^	Indicates where more is needed for a mark to be awarded (what is written is not wrong, but not enough). May also be used to annotate a response space that has been left completely blank.
SEEN	Indicates that a page has been seen.

Question	Answer	Marks
1(a)	(work =) force × displacement	**C1**
	units: kg m s^{-2} × m = kg m^2 s^{-2}	**A1**
1(b)(i)	units of *Q*: As	**C1**
	units of *C*: kg^{-1} m^{-2} A^2 s^4	**A1**
1(b)(ii)	**1.** e.g. reading scale from different angles (wrongly) interpolating between scale readings/divisions	**B1**
	2. e.g. zero error wrongly calibrated scale	**B1**

Question	Answer	Marks
2(a)	(resultant) force proportional to rate of change of momentum	**B1**
2(b)(i)	arrow drawn vertically downwards from point X	**B1**
2(b)(ii)	$s = ut + \frac{1}{2}at^2$ $h = \frac{1}{2} \times 9.81 \times 0.81^2$	**C1**
	$= 3.2$ m	**A1**
2(b)(iii)	$d = 5.4 \times 0.81$ $= 4.4$ m	**A1**
2(c)(i)	downward pointing arrow labelled weight	**B1**
	upward pointing arrow labelled air resistance	**B1**
2(c)(ii)	air resistance increases	**B1**
	weight constant **or** resultant force decreases	**B1**
	(so) acceleration decreases	**B1**
2(c)(iii)	gravitational potential energy to thermal/internal energy	**B1**

Question	Answer	Marks
3(a)	resultant force (in any direction) is zero	**B1**
	resultant torque/moment (about any point) is zero	**B1**
3(b)(i)	**1.** $T \sin 53° = 2.4$ $T = 3.0$ N	**A1**
	2. $F = T \cos 53°$ **or** $F^2 = T^2 - 2.4^2$ $F = 1.8$ N	**A1**
3(b)(ii)	$\sigma = T / A$ **or** $\sigma = F / A$	**C1**
	$A = \pi d^2 / 4$ **or** $A = \pi r^2$	**C1**
	$\sigma = 3.0 \times 4 / [\pi \times (0.50 \times 10^{-3})^2]$ $= 1.5 \times 10^7$ Pa	**A1**
3(c)(i)	$h = 75 - 75 \sin 53° = 15$ cm	**A1**
3(c)(ii)	$(\Delta)E = mg(\Delta)h$ **or** $(\Delta)E = W(\Delta)h$	**C1**
	$(\Delta)E = 2.4 \times 15 \times 10^{-2}$ $= 0.36$ J	**A1**
3(c)(iii)	$E = ½mv^2$	**B1**
	$0.36 = ½ \times (2.4 / 9.81) \times v^2$	**C1**
	$v = 1.7$ m s^{-1}	**A1**

Question	Answer	Marks
4(a)(i)	vibrations (of particles) are parallel to direction of energy propagation	**B1**
4(a)(ii)	waves meet/overlap (at a point)	**B1**
	(resultant) displacement is sum of individual displacements	**B1**
4(b)(i)	$\lambda = ax / D$	**C1**
	$= (3.7 \times 10^{-4} \times 4.3 \times 10^{-3}) / 2.3$	**C1**
	$= 6.9 \times 10^{-7}$ (m) = 690 nm	**A1**
4(b)(ii)	• no change to fringe separation/fringe width/number of fringes • bright fringes are darker • dark fringes are brighter *Any two marking points, 1 mark each*	**B2**

Question	Answer	Marks
5(a)(i)	$R = \rho L / A$	**C1**
	$A = (2.6 \times 10^{-8} \times 59) / 3.4 = 4.5 \times 10^{-7}$ m^2	**A1**
5(a)(ii)	I = 1.8 / 3.4 = 0.53 A	**A1**
5(a)(iii)	$I = Anvq$ v = 0.53 / $(4.5 \times 10^{-7} \times 6.1 \times 10^{28} \times 1.60 \times 10^{-19})$	**C1**
	= 1.2×10^{-4} m s^{-1}	**A1**
5(b)(i)	(cross-sectional) area/A is less	**M1**
	(I, n, e the same so) average drift speed is greater	**A1**
5(b)(ii)	(area is less so) more resistance/R	**M1**
	(I is the same, so) more power/P	**A1**
	or	
	($P = I^2\rho L / A$ so) $P \propto 1 / A$	**(M1)**
	(A is less so) more P	**(A1)**
5(c)(i)	180 Ω and 90 Ω resistors shown connected in parallel	**B1**
5(c)(ii)	resistors connected in parallel labelled as 180 Ω and 90 Ω **and** the other resistor labelled as 30 Ω	**M1**
	V_{OUT} or 8.0 V labelled across the two resistors in parallel	**A1**

Question	Answer	Marks
6(a)(i)	$E = \Delta V / \Delta d$	**C1**
	$E = (180 + 120) / (2.0 \times 10^{-2})$ $= 1.5 \times 10^{4}$ N C^{-1}	**A1**
6(a)(ii)	vertically downwards	**B1**
6(b)(i)	number of protons = 92	**A1**
	number of neutrons = 146	**A1**
	number of electrons = 90	**A1**
6(b)(ii)	$F = EQ$	**C1**
	$= 1.5 \times 10^{4} \times 2 \times 1.60 \times 10^{-19}$ $= 4.8 \times 10^{-15}$ N	**A1**
6(b)(iii)	number of α-particles = 2	**A1**
	number of β^- particles = 2	**A1**

