Name: .... Register no: .... Class: ....

NGEE ANN SECONDARY SCHOOL

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PRELIMINARY EXAMINATION

ADDITIONAL MATHEMATICS **4049/02**

Paper 2 **31 August 2026**

2 hours 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, register number and class in the spaces at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** the questions.
Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.
The use of an approved scientific calculator is expected, where appropriate.
You are reminded of the need for clear presentation in your answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

The total number of marks for this paper is 90.

For Examiner's Use

Total	**/90**

Checked by student: ……………………………… Date: …………………

This document consists of **25** printed pages and **1** blank page.

Mathematical Formulae

1. ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Binomial Expansion

$$(a+b)^n = a^n + \binom{n}{1} a^{n-1} b + \binom{n}{2} a^{n-2} b^2 + \ldots + \binom{n}{r} a^{n-r} b^r + \ldots + b^n,$$

where n is a positive integer and $\binom{n}{r} = \frac{n!}{r!\,(n-r)!} = \frac{n\,(n-1)\ldots(n-r+1)}{r!}$

2. TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sec^2 A = 1 + \tan^2 A$$

$$\operatorname{cosec}^2 A = 1 + \cot^2 A$$

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

$$\sin 2A = 2 \sin A \cos A$$

$$\cos 2A = \cos^2 A - \sin^2 A = 2\cos^2 A - 1 = 1 - 2\sin^2 A$$

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

Formulae for ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\Delta = \frac{1}{2} bc \sin A$$

1 The simultaneous equations $y = x^2 + px - 6$ and $y = 2x + \frac{3}{2}$ have a common solution for which $x = 3$. Find the value of p, and hence solve the simultaneous equations. [5]

2 **(a)** **(i)** In an architectural design, a support beam is modelled by the line

$$y = 2x + k$$

and a parabolic arch is modelled by

$$y = x^2 - 4x + 7.$$

The beam is to touch, but not cut, the arch. Find the value of k. [3]

(ii) The beam is then raised vertically by 3 units from this tangent position. Without drawing or referring to a graph, determine the number of points at which the beam intersects the arch. [2]

(b) Represent the solution set of $(2x+1)^2 \geq 4x+8$ on a number line. [3]

3 A cubic polynomial is given as $\mathrm{P}(x) = x^3 + ax^2 + bx + c$. The graph of $y = \mathrm{P}(x)$ cuts the y-axis at $(0, 2)$. The remainder when $\mathrm{P}(x)$ is divided by $x + 1$ is -3, and $x - 2$ is a factor of $\mathrm{P}(x)$.

(a) Find the values of a, b and c. [4]

(b) Hence solve the equation $\mathrm{P}(x)=0$, leaving your answers in exact form. [3]

4 The amount of medicine remaining in a patient's bloodstream t hours after it is taken is M mg. It is modelled by the equation

$$\ln\left(\frac{M}{5}\right) = \ln 16 - \frac{t}{3}\ln 2 .$$

(a) Show that the model can be written in the form

$$M = 80e^{-\frac{t}{3}\ln 2} .$$ [2]

(b) Find the time taken for the medicine to decrease to 20 mg. [3]

(c) A second dose should be taken only when the amount of medicine remaining in the bloodstream has fallen to less than 15 mg.

A patient takes the medicine at 07 00. The patient asks whether the second dose can be taken at 14 20.

Use the model to determine whether the second dose can be taken at 14 20.
Give a reason for your answer. [3]

5 The graph of $y = a\cos(bx) + c$ has adjacent minimum points at $(0, -1)$ and $(4\pi, -1)$. It also has a maximum point at $(2\pi, 5)$.

(a) Find the values of a, b and c. [3]

(b) Hence sketch the graph of $y = a\cos(bx) + c$ for $0 \le x \le \pi$. [2]

6 **(a)** Without using a calculator, show that $\tan\frac{\pi}{12} = 2-\sqrt{3}$. [2]

(b) Show that $\tan\left(\frac{\pi}{4}-\theta\right) = \frac{1-\tan\theta}{1+\tan\theta}$. [2]

A rotating stage turns through an angle θ radians, where $0 \le \theta \le \frac{\pi}{4}$.

A sensor signal S is given by $S = \frac{1-\tan\theta}{1+\tan\theta}$. The sensor is aligned when $S \le 2-\sqrt{3}$.

(c) Using the results in **(a)** and **(b)**, find the range of values of θ for which the sensor is aligned. [3]

(d) The rotating stage moves uniformly from $\theta = 0$ to $\theta = \frac{\pi}{4}$ in 24 seconds.

The locking mechanism is activated only if the sensor remains aligned continuously for more than 7.5 seconds.

Determine whether the locking mechanism is activated. Justify your answer. [2]

7 The points $A(-3,4)$, $B(5,0)$ and $C(1,-2)$ are joined to form triangle ABC. The perpendicular from C to AB meets AB at D. The point E lies on AB produced, such that $CE = CA$.

(a) Find the coordinates of point D. [4]

(b) Find the coordinates of point E. [3]

(c) Find the area of triangle ACE. [2]

8 The curve C has equation $y = x^3 + ax^2 + bx + 4$, where a and b are constants. It is given that C has a stationary point when $x = 1$. The tangent to C at $x = 2$ is parallel to the line $y = -3x + 7$.

(a) Find the values of a and b. [4]

(b) Find the coordinates of all the stationary points of C, and determine their nature. [5]

9 The radius, r cm, of a circular chemical stain t seconds after it starts spreading is modelled by $r = 0.04t^2 + 0.6t$ and $0 \le t \le 15$.

(a) Find $\frac{\mathrm{d}A}{\mathrm{d}t}$ in terms of t, where A is the area of the stain. [3]

(b) Find the rate of increase of the area of the stain when $t = 10$. [2]

(c) For safety reasons, the laboratory has an automatic alert system. The system is activated if the area of the chemical stain is increasing at a rate greater than 100 cm^2/s.

This is because the cleaning team needs to respond immediately before the stain spreads beyond the containment mat.

Determine whether the alert system would already have been activated by the time $t = 14$. Justify your answer clearly. [3]

10 A clinic uses an e-bike courier to deliver temperature-sensitive medicine to a care centre 12 km away.

The courier travels against a steady headwind. When riding at a speed of v km/h relative to the air, where $v > 5$, the actual ground speed is $v - 5$ km/h.

The total energy used for the journey, E watt-hours (Wh) consists of two parts.

- Motor energy: $\frac{v^2}{80}$ Wh for every kilometre travelled
- Cooling box energy: 112.5 Wh for every hour of the journey

(a) Show that $E = \frac{3v^2}{20} + \frac{1350}{v-5}$. [3]

(b) Find the value of v for which E is stationary. [4]

(c) Determine whether this stationary value of E is a minimum. [3]

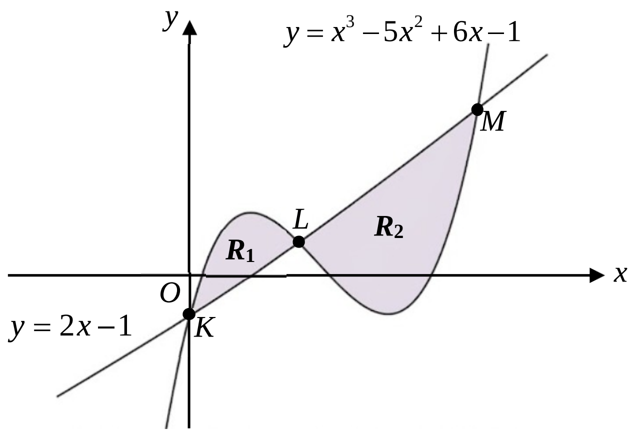
(d) For safety reasons, the courier is only allowed to choose a speed in the range

$$12 \leq v \leq 18.$$

The battery can supply at most 155 Wh for this journey.

Determine the speed the courier should choose, and whether the battery limit is satisfied. Justify your answer. [2]

11 The curve C has equation $y = x^3 - 5x^2 + 6x - 1$. Line l has equation $y = 2x - 1$. The curve C and the line l intersect at the points K, L and M, as shown in the diagram. The shaded region consists of the two regions R_1 and R_2.



(a) Find the coordinates of K, L and M. [4]

(b) Find the total shaded area. [6]

END OF PAPER

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