

**ADVANCED GCE
MATHEMATICS (MEI)**

Applications of Advanced Mathematics (C4) Paper A

4754A

Candidates answer on the answer booklet.

OCR supplied materials:

- 8 page answer booklet (sent with general stationery)
- MEI Examination Formulae and Tables (MF2)

Other materials required:

- Scientific or graphical calculator

**Friday 14 January 2011
Afternoon**

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- You are permitted to use a scientific or graphical calculator in this paper.
- Final answers should be given to a degree of accuracy appropriate to the context.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- You are advised that an answer may receive **no marks** unless you show sufficient detail of the working to indicate that a correct method is being used.
- The total number of marks for this paper is **72**.
- This document consists of **4** pages. Any blank pages are indicated.

NOTE

- This paper will be followed by **Paper B: Comprehension**.

Section A (36 marks)

- 1 (i) Use the trapezium rule with four strips to estimate $\int_{-2}^2 \sqrt{1+e^x} dx$, showing your working. [4]

Fig. 1 shows a sketch of $y = \sqrt{1+e^x}$.

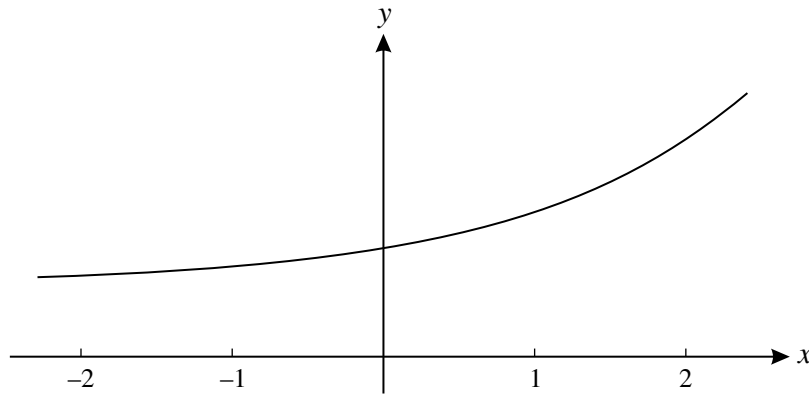


Fig. 1

- (ii) Suppose that the trapezium rule is used with more strips than in part (i) to estimate $\int_{-2}^2 \sqrt{1+e^x} dx$. State, with a reason but no further calculation, whether this would give a larger or smaller estimate. [2]

- 2 A curve is defined parametrically by the equations

$$x = \frac{1}{1+t}, \quad y = \frac{1-t}{1+2t}.$$

Find t in terms of x . Hence find the cartesian equation of the curve, giving your answer as simply as possible. [5]

- 3 Find the first three terms in the binomial expansion of $\frac{1}{(3-2x)^3}$ in ascending powers of x . State the set of values of x for which the expansion is valid. [7]
- 4 The points A, B and C have coordinates (2, 0, -1), (4, 3, -6) and (9, 3, -4) respectively.
- (i) Show that AB is perpendicular to BC. [4]
- (ii) Find the area of triangle ABC. [3]
- 5 Show that $\frac{\sin 2\theta}{1 + \cos 2\theta} = \tan \theta$. [3]

- 6 (i) Find the point of intersection of the line $\mathbf{r} = \begin{pmatrix} -8 \\ -2 \\ 6 \end{pmatrix} + \lambda \begin{pmatrix} -3 \\ 0 \\ 1 \end{pmatrix}$ and the plane $2x - 3y + z = 11$. [4]
- (ii) Find the acute angle between the line and the normal to the plane. [4]

Section B (36 marks)

- 7 A particle is moving vertically downwards in a liquid. Initially its velocity is zero, and after t seconds it is $v \text{ m s}^{-1}$. Its terminal (long-term) velocity is 5 m s^{-1} .

A model of the particle's motion is proposed. In this model, $v = 5(1 - e^{-2t})$.

- (i) Show that this equation is consistent with the initial and terminal velocities. Calculate the velocity after 0.5 seconds as given by this model. [3]

- (ii) Verify that v satisfies the differential equation $\frac{dv}{dt} = 10 - 2v$. [3]

In a second model, v satisfies the differential equation

$$\frac{dv}{dt} = 10 - 0.4v^2.$$

As before, when $t = 0$, $v = 0$.

- (iii) Show that this differential equation may be written as

$$\frac{10}{(5-v)(5+v)} \frac{dv}{dt} = 4.$$

Using partial fractions, solve this differential equation to show that

$$t = \frac{1}{4} \ln \left(\frac{5+v}{5-v} \right). \quad [8]$$

This can be re-arranged to give $v = \frac{5(1 - e^{-4t})}{1 + e^{-4t}}$. [You are **not** required to show this result.]

- (iv) Verify that this model also gives a terminal velocity of 5 m s^{-1} .

Calculate the velocity after 0.5 seconds as given by this model. [3]

The velocity of the particle after 0.5 seconds is measured as 3 m s^{-1} .

- (v) Which of the two models fits the data better? [1]

- 8 Fig. 8 shows a searchlight, mounted at a point A, 5 metres above level ground. Its beam is in the shape of a cone with axis AC, where C is on the ground. AC is angled at α to the vertical. The beam produces an oval-shaped area of light on the ground, of length DE. The width of the oval at C is GF. Angles DAC, EAC, FAC and GAC are all β .

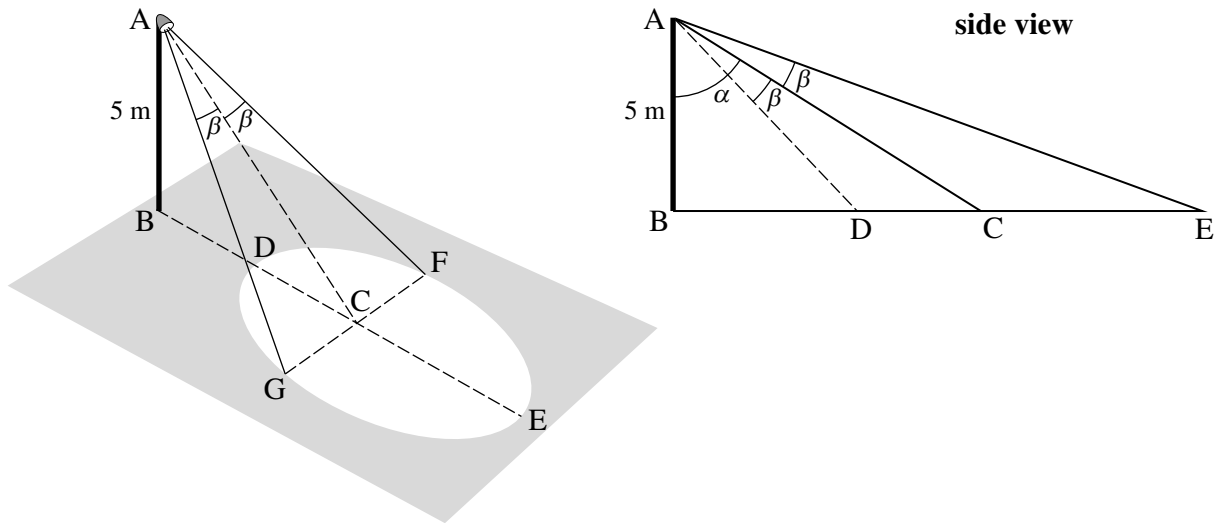


Fig. 8

In the following, all lengths are in metres.

- (i) Find AC in terms of α , and hence show that $GF = 10 \sec \alpha \tan \beta$. [3]

- (ii) Show that $CE = 5(\tan(\alpha + \beta) - \tan \alpha)$.

Hence show that $CE = \frac{5 \tan \beta \sec^2 \alpha}{1 - \tan \alpha \tan \beta}$. [5]

Similarly, it can be shown that $CD = \frac{5 \tan \beta \sec^2 \alpha}{1 + \tan \alpha \tan \beta}$. [You are **not** required to derive this result.]

You are now given that $\alpha = 45^\circ$ and that $\tan \beta = t$.

- (iii) Find CE and CD in terms of t . Hence show that $DE = \frac{20t}{1 - t^2}$. [5]

- (iv) Show that $GF = 10\sqrt{2}t$. [2]

For a certain value of β , $DE = 2GF$.

- (v) Show that $t^2 = 1 - \frac{1}{\sqrt{2}}$.

Hence find this value of β . [3]

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