Question	Answer	Marks	Guidance
1	KE gain = $\frac{1}{2} \times 80 \times (5.5^2 - 4^2)$ [= 570]	**B1**	Either initial or final KE correct
	WD against Res = $60P$	**B1**	
	[$\frac{1}{2} \times 80 \times (5.5^2 - 4^2) + 60P = 1200$]	**M1**	Four term work-energy equation
	$P = 10.5$	**A1**	
		4	

Question	Answer	Marks	Guidance
2	Driving force DF = $\frac{P}{15}$	**B1**	Correct use of $P = Fv$
	$\left[\text{DF} - 240\ 000g\sin 4 - 18\ 000 = 240\ 000 \times (-0.2)\right]$	**M1**	A four-term Newton 2nd law equation
		A1	Correct equation
	Power is 2 060 000 (W)	**A1**	Allow 2060 kW or 2.06 MW
		4	

Question	Answer	Marks	Guidance
3	[3 cos 60 = 2 cos θ]	M1	Attempt to resolve forces horizontally (2 terms)
	θ = 41.4	A1	
	[P = 3 sin 60 + 2 sin θ]	M1	Attempt to resolve forces vertically (3 terms)
	P = 3.92	A1	
		4	
	First alternative method for Q3		
	$\frac{P}{\sin(120-\theta)} = \frac{2}{\sin 150} = \frac{3}{\sin(90+\theta)}$	M1	Attempt two terms of Lami's equation which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	
	Second alternative method for Q3		
	[Triangle with sides 2, 3, P and angles opposite of 30, 90 – θ, 60 + θ] $\frac{P}{\sin(60+\theta)} = \frac{2}{\sin 30} = \frac{3}{\sin(90-\theta)}$	M1	Attempt two terms from the triangle of forces which can be used to find θ
	θ = 41.4	A1	
		M1	Attempt an equation which can be used to find P
	P = 3.92	A1	

Question	Answer	Marks	Guidance
4(i)	For example $100 = 4u + 8a$ or $100 = \frac{1}{2}(u + v) \times 4$ or $148 = 4v + 8a$ or any equation in two of the variables u, v, w, a	**M1**	Any relevant use of constant acceleration equations in any two of the variables below a is acceleration u is speed at A v is speed at B w is speed at C
		A1	One correct equation
	For example $248 = 8u + 32a$ or two further correct equations in 3 unknowns such as $148 = 4v + 8a$ **and** $v = u + 4a$ or $148 = \frac{1}{2}(v + w) \times 4$ and $248 = \frac{1}{2}(u + w) \times 8$	**A1**	A second correct equation in the same two variables or two further correct equations leading to three equations in three of the unknowns u, v, w, a
		M1	Attempt to solve for a or u This must reach $a = ...$ or $u = ...$
	$a = 3$	**A1**	**AG**
	$u = 19$	**B1**	
		6	

Question	Answer	Marks	Guidance
4(ii)	$61^2 = 19^2 + 2 \times 3 \times s$	M1	Attempt equation for $s = AD$
	$[s = 560 \ \rightarrow CD = 560 - 248]$	M1	Attempt to find CD
	Distance CD is 312	A1	
		3	
	Alternative method for 4(ii)		
	Speed at C is 19 + 8 × 3 [= 43]	M1	Attempt to find speed at C
	$\left[61^2 = 43^2 + 2 \times 3 \times CD\right]$	M1	Attempt to find CD
	Distance CD is 312	A1	

Question	Answer	Marks	Guidance
5	$R = 20g \cos 60$ [= 100]	B1	
	$F = \mu \times 20g \cos 60$ [= 100μ]	M1	Use $F = \mu R$
		M1	Resolve along plane in either case
	$(P_{max} =)\ 20g \sin 60 + F$	A1	One correct equation
	$(P_{min} =)\ 20g \sin 60 - F$	A1	Second correct equation
	$20g \sin 60 + F = 2(20g \sin 60 - F)$	M1	Use of $P_{max} = 2P_{min}$ to give four term equation in F or μ or P
	$\mu = \frac{\sqrt{3}}{3} = 0.577$	A1	
		7	
	lternative solution for final 3 marks if P_{min} is taken as acting down the plane		
	$P_{min} = F - 20g \sin 60$	A1	
	$20g \sin 60 + F = 2(F - 20g \sin 60)$	M1	
	$\mu = 3\sqrt{3} = 5.196$	A1	

Question	Answer	Marks	Guidance
6(i)		M1	Attempt to integrate a
	$v = 6t - 0.12t^2 \ (+ c)$	A1	
	$0 = 6 \times 20 - 0.12 \times 20^2 + c$	DM1	Substitute $v = 0$, $t = 20$ in an equation with arbitrary constant
	$0.12t^2 - 6t + 72 = 0$	DM1	Substitute $v = 0$ and attempt to solve a 3-term quadratic
	$t = 30$	A1	
		5	
6(ii)	$s = 3t^2 - 0.04t^3 - 72t \ (+ k)$	M1	Attempt to integrate v
	$s(30) - s(20) = -540 - (-560)$	DM1	Use of limits 20 and their 30
	Distance travelled = 20	A1	
		3	

Question	Answer	Marks	Guidance
7(i)	[$T = 1.6a$, $2.4g \sin 30 - T = 2.4a$] System is $2.4g \sin 30 = 4a$	M1	Attempt Newton's 2nd law for A or B or for the system
		A1	Two correct equations
		M1	Solve for a or T
	$a = 3$	A1	
	$T = 4.8$	A1	
		5	
7(ii)	Friction force on A is $F = 0.2 \times 1.6g$ [= 3.2]	B1	From $F = \mu R$
	$T - F = 1.6a$ $2.4g \sin 30 - T = 2.4a$ System is $2.4g \sin 30 - F = 4a$	M1	Attempt Newton's 2nd law for both particles or for the system
		A1	Correct equations for A and B or correct system equation
		M1	Attempt to solve for a
	$a = 2.2$	A1	
	$v^2 = 2 \times 2.2 \times 1$	M1	Attempt to find v or v^2 when B reaches the barrier
	Subsequent acceleration of A is –2	B1	
	$4.4 = 2 \times 2 \times s$	M1	Attempt to find distance A travels while decelerating to $v = 0$
	Total distance travelled is 2.1 m	A1	
		9	

Question	Answer	Marks	Guidance
7(ii)	**Alternative method for Q7 [Work-Energy applied to *A* and *B*]**		
	$F = 0.2 \times 1.6g$ [= 3.2]	**B1**	From $F = \mu R = 0.2 \times 1.6g = 3.2$
		M1	Attempt PE loss as *B* reaches the barrier
	PE loss = $2.4g \sin 30$ [= 12]	**A1**	
		M1	Attempt KE gain for both *A* and *B*
	KE gain = $\frac{1}{2}(1.6 + 2.4)v^2$ [= $2v^2$]	**A1**	
	[$2.4g \sin 30 = \frac{1}{2} \times 4 \times v^2 + 3.2 \times 1$] [$v^2 = 4.4$]	**M1**	Apply work-energy equation for the motion until *B* reaches the barrier (Three relevant terms)
	KE loss = $\frac{1}{2} \times 1.6 \times 4.4$	**B1**	Find KE loss as *A* comes to rest after *B* has stopped
	[$\frac{1}{2} \times 1.6 \times 4.4 = 3.2d$] [$d = 1.1$]	**M1**	Apply work-energy equation where *d* is the extra distance travelled by *A* leading to a positive value for *d*
	Total distance = 2.1 m	**A1**	Distance = $d + 1$

Question	Answer	Marks	Guidance
7(ii)	**Alternative scheme for first 6 marks of 7(ii) [Work-energy applied to *A*]**		
	Friction = $0.2 \times 1.6g$ [= 3.2]	**B1**	
	[$2.4g \sin 30 - T = 2.4a$ $T - F = 1.6a$]	**M1**	Apply Newton's 2nd law to *A* and *B* and solve for *T*
	$T = 6.72$	**A1**	
	[$\frac{1}{2} \times 1.6 \times v^2$]	**M1**	Attempt KE for *A* only
		A1	Correct KE for *A*
	[$6.72 \times 1 = \frac{1}{2} \times 1.6 \times v^2 + 3.2 \times 1$]	**M1**	Use work/energy equation for *A*
	Alternative scheme for first 6 marks of 7(ii) [Work-energy applied to *B*]		
	Friction = $0.2 \times 1.6g$ [= 3.2]	**B1**	
	[$2.4g \sin 30 - T = 2.4a$ $T - F = 1.6a$]	**M1**	Apply Newton's 2nd law to *A* and *B* and solve for *T*
	$T = 6.72$	**A1**	
		M1	Find energy loss/gain for *B* Allow either term
	$\pm(\frac{1}{2} \times 2.4 \times v^2 - 2.4g \sin 30)$	**A1**	
	$2.4g \sin 30 = \frac{1}{2} \times 2.4 \times v^2 + 6.72 \times 1$	**M1**	Use work/energy equation for *B*