MARK SCHEME for the May/June 2009 question paper

for the guidance of teachers

0606 ADDITIONAL MATHEMATICS

0606/01   Paper 1, maximum raw mark 80

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes must be read in conjunction with the question papers and the report on the examination.

- CIE will not enter into discussions or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the May/June 2009 question papers for most IGCSE, GCE Advanced Level and Advanced Subsidiary Level syllabuses and some Ordinary Level syllabuses.

Mark Scheme Notes

Marks are of the following three types:

M   Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

A   Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

B   Accuracy mark for a correct result or statement independent of method marks.

- When a part of a question has two or more "method" steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

- The symbol √ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously "correct" answers or results obtained from incorrect working.

- Note: B2 or A2 means that the candidate can earn 2 or 0.
  B2, 1, 0 means that the candidate can earn anything from 0 to 2.

The following abbreviations may be used in a mark scheme or used on the scripts:

AG   Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

BOD   Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)

CAO   Correct Answer Only (emphasising that no "follow through" from a previous error is allowed)

ISW   Ignore Subsequent Working

MR   Misread

PA   Premature Approximation (resulting in basically correct work that is insufficiently accurate)

SOS   See Other Solution (the candidate makes a better attempt at the same question)

Penalties

MR –1   A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become "follow through $\sqrt{}$" marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy.

OW –1,2 This is deducted from A or B marks when essential working is omitted.

PA –1   This is deducted from A or B marks in the case of premature approximation.

S –1   Occasionally used for persistent slackness – usually discussed at a meeting.

EX –1   Applied to A or B marks when extra solutions are offered to a particular equation. Again, this is usually discussed at the meeting.

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1	(i) $12 = 15\theta$, $\theta = 0.8$ rads	M1, A1 [2]	M1 for use of $s = r\theta$
	(ii) Area = $\frac{1}{2}15^2(0.8)$	M1	M1 for use of $A = \frac{1}{2}r^2\theta$
	leading to 90 (cm²)	A1 [2]	

2	$x^3 = 8$, leading to $x = 2$	B1	B1 for finding where curve crosses the x axis
	$\frac{dy}{dx} = 3x^2$ leading to grad of $-\frac{1}{12}$ for normal	M1	M1 for attempt to differentiate and use of $m_1m_2 = -1$
	$y - 0 = -\frac{1}{12}(x - 2)$ $\left(y = -\frac{1}{12}x + \frac{1}{6}\right)$	DM1 A1 [4]	DM1 for attempt at equation of normal Allow unsimplified

3	$\frac{1 - \cos^2\theta}{\sec^2\theta - 1} = \frac{\sin^2\theta}{\tan^2\theta}$	M1	M1 for use of $1 - \cos^2\theta = \sin^2\theta$
		M1	M1 for use of $\sec^2\theta - 1 = \tan^2\theta$
	$= \cos^2\theta$	M1	M1 for attempt to simplify
	$= 1 - \sin^2\theta$	A1 [4]	
	Alt Scheme $\frac{1 - \cos^2\theta}{\sec^2\theta - 1} = \frac{\sin^2\theta}{1 - \cos^2\theta \Big/ \cos^2\theta}$	M1	M1 for use of $1 - \cos^2\theta = \sin^2\theta$
		M1	M1 for attempting to get all in terms of cos
	$= \frac{\sin^2\theta \cos^2\theta}{\sin^2\theta}$	M1	M1 for attempt to simplify
	$= \cos^2\theta$ $= 1 - \sin^2\theta$	A1	

4	(i) $5x - 3 = kx^2 - 3x + 5$ $kx^2 - 8x + 8 = 0$ using $b^2 - 4ac = 0$, $k = 2$	M1 DM1, A1 [3]	M1 for equating line and curve equations DM1 for use of $b^2 - 4ac$ on resulting quadratic
	(Alt scheme: $5 = 2kx - 3$, $x = \frac{4}{k}$ $\frac{20}{k} - 3 = \frac{16}{k} - \frac{12}{k} + 5$ leading to $k = 2$)		(Alt scheme: M1 for attempt to differentiate quadratic and equate to 5 DM1 for simplification and solution using resulting quadratic
	(ii) leading to $x = 2$, $y = 7$	M1, A1 [2]	M1 for obtaining x and y coords

5	**(a)**	$3^{2(2x-1)} = 3^{3x}$	B1	B1 for $3^{2(2x-1)}$
		$4x - 2 = 3x$	B1	B1 for 3^{3x}
		$x = 2$	B1	B1 for $x = 2$
			[3]	
	(b)	$a^{-2}b$ or $\dfrac{b}{a^2}$ (allow here)	B1	B1 for each
		$p = -2, q = 1$	B1	
			[2]	

6		f(3), f(−5) or f(0.5) = 0 spotted	B1	B1 for spotting one root
	Either	$(2x-1)(x^2 + 2x - 15)$	M1	M1 for attempt to obtain quadratic factor
	Or	$(x+5)(2x^2 - 7x + 3)$	A1	A1 all correct
	Or	$(x-3)(2x^2 + 9x - 5)$	M1	M1 for solution of quadratic
		$x = 3, -5, 0.5$	A2,1,0	A2 for all 3 solutions (−1 each error) Correct factors only – lose 1 A mark
			[6]	

7	**(i)**	$3xe^{3x} + e^{3x} - e^{3x}$	M1, A1, B1	M1 for attempt to differentiate a product. A1 for correct product.
		$= 3xe^{3x}$	[3]	B1 for $-e^{3x}$
	(ii)	$\int xe^{3x}dx = \dfrac{1}{3}\left(xe^{3x} - \dfrac{e^{3x}}{3}\right)$	DM1 DM1 A1	DM1 for recognition of the 'reverse' to **(i)** DM1 for dealing with '3' A1 all correct (condone omission of *c*)
			[3]	

8	**(i)**	$\dfrac{dy}{dx} = \dfrac{(x^2 + 9)2 - 2x(2x)}{(x^2 + 9)^2}$	B2,1,0	Attempt to differentiate a quotient −1 each error
		$= \dfrac{18 - 2x^2}{(x^2 + 9)^2}$, turning points,	M1	M1 for correct attempt to find the turning points.
		$x = \pm 3$	A1	A1 for both
			[4]	
	(ii)	$\dfrac{dx}{dt} = 2$	B1	B1 for use of $\dfrac{dx}{dt} = 2$
		$\dfrac{dy}{dt} = 2 \times \left(\dfrac{16}{100}\right)$	M1	M1 for use of rates of change
		$= 0.32$ or $\dfrac{8}{25}$	A1	
			[3]	

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9 **(i)** $10\sqrt{2}\left(\dfrac{1}{\sqrt{2}}\mathbf{i}+\dfrac{1}{\sqrt{2}}\mathbf{j}\right)=10\mathbf{i}+10\mathbf{j}$	M1 A1 [2]	M1 for attempt at a correct direction vector A1 all correct	
(ii) $\left(-4\mathbf{i}+8\mathbf{j}\right)+\left(20\mathbf{i}+20\mathbf{j}\right)=16\mathbf{i}+28\mathbf{j}$	M1 A1 [2]	M1 for valid attempt A1 all correct	
(iii) $\left(10\mathbf{i}+10\mathbf{j}\right)-\left(8\mathbf{i}+6\mathbf{j}\right)=2\mathbf{i}+4\mathbf{j}$	M1 A1 [2]	M1 for attempt at vector difference A1 condone negative	
(iv) displacement of $\left(19\mathbf{i}+34\mathbf{j}\right)-\left(16\mathbf{i}+28\mathbf{j}\right)=3\mathbf{i}+6\mathbf{j}$ time =1330 hours (accept 1.5 hours) at $31\mathbf{i}+43\mathbf{j}$	M1 A1 A1 [3]	M1 for displacement and attempt to obtain time A1 for correct time A1 for correct position vector	
Alternative scheme: $\left(19\mathbf{i}+34\mathbf{j}\right)+\left(8\mathbf{i}+6\mathbf{j}\right)t=$ $\left(16\mathbf{i}+28\mathbf{j}\right)+\left(10\mathbf{i}+10\mathbf{j}\right)t$ or equivalent		M1 for attempt to equate like vectors A marks as above	
10 **(i)** $m_{AB}=0.75$ line AB $y-0=0.75(x+4)$ $m_{PQ}=-\dfrac{4}{3}$ line PQ $y-10=-\dfrac{4}{3}(x-1)$ intersection at $C\,(4,6)$ $Q\,(8.5\ 0)$	M1 A1 M1 A1 M1 A1 √ B1 [7]	M1 for attempt at m_{AB} and line AB M1 for use of '$m_1m_2=-1$' and attempt at line PQ M1 for attempt at solving simultaneous equations Ft on their line PQ	
(ii) $AC=10$, $CQ=7.5$ Area = 37.5	M1 A1 [2]	M1 for attempt at lengths and area	
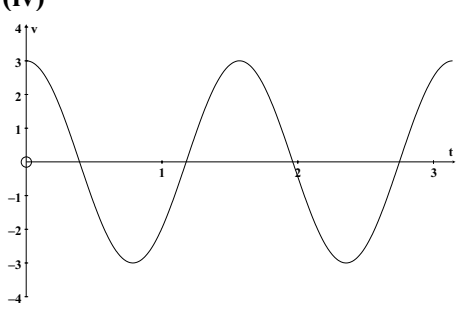
11 (i) $\ln s = n \ln t + \ln k$

$\ln t$	1.6	2.7	3.4	4.2	4.6
$\ln s$	7.2	5.9	5	4	3.6

Plot $\ln s$ against $\ln t$

M1, A1 — M1 for attempt to take logs
M1 — A1 for correct form
A1 — M1 for attempt to plot correct graph
A1 for a reasonable straight line
[4]

(ii) grad $n = -1.2$ (−1.4 to −1.0)
Intercept = $\ln k$, leading to
$k = 7900 – 10\,000$

M1, A1 — M1 for use of grad = n
M1, A1 — M1 for use of intercept = $\ln k$
[4]

(iii) when $t = 50$, $\ln t = 4.4$
leading to $s = 80$ (72 – 92)

M1 — M1 for attempt to obtain s
A1
[2]

Alternative method

(i) $\lg s = n \lg t + \lg k$

$\lg t$	0.7	1.2	1.5	1.8	2
$\lg s$	3.1	2.5	2.2	1.7	1.6

Same scheme applies

12 EITHER

   (i) amplitude = 1   B1   [1]

   (ii) period = 6π, 18.8   B1   [1]

   (iii) $\sin\left(\dfrac{x}{3}\right) = \dfrac{1}{2}$, $x = \dfrac{\pi}{2}, \dfrac{5\pi}{2}$ M1   M1 for attempt to solve correctly

           A1, A1   A1 for each (allow degrees here)

               [3]

   (iv) Area under curve

$$\int_{\frac{\pi}{2}}^{\frac{5\pi}{2}}\left(1 + \sin\frac{x}{3}\right)dx = \left[x - 3\cos\frac{x}{3}\right]_{\frac{\pi}{2}}^{\frac{5\pi}{2}}$$

       M1   M1 for attempt to integrate

       B1, B1   B1 for x, B1 for $-3\cos\dfrac{x}{3}$

       leading to $2\pi + 3\sqrt{3}$ DM1   DM1 for **correct** use of limits

       Area of rectangle $= \left(\dfrac{5\pi}{2} - \dfrac{\pi}{2}\right) \times \dfrac{3}{2}$ M1   M1 for attempt at rectangle plus subtraction – must be working in radians

                 $= 3\pi$

       Shaded area $= 3\sqrt{3} - \pi$ (2.05)   A1

                     [6]

Alternative solution: Shaded area   M1   M1 for subtraction (must be using radians)

                        M1   M1 for attempt to integrate

$$\int_{\frac{\pi}{2}}^{\frac{5\pi}{2}}\left(\sin\frac{x}{3} - 0.5\right)dx = \left[-0.5x - 3\cos\frac{x}{3}\right]_{\frac{\pi}{2}}^{\frac{5\pi}{2}}$$

       B1, B1   B1 for $-0.5x$, B1 for $-3\cos\dfrac{x}{3}$

       DM1, A1   DM1 for correct use of limits

OR

(i) $t = \dfrac{\pi}{8}$

B1

[1]

(ii) $a = -4k \sin 4t$

M1, A1

M1 for attempt to differentiate

[2]

(iii) $12 = -4k \sin \dfrac{3\pi}{2}$ leading to

M1

M1 for attempt to substitute into their acceleration equation

$k = 3$

A1

[2]

(iv)

B1

B1 for correct shape

√ B1

B1 ft on their value for k

[2]

(v) $s = \displaystyle\int_{0}^{\frac{\pi}{24}} 3 \cos 4t \, . \mathrm{d}t$

M1, √ A1

M1 for attempt to integrate
Ft on their value for k

$= \left[\dfrac{3}{4} \sin 4t \right]_{0}^{\frac{\pi}{24}}$ leading to $\dfrac{3}{8}$

DM1, A1

DM1 for application of limits or equivalent

[4]