Question	Answer	Marks	Guidance
1	$R = 2.5 \cos 15$	**B1**	
	$[F = \mu \times 2.5 \cos 15]$	**M1**	Using $F = \mu R$
	$[2.5 \sin 15 = 0.03g + F]$	**M1**	Resolve forces along the rod
	$\mu = 0.144$	**A1**	
		4	

Question	Answer	Marks	Guidance
2(i)	$[0 = 30^2 + 2(-g)s]$	**M1**	Using $v^2 = u^2 + 2as$ with $v = 0$, $u = 30$ and $a = -g$ For any complete method for finding maximum height s
	s = maximum height = 900/20 = 45 m	**A1**	**AG**
		2	

Question	Answer	Marks	Guidance
2(ii)	[$33.75 = 30t - ½ gt^2$]	**M1**	Applying $s = ut + ½at^2$ with $s = 33.75$, $u = 30$ and $a = -g$
	[$5t^2 - 30t + 33.75 = 0$ or $4t^2 - 24t + 27 = 0$]	**M1**	Solve a 3-term quadratic for t
	$t = 1.5$ (reject $t = 4.5$)	**A1**	
	$v = 30 - 1.5g = 15$	**B1ft**	Use $v = u + at$ with $u = 30$ and $t = 1.5$ ft on t value found
	Alternative method for question 2(ii)		
	$v^2 = 30^2 - 2g(33.75) = 225 \rightarrow v = 15$	**B1**	Use $v^2 = u^2 + 2as$ with $u = 30$, $a = -g$ and $s = 33.75$ to find v
	[$33.75 = ½ (30 + 15) \times t$] or [$15 = 30 - 10t$]	**M1**	Use $s = ½ (u + v) \times t$ with $s = 33.75$, $u = 30$ and v as found. or Use $v = u - gt$ with $u = 30$ and v as found
		M1	Solve for t
	$t = 1.5$	**A1ft**	ft on v value found
		4	

Question	Answer	Marks	Guidance
3		**M1**	Attempt to resolve forces horizontally or vertically
	$F\cos\alpha = 15\cos 20 - 5$ (= 9.095...)	**A1**	
	$F\sin\alpha = 15\sin 20 + 25$ (= 30.13....)	**A1**	
	$F = \sqrt{(15\cos 20 - 5)^2 + (15\sin 20 + 25)^2}$	**M1**	Use Pythagoras or trigonometry to find F
	$\propto = \tan^{-1}\left[(15\sin 20 + 25)\big/(15\cos 20 - 5)\right]$	**M1**	Use trigonometry to find α
	α = 73.2 **and** F = 31.5	**A1**	
		6	

Question	Answer	Marks	Guidance
4(i)	Driving force = 6000/20 [= 300 N]	**B1**	Using $F = P/v$
	R = 300 – 80 = 220	**B1ft**	Net force on system = 300 – R – 220 = 0 ft on DF found
		2	

Question	Answer	Marks	Guidance
4(ii)	[New driving force DF = 12500/25 = 500 N Car: DF – T – R = 1500a Trailer: T – 80 = 300a System: DF – 80 – R = 1800a]	**M1**	Any one equation from the following: Apply Newton's 2nd law to the car Apply Newton's 2nd law to the trailer Apply Newton's 2nd law to the system of car and trailer.
	Two correct equations	**A1ft**	Correct DF = 500 must be used. ft on R value found
		M1	EITHER solve two dimensionally correct simultaneous equations in a and T to find a or T OR solve the system equation to find a
	$a = 0.111 \text{ m s}^{-2}$	**A1**	Allow $a = 1/9$
	T = 113 N (= 113.3333...)	**A1**	Allow T = 340/3
		5	

Question	Answer	Marks	Guidance
5(i)	Velocity at t = 3 is 3 × 3 = 9	**B1**	
	[½ × 3 × 9 + ½ (9 + 7) × 2 + ½ × 3 × 7]	**M1**	Attempt distance travelled in the first 8 seconds using Distance = area under graph.
	Distance = 40 m	**A1**	
		3	

Question	Answer	Marks	Guidance
5(ii)	[32 = 40 + area of triangle]	**M1**	Use given displacement to set up equation for area of triangle or attempt to find distance or displacement from $t = 8$ to $t = 16$
	Area of triangle or displacement/distance = (–)8	**A1**	
	[Distance = ½ × 8 × V = (–)8]	**M1**	Set up an equation for the area of triangle involving V or use *suvat* equations to set up an equation involving V
	$V = –2$	**A1**	
		4	

Question	Answer	Marks	Guidance
6(i)	$[\int\left(0.4t^3 - 4.8t^{\frac{1}{2}}\right) dt]$	M1	Attempt to integrate a
	$v = 0.1t^4 - 3.2t^{\frac{3}{2}}\ (+c)$	A1	
	$[v = 0 \rightarrow 0.1t^4 - 3.2t^{\frac{3}{2}} = 0]$	DM1	Attempt to solve $v = 0$, and reach the form $t^{a/b} = k$
	$[t^{\frac{5}{2}} = 32]$	M1	Attempt to solve an equation of the form $t^{a/b} = k$
	$t = 4$	A1	
	$a = 16\text{ m s}^{-2}$	B1	
		6	
6(ii)	$[s = \int 0.1t^4 - 3.2t^{\frac{3}{2}}\ dt]$	M1	Attempt to integrate v
	Displacement = $\left[0.02t^5 - 1.28t^{\frac{5}{2}}\right]_0^5$	A1	Correct integration.
	Displacement = –9.05 m (–9.05417...)	A1	
		3	

Question	Answer	Marks	Guidance
7(i)	$R = 0.25g \times 0.6$ [= 1.5]	**B1**	
	[$F = 0.5 \times 0.25g \times 0.6$] [$F = 0.75$]	**M1**	Use $F = \mu R$
	[WD against friction = $F \times 8$]	**M1**	Using WD = Force × distance moved in direction of force
	WD = 6 J	**A1**	
		4	
7(ii)	[$\frac{1}{2} \times 0.25 \times 15^2 = \frac{1}{2} \times 0.25 \times v^2 + 6 + 0.25g \times 8 \times 0.8$]	**M1**	Work-energy equation in the form Initial KE = Final KE + WD against F + PE gain
		A1ft	Correct Work–Energy equation for the motion to Q. ft on WD
		M1	Solving the work-energy equation for v
	$v = 7$ m s^{-1}	**A1**	
	Alternative method for question 7(ii)		
	[$-F - 0.25g \sin \alpha = 0.25a$]	**M1**	Applying Newton's second law to the particle along the plane
	$a = -11$ m s^{-2}	**A1ft**	ft on friction found in **(i)**
		M1	Finding the speed of the particle at Q by applying $v^2 = u^2 + 2as$ with $u = 15$, $s = 8$ or equivalent complete method
	$v = 7$ m s^{-1}	**A1**	
		4	

Question	Answer	Marks	Guidance
7(iii)	[$\frac{1}{2} \times 0.25 \times 7^2 = 0.25 \times g \times H$] Or [$\frac{1}{2} \times m \times 7^2 = m \times g \times H$]	**M1**	KE lost from Q to R = PE gain from Q to R H is the height of R above Q
	$H = 7^2/2g = 2.45$ m	**A1**	
	Total height $h = 6.4 + H = 8.85$	**A1**	
	Alternative method for question 7(iii)		
	[$\frac{1}{2} \times 0.25 \times 15^2 = 6 + 0.25g \times h$]	**M1**	Work-energy from P to R
		A1	Correct Work-energy equation from P to R
	$h = 8.85$	**A1**	
		3	