GCE A level Mathematics (9MA0) – Paper 32 Mechanics

Summer 2019 shadow paper student-friendly 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 to good practice, indicating where marks are given for correct answers. As such, it doesn't 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.

This document is intended for guidance only and may differ significantly from the mark schemes used by examiners.

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).

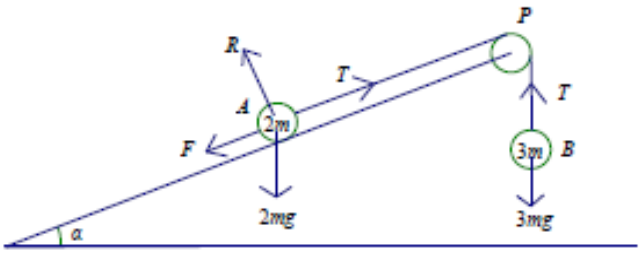
Question 1 (Total 6 marks)

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)	$\mathbf{a} = 8\mathbf{i} - \frac{45}{2} t^{\frac{1}{2}} \mathbf{j}$	M1	This mark is given for a method to differentiate the expression for **v**
		A1	This mark is given for correctly differentiating the expression for **v**
	$= 8\mathbf{i} - \frac{135}{2} \mathbf{j}$ m s^{-1}	A1	This mark is given for substituting $t = 9$ to find a correct vector expression for the acceleration of P
(b)	$\mathbf{r} = (\mathbf{r}_0) + 4t^2 \mathbf{i} - 6t^{\frac{5}{2}} \mathbf{j}$	M1	This mark is given for a method to integrate the expression for **v**
		A1	This mark is given for correctly integrating the expression for **v**
	$(-5\mathbf{i} + 3\mathbf{j}) + (64\mathbf{i} - 192\mathbf{j})$ $= 59\mathbf{i} - 189\mathbf{j}$ m	A1	This mark is given for substituting $t = 4$ to find a correct position vector of P

Question 2 (Total 8 marks)

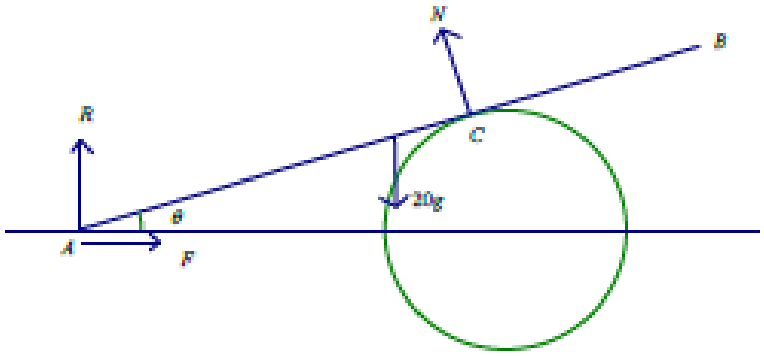
Part	Working or answer an examiner might expect to see	Mark	Notes
(a)	$\mathbf{v} = \mathbf{u} + \mathbf{a}t$ $\mathbf{v} = (-7\mathbf{i} + \mathbf{j}) + (3\mathbf{i} + 4\mathbf{j})t$	M1	This mark is given for a method to find a vector expression for **v**
	$= (-7 + 3t)\mathbf{i} + (1 + 4t)\mathbf{j}$	A1	This mark is given for finding a correct vector expression for **v**
	$\frac{1+4T}{-7+3T} = \frac{3}{2}$	M1	This mark is given for a correct use of ratios as a method to find the value of T
	$3(-7 + 3T) = 2(1 + 4T)$ $T = 2 + 21 = 23$	A1	This mark is given for finding the correct value of T
(b)	$\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ $\mathbf{s} = (-7\mathbf{i} + \mathbf{j})t + \frac{1}{2}(3\mathbf{i} + 4\mathbf{j})t^2$	M1	This mark is given for a method to find a vector expression for the distance AB
	$= (-7t + \frac{3}{2}t^2)\mathbf{i} + (t + 2t^2)\mathbf{j}$	A1	This mark is given for finding a correct vector expression for the distance AB
	$AB = \sqrt{(-4)^2 + 36^2}$	M1	This mark is given for a method to find the distance AB using Pythagoras and substituting $t = 4$
	$= 36.2$ m	A1	This mark is given for find a correct value for the distance AB

Question 3 (Total 12 marks)

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)			
	$R = 2mg\cos\alpha = \frac{24mg}{13}$	B1	This mark is given for using the model to state the normal reaction between A and the plane
	$F_{\max} = \frac{1}{3}R = \frac{8mg}{13}$	B1	This mark is given for the use of $F = \mu R$
	Equation of motion for A is $T - F_{\max} - 2mg\sin\alpha = 2ma$	M1	This mark is given for a method form an equation of motion for A
		A1	This mark is given for a correct equation of motion for A
	Equation of motion for B is $3mg - T = 3ma$	M1	This mark is given for a method to form an equation of motion for B
		A1	This mark is given for a correct equation of motion for B
	$2(3mg - T) = 3(T - \frac{8mg}{13} - \frac{10mg}{13})$ $6mg - 2T = 3T - \frac{54mg}{13}$	M1	This mark is given for a method using the equations of motion for A and B to solve for T
	$5T = \frac{132}{13}mg \Rightarrow T = \frac{132}{65}mg$	A1	This mark is given for a full method and correct working to show the answer given
(b)	$F_{\max} = \frac{8mg}{13} < \frac{10mg}{13}$ $\frac{10mg}{13}$ is the component of the weight parallel to the slope	M1	This mark is given for a comparison of $F_{\max}$ with the component of weight
	Thus A will move down the plane	A1	This mark is given for a fully justified and correct conclusion

(c)	Have the model consider air resistance Have the model use an extensible string	B2	These marks are given for two correct refinements stated (B1 for one refinement stated)

Question 4 (Total 11 marks)

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)	The drum is smooth so there is no friction; thus there is no component parallel to the ramp and therefore the reaction is perpendicular to the ramp	B1	This mark is given for a correct explanation stated
(b)			
	M(*A*): $5N = 20g \times 4\cos\theta$	M1	This mark is given for a method to find moments about *A*
	$N = 16g\cos\theta$ $N = 145$ (144.73846…)	A1	This mark is given for a correct value for *N*
	$R + N\cos\theta = 20g$	M1	This mark is given for finding an equation in *R* by resolving vertically
	$R + N \times \frac{12}{13} = 20g$	A1	This mark is given for a correct equation in *R*
	$F = N\sin\theta$	M1	This mark is given for finding an equation in *F* by resolving horizontally
	$F = N \times \frac{5}{13}$	A1	This mark is given for a correct equation for *F*
	$R = 62.4$ N, $F = 55.7$ N	M1	This mark is given for using trigonometry to correctly solve for *R* and *F*
	$\lvert\text{Force}\rvert = \sqrt{62.4^2 + 55.7^2}$	M1	This mark is given for a method to find the resultant force
	= 83.6 N	A1	This mark is given for correctly finding the resultant force
(c)	The magnitude of the normal reaction will decrease	B1	This mark is given for a correct reason given

Question 5 (Total 13 marks)

Part	Working or answer an examiner might expect to see	Mark	Notes
(a)	Horizontal speed = $20 \cos 30°$ $(= 10\sqrt{3}\ \text{m s}^{-1})$	B1	This mark is given for a correct expression for the horizontal speed of P
	$v = u + at$ at t = 1 Vertical speed = $20 \sin 30° - 9.8$ $= 0.2\ \text{m s}^{-1}$	M1	This mark is given for a method to find the vertical speed of P
		A1	This mark is given for a correct value for the vertical speed of P
	$\theta = \tan^{-1} \pm \dfrac{0.2}{10\sqrt{3}}$ (=0.662)	M1	This mark is given finding an expression for the value of θ
	Speed = $\sqrt{\left(10\sqrt{3}\right)^2 + 0.2^2}$	M1	This mark is given for using Pythagoras to find the magnitude of the speed of P
	$17.3\ \text{m s}^{-1}$ upwards at 0.662° to the horizontal	A1	This mark is given for finding the correct velocity of P (showing both magnitude and direction)
(b)	Sum of horizontal distances = 50 m	M1	This mark is given for stating the sum of the horizontal distances
	$(u \cos \theta) \times 1 = 50 - (20 \cos 30°) \times 1$ $u \cos \theta = 50 - 20 \cos 30°$	A1	This mark is given for a correct expression for the horizontal distance
	Vertical distances equal $(20 \sin 30°) - \dfrac{g}{2} = (u \sin \theta) - \dfrac{g}{2}$	M1	This mark is given for equating the vertical distances
	$u \sin \theta = 20 \sin 30°$	A1	This mark is given for a correct expression for the vertical distance
	$\tan \theta = \dfrac{20 \sin 30°}{50 - 20 \cos 30°}$	M1	This mark is given for a correct method to find θ and u
	$\theta = 17.0°$, $u = 34.2\ \text{m s}^{-1}$	A1	This mark is given for finding correct values of θ and u
(c)	For example: The effect of the wind The effect of the spinning of the balls The size of the balls	B1	This mark is given for one correct limitation of the model stated