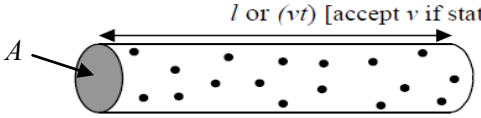
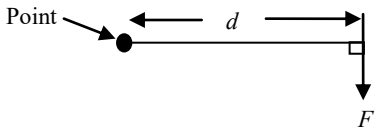
PH1

Question			Marking details	Marks Available
1	*(a)*	(i)	Horizontal velocity = $\frac{1.20}{0.60} = 2[.0\ \mathrm{m\,s^{-1}}]$	1
		(ii)	$0 = u^2 - 2 \times 9.81 \times 0.44$ [correct substitution into $v^2 = u^2 + 2ax$] (1) $u = 2.94\,[\mathrm{m\,s^{-1}}]$ (1) **or** $0 = u - 9.81 \times 0.30$ [correct substitution into $v = u + at$] (1) $u = 2.94\,[\mathrm{m\,s^{-1}}]$ (1) **[Other solutions possible]**	2
	(b)	(i)	$R = (4 + 8.64)^{1/2}$ (1) [**ecf** from (*a*)(i) and/or (*a*)(ii)] $R = 3.56\,[\mathrm{m\,s^{-1}}]$ (1)	2
		(ii)	$\theta = 55.8°$ **ecf**	1
	(c)	(i)	Force of gravity on earth due to grasshopper	1
		(ii)	$F = 3 \times 10^{-5} \times 9.81 = 2.9 \times 10^{-4}$ [N] Accept 0.3 m[N]	1
	(d)		←	1
			Question 1 Total	**[9]**
2	*(a)*		$\mathrm{V\,A^{-1}}$ and $\mathrm{W\,A^{-2}}$ 2 × (1)	2
	(b)	(i)	$V = 0.01 \times 450 = 4.5\,[\mathrm{V}]$	1
		(ii)	$12\,\mathrm{V} - 4.5\,\mathrm{V}$ [**ecf**] $= 7.5\,[\mathrm{V}]$	1
		(iii)	$R = \frac{7.5}{0.01}$ (1 for correct use of 7.5 or **ecf**) = 750 [Ω] (1) **or correct alternative**	2
		(iv)	$\frac{1}{750} = \frac{1}{900} + \frac{1}{R}$ (1) (substitution) $R_{\text{variable resistor}} = 4\,500\,[\Omega]$ (1) **Alternative solution to (iii) and (iv)** I through 900 Ω $= \frac{7.5}{900} = 0.0083\,[\mathrm{A}]$ (1) I through variable resistor $= 0.0017\,[\mathrm{A}]$ (1) $R_{\text{variable resistor}} = \frac{7.5}{0.0017} = 4\,500\,[\Omega]$ (1) Use of resistors in parallel formula to find total parallel resistance = 750 [Ω] (1)	2

Question			Marking details	Marks Available
	(c)		[No mark for stating circuit resistance decreases] Current in circuit increases (1) [accept explanation based on potential divider. Hence pd across 450 Ω increases (1) Hence pd across 900 Ω decreases (1**) this mark can't be awarded unless it is correctly substantiated** **Alternative solutions:** Resistance of parallel combination decreases (1) pd across parallel combination decreases (1) pd across 900 Ω decreases (1) OR current through the variable resistor increases (1) current through the 900 Ω decreases (1) pd across the 900 Ω decreases (1) **Question 2 total**	3 **[11]**

Question				Marking details	Marks Available
3	*(a)*	(i)		[Free] electrons forced to move by applied pd (Need a reference to drift velocity or electron flow but does not need to be explicitly stated) (1) They collide with atoms/nuclei/ions/lattice of the wire (1) don't accept particles or molecules	2
		(ii)		Power = $\frac{1.8}{60}$ = 0.03 [W] (1) $R = \frac{0.03(\text{ecf})}{1.6^2}$ = 0.0117 [Ω] (1) **Alternative solution possible** for the first 2 marks using $V = \frac{W}{Q}$ and $R = \frac{V}{I}$ $\rho = \frac{0.0117\text{x}2\text{x}10^{-6}}{0.4}$ (1) [**ecf** on R] = 5.9×10^{-8} [Ω m] (1)	4
	(b)	(i)		l or (vt) [accept v if stated dist travelled in 1 s]  [NB free electrons not required to be labelled] Number of free electrons = $nAvt$ [**or** nAl] (1) Total change = $nAvte$ [**or** $nAle$] (1) $I = \frac{nAvte}{t}$ with cancelling shown [or $\frac{nAle}{t}$, where $\frac{l}{t} = v$ shown] (1) Volume defined either from diagram [e.g. A and l labelled as shown] or in body of derivation [e.g. vol = Al] and n identified correctly– **for the first mark**	4
		(ii)		$1.6 = 6.4 \times 10^{28} \times 2 \times 10^{-6} \times v \times 1.6 \times 10^{-19}$ (1: substitution) $v = 7.8 \times 10^{-5}$ [m s^{-1}] (1)	2
		(iii)	(I) (II) (III)	**less than 1.6 A** identified/circled (1) **the same as** identified/circled (1) **half** identified/circled (1)	3
				Question 3 Total	**[15]**

Question			Marking details	Marks Available
4	*(a)*	(i)	Water bath or method of heating shown. Wire [coiled or uncoiled] shown (1). Voltmeter and ammeter and power supply correctly connected **or** ohmmeter only shown (1) Thermometer clearly identifiable. (1) Subtract 1 mark for poorly drawn diagrams. Method of cooling water to 0 °C not credited here.	3
		(ii)	Method of cooling water to 0 °C (1) [Can be credited from (i)] Resistance values taken [or V and I values taken and R calculated](1) ..at different temperatures [minimum 5 implied or implication that a number of temperatures considered] (1) Method to reduce experimental error/ ensure accuracy e.g. water stirred/ resistance of leads/heat slowly/remove heat to allow temperature to settle (1) Accept repeat the experiment again or obtain readings whilst cooling down or using a digital thermometer. Don't accept just repeat readings. Graph of R vs θ drawn (1)	5
	(b)	(i)	[-163 °C] is the temperature at which a sudden decrease in resistance occurs and the metal [alloy] (1) ...becomes a superconductor or resistance becomes zero (1)	2
		(ii)	Liquid nitrogen [Accept liquid helium, liquid oxygen, liquid hydrogen]	1
			Question 4 Total	**[11]**

Question				Marking details	Marks Available
5	*(a)*	(i)		$\text{power} = \frac{\text{work done or energy transferred}}{\text{time}}$ [Accept rate of doing work/ rate of energy transfer]	1
		(ii)		$\text{kg m s}^{-2} \times \text{m} \times \text{s}^{-1}$ (1) [Evidence of full correct methodology] $\text{kg m}^2\,\text{s}^{-3}$ (1)	2
	(b)	(i)		$E_p = 70 \times 9.81 \times 215$ (1) [= 147 641 J] $E_k = ½\,(70)(35)^2$ (1) [= 42 875 J] $E_{\text{lost}} = 147\,641 - 42\,875$ (1) [= 104 766](**ecf** on both E_p and E_k) $F = \frac{104766}{1600} = 65.5$ [N] (1) (**ecf** on E_{lost}) **Alternative solution:** using $v^2 = u^2 + 2ax$	4
		(ii)		$P = \frac{104766}{46}$ **ecf** (1) $= 2\,277\,\text{J s}^{-1}$ or W (1) **UNIT mark**	2
				Question 5 total	**[9]**
6	*(a)*			 (1) Moment = Fd (1) [award only if clear diagram shown] / if no right angle in diagram then **perpendicular** must be included in definition	2
	(b)	(i)		(F (sin 40°)(1) × 0.4) (1) = ((12 × 0.9) + (22 × 1.8)) (1) F = 196 [N] shown	3
		(ii)	(I)	Vertical component of force in strut = 126 [N] (1) Accept 128 [N] or 129 [N] if F = 200 N is used.	3
			(II)	Vertical **downward** arrow shown at hinge. (1)	
			(III)	Vertical force on bar due to hinge = 92 [N] (1) **ecf**	
				Question 6 Total	**[8]**

Question				Marking details	Marks Available
7	*(a)*	(i)		[Vector] distance between two locations measured along the shortest path joining them.	1
		(ii)	(I)	Time for outward journey = 7.5 hrs **and** homeward journey = 5 hrs calculated (1) Speed = $\frac{600}{12.5}$ (1) = 48 [km h^{-1}](1)	3
			(II)	0 km h^{-1} (1) displacement = 0 stated (1)	2
	(b)	(i)		Suitable tangent drawn (1) = 0.15 (accept range 0.12 to 0.18) (1) $\Sigma F = 1.2 \times 10^6 \times 0.15 = 180$[kN] (1) [**ecf** on gradient value] ΣF range = 144 kN to 216 kN	3
		(ii)		Line (or time axis) labelled at $\geq$ 92 or 94 seconds	1
		(iii)		Constant speed (1) Driving force balanced [equal to] resistive forces (1) [Do not accept $\Sigma F = 0$]	2
	(c)	(i)	(I)	$F = \frac{Wx}{t}$ and $\frac{x}{t}$ shown to be = v	1
			(II)	v (from graph) = 17.2 m s^{-1} (1) $F = \frac{4.5\text{x}10^6}{17.2}$ = 262[kN] (1)	2
		(ii)		180 000 = 262 000 – F_{drag} (1) [**ecf** on both forces] F_{drag} = 82 [kN] (1)	2
				Question 7 Total	**[17]**