Question	Scheme	Marks	AOs
1	Using the model and the conservation of energy principle	M1	3.4
	$\frac{1}{2}m(6^2 - v^2) = mg \times 5\sin\alpha$	A1	1.1b
		A1	1.1b
	Solve for v	M1	1.1b
	v = 4.7 or 4.69 (m s^{-1})	A1	1.1b
		(5)	
			(5 marks)

Notes:

M1: Correct no. of terms and dimensionally correct
A1: Correct equation, condone 1 error.
A1: Correct equation
M1: Must be solving a three term equation
A1: Since g = 9.8 has been used, only these two answers

Question	Scheme	Marks	AOs
2(a)	Using the Impulse-momentum principle	M1	3.1b
	$\frac{5mu}{3} = m(v - -u)$	A1	1.1b
	$v = \frac{2u}{3}$	A1	1.1b
	Using the model and the work-energy principle **OR**: $F = ma$ and $v^2 = u^2 + 2as$	M1	3.4
	$\frac{mgd}{6} = \frac{1}{2}mv^2$ oe	A1**ft**	1.1b
	Using correct strategy to solve the problem by linking the two equations and sub for v and solve for d	M1	3.1b
	$d = \frac{4u^2}{3g}$	A1	1.1b
		(7)	
(b)	Make the resistance dependent on the speed	B1	3.5c
		(1)	
			(8 marks)

Notes:

(a)

M1: Correct no. of terms, condone sign errors

A1: Correct equation

A1: Correct expression

M1: work-energy principle **or** $F = ma$ and $v^2 = u^2 + 2as$

A1ft: Correct equation but v does not need to be substituted

M1: Solve for d in terms of u and g only

A1: Any equivalent expression

(b)

B1: Appropriate comment

Question	Scheme	Marks	AOs
3(a)	Driving Force = Power / speed = 25000 / 20 = 1250	M1	1.1b
	Using model to form equation of motion	M1	3.4
	$1250 - 500g.\frac{1}{14} - (100 + C) = 0$	A1	1.1b
	Using complete strategy to solve the problem	M1	3.1b
	$C = 800$	A1	1.1b
		(5)	
(b)	Driving Force = $\frac{25000}{U}$	M1	1.1b
	Using model to form equation of motion	M1	3.4
	$\frac{25000}{U} - (5U + 800) = 0$	A1 **ft**	1.1b
	$U^2 + 160U - 5000 = 0$ oe	A1 **ft**	1.1b
	Using complete strategy to solve the problem	M1	3.1b
	$U =$ 27	A1	1.1b
		(6)	
			(11 marks)

Notes:

(a)
M1: For attempt to find the driving force
M1: Correct number of terms with weight resolved
A1: Correct equation
M1: Solve for C
A1: 800

(b)
M1: Must find the driving force
M1: Correct number of terms
A1ft: Correct equation, follow through on their C
A1ft: Correct 3 term quadratic = 0, follow through on their C
M1: This mark can be implied by a correct answer, but otherwise must see an explicit attempt to solve.
A1: 27 (2 SF)

Question	Scheme	Marks	AOs
4(a)	Use of conservation of momentum	M1	2.1
	$mu = mv_P + mv_Q$	A1	1.1b
	Use of NLR	M1	3.4
	$\boldsymbol{eu = v_P - v_Q}$	A1	1.1b
	Using a correct strategy to solve the problem by setting up two equations (need both) in v_P and v_Q and solving for $\boldsymbol{v_P}$	M1	3.1a
	$\boldsymbol{v_P} = \frac{u}{2}(1+e)$ *	A1*	2.2a
		(6)	
(b)	$\boldsymbol{v_Q = \frac{u}{2}(1-e)}$	B1	1.1b
		(1)	
(c)	KE Loss = Initial KE – Final KE	M1	1.1b
	$= \frac{1}{2}mu^2 - \left\{\frac{1}{2}m\left[\frac{u}{2}(1+e)\right]^2 + \frac{1}{2}m\left[\frac{u}{2}(1-e)\right]^2\right\}^2$	A1 A1	1.1b 1.1b
	Using a correct strategy to solve the problem: $\frac{1}{4}mu^2(1-e^2) = \frac{3mu^2}{16}$ and solve for e	M1	3.1a
	$e = \frac{1}{2}$	A1	1.1b
		(5)	
(d)	After 1st impact: $\boldsymbol{e = 1 \Rightarrow v_P = u}$ **and** $\boldsymbol{v_Q = 0}$	B1	1.1b
	After 2nd impact (*P* and wall): Using NLR with $e = 1$, $\boldsymbol{v_P = u}$	M1	3.1a
	Since $\boldsymbol{v_P = u}$ **and** $\boldsymbol{v_Q = 0}$, 3rd impact is a 'repeat' of 1st impact so $\boldsymbol{v_Q = u}$ **and** $\boldsymbol{v_P = 0}$	B1	2.2a
	Motion continues in the same way, with one particle coming to rest and the other moving with speed *u*	B1	3.2
		(4)	
			(16 marks)

Question 4 notes:
(a) **M1:** Correct no. of terms, condone sign errors **A1:** Correct equation (allow if *m* has been cancelled or extra *g*'s) **M1:** *e* must be on correct side of equation. **A1:** Correct equation in any form **M1:** Solving for v_Q **A1*:** PRINTED ANSWER
(b) **B1:** Any equivalent form
(c) **M1:** Correct no. of terms and dimensionally correct. Allow Final KE – Initial KE **A1:** Correct expression, condone 1 error **A1:** Correct expression in any form **M1:** Equate to $\frac{3mu^2}{16}$ and solve for *e* **A1:** $e = 0.5$
(d) **B1:** Need both $v_Q = 0$ and $v_P = u$ **M1:** Using NLR for impact with the wall to obtain $v_P = u$ **B1:** Clear explanation **B1:** Clear description