Question	Answer	Marks	Guidance
1	*EITHER*: WD = 20 cos θ × 1.5 × 12 (J)	**(B1**	Using WD = $Fd \cos \theta$
	[cos θ = 50/360] θ = ...	**M1**	Use WD = 50 and solve for θ
	$\theta = 82(.0)$	**A1)**	
	OR: Power P = 50/12 = 4.1666…	**(B1**	Using Power = WD/time
	[50/12 = 20 cos θ × 1.5] θ = ...	**M1**	Use $P = Fv$ and solve for θ
	$\theta = 82(.0)$	**A1)**	
	Total:	**3**	
2(i)	$v = \sqrt{2 \times 2.5 \times 5}$ (ms^{-1})	**B1**	**AG** Using $v^2 = u^2 + 2as$
	Total:	**1**	
2(ii)(a)		**M1**	Attempting PE loss or KE gain
	PE loss = 0.2 × 10 × 6 sin 30 [= 6] **and** KE gain = 0.5 × 0.2 × ($v^2 - 5^2$)	**A1**	Both PE **and** KE correct both unsimplified
	[6 = 0.1($v^2 - 5^2$)]	**M1**	PE loss = KE gain (3 terms)
	$v^2 = 85 \rightarrow v = 9.22$ ms^{-1}	**A1**	
	Total:	**4**	

Question	Answer	Marks	Guidance
2(ii)(b)	Max velocity at lowest point $[0.2 \times 10 \times 6 =$ $0.5 \times 0.2 \times (v^2 - 5^2)]$	**M1**	PE loss = KE gain
	$v^2 = 145 \rightarrow v = 12(.0)\ \text{ms}^{-1}$	**A1**	
	Total:	**2**	
3(i)		**M1**	Attempt s_A as $s_A = k + 10t$ (any k)
	$s_A = 20 + 10t$	**A1**	
	$s_B = 16t + \frac{1}{2}(-2)t^2$ $[= 16t - t^2]$	**B1 FT**	Allow FT only if $s_A = 10t$ and $s_B = 16(t - 2) + \frac{1}{2}(-2)(t - 2)^2$ i.e. t measured from when A passes O
	Total:	**3**	
3(ii)	$v_B = 16 - 2t \rightarrow v_B = 0,\ t = 8$	**B1**	
	$s = s_A - s_B$ $[= 20 + 10t + t^2 - 16t = t^2 - 6t + 20]$	**M1**	Finding distance between A and B at time $t = T$ ($T > 0$) found from a valid method for $v_B = 0$
	$t = 8,\ s = 36$ (m)	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
3(iii)	$\frac{ds}{dt} = 2t - 6$ **or** $s = t^2 - 6t + 20 = (t-3)^2 + 11$	**M1**	Either use differentiation or complete the square, or state value of t when speeds are the same
	$[t = 3]$	**M1**	Solve for t and evaluate $s_A - s_B$ at this value of t
	$s = s_A - s_B = 11$ m	**A1**	
	Total:	**3**	
4(i)(a)	$[P = 850 \times 42]$	**M1**	Using $P = Fv$
	$P = 35700$ W $= 35.7$ kW	**A1**	Must be in kW to 3sf
	Total:	**2**	
4(i)(b)	$P = 41700$ $\rightarrow$ [DF = 41700/42]	**M1**	Find new power and new DF based on power found in 4(i)(a)
	$[(993 - 850) = 1200a]$	**M1**	Apply Newton 2, three terms
	$a = 5/42 = 0.119$ ms^{-2}	**A1**	
	Total:	**3**	

Question	Answer	Marks	Guidance
4(ii)	DF = 80000/24	**B1**	DF = P/v
	[DF – 850 – mg sin θ = 0]	**M1**	Newton 2 along the hill, 3 terms
	[12000 sin θ = 80000/24 – 850] θ = …..	**M1**	Solve for θ, from a three term equation
	θ = 11.9	**A1**	
	Total:	**4**	
5		**M1**	Resolve perpendicular to the plane, three terms
	$R + P$ sin 30 = 0.12g cos 40	**A1**	R does not need to be the subject
	F = 0.32R	**M1**	Use $F = \mu R$
	[P_{min} cos 30 + F = 0.12g sin 40]	**M1**	About to slip down, 3 terms
	[P_{max} cos 30 – F = 0.12g sin 40]	**M1**	About to slip up, 3 terms
	[P cos 30 = 0.12g sin 40 ±0.32 (0.12g cos 40 – P sin 30)] OR [P cos 30 ± 0.32R = 0.12g sin 40 $R + P$ sin 30 = 0.12g cos 40] Must reach P =… in either method	**M1**	Substitute for F and solve for P in either case, 4 terms OR solve a pair of simultaneous equations (each with 3 terms) in R and P for P in one of the cases
	P_{max} = 1.04 P_{min} = 0.676	**A1**	For either correct
	0.676 $\leqslant P \leqslant$ 1.04	**A1**	
	Total:	**8**	

Question	Answer	Marks	Guidance
6(i)	A [$T = 0.3a$] B [$1.5g \sin \theta - T = 1.5a$] System [$1.5g \sin \theta = 1.8a$]	**M1**	Apply Newton's second law to A or to B or to the system
		A1	Any two correct equations
		M1	Solve 2 simultaneous equations for a and/or T or use the system equation.
	$a = 9/1.8 = 5$ ms^{-2}	**A1**	
	$T = 1.5$ N	**A1**	
	Total:	**5**	

Question	Answer	Marks	Guidance
6(ii)	[$5 = 3a$]	**M1**	$v = u + at$ used with $t = 3$, $u = 0$, $v = 5$
	$a = 5/3 = 1.67$	**A1**	
	$R_A = 3$ $R_B = 15 \cos 36.9 = 12$	**B1**	For either reaction
	[$F_A = 3\mu$ $F_B = 12\mu$]	**M1**	Use $F = \mu R$ for either term
	EITHER: A [$T - F_A = 0.3a$] B [$15 \sin 36.9 - T - F_B = 1.5a$] System equation is [$1.5g \sin 36.9 - F_A - F_B = 1.8a$]	**(M1**	Apply Newton's second law to A or to B or to the system
		A2/1/0	**A1** Correct equation for A or B **A2** Correct equations for A and B OR **A2** Correct system equation
	[$9 - 15\mu = 3$]	**M1**	Solve for μ from equations with correct number of terms
	$\mu = 0.4 = 2/5$	**A1)**	
	OR: $s = ½ (5/3) \times 3^2 = 7.5$	**(B1**	Find distance travelled in 3 secs
	PE loss = $1.5 \times 10 \times 7.5 \times (3/5) = 67.5$	**B1**	
	KE gain = $½ (1.8) \times 5^2 = 22.5$	**B1**	
	[$67.5 = 22.5 + 3\mu \times 7.5 + 12\mu \times 7.5$]	**M1**	Use Work/Energy equation
	$\mu = 2/5 = 0.4$	**A1)**	
	Total:	**9**	