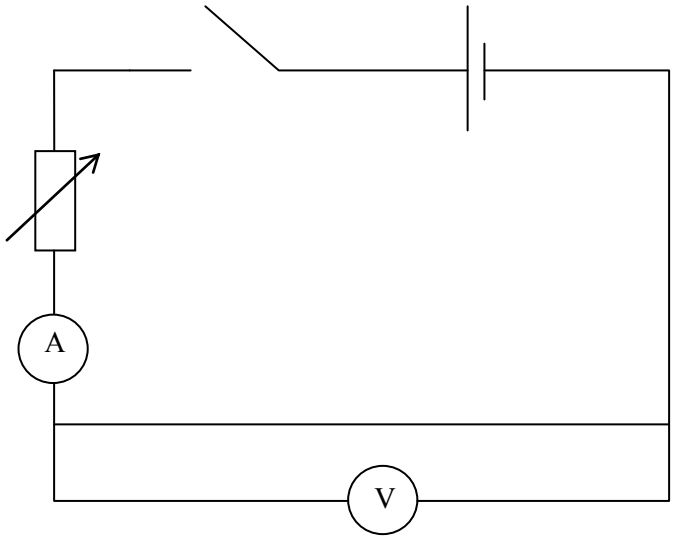
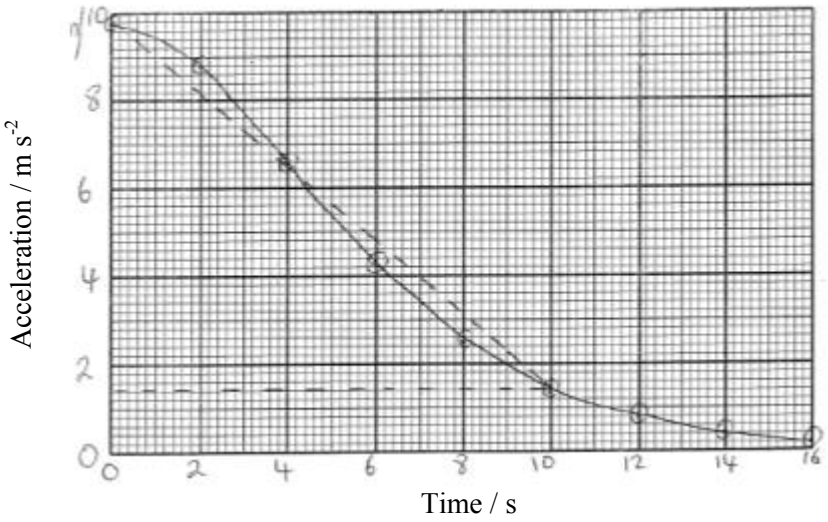
Question			Marking details	Marks Available
4	*(a)*		All 4 positions considered, 2 relevant statements per position At start (A) E_{Grav} – max E_k – zero $E_{Elastic}$ – zero (1) Free fall, Cord slack(B) E_{Grav} – decreasing E_k – increasing $E_{Elastic}$ – zero (1) Cord stretching (C) E_{Grav} – decreasing E_k – increasing or decreasing $E_{Elastic}$ – increasing (1) At lowest point (D) E_{Grav} – minimum (accept zero if explained) E_k – zero $E_{Elastic}$ – maximum (1) 5th mark available for other general comment e.g. Some of initial energy lost due to air resistance / rope gets hot (1) Don't accept statement of the conservation of energy on its own.	5
	(b)	(i)	$E_{p\ loss}$ = 70 x 9.8[1] x 130 (1) substitution (not g = 10 m s^{-2}) = 89 271 [J] (1) (accept 89 300 or 89 000)	2
		(ii)	89271 = ½ k (50)^2 (2) [1 mark for $E_{p\ loss}=\frac{1}{2}kx^2$; 1 mark for 50 [m]] k = 71.4 [N m^{-1}] (1) ecf from (b)(i)	3
		(iii)	$mg = kx$ (1) $= \frac{70 \times 9.81}{71.4}$ = 9.6 [m] (1) ecf on k from (b)(ii) N.B. Only penalise once for use of g = 10 m s^{-2}	2
			Question 4 total	[12]

Question			Marking details	Marks Available
5	*(a)*	(i)	$v_H = 16 \cos 40°$ (1) = 12.3 [m s^{-1}]	
			$v_V = 16 \sin 40°$ (1) = 10.3 [m s^{-1}]	2
		(ii)	Horizontal: constant velocity Vertical: acceleration / changing (both statements required)	1
	(b)	(i)	$0 = 10.3 - 1.6\,t$ (1) ecf from (a)(i) penalise only once for use of 9.8 m s^{-2}	
			t = 6.4 [s] (1)	
			t_{flight} = 12.8 [s] (1) ecf between 2nd and 3rd marks Or any other alternative method used to gain correct answer = 3 marks	3
		(ii)	D_H = 12.3 x 12.8 = 157 [m] ecf from (b)(i)	1
		(iii)	$0 = (10.3)^2 - 2 \times 1.6\ s$ (1) ecf from (a)(i)	
			S = 33.2[m] (1)	2
	(c)		Air resistance on Earth (1)	
			g on Earth different (accept greater) than on the Moon (1)	2
			Question 5 Total	[11]

Question			Marking details	Marks Available
6	*(a)*	(i)	 Circuit (without voltmeter and ammeter) (1) Voltmeter and Ammeter correctly positioned (1)	2
		(ii)	$R = \frac{10}{0.9}$ = 11.11 [Ω] (1) $A = 3.14\text{x}10^{-8}$ [m^2] (1) $\rho = \frac{11.11 \text{ x } 3.14\text{x}10^{-8}}{3.2}$ (1) substitution $\rho = 1.09\text{x}10^{-7}$ [Ω m] (1) ecf for R and A	4
		(iii)	Platinum and Tin	1
	(b)		$\rho = \frac{0.74\text{x}10^{-3}}{(3.14\text{x}10^{-8} \text{ x } 3.2)(1)} = 7365$ [kg m^{-3}] (1) ecf for A Tin (1) ecf from density value	3
			Question 6 Total	[10]

Question			Marking details	Marks Available
7	*(a)*		$F \rightarrow$ kg m s^{-2} (1) $\rho \rightarrow$ kg m^{-3} (1), $v^2 \rightarrow m^2 s^{-2}$ (1) Correct manipulation / cancelling seen $\rightarrow m^2$ (1)	4
	(b)	(i)	Correct statement of Newton's 3rd Law	1
		(ii)	• <u>May</u> not have same magnitude • Forces act on same object • Forces not of same type (e.g. not two '*g*' forces or contact forces) Don't accept : They are not equal unless qualified Only one statement required.	1
	(c)	(i)	60 x 9.8 = 588 N unit mark	1
		(ii)	$F_{res} = W - F_{drag}$ implied in any correct form (1) F_{drag} = 588 –[(60 x 1.4) (1)] ecf from (c)(i) F_{drag} = 504 [N] (1)	3

Question			Marking details	Marks Available
	(d)	(i)		
			Axes labelled with units (1); Points plotted correctly to within ±½ square division (1); Line (1)	3
		(ii)	Area attempted (1)	
			(1.4 x 10) + (½ x 10 x [9.8-14])	
			14 + 42 = 56 [m s^{-1}] (1) (accept range 52 – 60)	2
		(iii)	$504 = \frac{1.2 \times D \times 56^2}{2}$ substitution (1) allow ecf on F_{drag} and v	
			D = 0.27 [m^2] (1) (accept range 0.23 – 0.31)	2
			Question 7 total	[17]

Question			Marking details	Marks Available
8	*(a)*	(i)	= 5.4 [± 0.2] [day] (1)	
			P = 0.70 [± 0.1] x10^{30} [W] (1) ecf	2
		(ii)	$I = \frac{P}{4\pi r^2}$ (1) [or equivalent, or by implication]	
			r = 2.6x10^{20} [m] (1) ecf	2
			[1 mark only lost if factor of 4 omitted]	
	(b)	(i)	λ_{peak} = 450 n[m] (1) [±10 nm]	
			T = 6400 [K] (1) [ecf on λ_{peak}]	2
		(ii)	$A = \frac{P}{\alpha T^4}$ (1) [transposition at any stage]	
			= 10 x 10^{21} [m^2] (1) [or by implication] ecf on T	
			$r = \sqrt{\frac{A}{4\pi}}$ (1) [= 2.8 x 10^{10} [m]] [or by implication]	
			d = 5.6 x 10^{10} [m] (1) ecf (missing factor of 4 loses 1 mark)	4
			Question 8 Total	[10]

Question			Marking details	Marks Available
9	*(a)*	(i)	e^- : +1 e^+ : -1 (1) γ : 0 (1)	2
		(ii)	electromagnetic : γ involvement (1) both	1
	(b)		π^- (1) because either charge of x = -e [accept -1] and x must be a hadron / can't be a lepton Or u number = 0 - 1 = -1, d number = 0- (-1) = 1 or equivalent (1)	2
	(c)	(i)	e^+ or positron	1
		(ii)	Weak	1
	(d)		π^- [accept μ or $\bar{u}d$] → $e^- + \bar{\nu}_e$ (accept $+ \bar{\nu}$) [In fact, π^- → $\mu^- + \bar{\nu}_\mu$ much more likely]	1
			Question 8 Total	[8]

Solids under stress

a) YM is a value of the material regardless of shape or quantity.
   Useful when comparing materials
   When given YM, can then calculate the shape/amount needed for my project
   YM=stress/strain
   Can then calculate suitable loads/forces/contact area/how far the material will stretch under a certain load
b) Crystalline – long range order (or semi long for polysrystalline): metal/diamond
   Amorphous – no long range order : ceramic/fast cooled materials
   Polymeric – short range order due to repeated units of chains of molecules : plastics/polythene

Stars

Absorption spectra (gaps/dark lines in the spectra)

The starlight is absorbed at certain wavelengths/energies/frequencies

By the gas/dust

And re-emitted in all directions

Can learn:

What elements are present in the cloud

Redshift of the star

By comparing with lab data

Velocity of the star

Using redshift equation

Distance of the star

Using hubble law.