GCE A level Mathematics (9AM0) – Shadow Paper (Set 1)
9MA0-32 Mechanics

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
1.(a)	Resolve perpendicular to the plane	M1	3.4
	$R = mg\cos\alpha = \frac{12}{13}mg$	A1	1.1b
		(2)	
1(b)	Resolve parallel to the plane or horizontally or vertically	M1	3.4
	$F = mg\sin\alpha$ or $R\sin\alpha = F\cos\alpha$	A1	1.1b
	Use $F = \mu R$ and solve for μ	M1	2.1
	$\mu = \frac{5}{12}$	A1	2.2a
		(4)	
1(c)	The forces acting on C will still balance as the m's cancel oe Other possibilities: e.g. the friction will increase in the same proportion as the weight component or force down the plane. The force pulling the brick down the plane increases by the same amount as the friction oe This mark can be scored if they do the calculation.	B1	2.4
		(1)	
1(d)	Brick C slides down the plane with **constant** speed.	B1	2.4
	No resultant force down the plane (so no acceleration) oe	B1	2.4
	These marks can be scored if they do the calculation.	**(2)**	
			(9 marks)

Question	Scheme	Marks	AOs
2(a)	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ or integrate to give: $\mathbf{v} = (-2\mathbf{i} + 3\mathbf{j}) + 3(5\mathbf{i} - 4\mathbf{j})$	M1	3.1a
	$(13\mathbf{i} - 9\mathbf{j})\,(\text{m s}^{-1})$	A1	1.1b
		(2)	
2(b)	Solve problem through use of $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ or integration (M0 if $\mathbf{u} = \mathbf{0}$) **Or** any other complete method e.g use $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ and $\mathbf{r} = \frac{(\mathbf{u} + \mathbf{v})T}{2}$:	M1	3.1a
	$-5\mathbf{j} = 3t\mathbf{j} - \frac{1}{2}t^2 4\mathbf{j}$ ($\mathbf{j}$ terms only)	A1	1.1b
	The first two marks could be implied if they go straight to an algebraic equation.		
	Attempt to equate $\mathbf{j}$ components to give equation in T only $(-5 = 3T - 2T^2)$	M1	2.1
	$T = 2.5$	A1	1.1b
		(4)	
2(c)	Solve problem by substituting <u>their</u> T value (M0 if $T < 0$) into the $\mathbf{i}$ component equation to give an equation in λ only: $\lambda = -2T + \frac{1}{2}T^2 \times 5$ $\left(\lambda = -2 \times 2.5 + \frac{1}{2}(2.5)^2 \times 5\right)$	M1	3.1a
	$\lambda = 10.6$ or 10.625 or $\frac{85}{8}$ oe	A1	1.1b
		(2)	
Notes: Accept column vectors throughout			**(8 marks)**

Question	Scheme	Marks	AOs
3(i)(a)	Integrate **a** wrt t to obtain velocity	M1	3.4
	$\mathbf{v} = (2t - 4t^2)\mathbf{i} + \left(5t - \frac{1}{3}t^3\right)\mathbf{j}$ $(+\mathbf{C})$	A1	1.1b
	(When $t = 5$,) $66\mathbf{i} - \frac{50}{3}\mathbf{j}$ (m s^{-1})	A1	1.1b
		(3)	
3(i)(b)	Equate **i** component of **v** to zero	M1	3.1a
	$2t - 4t^2 + 156 = 0$	A1**ft**	1.1b
	$t = 6.5$ (ignore an incorrect second solution)	A1	1.1b
		(3)	
3(ii)	Differentiate **r** wrt to t to obtain velocity	M1	3.4
	$\mathbf{v} = (4t - 2)\mathbf{i} + 5\mathbf{j}$	A1	1.1b
	Use magnitude to give an equation in t only	M1	2.1
	$(4t - 2)^2 + 5^2 = 13^2$	A1	1.1b
	Solve problem by solving this equation for t $(16t^2 - 16t + 4 + 25 = 169)$ $(16t^2 - 16t + 140 = 0)$	M1	3.1a
	$t = 3.5$	A1	1.1b
		(6)	
			(12 marks)
Notes: Accept column vectors throughout			

Question	Scheme	Marks	AOs
4(a)	Take moments about A	M1	3.3
	$N \times \dfrac{12a}{\sin\alpha} = Mg \times 5a\cos\alpha$	A1	1.1b
	$\dfrac{75Mg}{338}$	A1	1.1b
		(3)	
4(b)	Resolve horizontally	M1	3.4
	$(\rightarrow)\ F = \dfrac{75Mg}{338}\sin\alpha$	A1	1.1b
	Resolve vertically	M1	3.4
	$(\uparrow)\ R + \dfrac{75Mg}{338}\cos\alpha = Mg$	A1	1.1b
	$F = \mu R$ used	M1	3.4
	Eliminate R and F and solve for μ $\left(\dfrac{75Mg}{338} \times \dfrac{12}{13} = \mu\left(Mg - \dfrac{75Mg}{338} \times \dfrac{5}{13}\right)\right)$ $(900Mg = \mu \times 4019Mg)$	M1	3.1b
	$\mu = \dfrac{900}{4019}$ (0.2239…..accept 0.22 or better)	A1	2.2a
		(7)	
			(10 marks)

Question	Scheme	Marks	AOs
5(a)	Using horizontal motion	M1	3.3
	$U\cos 60^\circ t = 150$	A1	1.1b
	Using vertical motion	M1	3.4
	$U\sin 60^\circ t - \frac{1}{2}gt^2 = -50$	A1	1.1b
	Solve problem by eliminating t and solving for U $t = \frac{300}{U}$ $\frac{\sqrt{3}}{2}U \times \frac{300}{U} - \frac{1}{2}g\left(\frac{300}{U}\right)^2 = -50$ $150\sqrt{3} - 4.9 \times \frac{90000}{U^2} = -50$	M1	3.1b
	$U = 37.728\ldots$ $U = 37.7$ (3 sig fig)	A1*	1.1b
		(6)	
5(b)	Using vertical motion	M1	3.4
	$0^2 = (37.7\sin 60^\circ)^2 - 2gh$	A1	1.1b
	$h = 54$ m Greatest height = 104 to 3 significant figures	A1	1.1b
		(3)	
5(c)	New value > 37.7	B1	3.5a
		(1)	
5(d)	e.g. wind effects, more accurate value of g, spin of ball, include size of the ball, not model as a particle, shape of ball	B1	3.5c
		(1)	
			(11 marks)