UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2010 question paper for the guidance of teachers

9709 MATHEMATICS

9709/22 Paper 2, maximum raw mark 50

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.

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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 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 marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.

- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking *g* equal to 9.8 or 9.81 instead of 10.

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

AEF Any Equivalent Form (of answer is equally acceptable)

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)

CWO Correct Working Only - often written by a 'fortuitous' answer

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)

SR Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

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 √" marks. MR is not applied when the candidate misreads his own figures - this is regarded as an error in accuracy. An MR-2 penalty may be applied in particular cases if agreed at the coordination meeting.

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.

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1 **EITHER:** State or imply non-modular inequality $(x+1)^2 > (x-4)^2$, or corresponding equation or pair of linear equations — M1

Obtain critical value $\frac{3}{2}$ — A1

State correct answer $x > \frac{3}{2}$ — A1

OR: State a correct linear equation for the critical value, e.g. $x+1 = -x+4$, or corresponding correct linear inequality, e.g. $x+1 > -(x-4)$ — M1

Obtain critical value $\frac{3}{2}$ — A1

State correct answer $x > \frac{3}{2}$ — A1 [3]

2 Use law for the logarithm of a product, a quotient or a power — M1*

Obtain $x\log 5 = (2x+1)\log 2$, or equivalent — A1

Solve for x, via correct manipulative technique(s) — M1(dep*)

Obtain answer $x = 3.11$. Allow $x \in [3.10, 3.11]$ — A1 [4]

3 Integrate and obtain $\frac{1}{2}e^{2x}$ term — B1

Obtain $2e^{x}$ term — B1

Obtain x — B1

Use limits correctly, allow use of limits $x = 1$ and $x = 0$ into an incorrect form — M1

Obtain given answer — A1 [5]

S. R. Feeding limits into original integrand, 0/5

4 **(i)** State $\frac{dx}{dt} = \frac{1}{t-2}$ or $\frac{dy}{dt} = 1 - 9t^{-2}$ — B1

Use $\frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt}$ — M1

Obtain given answer correctly — A1 [3]

(ii) Equate derivative to zero and solve for t — M1

State or imply that $t = 3$ is admissible c.w.o., and note $t = -3$, 2 cases — A1

Obtain coordinates (1, 6) and no others — A1 [3]

5 Use correct trig identity to obtain a quadratic in $\cot\theta$ or $\tan\theta$ — M1

Solve the quadratic correctly — A1

Obtain $\tan\theta = \frac{1}{2}$ or $-\frac{2}{3}$ — A1√

Obtain answer 26.6° or 146.3° — A1

Carry out correct method for second answer from either root — M1

Obtain remaining 3 answers from 26.6°, 146.3°, 206.6°, 326.3° and no others in the range — A1 [6]

[Ignore answers outside the given range]

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6 **(i)** Consider sign of $\frac{6}{x^2} - x - 1$ at $x = 1.4$ and $x = 1.6$, or equivalent M1

Complete the argument correctly with appropriate calculations A1 [2]

(ii) State $\frac{6}{x^2} = x + 1$ B1

Rearrange equation to given equation or *vice versa* B1 [2]

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

Obtain final answer 1.54 A1

Show sufficient iterations to justify its accuracy to 2 d.p. or show there is a sign change in the interval (1.535, 1.545) B1 [3]

7 **(i)** Substitute $x = 1$, equate to zero and obtain a correct equation in any form B1

Substitute $x = 2$ and equate to 10 M1

Obtain a correct equation in any form A1

Solve a relevant pair of equations for a or for b M1

Obtain $a = -17$ and $b = 12$ A1 [5]

(ii) At any stage, state that $x = 1$ is a solution B1

EITHER: Attempt division by $x - 1$ and reach a partial quotient of $3x^2 + 5x$ M1

Obtain quotient $3x^2 + 5x - 12$ A1

Obtain solutions $x = -3$ and $x = \frac{4}{3}$ A1

OR: Obtain solution $x = -3$ by trial and error or inspection B1

Obtain solution $x = \frac{4}{3}$ B2

[If an attempt at the quadratic factor is made by inspection, the M1 is earned if it reaches an unknown factor of $3x^2 + 5x + \lambda$ and an equation in λ] [4]

8 **(i)** Use product rule M1

Obtain correct derivative in any form A1

Substitute $x = \frac{1}{2}\pi$, and obtain gradient of –1 for normal A1√

from $y' = \sin x - x\cos x$ ONLY

Show that line through $\left(\frac{1}{2}\pi, \frac{1}{2}\pi\right)$ with gradient –1 passes through $(\pi, 0)$ M1

A1 [5]

(ii) Differentiate $\sin x$ and use product rule to differentiate $x\cos x$ M1

Obtain $x\sin x$, or equivalent A1 [2]

(iii) State that integral is $\sin x - x\cos x (+ c)$ B1

Substitute limits 0 and $\frac{\pi}{2}$ correctly M1

Obtain answer 1 A1 [3]

S. R. Feeding limits into original integrand, 0/3

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