing through the following points: d=0, P=750; d=3, P=300; d=6, P=120
	(d)	170 W	B1	Accept P=160 to 180 W
	(e)	Energy provided = Energy needed to raise temperature of soup + Energy needed to change state of soup $Pt = mc\Delta\theta + ml$ $750\ t = 0.25(2100)(18) + 0.25(340000)$ $t = 130$s	M1 M1 A1	

10. SJI: Thermal Physics [GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
10	(a)	The water at the base will be heated up, become less dense and rise. The cooler denser water will sink to the base and be heated up. Convection currents can be formed throughout the entire water.	B1 B1	
	(b)(i)	Minimise heat lost from the water to the surroundings through convection.	B1	
	(ii)	Metal is a good conductor of heat and heat will be transferred to the water through the metal casing quickly.	B1	
	(c)(i)	4200 J of thermal energy is needed to raise the temperature of 1 kg of water by 1 K.	B1	
	(ii)	Heat supplied = heat gain by water $Pt = mc\Delta\theta$ 1200 t = 0.500 (4200) (70) t = 123 s	 M1 A1	
	(iii)	Heat loss by hot milo = heat gain by ice $C\Delta\theta = ml_f + mc\Delta\theta$ 900 (65) = m (336000) + m (4200) (15) m = 0.15 kg	 M1 A1	
	(iv)	Not all the heat from the hot milo is transferred to the ice, as some is transferred to the surroundings.	B1	

11. CHIJ SNGS: Electricity and Magnetism (+ Mechanics) [AUSGAI]

Qn	Part	Suggested Answers	Marks	Remarks
10	(a)		B1	'N' at the left end of core Note for student: Use right-hand grip rule to determine polarity of electromagnet.
	(b)	C and D as they have higher relative permeability than A and B	B1 B1	
	(c)	Downward magnetic force exerted by metal blocks on the electromagnet/core	B1 B1	Note for student: Be clear which object exerts a force on which object, in accordance with Newton's Third Law.

	(d)		B1 B1	A: 3 straight parallel lines inside solenoid diverging slightly outside solenoid D: 3 straight parallel lines inside solenoid extending to the right end of core; outside the core, the lines on both ends of core diverge and connect to one another
	(e)(i)	1.65 A	B1	Answer should have 2 decimal places in accordance with the rule of reading points on a graph with grid to half a smallest square.
	(ii)	Increasing the e.m.f. will increase the current in the coil. However, based on the graph, increasing the current beyond 4.5 A will not increase the weight of blocks that can be lifted. Hence, the student's method will not work.	B1 B1	Accept 4.2 A or above

12. HIHS: Electricity and Magnetism [AUSGAI, GRILS]

Qn	Part	Suggested Answers	Marks	Remarks
10	(a)(i)	When *d* is from 0.5 to 1.5 cm, p.d. increases linearly. When *d* is more than 1.5 cm, p.d. increases non-linearly.	B1 B1	Note for student: Describe the parts with constant and changing gradients separately, instead of a generic statement like “p.d. increases with *d*”.
	(ii)	The high voltage might discharge through the air gap to the fingers near the switch.	B1	
	(iii)	Close to zero volts as the spheres will be touching each other	B1	Not 5 or 10 kV if the graph is extrapolated Note for student: A small (non-zero) p.d. is still required when *d* = 0 cm
	(b)(i)	$Q = It$ = (0.5)(0.05) + (2.0)(0.25) + (4.0)(0.30) + (12.0)(0.45) + (30.0)(0.70) = 0.025 + 0.50 + 1.20 + 5.4 + 21 = 28.1 C	M1 A1	
	(ii)	$E = VQ$ = 50 kV × 1.2 C + 75 kV × 5.4 C + 200 kV × 21 C = 60 kJ + 405 kJ + 4200 kJ = 4670 kJ (3 s.f.)	 M1 A1	Accept 4665 kJ Allow ECF from (b)(i)
	(iii)	average *P* = total energy / time taken = 4670 kJ / (0.30 + 0.45 + 0.70) s = 3220 kW	 A1	Allow ECF from (b)(ii)
	(iv)	The voltage (or energy) is higher, thus more charges can discharge or flow through the air.	B1	Accept any other logical answer

13. MSHS: Electricity and Magnetism [GRILS/PRC]

<table>
<tr><th>Qn</th><th>Part</th><th>Suggested Answers</th><th>Marks</th><th>Remarks</th></tr>
<tr><td>10</td><td>(a)(i)</td><td>Rheostat is needed to change the effective resistance in the circuit so that the current can be kept constant.</td><td>B1</td><td></td></tr>
<tr><td></td><td>(ii)</td><td>The cross-sectional area of the wire is inversely proportional to its potential difference.</td><td>B1</td><td>Note for student:
Cross-sectional area is inversely proportional to resistance and resistance is proportional to p.d. (when current is constant)</td></tr>
<tr><td></td><td>(iii)</td><td>As the cross-sectional area of the wire is doubled, when the data for wire K and wire L is used, the p.d. is halved.
For the wires K, L, M, N and P, the product of V and A is constant.
<table>
<tr><th>Wire</th><th>A / m^2</th><th>V / V</th><th>VA / V m^2</th></tr>
<tr><td>K</td><td>0.0020×10^{-6}</td><td>0.85</td><td>1.7×10^{-9}</td></tr>
<tr><td>L</td><td>0.0040×10^{-6}</td><td>0.43</td><td>1.7×10^{-9}</td></tr>
<tr><td>M</td><td>0.0080×10^{-6}</td><td>0.21</td><td>1.7×10^{-9}</td></tr>
<tr><td>N</td><td>0.016×10^{-6}</td><td>0.11</td><td>1.8×10^{-9}</td></tr>
<tr><td>O</td><td>0.032×10^{-6}</td><td></td><td></td></tr>
<tr><td>P</td><td>0.064×10^{-6}</td><td>0.028</td><td>1.8×10^{-9}</td></tr>
</table></td><td>B1

B1</td><td>Show at least 3 sets of working for VA
Accept explanation in words</td></tr>
<tr><td></td><td>(iv)</td><td>V = 0.11 / 2
= 0.055 V

Or V = 0.028 × 2</td><td>M1
A1

M1</td><td>Note for student:
Extrapolate from reading above or below, or use VA = constant</td></tr>
</table>

		= 0.056 V Or VA = constant = 1.7×10^{-9} $V = 1.7 \times 10^{-9} / (0.032 \times 10^{-6})$ = 0.053 V	A1 M1 A1	
	(b)(i)	p.d. across XY = 0.50 V e.m.f. = 0.50 + 1.00 = 1.50 V Or I = 1.00 / 0.20 = 5.00 A $V = IR$ = 5.00 × (0.10 + 0.20) = 1.50 V	 M1 A1 M1 A1	Note for student: Effective resistance across XY is half of resistance of YZ using parallel resistance formula
	(ii)	The potential difference across YZ increases. The effective resistance across XY decreases. Hence, by potential divider principle, a higher proportion of the e.m.f. will be across YZ. Or Total effective resistance of whole circuit decreases, hence current flowing through YZ is higher.	B1 B1 B1	