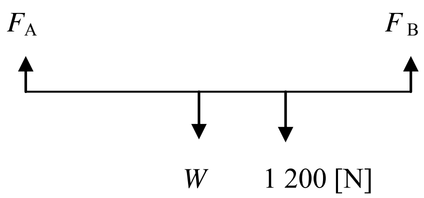
Question			Marking details	Marks Available
1	*(a)*	(i)	Energy cannot be created or destroyed; it can only change from one form to another. Don't accept can only be conserved.	[1]
		(ii)	$E_p \rightarrow E_k$ (1) can be implied Some energy lost as heat **or** due to air resistance **or** due to friction with air - general statement (1) Air molecules gain E_k and/or molecules of object gain E_k - **specific** statement (1)	[3]
	(b)	(i)	*mgh* calculated correctly = 376.7 [J] (1) accept *g* as 9.8 or 9.81 but not 10 $\frac{1}{2} mv^2$ calculated correctly = 288 [J] (1) $E_p - E_k$ = 88.7 [J] [**ecf** from calculated values of E_p and/or E_k] (1)	[3]
		(ii)	Correct substitution into $W = Fd$ i.e. 88.7 (**ecf**) = $F \times 4.0$ (1) F = 22[.2 N] (1) If either E_p or E_k substituted in for *W* then award 1 mark only **Alternative Solution:** Force down slope = $16 \times 9.81 \times \frac{2.4}{4}$ [$F = mg\sin\theta$] = 94.2 [N] Resultant Force $\Sigma F = 16 \times \left(\frac{6^2}{8}\right) = 72$ [N] Mean Frictional Force = 94.2 – 72 = 22[.2 N] Award 1 mark for **either** force values correct (or both) Award 2 marks for correct solution	[2]
			Question 1 total	**[9]**
2	*(a)*	(i)	Force α extension [provided elastic limit is not exceeded] Accept *F* α *x* but *x* must be defined	[1]
		(ii)	4.0 [cm]	[1]
	(b)		*F* (from graph) = 0.6 [N] (1) Correct application of $a = \frac{\sum F}{m}$ i.e $\frac{0.6}{0.4} = 1.5\ \text{m s}^{-2}$ (1) **UNIT mark** (**ecf** on *F*)	[2]
	(c)	(i)	substitution into $\frac{1}{2} Fx$ (**or** area under graph **or** $\frac{1}{2} kx^2$) (1) **ecf** on *F* $E_{\text{spring}} = 3.6 \times 10^{-2}$ [J] (1)	[2]
		(ii)	$E_{\text{spring}} = 0$ [J] (1) $\Sigma F = 0$ **or** acceleration = 0 so extension = 0 (1)	[2]
	(d)		New extension = ½ × original (1) Force in each spring = ½ × original **or** spring constant of system = 2 × original **or** energy in each spring = ¼ × original (1) Total energy (in both springs) = ½ × original (1) Accept algebraic equivalents	[3]
			Question 2 total	**[11]**

Question			Marking details	Marks Available
3	*(a)*	(i)	J s^{-1}	
		(ii)	V A^{-1}	[3×1]
		(iii)	A s	
	(b)	(i)	$t = 2 \times 3\,600$ or $7\,200$ s (1) $Q = 0.15 \times 7\,200 = 1\,080$ [C] (1)	[2]
		(ii)	$\frac{6480}{1080} = 6$ [V] (**ecf** on *Q*)	[1]
		(iii)	$\frac{5832}{1080} = 5.4$ [V] (**ecf** on *Q*)	[1]
		(iv)	6 - 5.4 = 0.6 [V] (1) (**ecf** from *(b)*(ii) & (iii)) $\frac{0.6}{0.15} = 4$ [Ω] (1) (**ecf** on 0.6 [V]) **Or** Correct substitution into $V=E - Ir$ (i.e. $5.4 = 6.0 - 0.15r$) (1) $r = 4$ [Ω] (1) (**ecf** from *(b)*(ii) & (iii)) **Alternative Solution:** $\frac{(6480-5832)}{7200} = 0.09$ J s^{-1} (Lost energy in cell per second) (1) $I^2r = 0.09$ and $r = 4$ [Ω] (1)	[2]
			Question 3 Total	**[9]**

Question			Marking details	Marks Available
4	*(a)*		Electrical energy (**or** work done) transferred [to other forms passing] between two points (1) per coulomb of charge (1) Definition of 1 V award 1 mark only	[2]
	(b)	(i)	$V_{supply} = V_1+V_2+V_3$	[1]
		(ii)	Energy	[1]
	(c)	(i)	$R_1+12 = \frac{9}{0.5}$ (1) Clear manipulation seen to show $R_1=6\,[\Omega]$ (1)	[2]
		(ii) (I)	$\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$ to show effective parallel combination = 6 Ω (1) this can be implied V across upper 6 Ω resistor shown = 4.5 [V] (**ecf** on parallel combination) (1)	[2]
		(II)	Total resistance = 12 Ω (1) $I = \frac{9.0}{12} = 0.75\,[\text{A}]$ (1) (accept $\frac{4.5}{6} = 0.75$ [A])	[2]
		(III)	$1.2 = \frac{9}{(6+R_{parallel})}$ (1) $R_{parallel} = 1.5\,[\Omega]$ (1) $n \times (\frac{1}{12}) = \frac{1}{1.5}$ (1) **ecf** on 1.5 [Ω] $n = 8$ (1) Full marks for correct answer based on trial and error **Alternative solution:** $\frac{9}{1.2} = 7.5$ [Ω] (1) $7.5 - 6 = 1.5$ [Ω] (1) $\frac{12}{n} = 1.5$ [Ω] (1) $n = 8$ (1)	[4]
			Question 4 Total	**[14]**

Question			Marking details	Marks Available
5	*(a)*	(i)	Ruler and wire shown and labelled (1) Moving pointer **or** jockey **or** crocodile clip indicated (1) **Either**: Correctly positioned ohmmeter with no power supply; **or** correctly positioned voltmeter and ammeter with power supply (1) [No labelling required for either method].	[3]
		(ii)	Diagonal line through origin	[1]
		(iii)	CSA from <u>diameter of wire</u> (1) Gradient from graph = (R/l) **or** (ρ/A) **Or** stated take a pair of R and l values from the graph (1) ρ = gradient × CSA **or** use of $\rho = RA/l$ (1)	[3]
	(b)	(i)	$R = \frac{144}{32} = 4.5\,[\Omega]$ (1) Correct substitution into $R = \rho l/A$ (1) $l = 0.375$ [m] (1) (**ecf** on R)	[3]
		(ii)	$I = 2.7$ [A] (from V/R **or** P/V etc) (1) (**ecf** on I) Correct substitution into $I = nAve$ (1) $v = 1.24 \times 10^{-2}$ [m s^{-1}] (1) accept 0.01 m s^{-1}	[3]
			Question 5 Total	**[13]**

Question			Marking details	Marks Available
6	*(a)*	(i)	Acceleration defined as rate of change of <u>velocity</u> [**or** equivalent] **or** $a = \frac{(v-u)}{t}$ (1) <u>Clear manipulation</u> to show that $v=u+at$ (1)	[2]
		(ii)	$v=u+at$ substituted into $x = (u+v)t/2$ (1) <u>Clear manipulation</u> shown (1)	[2]
	(b)	(i)	A (1) Horizontal velocity (= 65 m s^{-1}) constant **or** same speed as plane **or** sack lands directly underneath plane (1) Vertical velocity increases **or** there is a vertical acceleration (1)	[3]
		(ii) (I)	Substitution into $v^2=u^2+2ax$ **and** $u = 0$ shown (1) x calculated= 45.9 [m] (1)	[2]
		(II)	Correct substitution into $v = at$ **or** $x=1/2at^2$ ***or*** $x=\frac{(u+v)t}{2}$ (1) t=3.1 [s] (1)	[2]
		(iii)	$v_R{}^2= (65^2 + 30^2)$ (correct substitution into Pythagoras) (1) v_R = 71.6 [m s^{-1}] (1) Valid angle calculated <u>and shown</u> **or** described e.g. θ = 24.8° below horizontal (1)	[3]
			Question 6 Total	**[14]**
7	*(a)*		Replace *mass* with *force* (1) Don't accept weight Introduce *<u>perpendicular</u> distance <u>to pivot</u>* (1)	[2]
	(b)		(2 × 700) – 1 200 (1) Weight of beam = 200 [N] (1) **Alternative solution:** Moment about A or B e.g. (700 × 5) = (1 200 + *W*) × 2.5	[2]
	(c)	(i)	 Upward forces as shown and indicated (1) Downward forces as shown and indicated (1) N.B. 1 200 [N] force can be indicated anywhere between *W* and F_B	[2]
		(ii)	Taking moments about A: F_B × 5.0 (1) (1 200 × 3.5) + (200 × 2.5) (1) (**ecf** on 200) F_B = 940 [N] (1)	[3]
		(iii)	1 400 – 940 = 460 [N] (**ecf** from (*b*) and/or (*c*)(ii)) Accept answer based on moments calculated about B.	[1]
			Question 7 Total	**[10]**