

X100/701

NATIONAL
QUALIFICATIONS
2002

MONDAY, 27 MAY
9.00 AM – 12.00 NOON

MATHEMATICS
ADVANCED HIGHER

Read carefully

1. Calculators may be used in this paper.
2. There are five Sections in this paper.

Section A assesses the compulsory units Mathematics 1 and 2
Section B assesses the optional unit Mathematics 3
Section C assesses the optional unit Statistics 1
Section D assesses the optional unit Numerical Analysis 1
Section E assesses the optional unit Mechanics 1.

Candidates must attempt Section A (Mathematics 1 and 2) **and one** of the following Sections:

Section B (Mathematics 3)
Section C (Statistics 1)
Section D (Numerical Analysis 1)
Section E (Mechanics 1).

3. **Candidates must use a separate answer book for each Section.** Take care to show clearly the optional section chosen. On the front of the answer book, in the top right hand corner, write B, C, D or E.
4. A booklet of Mathematical Formulae and Statistical Tables is supplied for all candidates. It contains Numerical Analysis formulae and Statistical formulae and tables.
5. **Full credit will be given only where the solution contains appropriate working.**



Section A (Mathematics 1 and 2)

All candidates should attempt this Section.

Marks

Answer all the questions.

- A1.** Use Gaussian elimination to solve the following system of equations

$$\begin{aligned}x + y + 3z &= 2 \\2x + y + z &= 2 \\3x + 2y + 5z &= 5.\end{aligned}$$

5

- A2.** Verify that i is a solution of $z^4 + 4z^3 + 3z^2 + 4z + 2 = 0$.
Hence find all the solutions.

5

- A3.** A curve is defined by the parametric equations

$$x = t^2 + t - 1, \quad y = 2t^2 - t + 2$$

for all t . Show that the point $A(-1, 5)$ lies on the curve and obtain an equation of the tangent to the curve at the point A .

6

- A4.** (a) Given that $f(x) = \sqrt{x}e^{-x}$, $x \geq 0$, obtain and simplify $f'(x)$.

4

(b) Given $y = (x + 1)^2 (x + 2)^{-4}$ and $x > 0$, use logarithmic differentiation to

show that $\frac{dy}{dx}$ can be expressed in the form $\left(\frac{a}{x+1} + \frac{b}{x+2}\right)y$,

stating the values of the constants a and b .

3

- A5.** Use integration by parts to evaluate $\int_0^1 \ln(1+x) dx$.

5

- A6.** Use the substitution $x + 2 = 2 \tan \theta$ to obtain $\int \frac{1}{x^2 + 4x + 8} dx$.

5

- A7.** Prove by induction that $4^n - 1$ is divisible by 3 for all positive integers n .

5

- A8.** Express $\frac{x^2}{(x+1)^2}$ in the form $A + \frac{B}{x+1} + \frac{C}{(x+1)^2}$, ($x \neq -1$), stating the values of the constants A , B and C . 3

A curve is defined by $y = \frac{x^2}{(x+1)^2}$, ($x \neq -1$).

- (i) Write down equations for its asymptotes. 2
 (ii) Find the stationary point and justify its nature. 4
 (iii) Sketch the curve showing clearly the features found in (a) and (b). 2

- A9.** Functions $x(t)$ and $y(t)$ satisfy

$$\frac{dx}{dt} = -x^2y, \quad \frac{dy}{dt} = -xy^2.$$

When $t = 0$, $x = 1$ and $y = 2$.

- (a) Express $\frac{dy}{dx}$ in terms of x and y and hence obtain y as a function of x . 5
 (b) Deduce that $\frac{dx}{dt} = -2x^3$ and obtain x as a function of t for $t \geq 0$. 5

- A10.** Define $S_n(x)$ by

$$S_n(x) = 1 + 2x + 3x^2 + \dots + nx^{n-1},$$

where n is a positive integer.

Express $S_n(1)$ in terms of n . 2

By considering $(1-x)S_n(x)$, show that

$$S_n(x) = \frac{1-x^n}{(1-x)^2} - \frac{nx^n}{(1-x)}, \quad x \neq 1. \quad 4$$

Obtain the value of $\lim_{n \rightarrow \infty} \left\{ \frac{2}{3} + \frac{3}{3^2} + \frac{4}{3^3} + \dots + \frac{n}{3^{n-1}} + \frac{3}{2} \cdot \frac{n}{3^n} \right\}$. 3

[END OF SECTION A]

Candidates should now attempt ONE of the following

Section B (Mathematics 3) on Page four

Section C (Statistics 1) on Pages five and six

Section D (Numerical Analysis 1) on Pages seven and eight

Section E (Mechanics 1) on Pages nine and ten.

Section B (Mathematics 3)

Marks

ONLY candidates doing the course Mathematics 1, 2 and 3 should attempt this Section.

Answer all the questions.

Answer these questions in a separate answer book, showing clearly the section chosen.

- B1.** (a) Find an equation for the plane π_1 which contains the points $A(1, 1, 0)$, $B(3, 1, -1)$ and $C(2, 0, -3)$. 4

- (b) Given that π_2 is the plane whose equation is $x + 2y + z = 3$, calculate the size of the acute angle between the planes π_1 and π_2 . 3

- B2.** A matrix $A = \begin{pmatrix} 2 & 1 \\ -1 & 0 \end{pmatrix}$. Prove by induction that

$$A^n = \begin{pmatrix} n+1 & n \\ -n & 1-n \end{pmatrix},$$

where n is any positive integer. 6

- B3.** Find the Maclaurin expansion of

$$f(x) = \ln(\cos x), \quad \left(0 \leq x < \frac{\pi}{2}\right),$$

as far as the term in x^4 . 5

- B4.** Write down the 2×2 matrix A representing a reflection in the x -axis and the 2×2 matrix B representing an anti-clockwise rotation of 30° about the origin.

Hence show that the image of a point (x, y) under the transformation A followed by the transformation B is $\left(\frac{kx+y}{2}, \frac{x-ky}{2}\right)$, stating the value of k . 4

- B5.** Find the general solution of the differential equation

$$\frac{d^2y}{dx^2} + 2\frac{dy}{dx} + 5y = 4 \cos x. \quad 6$$

Hence determine the solution which satisfies $y(0) = 0$ and $y'(0) = 1$. 4

[END OF SECTION B]