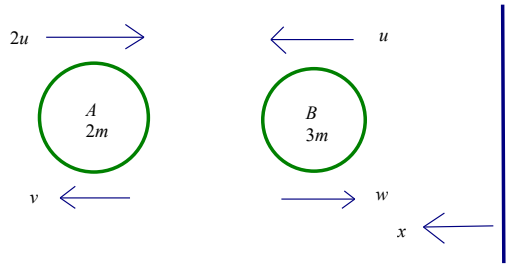
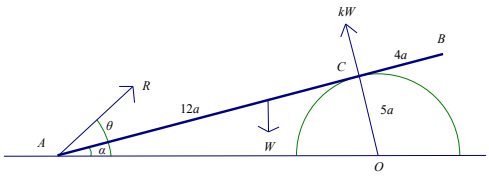
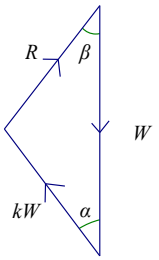
4a			
	Use of CLM	M1	Need all terms, dimensionally correct. Condone sign errors.
	$4mu-3mu=3mw-2mv$ $(u=3w-2v)$	A1	Correct unsimplified equation
	Use of impact law	M1	Used correctly. Condone sign errors
	$v+w=3eu$	A1	Correct unsimplified equation. Signs consistent with their CLM equation
	$\begin{cases} u=3w-2v \\ 6eu=2w+2v \end{cases}$	DM1	Dependent on both preceding M marks. Solve to find speed of B.
	$\Rightarrow 5w=u+6eu, \quad w=\frac{1}{5}u(1+6e)$ *	A1*	Obtain **given answer** from correct working
		[6]	
4b	$v=3eu-w=\frac{u}{5}(9e-1)$	B1	Check their diagram / directions and allow $v=\frac{u}{5}(1-9e)$ if correct for their working. Any equivalent form. Must be seen or used in (b)
	$x=\frac{u}{7}(1+6e)$	B1	Seen or implied. Accept $\pm$
	Second collision if $\frac{u}{7}(1+6e)>\frac{u}{5}(9e-1)$	M1	Correct inequality to find the upper limit for e, using their v and x
	$(0<)e<\frac{4}{11}$	A1	Final answer. Or equivalent Do not need to mention the lower limit, but if they do it must be stated correctly (strict inequality).
		[4]	

5a			
	Angle ACO is a right angle or state that AB is a tangent hence triangle is $5a$, $12a$, $13a$ *	B1*	Or equivalent **explanation** of **given answer.** They need to say why it is a 5, 12, 13 triangle. If they say nothing, check the diagram to see if there is a right angle marked.
		[1]	
5b	Moments about A:	M1	Dimensionally correct equation Condone sin / cos confusion
	$W \times 8a\cos\alpha = kW \times 12a$ $\left(W \times 8a \times \frac{12}{13} = kW \times 12a\right)$	A1	Correct unsimplified equation
	$k = \frac{8}{13}$ *	A1*	Obtain given answer from correct working. Need to see correct substitution for $\cos\alpha$ and correct final statement.
		[3]	
5c	$\leftrightarrow R_H = kW\sin\alpha$	M1	First equation e.g. resolve horizontally. Condone sin/cos confusion
	$= \frac{8W}{13} \times \frac{5}{13} = \frac{40W}{169}$	A1	Correct unsimplified expression for R_H
	$\updownarrow R_V + kW\cos\alpha = W$	M1	Second equation e.g. resolve vertically. Condone sin/cos confusion and sign errors.
	$R_V = W - \frac{8W}{13} \times \frac{12}{13} = \frac{73W}{169}$	A1	Correct unsimplified expression for R_V
	$\lvert R\rvert^2 = (R_V)^2 + (R_H)^2$	DM1	Dependent on the two preceding M marks. Method to obtain the magnitude, e.g.correct use of Pythagoras
	$\lvert R\rvert = \frac{W}{169}\sqrt{40^2 + 73^2}$ $= \frac{\sqrt{6929}}{169}W = \frac{\sqrt{41}}{13}W$	A1	Accept $0.49W$ or better Allow $\sqrt{\frac{41W^2}{169}}$ or correct unsimplified form. ISW
	$\tan\theta° = \frac{73}{40}$ $(=1.825)$	DM1	Dependent on the first 2 M marks. Method to obtain the angle, e.g.correct use of trigonometry to find a relevant angle $(\theta$ or $90-\theta)$
	$\theta = 61$ (61.3)	A1	61 or better (61.2796…)
		[8]	
	See overleaf for alternatives		
5c Alt 1	$P = W\sin\alpha$	M1	First equation e.g. resolve parallel to the rod. Condone sin/cos confusion.

	$=\frac{5W}{13}$	A1	Correct unsimplified expression for parallel component
	$Q+kW=W\cos\alpha$	M1	Second equation e.g. resolve perpendicular to the rod. Condone sin/cos confusion and sign errors.
	$Q=\frac{12}{13}W-\frac{8}{13}W=\frac{4W}{13}$	A1	Correct unsimplified expression for perpendicular component
	$\lvert R\rvert=\sqrt{P^2+Q^2}$	DM1	Dependent on the first 2 M marks. Correct use of Pythagoras
	$\lvert R\rvert=\frac{W}{13}\sqrt{4^2+5^2}=\frac{\sqrt{41}}{13}W$	A1	Accept $0.49W$ or better Allow correct unsimplified form
	$\theta°=\tan^{-1}\frac{5}{12}+\tan^{-1}\frac{4}{5}$	DM1	Dependent on the first 2 M marks. Correct use of trig to find the required angle
	$\theta=61\quad(61.3)$	A1	61 or better (61.2796…)
		[8]	
5c Alt2		M1 A1	Vector diagram showing the three forces acting Correctly configured
	Use of Cosine Rule:	M1	Correct use of cosine rule for their triangle
	$R^2=W^2+(kW)^2-2W(kW)\cos\alpha$	A1	Correct unsimplified equation.
	$R^2=W^2+\frac{64}{169}W^2-\frac{16}{13}\times\frac{12}{13}W^2\left(=\frac{41}{169}W^2\right)$	DM1	Solve for R. Dependent on the first 2 M marks
	$\lvert R\rvert=\frac{\sqrt{41}}{13}W$	A1	Accept $0.49W$ or better
	$\frac{R}{\sin\alpha}=\frac{kW}{\sin\beta}\quad\left(\sin\beta=\frac{8}{13}\times\frac{\sqrt{41}}{13}\times\frac{5}{13}\right)$	DM1	Dependent on the first M mark. Correct method to find a relevant angle e.g. by use of sine rule
	$\theta=90-28.7=61.3$	A1	61 or better (61.2796…)
		[8]	
		(12)	