Question	Answer	Marks	Guidance
1	[$P\cos\theta = 32\cos 20 - 17\sin 55$] [$P\sin\theta = 40 + 17\cos 55 - 32\sin 20$]	**M1**	Resolve forces horizontally or vertically 3 terms horizontally, 4 terms vertically
		A1	One correct
		A1	Both correct [$P\sin\theta = 38.8062$ $P\cos\theta = 16.1446$]
	$P = \sqrt{(17\cos 55 - 32\sin 20 + 40)^2 + (32\cos 20 - 17\cos 35)^2}$	**M1**	Either use Pythagoras to find P or use their value of θ to find P
	$\theta = \tan^{-1}\left[\dfrac{(17\cos 55 - 32\sin 20 + 40)}{(32\cos 20 - 17\cos 35)}\right]$	**M1**	Either use trigonometry to find θ or use their value of P to find θ [$\tan\theta = 2.4037$]
	$P = 42(.0)$ **and** $\theta = 67.4$	**A1**	
		6	

Question	Answer	Marks	Guidance
2	Possible equations include: $t = 0$ to $t = 5 \rightarrow 80 = 5u + 12.5a$ $t = 0$ to $t = 8 \rightarrow 160 = 8u + 32a$ $t = 5$ to $t = 8 \rightarrow 80 = 3(u + 5a) + 4.5a$ i.e. $80 = 3u + 19.5a$	**M1**	Use the equation $s = ut + ½at^2$ to set up one equation in u and a or using speeds as u (at $t = 0$), $u + 5a$ (at $t = 5$), $u + 8a$ (at $t = 8$) and then apply $s = ½ \times (u + v) \times t$
	$80 = 5u + ½ \times a \times 5^2 \rightarrow 5u + 12.5a = 80$	**A1**	One correct equation in a and u
	$160 = 8u + 0.5a \times 8^2 \rightarrow 8u + 32a = 160$	**A1**	Second correct equation in a and u
		M1	Attempt to solve a pair of valid simultaneous equations for a or u
	$a = \frac{8}{3}$	**A1**	Allow $a = 2.67$
	$u = \frac{28}{3}$	**A1**	Allow $u = 9.33$
		6	

Question	Answer	Marks	Guidance
3	$R = 13g \cos 22.6 = 13g \times (12/13)$, $[R = 120]$	**B1**	Resolve perpendicular to the plane
	$F = 0.3 \times 13g \cos 22.6$ $[F = 36]$	**M1**	Using $F = \mu R$
	$T = F + 13g \sin 22.6 = F + 13g \times (5/13)$, $[T = 86]$	**M1**	Apply Newton's second law parallel to the plane with $a = 0$
	WD = $T \times 2.5$ [= 86×2.5]	**M1**	WD = $T \times d$
	WD = 215 J	**A1**	
	Alternative method for question 3		
	$R = 13g \cos 22.6 = 13g \times (12/13)$, $[R = 120]$	**B1**	Resolve perpendicular to the plane
	$F = 0.3 \times 13g \cos 22.6$ $[F = 36]$	**M1**	Using $F = \mu R$
	PE gain = $13 \times g \times 2.5 \times (5/13)$ [= 125]	**M1**	Attempt PE gain. Allow sin 22.6 for 5/13
	[WD by $T = 13 \times g \times 2.5 \times (5/13) + F \times 2.5$]	**M1**	Using WD by T = PE gain + WD against F
	WD by T = 215 J	**A1**	
		5	

Question	Answer	Marks	Guidance
4	[$1200 - 350 - 1250 \times 10 \times 0.05 = 1250a$]	M1	Apply Newton's second law for motion up the hill
	[$a = 225/1250 = 0.18$]	A1	Correct Newton's law for motion up the hill
	[$1200 - 350 + 1250 \times 10 \times 0.05 = 1250a$]	M1	Apply Newton's second law for motion down the hill
	[$a = 1475/1250 = 1.18$]	A1	Correct Newton's law for motion down the hill
	Up the hill: $v^2 = 0 + 2 \times 0.18 \times 100$ Down the hill: $v^2 = 0 + 2 \times 1.18 \times 100$	M1	Use their a in the constant acceleration equations either to find v going up or going down the hill
	Up the hill: $v = 6\ \text{ms}^{-1}$	A1	
	Down the hill: $v = 15.4\ \text{ms}^{-1}$	A1	Allow $v = 2\sqrt{59}$
	Alternative method for question 4		
	[$1200 \times 100 = 350 \times 100 + 1250g \times 100 \times 0.05 + ½ \times 1250 \times v^2$]	M1	Attempt the work-energy equation for motion up the hill
		A1	Correct work-energy equation for motion up the hill
	[$1200 \times 100 + 1250g \times 100 \times 0.05 = 350 \times 100 + ½ \times 1250 \times v^2$]	M1	Attempt work-energy equation for motion down the hill
		A1	Correct work-energy equation for motion down the hill
		M1	Attempt to solve either energy equation to find either v going up the hill or v going down the hill
	Up the hill: $v = 6\ \text{ms}^{-1}$	A1	
	Down the hill: $v = 15.4\ \text{ms}^{-1}$	A1	Allow $v = 2\sqrt{59}$
		7	

Question	Answer	Marks	Guidance
5(i)	A: $4 - T = 0.4a$ B: $T - 2 = 0.2a$ System: $4 - 2 = (0.4 + 0.2)a$	**M1**	Apply Newton' second law to particle A (3 terms) or to particle B (3 terms) or to the system (4 terms implied)
		A1	Two correct equations
		M1	Either solve the system equation for a or solve two simultaneous equations for a or T or verify the given value of a by finding the same T value in both equations
	$a = \dfrac{10}{3}$, $T = \dfrac{8}{3}$	**A1**	Both correct **AG**
		4	
5(ii)		**M1**	Apply $v^2 = u^2 + 2as$ to particle A or particle B with $a = 10/3$
	$v^2 = 0 + 2 \times 10/3 \times 0.5$	**A1**	[$v = 1.83$ but not needed specifically]
	$0 = 10/3 - 2 \times 10 \times s$ [$s = \dfrac{1}{6}$]	**M1**	Apply $v^2 = u^2 + 2as$ to particle B to find s, the distance travelled by B after A has hit the ground
	Maximum height $= \dfrac{7}{6} = 1.17$ m	**A1**	Maximum height = 1/2 + 1/2 + 1/6 = 7/6 = 1.17
		4	

Question	Answer	Marks	Guidance
6	Case 1: DF = 36000/18 or Case 2: DF = 21000/12	**B1**	DF = P/v in either case
	$18A + B$ = DF [$36000/18 = 18A + B = 2000$]	**M1**	Use DF = resistance (case 1)
	$18A + B = 2000$ oe	**A1**	Correct equation, unsimplified
	$12A + B$ = DF + weight component [$21000/12 = 12A + B + 1000\,g \times 1/20$]	**M1**	Use DF = resistance + weight component (case 2)
	$12A + B = 1250$ oe	**A1**	Correct equation, unsimplified
		DM1	Solve two simultaneous equations in A and B only for A or B Dependent on both previous M1's
	$A = 125$, $B = -250$	**A1**	Both correct
		7	

Question	Answer	Marks	Guidance
7(i)	Straight line, reaching positive v-axis and positive t-axis (negative gradient)	**B1**	
	Quadratic (U shape, through (0,0) and cutting t-axis at $t < 5$)	**B1**	
	Fully correct graphs with correct labelling with $t = 3$, $t = 5$, $v = 10$, $v = 60$ seen	**B1**	
		3	
7(ii)	$s = \int(10 - 2t)\,dt = 10t - t^2\ (+ c)$ or use area of a triangle ½ × 10 × 5 [= 25]	**B1**	Use either integration to find s for Q or use a correct formula to find the area under the relevant triangle
		M1	Use integration to find the displacement for P
	$s = \int(6t^2 - 18t)\,dt = 2t^3 - 9t^2\ (+c)$	**A1**	Correct integration for P (unsimplified)
	$s(P) = \left[2t^3 - 9t^2\right]_0^5 = 25$ or solve $10t - t^2 = 2t^3 - 9t^2$	**B1**	**Either** evaluation of $s(P)$ at $t = 5$ and show that at $t = 5$, $s(P) = s(Q) = 25$ **or** show that $t = 5$ is a solution of the cubic by solving **or** verify $t = 5$ is a solution of the cubic by substitution.
		4	

Question	Answer	Marks	Guidance
7(iii)	Distance $PQ = \|s_P - s_Q\| = \pm(2t^3 - 8t^2 - 10t)$	**M1**	Find the distance between P and Q Allow either sign s_P and s_Q must have been found by integration
	Maximum s if $6t^2 - 16t - 10 = 0$	**M1**	Differentiate to obtain an equation in t and attempt to solve
	$t = 3.19$	**A1**	
	Maximum Distance $PQ = (-)48.4$ m	**A1**	
	Alternative method for question 7(iii)		
	$6t^2 - 18t = 10 - 2t$	**M1**	State that greatest distance between P and Q occurs when $v_P = v_Q$
	$6t^2 - 16t - 10 = 0$	**M1**	Rearrange and attempt to solve for t
	$t = 3.19$	**A1**	
	Maximum Distance $PQ = (-)48.4$ m	**A1**	
		4	