# MARK SCHEME for the May/June 2009 question paper

# for the guidance of teachers

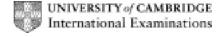## 9709 MATHEMATICS

**9709/02**      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.

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

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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.

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 $\sqrt{}$" 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.

**1** Use logarithms to linearise an equation          M1

Obtain $\dfrac{x}{y} = \dfrac{\ln 2.5}{\ln 1.25}$, or equivalent          A1

Obtain answer 4.11          A1√    [3]

**2** *EITHER:* State or imply non-modular inequality $(3x + 2)^2 < x^2$, or corresponding quadratic equation,
             or pair of linear equations $3x + 2 = \pm x$        M1
             Make reasonable solution attempt at a 3-term quadratic, or solve two linear equations   M1
             Obtain critical values $x = -1$ and $x = -\tfrac{1}{2}$        A1

             State answer $-1 < x < -\tfrac{1}{2}$        A1

    *OR:*      Obtain the critical value $x = -1$ from a graphical method or by inspection, or by solving
             a linear equation or inequality        B1
             Obtain the critical value $x = -\tfrac{1}{2}$ similarly        B2

             State answer $-1 < x < -\tfrac{1}{2}$        B1    [4]

**3**     **(i)**   Show or imply correct ordinates 1, 0.5, 0.414213 ...        B1
          Use correct formula, or equivalent, with $h = 1$ and three ordinates        M1
          Obtain answer 1.21 with no errors seen        A1    [3]

    **(ii)**   Justify the statement that the rule gives an over-estimate        B1    [1]

**4** State $\dfrac{dx}{d\theta} = 4 \cos \theta$          B1

State $\dfrac{dy}{d\theta} = 4 \sin 2\theta$, or equivalent          B1

Use $\dfrac{dy}{dx} = \dfrac{dy}{d\theta} \div \dfrac{dx}{d\theta}$          M1

Obtain $\dfrac{dy}{dx}$ in any correct form, e.g. $\dfrac{\sin 2\theta}{\cos \theta}$          A1

Simplify and obtain answer $2 \sin\theta$          A1√    [5]
[The f.t. is on gradients of the form $k \sin 2\theta / \cos \theta$, or equivalent.]

**5** Use $\tan^2 x = \sec^2 x - 1$ or $\sin^2 x = 1 - \cos^2 x$          M1
Obtain 3-term quadratic in sec $x$ or cos $x$, e.g. $2\sec^2 x + \sec x - 6 = 0$          A1
Make reasonable solution attempt at a 3-term quadratic          M1
Obtain sec $x = \tfrac{3}{2}$ and sec $x = -2$, or equivalent          A1

[**or**   $6\cos^2 x - \cos x - 2 = 0$
     $\cos x = \tfrac{2}{3}, \ -\tfrac{1}{2}$ ]
Obtain answer $x = 48.2°$          A1
Obtain answer $x = 120°$ and no others in the range          A1    [6]
[Ignore answers outside the given range.]

**6**     **(i)**   Substitute $x = 2$, equate to zero and state a correct equation, e.g. $8 + 4a + 2b + 6 = 0$    B1
            Substitute $x = 1$ and equate to 4    M1
            Obtain a correct equation. e.g. $1 + a + b + 6 = 4$    A1
            Solve for $a$ or for $b$    M1
            Obtain $a = –4$ and $b = 1$    A1    [5]

       **(ii)**   *EITHER:*   Attempt division by $x – 2$ reaching a partial quotient of $x^2 + kx$    M1
                    Obtain remainder quadratic factor $x^2 – 2x – 3$    A1
                    State linear factors $(x – 3)$ and $(x + 1)$    A1
          *OR:*     Obtain linear factor $(x + 1)$ by inspection    B1
                    Obtain factor $(x – 3)$ similarly    B2    [3]

**7**     **(i)**   Use product rule    M1*
            Obtain derivative in any correct form    A1
            Equate derivative to zero and solve for $x$    M1(dep*)
            Obtain answer $x = –\frac{1}{2}$ correctly    A1
            Obtain $y = –1/(2e)$ or exact equivalent    A1    [5]

       **(ii)**   Show that $20 = xe^{2x}$ is equivalent to $x = \frac{1}{2}\ln(20 / x)$ or *vice versa*    B1    [1]

      **(iii)**   Use the iterative formula correctly at least once    M1
            Obtain final answer 1.35    A1
            Show sufficient iterations to justify its accuracy to 2 d.p.    A1    [3]

**8**   **(a)**   State derivative is $k/(3x – 2)$ where $k = 3.1$, or $\frac{1}{3}$    M1
           State correct derivative $3/(3x – 2)$    A1
           Form the equation of the tangent at the point where $x = 1$    M1
           Obtain answer $y = 3x – 3$, or equivalent    A1    [4]

   **(b)**   **(i)**   Carry out a complete method for finding $A$    M1
               Obtain $A = 4$    A1    [2]

         **(ii)**   Integrate and obtain term $2x$    B1
              Obtain second term of the form $a\ln(3x – 2)$    M1
              Obtain second term $\frac{4}{3}\ln(3x – 2)$    A1√
              Substitute limits correctly    M1
              Obtain given answer following full and correct working    A1    [5]