

^	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)	(velocity =) change in displacement / time (taken)	**B1**
1(b)	units of F: kg m s^{-2}	**C1**
	units of k: kg m s^{-2} / [$m^2 \times (m\ s^{-1})^2$] = kg m^{-3}	**A1**
1(c)	$P = Fv$	**C1**
	$4.8 \times 10^4 = 0.24 \times 5.1 \times v^3$	**C1**
	v = 34 m s^{-1}	**A1**

Question	Answer	Marks
2(a)(i)	area = $ut + \frac{1}{2}(v - u)t$ **or** area = $vt - \frac{1}{2}(v - u)t$ **or** area = $\frac{1}{2}(u + v)t$	**A1**
2(a)(ii)	displacement	**A1**
2(b)(i)	u = 15 sin 60° (= 13 m s^{-1})	**C1**
	t = 15 sin 60° / 9.81	**C1**
	= 1.3 s	**A1**
2(b)(ii)	the force in the horizontal direction is zero	**B1**
2(b)(iii)	(velocity =) 15 cos 60° = 7.5 (m s^{-1}) **or** (velocity =) 15 sin 30° = 7.5 (m s^{-1})	**A1**
2(c)(i)	$p = mv$ **or** 0.40×7.5 **or** 0.40×4.3	**C1**
	Δp = 0.40 (7.5 + 4.3) = 4.7 kg m s^{-1}	**A1**
2(c)(ii)	force = 4.7 / 0.12 **or** $0.40 \times [(7.5 + 4.3) / 0.12]$ = 39 N	**A1**

Question	Answer	Marks
3(a)	(work done =) force × displacement in direction of the force	**B1**
3(b)(i)	**1.** $(\Delta)E = mg(\Delta)h$	**C1**
	$= 0.42 \times 9.81 \times 78$ $= 320$ J	**A1**
	2. $E = \frac{1}{2}mv^2$	**C1**
	$(\Delta)E = \frac{1}{2} \times 0.42 \times 23^2$ $= 110$ J	**A1**
3(b)(ii)	work done = 320 – 110 (= 210 N)	**C1**
	average resistive force = 210 / 78 = 2.7 N	**A1**
3(c)	downward sloping line from (0, *g*) to a non-zero value on the time axis	**M1**
	line is curved with a gradient that becomes less negative **and** the line meets *t*-axis at time $t < T$	**A1**

Question	Answer	Marks
4(a)	progressive waves transfer energy **or** stationary waves do not transfer energy	**B1**
4(b)(i)	0.32 m	**A1**
4(b)(ii)	$v = \lambda / T$ **or** $v = f\lambda$ **and** $f = 1 / T$	**C1**
	v = 0.32 / 0.020 **or** 50×0.32 = 16 m s^{-1}	**A1**
4(b)(iii)	450° **or** 90°	**A1**
4(b)(iv)	(P has) maximum downward displacement at 0.005 s	**B1**
	returns to original position/point (at 0.010 s)	**B1**
4(c)(i)	(position where) zero amplitude	**B1**
4(c)(ii)	2	**A1**
4(c)(iii)	180°	**A1**
4(c)(iv)	string drawn between X and Y with one antinode midway along the string	**B1**

Question	Answer	Marks
5(a)	Hooke's (law)	**B1**
5(b)(i)	$\sigma = F / A$	**C1**
	$= 36 / (4.1 \times 10^{-7})$ $= 8.8 \times 10^{7}$ Pa	**A1**
5(b)(ii)	Young modulus = σ / ε **or** $F / A\varepsilon$	**C1**
	$\varepsilon = 8.8 \times 10^{7} / (1.7 \times 10^{11})$ $= 5.2 \times 10^{-4}$	**A1**
5(c)	$R = \rho L / A$	**C1**
	$\Delta R = \rho \Delta x / A$ $= 3.7 \times 10^{-7} \times 0.12 \times 10^{-3} / (4.1 \times 10^{-7})$	**C1**
	$= 1.1 \times 10^{-4}\ \Omega$	**A1**
5(d)	remove the force/F and wire returns to original length	**B1**

Question	Answer	Marks
6(a)(i)	energy is dissipated in the internal resistance/*r*	**B1**
6(a)(ii)	**1.** $I = Q / t$	**C1**
	= 750 / 1500 = 0.50 A	**A1**
	2. $V = W / Q$ **or** $V = W / It$	**C1**
	= 5700 / 750 **or** 5700 / (0.50 × 1500) = 7.6 V	**A1**
	or	
	$V = P / I$ **and** $P = W / t$	**(C1)**
	V = 3.8 / 0.50 = 7.6 V	**(A1)**
	3. r = (7.8 – 7.6) / 0.50	**C1**
	= 0.40 Ω	**A1**
6(b)(i)	90 Ω and 45 Ω resistors shown connected in parallel	**B1**
6(b)(ii)	the resistors connected in parallel labelled as 90 Ω and 45 Ω with the other resistor labelled as 20 Ω	**M1**
	V_{OUT} or 3.6 V labelled across the 20 Ω resistor	**A1**

Question	Answer	Marks
7(a)(i)	P = 0 **and** Q = 39	**A1**
	R = (+)1 **and** S = 20	**A1**
7(a)(ii)	weak (nuclear force/interaction)	**B1**
7(b)	charge of quark(s) = (+) 2*e* / 3	**B1**
	up/u (quarks)	**B1**