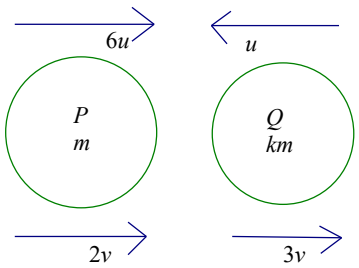
8a			
	Use of impact law	M1	Used the right way round. Condone sign errors
	$\frac{3v-2v}{6u+u}=\frac{1}{3}$	A1	Correct unsimplified equation e.g. If see just $\frac{v}{5u}=\frac{1}{3}$ assume a sign slip and allow M1A0A0
	$v=\frac{7}{3}u$	A1	Correct only. CSO
		[3]	
8b	Use of CLM (or equal and opposite impulses)	M1	Dimensionally consistent. Need all terms. Condone sign errors. Condone one slip in matching speeds and masses. Condone consistent omission of m.
	$6mu-kmu=3kmv+2mv$ or $6u-ku=3kv+2v$	A1	Correct unsimplified equation Allow the marks if CLM stated correctly in (a) and used here.
	$6-k=3k\times\frac{7}{3}+2\times\frac{7}{3},\quad 8k=\frac{4}{3},\quad k=\frac{1}{6}$	A1	Correct only from correct work only
		[3]	
8c	This method looks at the total time between the two collisions between P and Q		
	Speed of Q after rebound $=f\times 3v\left(=f\times 7u\right)$	B1ft	Seen or implied ft is for correct use of their v
	t_P between collisions $=\frac{6d}{7\times 2v}\left(=\frac{3d}{7v}=\frac{9d}{49u}\right)$	B1ft	Seen or implied For P distance $6d/7$ at $2v$ ft is for correct use of their v
	t_Q between collisions $=\frac{d}{3v}+\frac{d}{7\times 3fv}$ $\left(=\frac{d}{7u}+\frac{d}{49fu}\right)$	M1	For Q distance d at $3v$ and distance $d/7$ at $3vf$
	$t_Q=t_P\Rightarrow\frac{3d}{7v}=\frac{d}{3v}+\frac{d}{21fv}$	DM1	Equate times and solve for f Dependent on preceding M1
	$\frac{3}{7}=\frac{1}{3}+\frac{1}{21f},\quad\frac{2}{21}=\frac{1}{21f},\quad f=\frac{1}{2}$	A1	Correct only from correct working
		[5]	
	See over for alternatives		

8c alt	This method looks at the time between the collision between Q and the wall and the second collision between P and Q		
	Speed of Q after rebound $= f \times 3v \left(= f \times 7u\right)$	B1ft	Seen or implied ft is for correct use of their v
	Distance apart when Q hits wall $= d - \frac{14u}{3} \times \frac{d}{7u} \left(= \frac{d}{3}\right)$	B1ft	Seen or implied ft is for correct use of their v Distance moved by Q – distance moved by P
	t_P for extra distance $= \frac{4d}{21} \div \frac{14u}{3} \left(= \frac{4d}{21} \div 2v\right)$	M1	Additional time to second collision = extra distance divided by speed of P
	$t_Q = t_P \Rightarrow \frac{4d}{21} \div \frac{14u}{3} = \frac{d}{7} \div 7uf$	DM1	Equate times to second collision and solve for f Dependent on preceding M1
	$\frac{12}{3 \times 2 \times 49} = \frac{1}{49f}, \quad f = \frac{1}{2}$	A1	Correct only from correct working
		[5]	
8c alt	This method looks at how far Q travels after the rebound		
	Speed of Q after rebound $= f \times 3v \left(= f \times 7u\right)$	B1ft	Seen or implied ft is for correct use of their v
	t_P between collisions $= \frac{6d}{7 \times 2v} \left(= \frac{3d}{7v}\right)$	B1ft	
	Distance travelled by Q if $f = 1$ $= \frac{3d}{7v} \times 3v = \frac{9}{7}d$	M1	
	$f = \frac{\text{actual distance after rebound}}{\frac{9}{7}d - d}$	M1	This is equivalent to $\frac{3d}{7v} \times 3v = \frac{d}{3v} \times 3v + \frac{d}{21fv} \times 3v$ or $\frac{9d}{7} = d + \frac{d}{7f}$
	$= \frac{1}{2}$	A1	Correct only from correct working
		[5]	
8c alt	This method looks at distances		
	Speed of Q after rebound $= f \times 3v \left(= f \times 7u\right)$	B1ft	Seen or implied ft is for correct use of their v
	If t_1 is the time for Q to the wall and t_2 is the time between wall and second collision distance travelled by P is $\left(t_1 + t_2\right)\frac{14}{3}u$	B1ft	

	$(t_1 + t_2)\frac{14}{3}u = \frac{6}{7} \times 7ut_1$	M1	Equate distances for *P* and *Q*
	Use $\frac{d}{7} = 7uf \times t_2$ and solve	M1	
	Obtain $f = \frac{1}{2}$	A1	Correct only from correct working
		[5]	

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