GCE AS Further Mathematics (8FM0) – Shadow Paper (Set 1)
8FM0-25 Further Mechanics 1

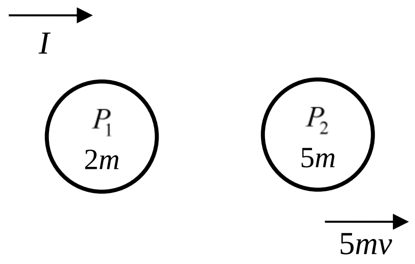
October 2020 Shadow Paper mark scheme

Please note that this mark scheme is not the one used by examiners for making scripts. It is intended more as a guide, indicating where marks are given for correct answers. As such, it may not show follow-through marks (marks that are awarded despite errors being made) or special cases.

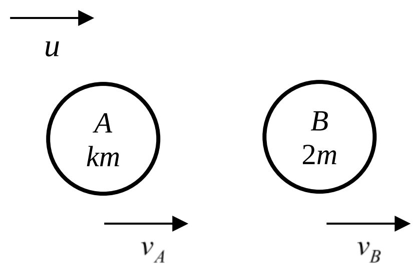
It should also be noted that for many questions, there may be alternative methods of finding correct solutions that are not shown here – they will be covered in the formal mark scheme from the original paper.

This document is intended for guidance only and may differ significantly from the examiners' final mark scheme for the original paper which was published in December 2020.

Guidance on the use of codes within this document
M1 – method mark. This mark is generally given for an appropriate method in the context of the question. This mark is given for showing your working and may be awarded even if working is incorrect. A1 – accuracy mark. This mark is generally given for a correct answer following correct working. B1 – working mark. This mark is usually given when working and the answer cannot easily be separated. Some questions require all working to be shown; in such questions, no marks will be given for an answer with no working (even if it is a correct answer).

Question	Scheme	Marks	AOs
1a			
	Use of CLM: $2m\times\dfrac{I}{2m}=5mv$	M1	3.1a
	$I=5mv$ (Answer not given, so a correct answer with no clear error seen will score M1 A1. An answer that relies on an impulse-momentum equation using 5m will score M0.)	A1	1.1b
		(2)	
1b	$e=\dfrac{v}{\left(\dfrac{5mv}{2m}\right)}=0.4$	B1	3.4
		(1)	
1c	KE Loss = $\dfrac{1}{2}\times 2m\times\left(\dfrac{5v}{2}\right)^2-\dfrac{1}{2}\times 5m\times v^2$	M1	3.4
	$=\dfrac{15mv^2}{4}$	A1	1.1b
		(2)	
			(5 marks)

Question	Scheme	Marks	AOs
2a	Use of $F = \frac{P}{v}$ and using the model	M1	3.4
	Equation of motion and using the model to form equation in k	M1	3.1b
	$\frac{240}{4} - k\left(4^2 + 2\times 4\right) = 75\times\frac{2}{3}$ $\left(c = \frac{5}{12}\right)$	A1ft	1.1b
	Equation of motion and using the model	M1	3.1b
	$\frac{240}{6} - k\left(6^2 + 2\times 6\right) = 75a$	A1ft	1.1b
	Solve for a	M1	1.1b
	$\frac{4}{15}$ (m s^{-2}) (Accept 0.266… etc)	A1	1.1b
		(7)	
2b	Equation of motion horizontally and using the model	M1	3.1b
	$\frac{240}{V} - \frac{5}{12}\left(V^2 + 2V\right) = 0$ (max speed is V m s^{-1})	A1ft	
	Solve for V $\left(V^3 + 2V^2 - 576 = 0\right)$ (Ignore any complex roots seen.)	M1	1.1b
	V = 7.70 (m s^{-1})	A1	1.1b
		(4)	
			(11 marks)

Question	Scheme	Marks	AOs
3a			
	Use of CLM	M1	3.1a
	$kmu = kmv_A + 2mv_B$	A1	1.1b
	Use of NLR	M1	3.1a
	$\frac{1}{3}u = v_B - v_A$	A1	1.1b
	Solve for v_A	M1	1.1b
	$v_A = \frac{u(3k-2)}{3(k+2)}$	A1	1.1b
	Use of $v_A < 0$ and solve for k	M1	3.4
	$(0 <)\ k < \frac{2}{3}$	A1	1.1b
	Alternative for last 4 marks		
	Solve for v_A in terms of v_B only	M1	
	$v_A = \frac{(2-3k)v_B}{4k}$	A1	
	Use of $v_A < 0$ and $v_B > 0$ to solve for k (Allow loose inequality for method mark.)	M1	
	$(0 <)\ k < \frac{2}{3}$ (CAO LHS not needed, but if there it must be correct.)	A1	
		(8)	
3b	Impulse-momentum equation	M1	3.1a
	$-\frac{10kmu}{9} = km(v_A - u)$ $\left(v_A = -\frac{u}{9}\right)$ or $\frac{10kmu}{9} = 2mv_B$	A1	1.1b
	Complete method to solve for k	M1	1.1b
	$k = \frac{2}{5}$	A1	2.2a
		(4)	

			(12 marks)

Question	Scheme	Marks	AOs
4a	Work done against resistance is $\frac{1}{4}mgx$	B1	1.1b
	Kinetic energy lost $\frac{1}{2}m(16gx-v^2)$	B1	1.1b
	Apply the work-energy principle. (Must have correct number of terms, dimensionally correct. Condone sign errors.)	M1	3.3
	$\frac{1}{4}mgx=\frac{1}{2}m(16gx-v^2)-mgx$	A1	1.1b
	$v=\frac{3\sqrt{6gx}}{2}$ o.e.	A1	1.1b
		(5)	
4b	Use NLR to find rebound speed: $\frac{1}{4}\times\frac{3\sqrt{6gx}}{2}=\frac{3\sqrt{6gx}}{8}$	M1	3.4
	Apply the work-energy principle or *suvat* with $a=g-\frac{1}{4}g=\frac{3}{4}g$	M1	3.3
	$\frac{1}{4}mgx=mgx-\frac{1}{2}m\left(v_1^{\,2}-\frac{27gx}{32}\right)$ or $(v_1)^2=\frac{27gx}{32}+2\times\frac{3g}{4}\times x$ (M1 A1ft is available to a candidate who has not scored the first M1.)	A1ft A1	1.1b 1.1b
	Reaches $v_1=\frac{5\sqrt{6gx}}{8}$ (All working clear for this mark to be awarded with no errors seen.)	A1	2.2a
		(5)	

4c	Work-energy principle Maximum kinetic energy possible immediately after rebound is $\frac{1}{2}mv_1^2 = \frac{75mgx}{64}$ (if collision between the ball bearing and the floor is perfectly elastic, ie if $e = 1$; otherwise $\frac{1}{2}mv_1^2 < \frac{75mgx}{64}$, or $\frac{1}{2}mv_1^2 = \frac{75me^2gx}{64} \le \frac{75mgx}{64}$ since $e^2 \le 1$)	B1	2.4
	Work done against resistance and potential energy gained in reaching the ceiling is $\frac{1}{4}mgx + mgx = \frac{5}{4}mgx > \frac{75mgx}{64}$ or $\frac{1}{4}mgx + mgx = \frac{5}{4}mgx > \frac{75me^2gx}{64}$ so the ball bearing does not have enough kinetic energy for it to reach the ceiling.	B1	2.4
		(2)	
	suvat Maximum velocity possible immediately after rebound is $\frac{5\sqrt{6gx}}{8}$ (if collision between the ball bearing and the floor is perfectly elastic, ie if $e = 1$; otherwise $v = \frac{5e\sqrt{6gx}}{8} < \frac{5\sqrt{6gx}}{8}$ since $e < 1$	B1	2.4
	Use $v^2 = u^2 + 2as$ with $a = -g - \frac{1}{4}g = -\frac{5}{4}g$ to obtain $0 \le \frac{75gx}{32} + 2\times\frac{-5g}{4}\times s$ or $0 = \frac{75e^2gx}{32} + 2\times\frac{-5g}{4}\times s$ so $s = \frac{\left(\frac{75e^2gx}{32}\right)}{\left(2\times\frac{5g}{4}\right)} = \frac{15e^2x}{16} \le \frac{15x}{16} < x$ or $s \le \frac{\left(\frac{75gx}{32}\right)}{\left(2\times\frac{5g}{4}\right)} = \frac{15x}{16} < x$ so the ball bearing does not reach the ceiling. (Note: alternative of using *suvat* is given here since the question in part *(c)* does not state any requirement to use work-energy principle.)	B1	2.4
		(2)	
			(12 marks)