1 (i)		**M1**		For resolving forces in the x direction
	$15 + F\cos60^\circ = F\cos30^\circ$	**A1**		
	$F = 41.0$	**A1**	3	**AG** $F = 15(1 + \sqrt{3})$
(ii)	$[G = F(\sin30^\circ + \sin60^\circ)]$	**M1**		For resolving forces in the y direction
	$G = 56.0$	**A1**	2	Allow $15(2 + \sqrt{3})$
2 (i)	$[V^2 = (V - 10)^2 + 2g \times 35]$	**M1**		For using $v^2 = u^2 + 2gs$ to obtain an equation in V only **or** to obtain two equations in V and H and attempting to eliminate H
	$20V = 100 + 70g$	**A1**		
	$V = 40$	**A1**	3	
	Alternative for 2(i)			
(i)		**M1**		A complete method to find V by considering the final 35 m using $v = u + at$ and either $s = ut + \frac{1}{2}at^2$ or $s = (u + v)/2 \times t$
	$V = V - 10 + 10t \rightarrow t = 1$ and $35 = (V - 10) \times 1 + \frac{1}{2} \times 10 \times 1^2$ or $35 = (V - 10 + V)/2 \times 1$	**A1**		
	$V = 40$	**A1**	3	
(ii)	$[40^2 = 0^2 + 20H]$	**M1**		For using $v^2 = u^2 + 2gs$
	$H = 80$	**A1**	2	
3 (i)	$[a(t) = 0.00012t^2 - 0.012t + 0.288]$	**M1***		For attempting to differentiate $v(t)$
	$[a(t) = 0.00012(t^2 - 100t + 2400)$ $= 0.00012(t - 40)(t - 60) = 0]$	**dM1***		For setting $a(t) = 0$ and attempting to solve a three term quadratic
	$a(t) = 0$ when $t = 40$ and $t = 60$	**A1**	3	
(ii)	$[0.00001t^4 - 0.002t^3 + 0.144t^2]$	**M1†**		For attempting to integrate $v(t)$
	$[0.00001(100)^4 - 0.002(100)^3 + 0.144(100)^2]$	**dM1†**		Integration attempted using correct limits $t = 0$ to $t = 100$
	Displacement is 440 m	**A1**	3	

4		**M1**		For using $R = 2\cos45^o$ and $F = \mu R$
	Frictional force $= 0.4 \times 2 \cos 45$ $= 0.4\sqrt{2}$	**A1**		
	KE gain = $\frac{1}{2} \times 0.2 \times V_C^2$ and PE loss $= 0.2 \times g \times (2.5 + 2\sqrt{2})$	**B1**		
		M1		For using KE gain from A to C = PE loss from A to C – Work done by frictional force
	$0.1\ V_C^2 = (5 + 4\sqrt{2}) - 0.4\sqrt{2} \times 4$	**A1**		
	Speed at C is $9.16\,\text{ms}^{-1}$	**A1**	6	
First alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow V_B^2 = 50$	**B1**		
		M1		For using KE gain from B to C = PE loss from B to C – Work done by frictional force
	$0.1\ (V_C^2 - V_B^2) = 0.2 \times g \times (4 \div \sqrt{2}) - 0.4\sqrt{2} \times 4$	**A1**		
	Speed at C is $9.16\,\text{ms}^{-1}$	**A1**		
Second alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow V_B^2 = 50$	**B1**		
		M1		For using Newton's 2nd law to find acceleration along BC **and** using $v^2 = u^2 + 2as$ to find V_C
	$\sqrt{2} - 0.4\sqrt{2} = 0.2a \rightarrow a = 3\sqrt{2}\ \text{ms}^{-2}$ and $V_C^2 = V_B^2 + 2 \times 3\sqrt{2} \times 4$	**A1**		
	Speed at C is $9.16\,\text{ms}^{-1}$	**A1**		

5 (i)		**M1**		For applying Newton 2nd law to P **or** to Q **or** for applying N2 to the system
	$0.5g \times \frac{7}{25} - T = 0.5a$ $T - 0.1g = 0.1a$ $1.4 - 1 = 0.6a$	**A1**		Any two correct Allow sin 16.3 for 7/25
	For eliminating T and obtaining $a = \frac{2}{3}$ ms^{-2}	**B1**		
		M1		For substituting for a to find T
	Tension is 1.07 N	**A1**	5	Allow T = 16/15 N
(ii)	$[v^2 = 2 \times \left(\frac{2}{3}\right) \times 0.7]$	**M1**		For using $v^2 = u^2 + 2as$ to find the speed of the particles immediately before the string breaks
	$[2^2 = 2 \times \frac{2}{3} \times 0.7 + 2 \times 0.28g \times s]$	**M1**		For applying $v^2 = u^2 + 2as$ for the motion of P when the string is slack and s is the distance travelled by P after the break until it reaches the floor
	Length of string = 2.5 – s = 1.95 m	**A1**	3	Allow length = 41/21 m
6 (i)	$[0.195 \cos \theta = F]$	**M1**		For resolving forces horizontally
	$F = 0.195\cos 22.6 = 0.195 \times \frac{12}{13}$ $= 0.18 = \frac{9}{50}$	**A1**		
	$[R = 0.24 + 0.195 \sin \theta]$	**M1**		For resolving forces vertically
	$R = 0.24 + 0.195\sin 22.6 =$ $0.24 + 0.195 \times \frac{5}{13} = 0.315$ $= \frac{63}{200}$	**A1**		
		M1		For using $\mu = F/R$
	Coefficient μ = 4/7 or 0.571	**A1**	6	

(ii)	$R = 0.24 - 0.195\sin 22.6$ $= 0.24 - 0.195 \times \frac{5}{13}$ $= 0.165 = \frac{33}{200}$	B1		
		M1		For using Newton's second law for motion along the rod
	$0.195 \times \frac{12}{13} - \left(\frac{4}{7}\right) \times 0.165$ $= 0.024a$	A1		
	Acceleration is $3.57\,\text{ms}^{-2}$	A1	4	Allow acceleration = 25 / 7
7 (i)	[WD = 14000 × 25]	M1		For using $P = \text{WD} \div \Delta t$
	Work done is 350 kJ or 350 000 J	A1	2	
(ii)		M1		For using DF = P / v and Newton's 2nd law to find the speed of the car at A **or** at B
	$14000 / v_A - 235 = 1600 \times 0.5 \rightarrow$ $v_A = 13.53\ \text{ms}^{-1}$	A1		$v_A = 2800 / 207$
	$14000 / v_B - 235 = 1600 \times 0.25 \rightarrow$ $v_B = 22.05\ \text{ms}^{-1}$	A1		$v_B = 2800 / 127$
	[KE gain = $\frac{1}{2}\ 1600(22.05^2 - 13.53^2)$]	M1		For using KE gain $= \frac{1}{2}\ m(v_B^2 - v_A^2)$
	KE gain = 242.5 kJ or 242 500 J	A1	5	
(iii)		M1		For using WD by DF = KE gain + resistance × AB
	350 000 = 242 500 + 235 × AB	A1√		
	Distance AB is 457 m	A1	3	