



Rewarding Learning

ADVANCED
General Certificate of Education
2015

Mathematics

Assessment Unit M3
assessing
Module M3: Mechanics 3

[AMM31]

FRIDAY 12 JUNE, MORNING

MARK
SCHEME

GCE ADVANCED/ADVANCED SUBSIDIARY (AS) MATHEMATICS

Introduction

The mark scheme normally provides the most popular solution to each question. Other solutions given by candidates are evaluated and credit given as appropriate; these alternative methods are not usually illustrated in the published mark scheme.

The marks awarded for each question are shown in the right hand column and they are prefixed by the letters **M**, **W** and **MW** as appropriate. The key to the mark scheme is given below:

M indicates marks for correct method.

W indicates marks for working.

MW indicates marks for combined method and working.

The solution to a question gains marks for correct method and marks for an accurate working based on this method. Where the method is not correct no marks can be given.

A later part of a question may require a candidate to use an answer obtained from an earlier part of the same question. A candidate who gets the wrong answer to the earlier part and goes on to the later part is naturally unaware that the wrong data is being used and is actually undertaking the solution of a parallel problem from the point at which the error occurred. If such a candidate continues to apply correct method, then the candidate's individual working must be followed through from the error. If no further errors are made, then the candidate is penalised only for the initial error. Solutions containing two or more working or transcription errors are treated in the same way. This process is usually referred to as "follow-through marking" and allows a candidate to gain credit for that part of a solution which follows a working or transcription error.

Positive marking:

It is our intention to reward candidates for any demonstration of relevant knowledge, skills or understanding. For this reason we adopt a policy of **following through** their answers, that is, having penalised a candidate for an error, we mark the succeeding parts of the question using the candidate's value or answers and award marks accordingly.

Some common examples of this occur in the following cases:

- (a) a numerical error in one entry in a table of values might lead to several answers being incorrect, but these might not be essentially separate errors;
- (b) readings taken from candidates' inaccurate graphs may not agree with the answers expected but might be consistent with the graphs drawn.

When the candidate misreads a question in such a way as to make the question easier only a proportion of the marks will be available (based on the professional judgement of the examining team).

1 (i)

Relative Mass	1	3	2	1	1	2
Distance of C.O.M. from BC (m)	0.5	0	1	2	1.5	1
Distance of C.O.M. from CD (m)	3	1.5	0	0.5	1	2

M2

$$\mathbf{M(BC): } 10\bar{x} = 0.5 + 0 + 2 + 2 + 1.5 + 2 = 8$$

$$\bar{x} = 0.8$$

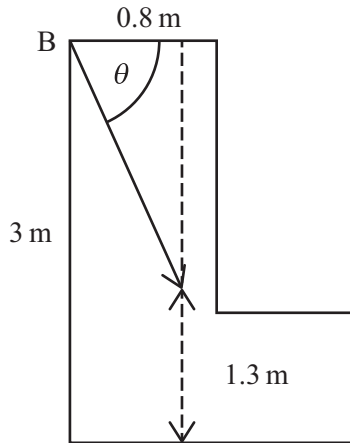
M1MW1
W1

$$\mathbf{M(CD): } 10\bar{y} = 3 + 4.5 + 0 + 0.5 + 1 + 4 = 13$$

$$\bar{y} = 1.3$$

M1
MW1

(ii)



$$\tan \theta = \frac{3 - 1.3}{0.8}$$

$$\theta = 64.8^\circ \text{ (3 s.f.)}$$

M1MW1

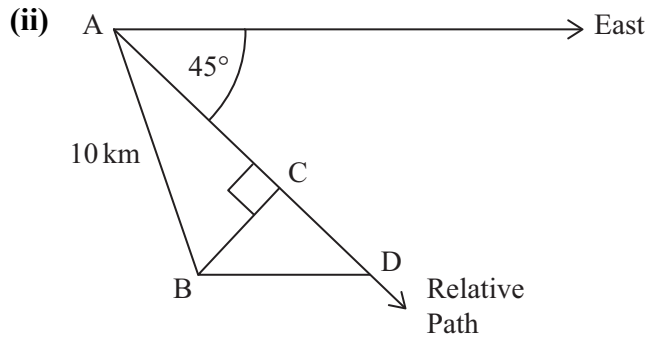
W1

10

AVAILABLE
MARKS

2 (i) $\mathbf{V}_A = (6\mathbf{i} + 2\mathbf{j}) \text{ km h}^{-1}$
 $\mathbf{V}_B = (-2\mathbf{i} + 10\mathbf{j}) \text{ km h}^{-1}$
 $\mathbf{V}_{AB} = \mathbf{V}_A - \mathbf{V}_B = (8\mathbf{i} - 8\mathbf{j}) \text{ km h}^{-1}$

M1MW1



MW2

Shortest distance apart = $BC = 10 \sin 15^\circ = 2.59 \text{ km}$ (3 s.f.)

M1W1

(iii) D is the point on the relative path, due east of B.

$|\mathbf{V}_{AB}| = \sqrt{8^2 + (-8)^2} = 8\sqrt{2} \text{ km h}^{-1}$

MW1

$AD = 10(\sin 15^\circ + \cos 15^\circ) \text{ km}$

M1W1

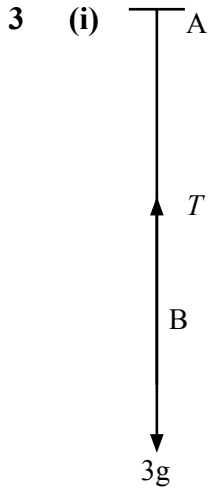
Time taken (A \rightarrow D) = $\frac{AD}{|\mathbf{V}_{AB}|} = 1.08\dots \text{ hours} = 65.0 \text{ minutes}$ (3 s.f.)

M1

A is due east of B at 1.05 pm.

W1

11



$$\mathbf{R}(\uparrow): T = 3g = \frac{980e}{2} \text{ (Hooke's Law)}$$

$$e = \frac{6 \times 9.8}{980} = 0.06 \text{ m}$$

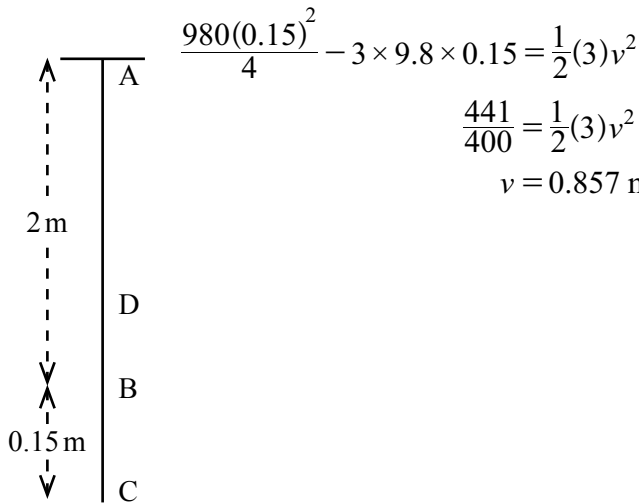
MW1M1

W1

(ii) Conservation of energy:

Total energy at C = Total energy at B

M1



$$\frac{980(0.15)^2}{4} - 3 \times 9.8 \times 0.15 = \frac{1}{2}(3)v^2$$

M1W2

$$\frac{441}{400} = \frac{1}{2}(3)v^2$$

$$v = 0.857 \text{ ms}^{-1} \text{ (3 s.f.)}$$

W1

(iii) Let the particle come to rest at D, d metres above B.

Total energy at C = Total energy at D

M1

$$\frac{441}{400} = 3gd + \frac{980d^2}{4}$$

M1W2

$$25d^2 + 3d - 0.1125 = 0$$

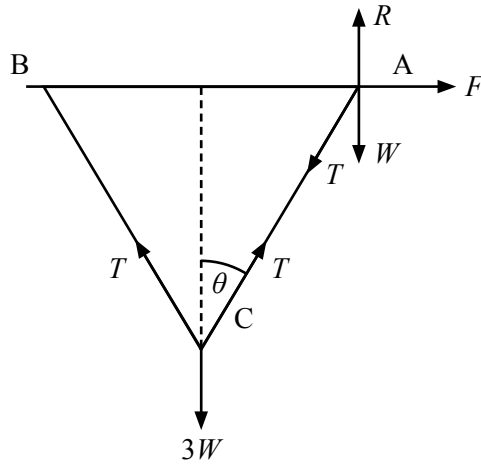
$$d(> 0) = 0.03$$

MW1

13

		AVAILABLE MARKS
4 (i)	Amplitude, $a = \frac{1}{2}(1) = 0.5\text{m}$	MW1
	Period = $2 \times 6 = 12\text{s}$	MW1
(ii)	$\frac{2\pi}{\omega} = 12 \Rightarrow \omega = \frac{\pi}{6}$	MW1
	$v^2 = \omega^2(a^2 - x^2)$	M1
	$v^2 = \left(\frac{\pi}{6}\right)^2 (0.5^2 - 0.4^2)$	W1
	$v = \frac{\pi}{20} \cong 0.157\text{ms}^{-1}$	W1
(iii)	From O: $x = a \sin \omega t$	M1
	$0.4 = 0.5 \sin \frac{\pi}{6} t_1$	
	$t_1 = 1.771\dots$	W1
	$0.2 = 0.5 \sin \frac{\pi}{6} t_2$	
	$t_2 = 0.7859\dots$	MW1
	Least time = $t_1 + t_2 = 2.56\text{s}$ (3 s.f.)	M1W1
		11

5 (i)



MW2

(ii) At C

$$\mathbf{R}(\uparrow): 3W = 2T \cos \theta$$

M1

$$T = \frac{3W}{2 \cos \theta}$$

MW1

(iii) At A

$$\mathbf{R}(\uparrow): R = T \cos \theta + W$$

M1

$$R = \frac{3W}{2} + W = \frac{5W}{2}$$

MW1

(iv) $\mathbf{R}(\rightarrow): F = T \sin \theta$

MW1

$$F = \frac{3W}{2 \cos \theta} \sin \theta = \frac{3W}{2} \tan \theta$$

MW1

(v) Since the rings are in equilibrium, $F \leq \mu R$

M2

$$\frac{3W}{2} \tan \theta \leq \frac{1}{4} \cdot \frac{5W}{2}$$

MW1

$$\tan \theta \leq \frac{5}{12} \Rightarrow \sin \theta \leq \frac{5}{13}$$

$$AB = 2l \sin \theta \leq 2l \cdot \frac{5}{13}$$

MW1

$$AB \leq \frac{10l}{13}$$

W1

AVAILABLE
MARKS

13

			AVAILABLE MARKS
6 (a) (i)	Resultant force = $\begin{pmatrix} 1 \\ 2 \\ -4 \end{pmatrix} + \begin{pmatrix} -3 \\ 8 \\ 10 \end{pmatrix} + \begin{pmatrix} 3\alpha + 5 \\ \alpha - 3 \\ 5 - 7\alpha \end{pmatrix} = \begin{pmatrix} 3\alpha + 3 \\ \alpha + 7 \\ 11 - 7\alpha \end{pmatrix}$	MW1	
	$\begin{pmatrix} 3\alpha + 3 \\ \alpha + 7 \\ 11 - 7\alpha \end{pmatrix} = c \begin{pmatrix} 6 \\ 4 \\ -8 \end{pmatrix}$	M1	
	$\alpha = 2c - 1 = 4c - 7$	M1	
	$c = 3, \alpha = 5$	W1	
	check $11 - 35 = 3x - 8$		
(ii)	Work done = $\begin{pmatrix} 18 \\ 12 \\ -24 \end{pmatrix} \cdot \begin{pmatrix} 6 \\ 4 \\ -8 \end{pmatrix}$	M1	
	$= 108 + 48 + 192 = 348\text{J}$	MW1	
(b) (i)	Work done = $\int_1^a \left(\frac{2}{x^2} - \frac{8}{x^3} \right) dx$	M1W1	
	$= \left[\frac{-2}{x} + \frac{4}{x^2} \right]_1^a$	MW1	
	$= \frac{4}{a^2} - \frac{2}{a} - (-2 + 4)$	W1	
	$= -\frac{35}{16}$		
	$3a^2 - 32a + 64 = 0$	M1	
	$a = \frac{8}{3}, a = 8$	W1	
(ii)	$F = 0 \Rightarrow 2x^3 = 8x^2, x = 4$	M1MW1	
	Work–Energy Principle:		
	$\frac{1}{2} \cdot \frac{1}{8} v^2 - \frac{1}{2} \cdot \frac{1}{8} 8^2 = \frac{4}{16} - \frac{2}{4} - (-2 + 4)$	M1MW1	
	$v = \sqrt{28} \text{ ms}^{-1}$	W1	17
	Total		75