Question	Answer	Marks
1(a)	rate of change of velocity	**B1**
1(b)(i)	$s = ut + ½at^2$ **and** $u = 0$ or $s = ½at^2$ $t = \sqrt{(2 \times 14 / 9.81)}$	**C1**
	$t = 1.7$ s	**A1**
	OR $v = \sqrt{(0^2 + 2 \times 9.81 \times 14)}$ $v = 17$ (m s^{-1}) $17 = (0 + 9.81) \times t$ **or** $17 = 9.81 \times t$ or $14 = ½ \times (0 + 17) \times t$ **or** $14 = ½ \times 17 \times t$	**(C1)**
	$t = 1.7$ s	**(A1)**
1(b)(ii)	$s = ut + ½at^2$ $u = (3.6 – ½ \times 9.81 \times 1.7^2) / 1.7$	**C1**
	$u = (–)\ 6.2$ m s^{-1}	**A1**
	OR $v = (3.6 + ½ \times 9.81 \times 1.7^2) / 1.7$ $v = 10$ (m s^{-1}) $10 = u + 9.81 \times 1.7$ or $10^2 = u^2 + (2 \times 9.81 \times 3.6)$ or $3.6 = ½ \times (u + 10) \times 1.7$	**(C1)**
	$u = (−)\ 6.2$ m s^{-1}	**(A1)**

Question	Answer	Marks
1(c)(i)	Less time (as it reaches a lower height)	**B1**
	(because) the initial <u>vertical</u> (component of the) velocity is smaller (than in part **(b)**)	**B1**
1(c)(ii)	The (total) initial energy is the same (as in part **(b)**)	**B1**
	change in gravitational potential energy is same, so speed is the same	**B1**

Question	Answer	Marks
2(a)	in (rotational) equilibrium	**B1**
	<u>sum / total</u> of clockwise moments about a point = <u>sum / total</u> of anticlockwise moments about the (same) point.	**B1**
2(b)	$80 \times 9.81 \times 3$ **or** $60 \times 9.81 \times 3$ **or** $45 \times 9.81 \times x$	**C1**
	$80 \times 9.81 \times 3 = (60 \times 9.81 \times 3) + (45 \times 9.81 \times x)$	**C1**
	$x = 1.3$ m	**A1**
2(c)(i)	$k = F / x$	**C1**
	$x = 0.80 - 0.59$ $= 0.21$ m	**C1**
	$k = (60 \times 9.81) / 0.21$ $= 2800\ \text{N m}^{-1}$	**A1**

Question	Answer	Marks
2(c)(ii)	$E = ½ kx^2$ **or** $E = ½ Fx$ **or** $E = ½ F^2/k$ $= ½ \times 2800 \times 0.21^2$ or $= ½ \times 60 \times 9.81 \times 0.21$ or $= ½ \times (60 \times 9.81)^2 / 2800$	**C1**
	= 62 J	**A1**

Question	Answer	Marks
3(a)	work done per unit time	**B1**
3(b)(i)	$P = F \times v$ $= 1750 \times 35$	**C1**
	$= 6.1 \times 10^4$ W	**A1**
3(b)(ii)	$W = Fs$ $= 1750 \times 17\,000$	**C1**
	$= 3.0 \times 10^7$ J	**A1**
	or $W = Pt$ $= 6.1 \times 10^4 \times (17\,000 / 35)$	**(C1)**
	$= 3.0 \times 10^7$ J	**(A1)**

Question	Answer	Marks
3(b)(iii)	$P = V \times I$ Power in = $600 \times I$	**C1**
	Efficiency = $\dfrac{\underline{\text{useful}}\text{ power output}}{\text{(total) power input}}$	**C1**
	$0.85 = 6.1 \times 10^4 / (600 \times I)$ I = 120 A	**A1**
3(c)(i)	Air resistance is the same, as the speed is the same	**B1**
3(c)(ii)	The motor is producing less power (because of gravitational force / conversion of gravitational potential energy to kinetic energy) so the current will be smaller.	**B1**

Question	Answer	Marks
4(a)	(when two or more) waves meet / overlap (at a point)	**B1**
	(resultant) displacement is sum of the individual displacements	**B1**
4(b)(i)	Fringe width, $x = 3.2 \times 10^{-2} / 8$ $= 4.0 \times 10^{-3}$ (m)	**C1**
	$D = ax / \lambda$ $= (4.0 \times 10^{-3} \times 0.16 \times 10^{-3}) / 7.2 \times 10^{-7}$	**C1**
	= 0.89 m	**A1**

Question	Answer	Marks
4(b)(ii)	Curved line with a negative gradient of decreasing magnitude throughout, from slit separation 0.04 mm to 0.16 mm	**B1**
	Line of negative gradient ending at (0.16, 0.4), from slit separation 0.04 mm	**B1**
	Line of negative gradient passing through (0.08, 0.8) <u>and</u> (0.04, 1.6)	**B1**

Question	Answer	Marks
5(a)	wavelength: • wavelength = distance between successive / adjacent in phase points / wavefronts / crests / troughs • $\lambda = d$ / (number of) oscillations frequency: • frequency = (number of) oscillations / cycles crests / troughs / wavefronts (passing a point) per unit time • f = (number of) oscillations / t One correct point from **either** list	**B1**
	One correct point from **both** lists **and** speed = distance / time **and** one of: • wavelength × frequency (= distance per unit time) = speed • [(number of) oscillations / t] × [d / (number of) oscillations] = $f\lambda$ • v (= d / t) = λ / (1/f) = $f\lambda$ or v (= d / t) = λ / T = $f\lambda$	**B1**
5(b)(i)	$T = 4 \times 10^{-3}$ $f = 1 / T = 1 / 0.004$	**C1**
	$f = 250$ Hz	**A1**

Question	Answer	Marks
5(b)(ii)	$f_o = f_s\, v / (v - v_s)$ $250 = 236 \times v / (v - 20)$ $v = (250 \times 20) / (250 - 236)$	C1
	$= 360\ \mathrm{m\,s^{-1}}$	A1

Question	Answer	Marks
6(a)(i)	$I = 1.3 / 1.1$ $= 1.2\ \mathrm{A}$	A1
6(a)(ii)	$v = I / nqA$ $= 1.2 / (8.5 \times 10^{28} \times 1.60 \times 10^{-19} \times 4.7 \times 10^{-7})$	C1
	$= 1.9 \times 10^{-4}\ \mathrm{m\,s^{-1}}$	A1
6(a)(iii)	$\rho = RA / L$	C1
	$= (1.1 \times 4.7 \times 10^{-7}) / 0.45$	C1
	$= 1.1 \times 10^{-6}\ \Omega\,\mathrm{m}$	A1
6(b)(i)	(Total) resistance decreases (and the potential difference stays the same)	M1
	(so the reading on the ammeter) increases	A1
6(b)(ii)	(The average drift speed will be) the same because the current is the same (in X).	B1

<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td rowspan="3">7(a)</td><td>$^{12}_{7}N \rightarrow {}^{12}_{6}C + {}^{0}_{1}\beta^{+} + {}^{(0)}_{(0)}\nu$

beta-plus shown</td><td>B1</td></tr>
<tr><td>neutrino shown</td><td>B1</td></tr>
<tr><td>symbols, nucleon numbers and proton numbers all correct</td><td>B1</td></tr>
<tr><td>7(b)(i)</td><td>+1</td><td>B1</td></tr>
<tr><td>7(b)(ii)</td><td>Lepton(s)</td><td>B1</td></tr>
<tr><td rowspan="4">7(b)(iii)</td><td><table><tr><th>flavour</th><th>charge / e</th></tr><tr><td>up / u</td><td>$-\frac{2}{3}$</td></tr><tr><td>up / u</td><td>$-\frac{2}{3}$</td></tr><tr><td>down / d</td><td>$(+)\frac{1}{3}$</td></tr></table></td><td></td></tr>
<tr><td>3 correct quark flavours</td><td>B1</td></tr>
<tr><td>Charge on anti-up quark $-\frac{2}{3}(e)$</td><td>B1</td></tr>
<tr><td>Charge on anti-down quark $(+)\frac{1}{3}(e)$</td><td>B1</td></tr>
</table>

