Question	Answer	Marks	Guidance
7(a)	$R = 3g\cos\alpha = 3\times10\times0.8$	B1	
	$F = 3g\sin\alpha = 3\times10\times0.6$	M1	Resolving parallel to plane.
	$\mu = \frac{18}{24} = 0.75$ or $\mu = \frac{3g\sin\alpha}{3g\cos\alpha} = \tan\alpha = 0.75$	A1	Uses $\mu = \frac{F}{R}$ AG.
		3	
7(b)	$a = g\sin\alpha$ or PE loss $= 1.5gx\sin\alpha$ for AB and $a = 0$ for BC $4.5g\times\sin\alpha - 0.75\times4.5g\cos\alpha = 4.5a$ leading to $a = 0$	B1	Accelerations for AB and BC.
	$v_1^2 = 2\times g\sin\alpha\times x$] or $[1.5g\times x\sin\alpha = 0.5\times1.5\times v_1^2$	M1	Uses '*suvat*' or PE loss = KE gain for AB.
	$v_1^2 = 20x\sin\alpha = 12x$ leading to $v_1 = \sqrt{12x}$	A1	
	$1.5\times\sqrt{12x} + 0 = 4.5\times v_2$ leading to $v_2 = \frac{1}{3}\sqrt{12x}$	M1	Conservation of momentum.
	$4 = \frac{2}{3}\times\sqrt{12x}$	M1	Use of $s = vt$ on BC since $a = 0$.
	$x = 3$	A1	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for 7(b)**		
	$a = g\sin\alpha$ or PE loss $= 1.5gx\sin\alpha$ for AB and $a = 0$ for BC $4.5g\times\sin\alpha - 0.75\times 4.5g\cos\alpha = 4.5a$ leading to $a = 0$	**B1**	Accelerations for AB and BC.
	$4 = 2v_2$ leading to $v_2 = 2$	**M1**	Uses $s = vt$ on BC since $a = 0$.
	$1.5\times v_1 + 0 = 4.5\times 2$	**M1**	Conservation of momentum.
	$v_1 = 6$	**A1**	Velocity before collision.
	$6^2 = 2\times g\sin\alpha\times x$ **or** $1.5g\times x\sin\alpha = 0.5\times 1.5\times 6^2$	**M1**	Uses *suvat* or PE loss = KE gain for AB.
	$x = 3$	**A1**	
		6	
7(c)	KE $= 0.5\times 4.5\times 2^2 = 9$J	**B1**	KE gain for AC.
	PE loss $= 15\times(4+3)\times\frac{3}{5} + 30\times 4\times\frac{3}{5} = 135$J	**M1**	Evaluates PE loss for AC.
	Loss of energy = 126 J	**A1**	
		3	

Question	Answer	Marks	Guidance
3(c)	[$v^2 = 2\times2.4\times3 \Rightarrow$ greatest speed =] $3.79\ \text{ms}^{-1} = \frac{6\sqrt{10}}{5}$	B1	3.79473… (3.8 without a more accurate value seen gets B0 and should be annotated SF).
		1	

Question	Answer	Marks	Guidance
4(a)	$P = 480\times24$ or, e.g. $\frac{P}{24} - 480 = 0$	M1	For $\frac{P}{v} - F = 0$ or $P = Fv$ oe.
	$P = 11.52$ [kW]	A1	Allow 11.5 M1A0 for 11 520 or 11 500.
		2	

Question	Answer	Marks	Guidance
4(b)	$\left[\text{KE}_{before}\right]=\frac{1}{2}\times1600\times24^2\left[=460800\right]$ $\left[\text{KE}_{after}\right]=\frac{1}{2}\times1600\times32^2\ \left[=819200\right]$	B1	For either correct. Do not allow $\frac{1}{2}\times1600\times(32-24)^2$.
	$\left[\text{PE}_{loss}\right]=1600g\times280\times0.09\left[=1600g\times25.2=403200\right]$	B1	Allow $1600g\times280\times\sin5.16°$ or $1600g\times280\times\sin5.2°$ but not simply $1600g\times280\times\sin\theta$ (unless implied by correct final answer).
	Total WD $=12000\times10\ [=120000]$	B1	oe, e.g. $12000=\frac{\text{WD}}{10}$.
4(b)	Work done against resistance = or $280F=$ or WD = or W = oe $12000\times10+1600g\times280\times0.09-\frac{1}{2}\times1600\times32^2+\frac{1}{2}\times1200\times24^2$ $\left[=120000+403200-819200+460800\right]$	M1	Attempt at work energy equation with 5 relevant terms (4 relevant terms plus work done against resistance); dimensionally correct. Allow sign errors. M0 for use of constant acceleration. Do not allow $\frac{1}{2}\times1600\times(32-24)^2$.
	WD = 164 800 [J]	A1	Or 164.8 kJ CAO but condone 165 kJ or 165 000 [J] Not from use of constant acceleration or Newton's second law. ISW attempt to find force after correct WD found.
		5	

Question	Answer	Marks
1	Use of conservation of momentum	M1
	$m \times 2 + 0 = m \times (-0.5) + 0.2 \times 1$	A1
	$m = 0.08$	A1
		3

Question	Answer	Marks
2(a)	$F - 900 = 4000 \times 0.5$ (M1 for use of Newton's second law, 3 terms)	M1
	$F = 2900$ N	A1
2(b)	900×25 (M1 for use of $P = Fv$ with F = resistance only)	M1
	22 500 W or 22.5 kW	A1

Question	Answer	Marks	Guidance
4(a)(i)	[WD = 1250 × 36 × 8]	M1	For using Work Done = Force × Distance.
	WD = 360000 J	A1	or 360 kJ
		2	
4(a)(ii)	Power = 1250 × 36 or P = $\frac{360000}{8}$ [= 45000 J]	B1 FT	FT Work Done from $\frac{\text{a(i)}}{8}$.
	= 45 kW	B1	
		2	
4(a)(iii)	DF = $\frac{57000}{36}$ [= 1583.3..]	M1	Use changed Power in $P = \text{DF} \times v$.
	$\frac{57000}{36} - 1250 = 1400a$	M1	For using Newton's 2nd law applied to the car.
	$a = 0.238\ \text{ms}^{-2}$	A1	
		3	
4(b)	$\frac{64000}{32} = 1250 + 1400g \sin\theta$	M1	For using DF = resistance + component of the weight of the car.
	$\theta = 3.1$ [3.0708…]	A1	
		2	

Question	Answer	Marks	Guidance
1(a)	$120\times8=120v+40v$	M1	Applying conservation of momentum.
	$v=6$ ms^{-1}	A1	
		2	
1(b)	$1600-4800=160a$ leading to $a=-20$	M1	Applying Newton's 2nd law to the system.
	$0=6^2+2\times(-20)\times s$	M1	Use of constant acceleration equations such as $v^2=u^2+2as$.
	Distance travelled by post = 0.9 m	A1	
	Alternative method for question 1(b)		
	Initial KE = $\frac{1}{2}\times160\times6^2$	M1	Use of KE = $\frac{1}{2}mv^2$ for combined mass.
	$\frac{1}{2}\times160\times6^2+160\times10\times s=4800s$	M1	Forms work/energy equation.
	Distance travelled by post = 0.9 m	A1	
		3	

Question	Answer	Marks
5(a)	Decrease in KE = $\frac{1}{2} \times 4 \times (12^2 - 8^2)$	M1
	160 J	A1
		2
5(b)	PE gained = $4g \times 10\sin 30$ (= 200)	B1
	Total work done = 200 – 160	M1
	Total work done = 40 J	A1 FT
		3
5(c)	$-4g\sin 30 = 4a$	M1
	$a = -5$	A1
	$-10 = 8t - \frac{1}{2} \times 5t^2$	M1
	$t = 4.16$ s	A1
		4

Question	Answer	Marks	Guidance
1	$0.4 \times 2.5 - 0.5 \times 1.5$	M1	Attempt momentum before impact.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$	M1	Use of conservation of momentum, either case.
	$0.4 \times 2.5 - 0.5 \times 1.5 = 0.4v + 0.5 \times 2v$ or $0.4 \times 2.5 - 0.5 \times 1.5 = -0.4v + 0.5 \times 2v$	A1	One correct equation
	Speed is 0.179 m s^{-1} or 0.417 m s^{-1}	A1	Both values
		4	

Question	Answer	Marks	Guidance
2(a)	Forward force exerted by cyclist = $\frac{150}{4}$ N [= 37.5 N]	B1	OE. $P = Fv$ used correctly.
	$\frac{150}{4} - 20 = m \times 0.25$	M1	Use of Newton's second law
	m = 70 kg	A1	
		3	
2(b)	$150/3 - 20 - 70g\sin\theta = 0$	M1	For resolving up the plane
	$\theta = 2.5°$ to 1d.p.	A1 FT	From 2.456.... FT $\theta = \sin^{-1}\left(\frac{3}{m}\right)$ from **(a)**
		2	

Question	Answer	Marks	Guidance
1(a)	$0.3\times4+0=0.3v+0.2\times3$	M1	For attempt at use of conservation of momentum
	Speed = 2 ms^{-1}	A1	
		2	
1(b)	$0.2\times3+0=(0.2+m)\times2$	M1	For attempt at use of conservation of momentum
	$m = 0.1$	A1	
		2	

Question	Answer	Marks	Guidance
2(a)	$0=u^2-2g\times45$	M1	For use of $v^2=u^2+2as$ OE complete method that would lead to finding u
	Speed = 30 ms^{-1}	A1	
		2	
2(b)	$10=30-gt$ leading to $t=2$	M1	For use of $v=u+at$ to find time to 10 ms^{-1} or use of '*suvat*' to find time for one stage of motion
	2×2 s	M1	$2\times$ time to 10 ms^{-1} OE
	Total time = 4 s	A1	
		3	