CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/21 Paper 2 (Pure Mathematics), maximum raw mark 50

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ISW Ignore Subsequent Working

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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)

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1 Either State or imply non-modular inequality $(x+1)^2 < (3x+5)^2$, or corresponding equation or pair of linear equations M1
Make reasonable solution attempt at a 3-term quadratic, or solve two linear equations M1
Obtain critical values −2 and $-\frac{3}{2}$ A1
State correct answer $x < -2$ or $x > -\frac{3}{2}$ A1

Or Obtain one critical value, e.g. $x = -2$, by solving a linear equation (or inequality) or from a graphical method or by inspection B1
Obtain the other critical value similarly B2
State correct answer $x < -2$ or $x > -\frac{3}{2}$ B1 [4]

2 **(i)** Consider sign of $x^4 + 2x - 9$ at $x = 1.5$ and $x = 1.6$ M1
Complete the argument correctly with appropriate calculations A1 [2]
$(f(1.5) = -0.9375, f(1.6) = 0.7536)$

(ii) Rearrange $x^4 + 2x - 9 = 0$ to given equation or *vice versa* B1 [1]

(iii) Use the iterative formula correctly at least once M1
Obtain final answer 1.56 A1
Show sufficient iterations to justify its accuracy to 2 d.p. B1 [3]

$x_o = 1.5$	$x_o = 1.55$	$x_o = 1.6$
1.5874	1.5614	1.5362
1.5424	1.5556	1.5685
1.5653		1.5520
1.5536		1.5604
1 5595		1.5561
1.5565		

or show there is a sign change in the interval (1.555, 1.565)

3 Obtain derivative $e^{2x} - 5e^x + 4$ B1
Equate derivative to zero and carry out recognisable solution method for a quadratic in e^x M1
Obtain $e^x = 1$ or $e^x = 4$ A1
Obtain $x = 0$ and $x = \ln 4$ A1
Use an appropriate method for determining nature of at least one stationary point M1
$\left(\frac{d^2y}{dx^2} = 2e^{2x} - 5e^x, \text{when } x = 0, \frac{d^2y}{dx^2} = -(3), x = \ln 4, \frac{d^2y}{dx^2} = +(12)\right)$
Conclude maximum at $x = 0$ and minimum at $x = \ln 4$ (no errors seen) A1 [6]

4 **(i)** Substitute $x = 3$ and equate to 14 $(9a + 3b + 35 = 14)$ M1
Substitute $x = -2$ and equate to 24 $(4a - 2b = 24)$ M1
Obtain a correct equation in any form A1
Solve a relevant pair of equations for a or for b M1
Obtain $a = 1$ and $b = -10$ A1 [5]

(ii) Attempt division by $x^2 + 2x - 8$ and reach a partial quotient of $x - k$ M1
Obtain quotient $x - 1$ with no errors seen (can be done by observation) A1
Correct solution method for quadratic e.g. factorisation M1
All solutions $x = 1$, $x = 2$ and $x = -4$ given and no others CWO A1 [4]

5 **(i)** State $\frac{\mathrm{d}x}{\mathrm{d}\theta} = -2\sin 2\theta + \sin\theta$ or $\frac{\mathrm{d}y}{\mathrm{d}\theta} = 8\sin\theta\cos\theta$ B1

Use $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}\theta} \div \frac{\mathrm{d}x}{\mathrm{d}\theta}$ M1
Use $\sin 2\theta = 2\sin\theta\cos\theta$ M1
Obtain given answer correctly A1 [4]

(ii) Equate derivative to −4 and solve for $\cos\theta$ M1
Obtain $\cos\theta = ½$ A1
Obtain $x = -1$ A1
Obtain $y = 3$ A1 [4]

6 **(a)** **(i)** Attempt to divide by e^{2x} and attempt to integrate 2 terms M1
Integrate a term of form ke^{-2x} correctly A1√
Fully correct integral $x - 3e^{-2x}$ $(+ c)$ A1 [3]

(ii) State correct expression $\frac{1}{2}\cos 2x + \frac{1}{2}$ or equivalent B1
Integrate an expression of the form $a + b\cos 2x$, where $ab \neq 0$, correctly M1
State correct integral $\frac{3\sin 2x}{4} + \frac{3x}{2}(+c)$ A1 [3]

(b) State or imply correct ordinates 5.46143…, 4.78941…, 4.32808… B1
Use correct formula, or equivalent, correctly with $h = 0.5$ and three ordinates M1
Obtain answer 4.84 with no errors seen A1 [3]

7 **(i)** State $R = \sqrt{10}$ B1
Use trig formula to find α M1
Obtain $\alpha = 18.43^0$ with no errors seen A1 [3]

(ii) Carry out evaluation of $\cos^{-1}\left(\frac{2}{R}\right)$ $\left(\approx 50.77^0\right)$ M1
Carry out correct method for one correct answer M1
Obtain one correct answer e.g. 34.6° A1
Carry out correct method for a further answer M1
Obtain remaining 3 answers 163.8°, 214.6°, 343.8° and no others in the range A1 [5]

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PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

1 **(i)** State indefinite integral of the form $k \ln (4x - 1)$, where $k = 2$, 4, or ½ M1
State correct integral ½ ln $(4x - 1)$ A1 [2]

(ii) Substitute limits correctly M1
Use law for the logarithm of a power or a quotient M1
Obtain ln 3 correctly A1 [3]

2 Use quotient or product rule M1
Obtain correct derivative in any form A1
Equate (numerator) of derivative to zero and solve for x DM1
Obtain $x = \frac{1}{3}$ A1
Obtain $y = \frac{3}{2}$ A1 [5]

3 Use trig identity correctly to obtain a quadratic in cosec θ or sin θ M1
Solve the quadratic correctly M1
Obtain sin θ = ¼ or $-\frac{2}{3}$ A1
Obtain one correct answer A1
Carry out correct method for second answer from either root DM1
Obtain remaining 3 answers from 14.5, 165.5, 221.8, 318.2 and no others in the range A1
[Ignore answers outside the given range] [6]

4 **(i)** Substitute $x = 3$ or $x = -2$ and equate to zero M1
Obtain a correct equation in any form A1
Obtain a second correct equation in any form A1
Solve a relevant pair of equations for a or for b M1
Obtain $a = 4$ and $b = -3$ A1 [5]

(ii) Attempt division by $x + 2$ (or $x - 3$) and obtain partial quotient of $ax^2 + kx$ M1
Obtain linear factors $4x + 1$, $x + 2$ and $x - 3$ A1
[If linear factor $4x + 1$ obtained by remainder theorem or inspection, award B2]
[If linear factor $4x + 1$ obtained by division by $x^2 - x - 6$, award M1 A1] [2]

Alternative Method:
Attempt to form identity $(x^2 - x - 6)(rx + s) \equiv ax^3 + bx^3 - 25x - 6$ M1
Attempt to equate like terms M1
Leads to $s = 1$ B1, $r = 4$ A1, $b = -3$ A1, $a = 4$ A1
Obtain linear factors $4x + 1$, $x + 2$ and $x - 3$ A1

5 **(i)** State $\frac{\mathrm{d}x}{\mathrm{d}t} = \frac{1}{2}t^{-\frac{1}{2}}$ or $\frac{\mathrm{d}y}{\mathrm{d}t} = \frac{3}{t}$ B1

Use $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}t} \div \frac{\mathrm{d}x}{\mathrm{d}t}$ M1

Use $y = 6$ to find t M1

Obtain $t = \mathrm{e}^2$ A1

Obtaind $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{6}{\mathrm{e}}$ A1 [5]

(ii) Obtain x and form equation of the tangent at their point M1

Obtain correct equation for tangent $\left(y - 6 = \frac{6}{\mathrm{e}}\left(x - \left(1 + \mathrm{e}\right)\right)\right)$ A1

Show that tangent passes through (1, 0) by substitution A1 [3]

6 **(a)** Expand brackets and use $\sin^2 x + \cos^2 x = 1$ M1

Obtain $1 - \sin 2x$ A1

Integrate and obtain term of form $\pm k \cos 2x$, where $k = ½$, 1 or 2 M1

State correct integral $x + \frac{\cos 2x}{2}(+c)$ A1 [4]

(b) **(i)** State or imply correct ordinates 1.4142…, 1.0823…, 1 B1

Use correct formula, or equivalent, correctly with $h = \frac{\pi}{8}$ and three ordinates M1

Obtain answer 0.899 with no errors seen A1 [3]

(ii) Make a recognisable sketch of $y = \mathrm{cosec}\, x$ for $0 < x \leqslant \frac{1}{2}\pi$ B1

Justify statement that the trapezium rule gives an over-estimate B1 [2]

7 **(i)** Integrate to obtain terms $4x^2$ and $\frac{1}{2}e^x$ B1 + B1

Substitute limits correctly M1

Obtain correct equation in any form $4a^2 + \frac{1}{2}e^a - \frac{1}{2} = \frac{1}{2}$ A1

Rearrange to given answer correctly A1 [5]

(ii) Consider sign of $\sqrt{\frac{2-e^a}{8}} - a$, or equivalent M1

Complete the argument correctly with appropriate calculations A1 [2]
$(f(0.2) = 0.112,\ f(0.3) = -0.015)$

(iii) Use the iterative formula correctly at least once M1

Obtain final answer 0.29 A1

Show sufficient iterations to justify its accuracy to 2 d.p. B1

$x_0 = 0.2$	$x_0 = 0.25$	$x_0 = 0.3$
0.3120	0.2992	0.2851
0.2815	0.2853	0.2894
0.2905	0.2894	
0.2879		

or show there is a sign change in the interval (0.285, 0.295) [3]

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(ii) Rearrange $x^4 + 2x - 9 = 0$ to given equation or *vice versa* B1 [1]

(iii) Use the iterative formula correctly at least once M1
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Show sufficient iterations to justify its accuracy to 2 d.p. B1 [3]

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or show there is a sign change in the interval (1.555, 1.565)

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Equate derivative to zero and carry out recognisable solution method for a quadratic in e^x M1
Obtain $e^x = 1$ or $e^x = 4$ A1
Obtain $x = 0$ and $x = \ln 4$ A1
Use an appropriate method for determining nature of at least one stationary point M1
$\left(\frac{d^2y}{dx^2} = 2e^{2x} - 5e^x, \text{when } x = 0, \frac{d^2y}{dx^2} = -(3), x = \ln 4, \frac{d^2y}{dx^2} = +(12)\right)$
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Obtain quotient $x - 1$ with no errors seen (can be done by observation) A1
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All solutions $x = 1$, $x = 2$ and $x = -4$ given and no others CWO A1 [4]

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Use $\frac{\mathrm{d}y}{\mathrm{d}x} = \frac{\mathrm{d}y}{\mathrm{d}\theta} \div \frac{\mathrm{d}x}{\mathrm{d}\theta}$ M1
Use $\sin 2\theta = 2\sin\theta\cos\theta$ M1
Obtain given answer correctly A1 [4]

(ii) Equate derivative to −4 and solve for $\cos\theta$ M1
Obtain $\cos\theta = ½$ A1
Obtain $x = -1$ A1
Obtain $y = 3$ A1 [4]

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Integrate a term of form ke^{-2x} correctly A1√
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