

GCE A2

Mathematics

January 2009

Mark Schemes

Issued: April 2009

**NORTHERN IRELAND GENERAL CERTIFICATE OF SECONDARY EDUCATION (GCSE)
AND NORTHERN IRELAND GENERAL CERTIFICATE OF EDUCATION (GCE)**

MARK SCHEMES (2009)

Foreword

Introduction

Mark Schemes are published to assist teachers and students in their preparation for examinations. Through the mark schemes teachers and students will be able to see what examiners are looking for in response to questions and exactly where the marks have been awarded. The publishing of the mark schemes may help to show that examiners are not concerned about finding out what a student does not know but rather with rewarding students for what they do know.

The Purpose of Mark Schemes

Examination papers are set and revised by teams of examiners and revisers appointed by the Council. The teams of examiners and revisers include experienced teachers who are familiar with the level and standards expected of 16- and 18-year-old students in schools and colleges. The job of the examiners is to set the questions and the mark schemes; and the job of the revisers is to review the questions and mark schemes commenting on a large range of issues about which they must be satisfied before the question papers and mark schemes are finalised.

The questions and the mark schemes are developed in association with each other so that the issues of differentiation and positive achievement can be addressed right from the start. Mark schemes therefore are regarded as a part of an integral process which begins with the setting of questions and ends with the marking of the examination.

The main purpose of the mark scheme is to provide a uniform basis for the marking process so that all the markers are following exactly the same instructions and making the same judgements in so far as this is possible. Before marking begins a standardising meeting is held where all the markers are briefed using the mark scheme and samples of the students' work in the form of scripts. Consideration is also given at this stage to any comments on the operational papers received from teachers and their organisations. During this meeting, and up to and including the end of the marking, there is provision for amendments to be made to the mark scheme. What is published represents this final form of the mark scheme.

It is important to recognise that in some cases there may well be other correct responses which are equally acceptable to those published: the mark scheme can only cover those responses which emerged in the examination. There may also be instances where certain judgements may have to be left to the experience of the examiner, for example, where there is no absolute correct response – all teachers will be familiar with making such judgements.

The Council hopes that the mark schemes will be viewed and used in a constructive way as a further support to the teaching and learning processes.

CONTENTS

	Page
Module C3: Core Mathematics 3	1
Module C4: Core Mathematics 4	7
Module FP2: Further Pure Mathematics 2	13
Module M2: Mechanics 2	21



Rewarding Learning

ADVANCED
General Certificate of Education
January 2009

Mathematics

Assessment Unit C3

assessing

Module C3: Core Mathematics 3

[AMC31]

FRIDAY 9 JANUARY, MORNING

**MARK
SCHEME**

GCE Advanced/Advanced Subsidiary (AS) Mathematics

Mark Schemes

Introduction

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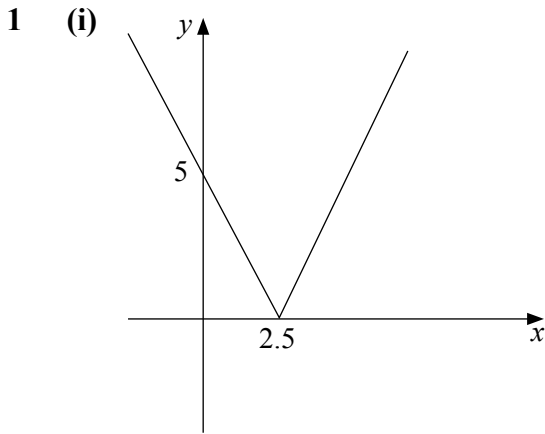
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- (a) a numerical error in one entry in a table of values might lead to several answers being incorrect, but these might not be essentially separate errors;
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When the candidate misreads a question 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).



M1W1

(ii) $2x - 5 > 10$ or $-(2x - 5) > 10$
 $2x > 15$ $-2x + 5 > 10$
 $x > 7.5$ $x < -\frac{5}{2}$

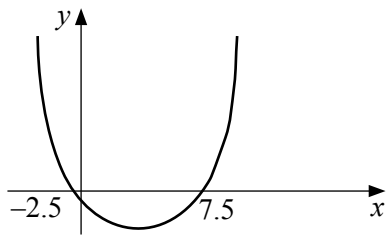
MW1
W1
MW2

Alternative Solution

(ii) $(2x - 5)^2 > 10^2$
 $4x^2 - 20x - 75 > 0$
 $(2x - 15)(2x + 5) = 0$
 $x = 7.5$ or $x = -2.5$

M1

MW1



$x > 7.5$ or $x < -2.5$

MW2

6

2

x	y
0	1.73205
0.5	1.69634
1	1.59383
1.5	1.43900
2	1.25851
2.5	1.09492
3	1.00499

M1MW2

$A \approx \frac{1}{3} h [y_0 + 4(y_1 + y_3 + y_5) + 2(y_2 + y_4) + y_6]$
 $= \frac{1}{3} \times \frac{1}{2} [1.73205 + 4(4.23027) + 2(2.85234) + 1.00499]$

$= 4.22713 \approx 4.23$

M1MW1
W1

6

		AVAILABLE MARKS
3	<p>(i) $\cos \theta = \frac{x-3}{3}$ and $\sin \theta = \frac{y}{2}$</p> <p>$\sin^2 \theta + \cos^2 \theta = 1$</p> $\left(\frac{x-3}{3}\right)^2 + \left(\frac{y}{2}\right)^2 = 1$	M1W1 M1W1
	<p>(ii) $y = 0 \Rightarrow \left(\frac{x-3}{3}\right)^2 = 1$</p> <p>$x^2 - 6x + 9 = 9$</p> <p>$x(x-6) = 0$</p> <p>$x = 0$ or $x = 6$</p> <p>$(0,0)$ or $(6,0)$</p> <p>Alternative Solution</p>	M1 MW1 MW1
	<p>(ii) $y = 0 \Rightarrow 2 \sin \theta = 0 \Rightarrow \theta = 0^\circ$ or $\theta = 180^\circ$</p> <p>$\theta = 0^\circ \Rightarrow x = 6$</p> <p>$\theta = 180^\circ \Rightarrow x = 0$</p> <p>$(0,0)$ or $(6,0)$</p>	MW1 MW1 MW1
4	<p>(a) $\frac{4x^2 - 9}{x^2 + 2x + 1} \times \frac{2x + 2}{2x - 3}$</p> $\frac{(2x-3)(2x+3)}{(x+1)(x+1)} \times \frac{2(x+1)}{(2x-3)}$ $\frac{2(2x+3)}{x+1}$	M1 M1W2 MW1
	<p>(b) $x^2 - 2x \sqrt{2x^2 - 9}$</p> $\frac{2x^2 - 4x}{4x - 9}$ <p>$2 + \frac{4x - 9}{x(x-2)}$</p> $\frac{4x - 9}{x(x-2)} = \frac{A}{x} + \frac{B}{x-2}$ <p>$4x - 9 = A(x-2) + Bx$</p> <p>Let $x = 2$ $8 - 9 = 2B$</p> <p>$B = -\frac{1}{2}$</p> <p>Let $x = 0$ $0 - 9 = -2A$</p> <p>$A = \frac{9}{2}$</p> $\frac{2x^2 - 9}{x(x-2)} = 2 + \frac{9}{2x} - \frac{1}{2(x-2)}$	M1W1 M1W1 M1 M1 W1 MW1 MW1
		MW1
		7
		14

		AVAILABLE MARKS
5	(i) $C = 30^\circ$	MW1
	(ii) $130 = 180 - 150e^{5k}$ $e^{5k} = \frac{1}{3}$ $5k = \ln \frac{1}{3}$ $k = -0.219722 \approx -0.22$	M1 M1W1 W1
	(iii) $\frac{dC}{dt} = 33e^{-0.22t}$ $t = 10 \Rightarrow \frac{dC}{dt} = 3.6565 \approx 3.66$	M1W1 M1W1
6	(a) (i) $u = 5x \quad v = \ln(x^2 - 2)$ $\frac{du}{dx} = 5 \quad \frac{dv}{dx} = \frac{2x}{x^2 - 2}$ $\frac{dy}{dx} = 5x \left[\frac{2x}{x^2 - 2} \right] + 5 \ln(x^2 - 2)$ $\frac{dy}{dx} = \left[\frac{10x^2}{x^2 - 2} \right] + 5 \ln(x^2 - 2)$	MW2 M1W1
	(ii) $u = \sin x \quad v = \cos 3x$ $\frac{du}{dx} = \cos x \quad \frac{dv}{dx} = -3 \sin 3x$ $\frac{dy}{dx} = \frac{\cos 3x(\cos x) - \sin x(-3 \sin 3x)}{\cos^2 3x}$ $\frac{dy}{dx} = \frac{\cos 3x \cos x + 3 \sin 3x \sin x}{\cos^2 3x}$	M1W3
	(b) $2x + 2 \ln x + \frac{1}{3}e^{3x} + \tan x + c$	MW5
7	$\sqrt{4-x} = (4-x)^{\frac{1}{2}}$ $(4-x)^{\frac{1}{2}} = \left[4 \left(1 - \frac{x}{4} \right) \right]^{\frac{1}{2}} = 2 \left(1 - \frac{x}{4} \right)^{\frac{1}{2}}$ $2 \left(1 - \frac{x}{4} \right)^{\frac{1}{2}} = 2 \left[1 + \frac{1}{2} \left(\frac{-x}{4} \right) + \frac{\frac{1}{2} \left(\frac{-1}{2} \right) \left(\frac{-x}{4} \right)^2}{2} + \frac{\frac{1}{2} \left(\frac{-1}{2} \right) \left(\frac{-3}{2} \right) \left(\frac{-x}{4} \right)^3}{2 \times 3} \right]$ $2 \left[1 - \frac{x}{8} - \frac{x^2}{128} - \frac{x^3}{1024} \right] = 2 - \frac{x}{4} - \frac{x^2}{64} - \frac{x^3}{512}$	MW1 M1W1 MW3 MW1
		9 13 7

8 (a) $\tan^2 \theta + 2(\tan^2 \theta + 1) = 11$
 $3 \tan^2 \theta = 9$
 $\tan \theta = \sqrt{3}$ or $\tan \theta = -\sqrt{3}$
 $\theta = \frac{\pi}{3}, \frac{-2\pi}{3}$ or $\frac{2\pi}{3}, \frac{-\pi}{3}$

M1W1

AVAILABLE
MARKS

MW2

MW2

(b) LHS $\frac{\sec \theta - \cos \theta}{\operatorname{cosec} \theta - \sin \theta}$

$$\frac{\frac{1}{\cos \theta} - \cos \theta}{\frac{1}{\sin \theta} - \sin \theta}$$

M1W1

$$\frac{1 - \cos^2 \theta}{\cos \theta} \div \frac{1 - \sin^2 \theta}{\sin \theta}$$

M1W1

$$\frac{\frac{\sin^2 \theta}{\cos \theta}}{\frac{\cos^2 \theta}{\sin \theta}}$$

M1W1

$$\frac{\sin^2 \theta}{\cos \theta} \times \frac{\sin \theta}{\cos^2 \theta} \equiv \frac{\sin^3 \theta}{\cos^3 \theta}$$

$\tan^3 \theta \equiv \text{RHS}$

MW1

Alternative Solution

$$\text{LHS } \frac{\frac{1}{\cos \theta} - \cos \theta}{\frac{1}{\sin \theta} - \sin \theta} \times \frac{\sin \theta \cos \theta}{\sin \theta \cos \theta}$$

M2W2

$$\frac{\sin \theta - \sin \theta \cos^2 \theta}{\cos \theta - \sin^2 \theta \cos \theta}$$

$$\frac{\sin \theta(1 - \cos^2 \theta)}{\cos \theta(1 - \sin^2 \theta)} \equiv \frac{\sin^3 \theta}{\cos^3 \theta}$$

M1W1

$\tan^3 \theta \equiv \text{RHS}$

MW1

13

Total

75



Rewarding Learning

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Mathematics

Assessment Unit C4

assessing

Module C4: Core Mathematics 4

[AMC41]

WEDNESDAY 21 JANUARY, AFTERNOON

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Answer all eight questions.

Show clearly the full development of your answers.

Answers should be given to three significant figures unless otherwise stated.

- 1 direction \mathbf{r}_1 is given by $(3\mathbf{i} + 4\mathbf{j} - \mathbf{k})$ M1
 \mathbf{r}_2 $(\mathbf{i} - \mathbf{j} + 2\mathbf{k})$
- $\mathbf{a} \cdot \mathbf{b} = |\mathbf{a}| |\mathbf{b}| \cos \theta$ M1
- $\mathbf{a} \cdot \mathbf{b} = \sqrt{3^2 + 4^2 + 1^2} \sqrt{1^2 + 1^2 + 2^2} \cos \theta$ M1
- $-3 = \sqrt{26} \sqrt{6} \cos \theta$ M1W1W2
- $\cos \theta = \frac{-3}{\sqrt{156}}$
- $\theta = 104^\circ$ W1 8
- 2 (i) $x = 2t$ $y = t^3 - 3t$
- $\frac{dx}{dt} = 2$ $\frac{dy}{dt} = 3t^2 - 3$ MW2
- $\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx}$ M1
- $= \frac{3t^2 - 3}{2}$ W1
- (ii) $\frac{d^2y}{dx^2} = \frac{d}{dt} \left(\frac{dy}{dx} \right) \times \frac{dt}{dx}$ M1
- $= 3t \times \frac{1}{2}$
- $= \frac{3t}{2}$ W2 7

3 $\frac{dx}{dt} = \frac{k}{x}$
 $\int x dx = \int k dt$

$$\frac{x^2}{2} = kt + c$$

when $x = 100, t = 0$

$$\frac{10000}{2} = c \Rightarrow c = 5000$$

when $x = 50, t = 5$

$$\frac{2500}{2} = 5k + 5000$$

$$-750 = k$$

$$\frac{x^2}{2} = -750t + 5000$$

when $x = 0, t = \frac{5000}{750}$

$$= \frac{20}{3} \text{ s}$$

M2W1

MW2

M1

W1

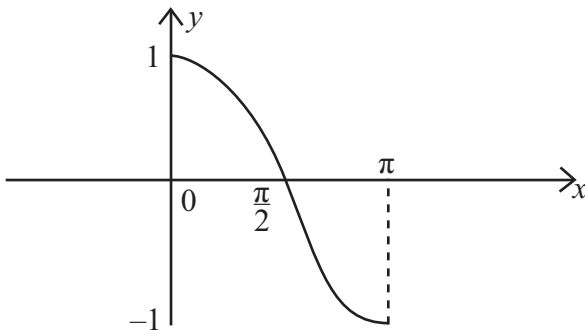
MW1

M1

W1

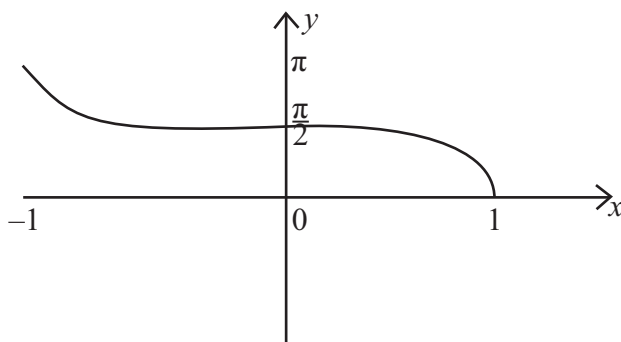
10

4 (i)



MW2

(ii)



MW3

5

<p>5 (i) $\frac{3x+4}{x(x+1)} = \frac{A}{x} + \frac{B}{x+1}$ $3x+4 = A(x+1) + Bx$ Let $x = -1$ $1 = -B \Rightarrow B = -1$ $x = 0$ $4 = A$ $\frac{3x+4}{x(x+1)} = \frac{4}{x} - \frac{1}{x+1}$</p>	<p>M1W1 M1 M1W1 W1</p>	
<p>(ii) Area = $\int_2^3 \frac{3x+4}{x(x+1)} dx$ $= \int_2^3 \left(\frac{4}{x} - \frac{1}{x+1} \right) dx$ $= [4 \ln x - \ln x+1]_2^3$ $= (4 \ln 3 - \ln 4) - (4 \ln 2 - \ln 3)$ $= 5 \ln 3 - 6 \ln 2$ $= \ln \frac{243}{64}$</p>	<p>M1W1 MW1 W2 M1 W1</p>	13
<p>6 (i) $f(x) \geq 5$</p>	<p>MW1</p>	
<p>(ii) fg $x \rightarrow x \rightarrow 2 x + 5$ fg: $x \rightarrow 2 x + 5$ domain $x > -1$</p>	<p>M1W1 MW1 MW1</p>	
<p>(iii) $y = 2x + 5$ $\frac{y-5}{2} = x$ $f^{-1} : x \rightarrow \frac{x-5}{2}$ domain $x > 5$ range f^{-1} $f^{-1}(x) \geq 0$</p>	<p>M1 W1 MW1 MW1 MW1</p>	10

			AVAILABLE MARKS	
7	<p>(i) $\sin 3A = \sin (A + 2A)$</p> $= \sin A \cos 2A + \cos A \sin 2A$ $= \sin A (2 \cos^2 A - 1) + 2 \sin A \cos^2 A$ $= 4 \sin A \cos^2 A - \sin A$ $= 4 \sin A (1 - \sin^2 A) - \sin A$ $= 4 \sin A - 4 \sin^3 A - \sin A$ $= 3 \sin A - 4 \sin^3 A$	<p>M1</p> <p>M1W1</p> <p>M1W1</p> <p>M1</p> <p>W1</p>	15	
	<p>(ii) $\sin A + \sin 3A = 0$</p> $\sin A + 3 \sin A - 4 \sin^3 A = 0$ $\sin A - \sin^3 A = 0$ $\sin A [1 - \sin^2 A] = 0$ $\sin A = 0 \text{ or } \sin A = \pm 1$ $A = 0^\circ, 90^\circ, 180^\circ, 270^\circ, 360^\circ$	<p>M1W1</p> <p>MW3</p> <p>MW3</p>		
8	$\int x \operatorname{cosec}^2 x \, dx$ $= -x \cot x + \int \cot x \, dx$ $= -x \cot x + \ln \sin x + c$	<p>M1</p> <p>W3</p> <p>W3</p>		7
Total				75



Rewarding Learning

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Mathematics

Assessment Unit F2

assessing

Module FP2: Further Pure Mathematics 2

[AMF21]

THURSDAY 29 JANUARY, MORNING

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Answer all six questions.

Show clearly the full development of your answers.

Answers should be given to three significant figures unless otherwise stated.

1	$\tan\left(2\theta + \frac{\pi}{4}\right) = \tan\left(\frac{\pi}{3} - 3\theta\right)$	M1W1	
	$2\theta + \frac{\pi}{4} = n\pi + \left(\frac{\pi}{3} - 3\theta\right)$	M2W1	
	$5\theta = n\pi + \frac{\pi}{12}$		
	$\theta = n\frac{\pi}{5} + \frac{\pi}{60}$	W1	6

$$2 \quad (i) \quad \frac{x^3 - 4x^2 + 9x + 10}{(x^2 + 5)(x - 3)^2} = \frac{Ax + B}{x^2 + 5} + \frac{C}{x - 3} + \frac{D}{(x - 3)^2} \quad \text{M1MW1}$$

$$x^3 - 4x^2 + 9x + 10 = (x - 3)^2(Ax + B) + (x - 3)(x^2 + 5)C + (x^2 + 5)D \quad \text{M1}$$

$$x = 3 \quad 27 - 36 + 27 + 10 = 14D \quad \text{M1}$$

$$D = 2 \quad \text{W1}$$

$$\text{Coeff of } x^3: A + C = 1$$

$$\text{Coeff of } x^2: B - 6A - 3C + D = -4$$

$$B - 6A - 3C = -6$$

$$B + 3C = 0$$

$$\text{Coeff of } x^0: 9B - 15C + 5D = 10$$

$$9B = 15C$$

$$\Rightarrow B = C = 0 \quad \text{W2}$$

$$\Rightarrow A = 1 \quad \text{W1}$$

$$\therefore \text{exp r} \equiv \frac{x}{x^2 + 5} + \frac{2}{(x - 3)^2}$$

$$(ii) \quad (x^2 + 5)(x - 3) \frac{dy}{dx} - (x^2 + 5)y = x^3 - 4x^2 + 9x + 10$$

$$\frac{dy}{dx} - \frac{1}{x - 3} y = \frac{x^3 - 4x^2 + 9x + 10}{(x^2 + 5)(x - 3)} \quad \text{MW1}$$

$$\text{IF} = e^{\int \frac{-1}{x-3} dx} = e^{-\ln(x-3)} = \frac{1}{x-3} \quad \text{M1W1}$$

$$\frac{1}{x-3} \frac{dy}{dx} - \frac{1}{(x-3)^2} y = \frac{x^3 - 4x^2 + 9x + 10}{(x^2 + 5)(x - 3)^2} \quad \text{MW1}$$

$$\frac{d}{dx} \left[\frac{1}{x-3} y \right] = \text{RHS} \quad \text{MW1}$$

$$= \frac{x}{x^2 + 5} + \frac{2}{(x - 3)^2} \quad \text{M1}$$

$$\frac{y}{x-3} = \frac{1}{2} \ln(x^2 + 5) - \frac{2}{(x-3)} + C \quad \text{M1}$$

W1

Put $x = 4, y = -2$

$$-2 = \frac{1}{2} \ln 21 - 2 + C \Rightarrow C = -\frac{1}{2} \ln 21 \quad \text{M1W1}$$

$$y = \frac{1}{2}(x - 3) \ln \left[\frac{x^2 + 5}{21} \right] - 2$$

$$\begin{array}{l}
 \mathbf{3} \quad \mathbf{(i)} \quad \left. \begin{array}{l}
 f(x) = \ln(1+x) \quad f(0) = 0 \\
 f'(x) = (1+x)^{-1} \quad f'(0) = 1 \\
 f''(x) = -(1+x)^{-2} \quad f''(0) = -1 \\
 f'''(x) = 2(1+x)^{-3} \quad f'''(0) = 2 \\
 f^{iv}(x) = -6(1+x)^{-4} \quad f^{iv}(0) = -6 \\
 f^v(x) = 24(1+x)^{-5} \quad f^v(0) = 24
 \end{array} \right\}
 \end{array}$$

M1W2

$$f(x) = f(0) + xf'(0) + x^2 \frac{f''(0)}{2!} + x^3 \frac{f'''(0)}{3!} + \dots$$

M1

$$\ln(1+x) = x - \frac{1}{2}x^2 + \frac{1}{3}x^3 - \frac{1}{4}x^4 + \frac{1}{5}x^5 \dots$$

W1

$$\mathbf{(ii)} \quad \ln\left(\frac{1+x}{1-x}\right) = \ln(1+x) - \ln(1-x)$$

M1

$$= \ln(1+x) - \left\{ -x - \frac{1}{2}x^2 - \frac{1}{3}x^3 - \frac{1}{4}x^4 - \frac{1}{5}x^5 \right\} \dots$$

$$= 2 \left\{ x + \frac{1}{3}x^3 + \frac{1}{5}x^5 \right\} \dots$$

W2

$$\mathbf{(iii)} \quad \frac{1+x}{1-x} = 2 \quad x = \frac{1}{3}$$

M1

$$\ln 2 \div 2 \left\{ \frac{1}{3} + \frac{1}{3} + \frac{1}{5} \frac{1}{3} \right\} \dots$$

W1

$$= 2 \left\{ \frac{1}{3} + \frac{1}{81} + \frac{1}{1215} \right\}$$

$$= \frac{842}{1215}$$

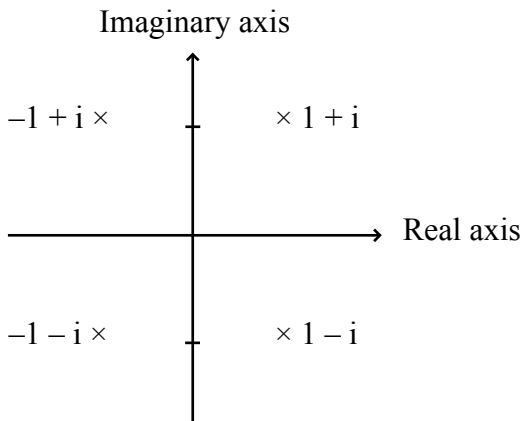
W1

11

4 (a) $\left[\cos \frac{\pi}{7} + i \sin \frac{\pi}{7} \right]^3 = \left[e^{i\frac{\pi}{7}} \right]^3 = e^{\frac{3}{7}i\pi}$ M1W1
 $\left[\cos \frac{\pi}{7} - i \sin \frac{\pi}{7} \right]^4 = \left[e^{-i\frac{\pi}{7}} \right]^4 = e^{\frac{4}{7}i\pi}$ W1
 Product = $e^{\frac{7}{7}i\pi} = e^{i\pi} = -1$ MW1

(b) $z^4 = -4$
 $(re^{i\theta})^4 = 4e^{\pi i + 2n\pi i}$
 $r^4 e^{4i\theta} = 4e^{i(\pi+2n\pi)} \quad n = 0, 1, 2, 3 \dots$ M1
 $\therefore r = \sqrt[4]{4} \quad \theta = \frac{\pi}{4} + \frac{n\pi}{2} \quad n = 0, 1, 2, 3 \dots$ MW2

Roots $\sqrt[4]{4} e^{i\frac{\pi}{4}}$
 $\sqrt{2} \left[\cos \frac{\pi}{4} + i \sin \frac{\pi}{4} \right]$
 $= \sqrt{2} \left[\frac{1}{\sqrt{2}} + i \frac{1}{\sqrt{2}} \right] = 1 + i$
 with 90° rotations MW1
 $= \pm 1 \pm i$



MW2 12

5 (i) When $n = 1$ $x^n = x$ and $\frac{x^n - 1}{x - 1} = 1$

$$\text{so } \mathbf{A}^1 = \begin{pmatrix} x^1 & \frac{x^1 - 1}{x - 1} \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} x & 1 \\ 0 & 1 \end{pmatrix} \text{ is true} \quad (1)$$

MW1

$$\text{Assume } \mathbf{A}^k = \begin{pmatrix} x^k & \frac{x^k - 1}{x - 1} \\ 0 & 1 \end{pmatrix}$$

M1

Consider \mathbf{A}^{k+1}

M1

$$= \mathbf{A} \mathbf{A}^k$$

$$= \begin{pmatrix} x & 1 \\ 0 & 1 \end{pmatrix} \begin{pmatrix} x^k & \frac{x^k - 1}{x - 1} \\ 0 & 1 \end{pmatrix}$$

MW1

$$= \begin{pmatrix} x^{k+1} & \frac{x^{k+1} - x}{x - 1} + 1 \\ 0 & 1 \end{pmatrix}$$

$$= \begin{pmatrix} x^{k+1} & \frac{x^{k+1} - 1}{x - 1} \\ 0 & 1 \end{pmatrix}$$

W1

\therefore statement true for $n = k + 1$ (2)

M1

(1) and (2) imply statements true for all $n \geq 1, n \in \mathbb{Z}$

M1

(ii) $\mathbf{B}^{10} = \begin{pmatrix} 2^{10} & \frac{2^{10} - 1}{2 - 1} \\ 0 & 1 \end{pmatrix} = \begin{pmatrix} 1024 & 1023 \\ 0 & 1 \end{pmatrix}$

M1W1

9

<p>6 (i) $a^2 = 4 \quad b^2 = a^2(1 - e^2) = 3$ $4 - 4e^2 = 3 \quad e = \frac{1}{2}$ Focus $(ae, 0) = (\frac{1}{2} \times 2, 0) = (1, 0)$ Directrix $x = \frac{a}{e} = 2 \div \frac{1}{2} = 4$</p>	<p>M1W1 MW1 MW1</p>
<p>(ii) $\frac{x^2}{4} + \frac{y^2}{3} = \frac{4\cos^2\theta}{4} + \frac{3\sin^2\theta}{3} = 1$</p>	<p>M1W1</p>
<p>(iii) At P, $\frac{dy}{dx} = \frac{\frac{dy}{d\theta}}{\frac{dx}{d\theta}}$ $= \frac{\sqrt{3}\cos\theta}{-2\sin\theta}$ $y - \sqrt{3}\sin\theta = \frac{\sqrt{3}\cos\theta}{2\sin\theta} (x - 2\cos\theta)$ $\frac{y\sin\theta}{\sqrt{3}} - \sin^2\theta = -\frac{\cos\theta}{2}x + \cos^2\theta$ $\frac{x}{2}\cos\theta + \frac{y}{\sqrt{3}}\sin\theta = \cos^2\theta + \sin^2\theta = 1$</p>	<p>M1 W2 M1W1 W1</p>
<p>(iv) On directrix $x = 4 \therefore \frac{y}{\sqrt{3}}\sin\theta = 1 - 2\cos\theta$ $Q\left[4, \frac{\sqrt{3}(1 - 2\cos\theta)}{\sin\theta}\right]$ $m_{PS} = -\frac{\sqrt{3}\sin\theta}{1 - 2\cos\theta}$ $m_{SQ} = \frac{\sqrt{3}(1 - 2\cos\theta)}{3\sin\theta}$ $m_{PS} \times m_{SQ} = -\frac{\sqrt{3}\sin\theta}{1 - 2\cos\theta} \frac{1 - 2\cos\theta}{\sqrt{3}\sin\theta} = -1$ $\therefore \hat{PSQ} = 90^\circ$</p>	<p>M1W1 W1 M1W1 MW1 MW1</p>

19

Total

75



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General Certificate of Education
January 2009

Mathematics

Assessment Unit M2

assessing

Module M2: Mechanics 2

[AMM21]

TUESDAY 27 JANUARY, AFTERNOON

**MARK
SCHEME**

GCE Advanced/Advanced Subsidiary (AS) Mathematics

Mark Schemes

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 correct 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 candidates' 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) $KE = \frac{1}{2}mv^2$ M1
 $= \frac{1}{2} \times 1500 \times 25$
 $= 18750J$ W1
 $= 18800J$

(ii) Work done = change in KE M1
 $= \frac{1}{2} \times 1500 \times 0 - \frac{1}{2} \times 1500 \times 25$ W1
 $= -18750J$ W1
 $= -18800J$

(iii) $WD = Fs$ M1
 $-18750 = -30F$ W1
 $F = 625N$ W1

8

2 (i) Total force = $4\mathbf{i} + \mathbf{j} - 2\mathbf{i} + \mathbf{j}$
 $= 2\mathbf{i} + 2\mathbf{j}$ M1W1
 $\mathbf{F} = m\mathbf{a}$ M1
 $2\mathbf{i} + 2\mathbf{j} = 0.5\mathbf{a}$
 $\mathbf{a} = 4\mathbf{i} + 4\mathbf{j}$ W1

(ii) $\mathbf{u} = \mathbf{i} - \mathbf{j}$ $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ M1
 $\mathbf{v} = ?$ $\mathbf{v} = \mathbf{i} - \mathbf{j} + (4\mathbf{i} + 4\mathbf{j})$
 $t = 1$ $\mathbf{v} = 5\mathbf{i} + 3\mathbf{j}$ W1
 $\mathbf{a} = 4\mathbf{i} + 4\mathbf{j}$ $|\mathbf{v}| = \sqrt{25 + 9} = \sqrt{34} \text{ ms}^{-1}$ M1W1

(iii) $\mathbf{u} = \mathbf{i} - \mathbf{j}$ $\mathbf{s} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ M1
 $t = 4$ $\mathbf{s} = 36\mathbf{i} + 28\mathbf{j}$ W1
 $\mathbf{a} = 4\mathbf{i} + 4\mathbf{j}$

10

<p>3 (i) $\mathbf{r} = 3t^2\mathbf{i} + (2t^3 - t)\mathbf{j} + 2t\mathbf{k}$</p> <p>$\mathbf{v} = \frac{d\mathbf{r}}{dt} = 6t\mathbf{i} + (6t^2 - 1)\mathbf{j} + 2\mathbf{k}$</p>	<p>M1W1</p>	
<p>(ii) Initial velocity when $t = 0$</p> <p>$\mathbf{v} = -\mathbf{j} + 2\mathbf{k}$</p>	<p>M1</p> <p>W1</p>	
<p>(iii) $\mathbf{a} = \frac{d\mathbf{v}}{dt} = 6\mathbf{i} + 12t\mathbf{j}$</p> <p>at $t = 3$</p> <p>$\mathbf{a} = 6\mathbf{i} + 36\mathbf{j}$</p>	<p>M1W1</p> <p>MW1</p>	
<p>(iv) Magnitude of acceleration increasing or no other value of t makes $\mathbf{r} = \mathbf{0}$</p>	<p>MW1</p>	<p>8</p>
<p>4 (i) Power = rate of change of energy</p> <p>$= \frac{\frac{1}{2}mv^2 - \frac{1}{2}mu^2 + mgh}{t}$</p> <p>$= \frac{1}{2} \times 100 \times 20^2 - 0 + 100 \times 9.8 \times 8$</p> <p>$= 27800 \text{ watts}$</p>	<p>M1</p> <p>M1</p> <p>W2</p> <p>W1</p>	
<p>(ii) $u = 20$ $v^2 = u^2 + 2as$</p> <p>$v = 0$ $0 = 400 - 19.6s$</p> <p>$a = -9.8$ $s = 20.4 \text{ m}$</p> <p>$s = ?$</p>	<p>M1</p> <p>M1</p> <p>W1</p>	
<p>(iii) no resistance to motion</p>	<p>MW1</p>	<p>9</p>

5 (i) $PE = mgh$
 $= -Mgd \sin 30^\circ = \frac{-Mgd}{2}$

M1W2

(ii) $0 + \frac{1}{2}Mu^2 = -Mgd \sin 30^\circ + \frac{1}{2}M(2u)^2$

M1W2

$$\frac{Mgd}{2} = \frac{3}{2}Mu^2$$

$$u = \sqrt{\frac{gd}{3}}$$

W1

7

6 (i) Vertical $s = ut + \frac{1}{2}at^2$

M1

$$u = 0$$

$$19.6 = 4.9t^2$$

$$a = 9.8$$

$$t = 2s$$

W1

$$s = 19.6$$

$$t = ?$$

(ii) Horizontal $s = ut + \frac{1}{2}at^2$

M1

$$u = 20$$

$$= 2 \times 20$$

$$t = 2$$

$$= 40m$$

W1

$$a = 0$$

$$s = ?$$

(iii) Vertical

$$u = 0$$

$$v = u + at$$

M1

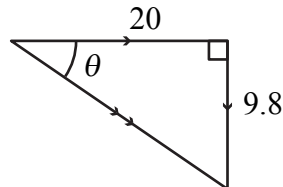
$$t = 1$$

$$v = 9.8 \text{ ms}^{-1}$$

W1

$$a = 9.8$$

$$v = ?$$



M1

$$\tan \theta = \frac{9.8}{20}$$

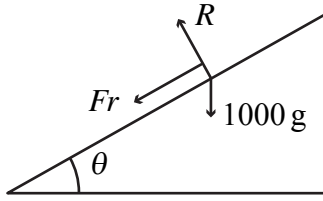
M1

$$\theta = 26.1^\circ \text{ below horizontal}$$

W1

9

7 (i)



MW2

(ii) $F = ma$

M1

$$\uparrow R \cos \theta - 1000g - \mu R \sin \theta = 0$$

W2

$$R \frac{12}{13} - 9800 - 0.4R \frac{5}{13} = 0$$

MW1

$$R = 12740 \text{ N}$$

$$12700 \text{ N}$$

W1

(iii) $\leftrightarrow F = ma$

$$R \sin \theta + \mu R \cos \theta = \frac{mv^2}{r}$$

M1W1M1

$$12740 \times \frac{5}{13} + 0.4 \times 12740 \times \frac{12}{13} = \frac{1000v^2}{50}$$

W1

$$v = 21.9 \text{ ms}^{-1}$$

W1

12

8 (i)

$$F = ma$$

M1

$$-0.004v^2 - 0.2 \times 10 = 0.2a$$

W2

$$-0.02(500 + v^2) = \frac{v dv}{dx}$$

MW1

(ii) $v \frac{dv}{dx} = -0.02(500 + v^2)$

$$\int \frac{v}{500 + v^2} dv = \int -0.02 dx$$

M2W1

$$\frac{1}{2} \ln |500 + v^2| = -0.02x + c$$

W2

$$\text{at } x = 0 \quad v = 15$$

$$c = \frac{1}{2} \ln |725|$$

MW1

$$\frac{1}{2} \ln |500 + v^2| = -0.02x + \frac{1}{2} \ln |725|$$

$$\text{at maximum height } v = 0$$

M1

$$\frac{1}{2} \ln 500 - \frac{1}{2} \ln 725 = -0.02x$$

$$x = 9.29 \text{ m}$$

W1

12

Total

75