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ADDITIONAL MATHEMATICS

0606/22

Paper 2

May/June 2026

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You should use a scientific calculator where appropriate.
- You must show all necessary working clearly.
- Give non-exact numerical answers correct to 3 significant figures, or 1 decimal place for angles in degrees, unless a different level of accuracy is specified in the question.
- For π , use either your calculator value or 3.142.

INFORMATION

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [].

This document has 16 pages.



List of formulas

Equation of a circle with centre (a, b) and radius r .

$$(x - a)^2 + (y - b)^2 = r^2$$

Curved surface area, A , of cone of radius r , sloping edge l .

$$A = \pi r l$$

Surface area, A , of sphere of radius r .

$$A = 4\pi r^2$$

Volume, V , of pyramid or cone, base area A , height h .

$$V = \frac{1}{3} Ah$$

Volume, V , of sphere of radius r .

$$V = \frac{4}{3} \pi r^3$$

Quadratic equation

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

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

Binomial theorem

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

$$\text{where } n \text{ is a positive integer and } \binom{n}{r} = \frac{n!}{(n-r)!r!}$$

Arithmetic series

$$u_n = a + (n-1)d$$

$$S_n = \frac{1}{2} n(a + l) = \frac{1}{2} n\{2a + (n-1)d\}$$

Geometric series

$$u_n = ar^{n-1}$$

$$S_n = \frac{a(1-r^n)}{1-r} \quad (r \neq 1)$$

$$S_\infty = \frac{a}{1-r} \quad (|r| < 1)$$

Identities

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

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

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

Formulas for $\triangle ABC$

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

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

$$\Delta = \frac{1}{2} ab \sin C$$



- 1 The point A is the minimum point on the curve $y = x^2 - 6x + 10$.

- (a) Using the method of completing the square, find the coordinates of A . [2]

$$y = x^2 - 6x + (-3)^2 - (-3)^2 + 10$$

$$y = (x - 3)^2 + 1$$

$$\therefore A(3, 1)$$

- (b) The point B has coordinates $(6, 7)$.
The curve cuts the y -axis at the point C .

Find the equation of the line through B parallel to the line AC . [2]

$$\text{at } C, x = 0$$

$$y = (0 - 3)^2 + 1$$

$$= 10$$

$$C(0, 10)$$

$$m_{AC} = \frac{10 - 1}{0 - 3} = -3$$

equation of line ; $y - 7 = -3(x - 6)$ ✖

or

$$y = -3x + 25$$

- 2 Show that there is no real value of k for which the equation

$$(k-2)x^2 + (2k+3)x + 3 = 0$$

has two equal roots.

[3]

$$b^2 - 4ac = 0$$

$$(2k+3)^2 - 4(k-2)(3) = 0$$

$$4k^2 + 12k + 9 - 12k + 24 = 0$$

$$4k^2 + 33 = 0$$

alternative

$$4k^2 = -33$$

$$k = \pm \sqrt{-\frac{33}{4}}$$

$$b^2 - 4ac$$

$$0^2 - 4(4)(33)$$

since $b^2 - 4ac < 0$

hence no real value of k .

can't get square root of negative.
hence no real value of k .

- 3 (a) Differentiate $y = \sqrt{x+1} + \cos(5x+3)$ with respect to x .

[3]

$$\begin{aligned} \frac{dy}{dx} &= \frac{1}{2}(x+1)^{-\frac{1}{2}}(1) - \sin(5x+3) \times 5 \\ &= \frac{1}{2\sqrt{x+1}} - 5\sin(5x+3) \end{aligned}$$

- (b) Find $\int \sec^2 \frac{x}{3} dx$.

[3]

$$\frac{\tan \frac{x}{3}}{\frac{1}{3}} + c$$

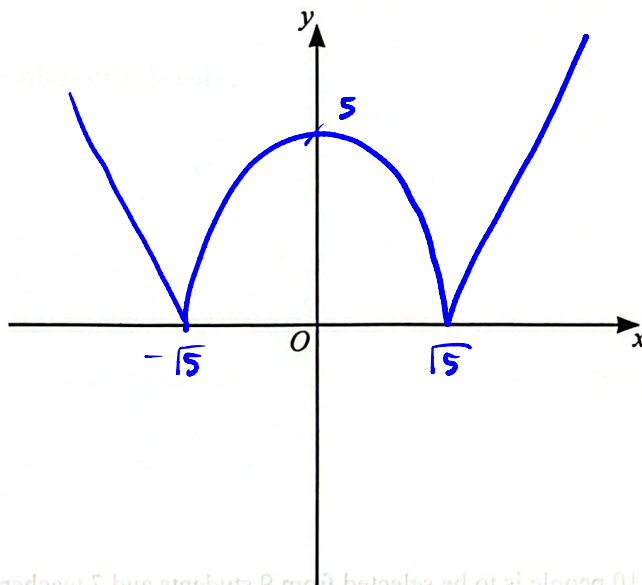
$$3 \tan \frac{x}{3} + c$$



- 4 (a) On the axes, sketch the graph of $y = |x^2 - 5|$.

State the intercepts with the coordinate axes.

[3]



- (b) It is given that $f(x) = ax + b$ where a and b are non-zero integers.
The solutions of the equation $|f(x)| = 4$ are $x = 2.5$ and $x = -1.5$.

Find the possible expressions for $f(x)$.

[4]

$$|f(x)| = 4$$

$$\begin{array}{l} \swarrow x = 2.5 \quad \searrow x = -1.5 \\ f(x) = 4 \quad \quad \quad f(x) = -4 \end{array}$$

$$\begin{array}{l} \frac{5}{2}a + b = 4 \\ 5a + 2b = 8 \quad \text{--- ①} \end{array}$$

$$\begin{array}{l} -\frac{3}{2}a + b = -4 \\ -3a + 2b = -8 \quad \text{--- ②} \end{array}$$

$$\text{①} - \text{②}$$

$$\begin{array}{l} 8a = 16 \\ a = 2 \end{array}$$

$$\therefore 2b = 8 - 5a$$

$$b = \frac{-2}{2}$$

$$b = -1$$

$$\therefore f(x) = 2x - 1$$

$$f(x) = -2x + 1$$

- 5 (a) In this question, 6-digit numbers do not start with 0.

Find how many 6-digit numbers have 6 different digits and are divisible by 2. [3]

Start with 2, 4, 6, 8 $\begin{array}{|c|c|c|c|c|c|} \hline 4 & 8 & 7 & 6 & 5 & 4 \\ \hline \end{array} = 26,880$

Start with 1, 3, 5, 7, 9 $\begin{array}{|c|c|c|c|c|c|} \hline 5 & 8 & 7 & 6 & 5 & 5 \\ \hline \end{array} = 42,000$

$\left. \begin{array}{l} 26,880 \\ + \\ 42,000 \end{array} \right\} 68,880 \times$

Alternative:

end with 0 $\begin{array}{|c|c|c|c|c|c|} \hline 9 & 8 & 7 & 6 & 5 & 0 \\ \hline \end{array} = 15120$

end with 2, 4, 6, 8 $\begin{array}{|c|c|c|c|c|c|} \hline 8 & 8 & 7 & 6 & 5 & 4 \\ \hline \end{array} = 53760$

$\left. \begin{array}{l} 15120 \\ + \\ 53760 \end{array} \right\} 68,880 \times$

- (b) A committee of 10 people is to be selected from 9 students and 7 teachers.

Find the number of different committees that can be selected if the committee must have at least 4 students and at least 4 teachers. [3]

$S(9)$	$T(7)$	
4	6	$= {}^9C_4 \times {}^7C_6 = 882$
5	5	$= {}^9C_5 \times {}^7C_5 = 2646$
6	4	$= {}^9C_6 \times {}^7C_4 = 2940$
		$\underline{\hspace{1cm}}$
		$6,468 \times$



- 6 In this question, a , b and c are integers.

When the expansion of $(a+x)^4(1+ax)^5$ is written in ascending powers of x , the first three terms are $16+bx+cx^2$.

Find all the possible values of a , b and c .

[8]

$$(a+x)^4 = a^4 + 4a^3x + 6a^2x^2 + \dots$$

$$(1+ax)^5 = 1 + 5ax + 10a^2x^2 + \dots$$

$$\therefore (a+x)^4(1+ax)^5 = (a^4 + 4a^3x + 6a^2x^2)(1 + 5ax + 10a^2x^2)$$

$$x^0: \quad 16 = a^4(1)$$

$$a = \pm 2$$

$$x^1: \quad b = a^4(5a) + 4a^3(1)$$

$$\text{when } a = 2, \quad b = 16(5 \times 2) + 4(8) = 192$$

$$\text{when } a = -2, \quad b = 16(5 \times -2) + 4(-8) = -192$$

$$x^2: \quad c = a^4(10a^2) + 4a^3(5a) + 6a^2(1)$$

$$\text{when } a = 2, \quad c = 10(2)^6 + 20(2)^4 + 6(2)^2 = 984$$

$$\text{when } a = -2, \quad c = 10(-2)^6 + 20(-2)^4 + 6(-2)^2 = 984$$

$$\therefore a = 2, \quad b = 192, \quad c = 984$$

$$a = -2, \quad b = -192, \quad c = 984 \quad \times$$

- 7 In this question, $\mathbf{i}$ is a unit vector due east and $\mathbf{j}$ is a unit vector due north. Distances are measured in kilometres and time is measured in hours.

Point P has position vector $2\mathbf{i} + 5\mathbf{j}$ relative to an origin O .

At 1300, boat A sails from point P with velocity vector $8\mathbf{i} + 8\mathbf{j}$.

[8]

- (a) Find the position vector of A at the end of 2 hours of sailing.

[1]

$$t = 2, \quad \text{velocity vector} = 16\mathbf{i} + 16\mathbf{j}$$

$$\begin{aligned} \therefore \vec{OA} &= 2\mathbf{i} + 5\mathbf{j} + 16\mathbf{i} + 16\mathbf{j} \\ &= 18\mathbf{i} + 21\mathbf{j} \end{aligned}$$

- (b) Write down the position vector of A at the end of t hours of sailing.

[1]

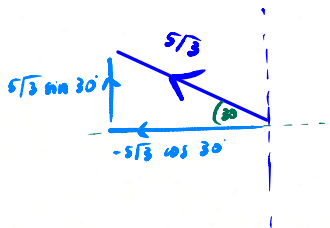
$$\begin{aligned} \vec{OA} &= 2\mathbf{i} + 5\mathbf{j} + (8\mathbf{i} + 8\mathbf{j})t \\ &= (2 + 8t)\mathbf{i} + (5 + 8t)\mathbf{j} \quad * \end{aligned}$$

- (c) Point Q has position vector $20\mathbf{i} + 8\mathbf{j}$ relative to the origin O .

At 1500, boat B sails from point Q on a bearing of 300° with a constant speed of $5\sqrt{3}$.

Find the position vector of B at 1700.

[3]



$$\begin{aligned} \text{velocity vector} &: (-5\sqrt{3} \cos 30)\mathbf{i} + 5\sqrt{3} \sin 30 \mathbf{j} \\ &= -\frac{5(3)}{2}\mathbf{i} + \frac{5\sqrt{3}}{2}\mathbf{j} \\ &= -\frac{15}{2}\mathbf{i} + \frac{5\sqrt{3}}{2}\mathbf{j} \end{aligned}$$

$$\text{at 1700, } t = 2$$

$$\begin{aligned} \vec{OB} &= 20\mathbf{i} + 8\mathbf{j} + \left(-\frac{15}{2}\mathbf{i} + \frac{5\sqrt{3}}{2}\mathbf{j}\right)(2) \\ &= (20 - 15)\mathbf{i} + (8 + 5\sqrt{3})\mathbf{j} \\ &= 5\mathbf{i} + (8 + 5\sqrt{3})\mathbf{j} \quad * \end{aligned}$$

(d) Find the distance between the two boats at 1700. [3]

at 1700, $t=4$ for boat A. $t=2$ for boat B

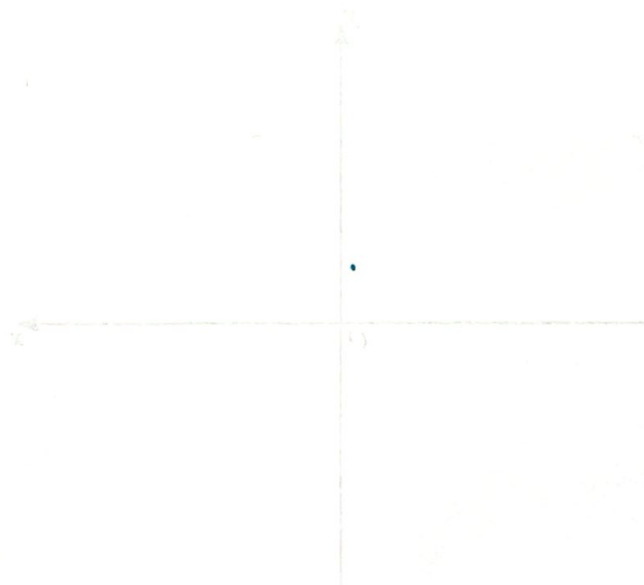
$$\begin{aligned}\vec{OA} &= (2+8(4))\mathbf{i} + (5+8(4))\mathbf{j} \\ &= 34\mathbf{i} + 37\mathbf{j}\end{aligned}$$

$$\vec{OB} = 5\mathbf{i} + (8+5\sqrt{3})\mathbf{j}$$

$$\begin{aligned}\vec{AB} &= \vec{OB} - \vec{OA} \\ &= (5-34)\mathbf{i} + (8+5\sqrt{3}-37)\mathbf{j} \\ &= -29\mathbf{i} + (5\sqrt{3}-29)\mathbf{j}\end{aligned}$$

distance.

$$\begin{aligned}|\vec{AB}| &= \sqrt{29^2 + (5\sqrt{3}-29)^2} \\ &= 35.4 \text{ km}\end{aligned}$$



- 8 The function f is defined, for $x \geq -1$, by $f(x) = 1 + 2^x$.

(a) Find the range of f .

[1]

$$f(-1) = 1 + 2^{-1} = \frac{3}{2}$$

$$\therefore f \geq \frac{3}{2} *$$

(b) (i) Write down the domain of f^{-1} .

[1]

$$x \geq \frac{3}{2}$$

(ii) Find an expression for $f^{-1}(x)$.

[2]

$$\text{let } y = 1 + 2^x$$

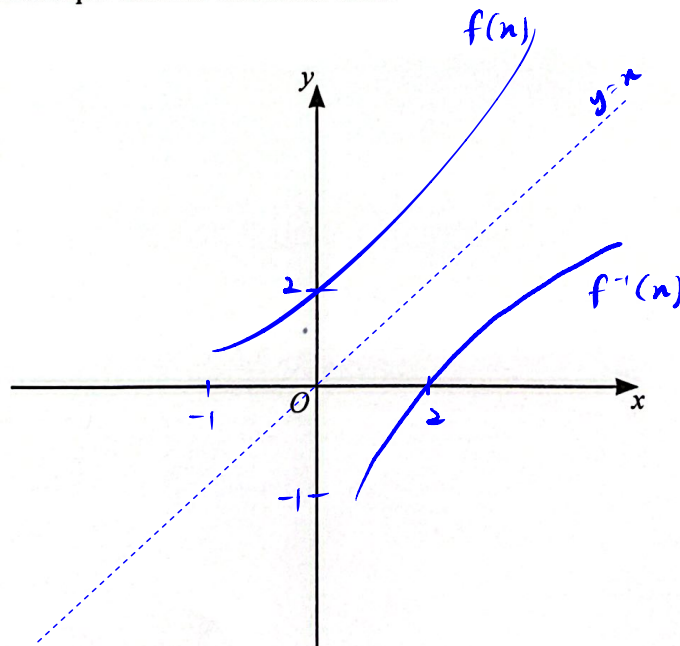
$$2^x = y - 1$$

$$x = \log_2(y - 1)$$

$$\therefore f^{-1}(x) = \log_2(x - 1) *$$

(iii) On the axes, sketch the graph of $y = f(x)$ and hence the graph of $y = f^{-1}(x)$. State any intercepts with the coordinate axes.

[4]



(c) The function g is defined, for $x \geq -1$, by $g(x) = x(x+k)$ where k is a constant.

(i) Explain why gf exists.

[1]

because the range of f ($f \geq \frac{3}{2}$)
is contain within domain of g ($x \geq -1$)

(ii) Find an expression for $gf(x)$.

[1]

$$\begin{aligned} gf(x) &= g(1+2^x) \\ &= (1+2^x)(1+2^x+k) \end{aligned}$$

(iii) It is given that $gf(3) = 126$.

Find the value of k .

[2]

$$gf(3) = (1+8)(1+8+k)$$

$$126 = 9(9+k)$$

$$14 = 9+k$$

$$k = 5$$

- 9 A particle P moves in a straight line such that t seconds after passing through a fixed point O , its displacement from O , s metres, is given by $s = e^{4t} - 10e^{2t} + 9$.

(a) The velocity of P is $v \text{ ms}^{-1}$.

Find the value of t for which v has a stationary value.

[5]

$$v = \frac{ds}{dt}$$

$$= 4e^{4t} - 20e^{2t}$$

at stationary, $v = 0$

$$20e^{2t} = 4e^{4t}$$

$$5 = e^{2t}$$

$$t = \frac{1}{2} \ln 5 \text{ seconds} \times$$

(b) Find the acceleration of P when $t = \ln 2$.

[2]

$$a = \frac{dv}{dt}$$

$$= 16e^{4t} - 40e^{2t}$$

when $t = \ln 2$

$$a = 16e^{4(\ln 2)} - 40e^{2(\ln 2)}$$

$$= 16e^{\ln 16} - 40e^{\ln 4}$$

$$= 16(16) - 40(4)$$

$$= 96 \text{ m/s}^2 \times$$



10 Solve the equation $\tan(3x+1) = 5 \sin(3x+1)$ for $-\frac{\pi}{3} < x < \frac{\pi}{3}$.

[6]

$$-\pi < 3x < \pi$$

$$-\pi+1 < 3x+1 < \pi+1$$

$$\frac{\sin(3x+1)}{\cos(3x+1)} - 5 \sin(3x+1) = 0$$

$$\sin(3x+1) \left[\frac{1}{\cos(3x+1)} - 5 \right] = 0$$

$$\sin(3x+1) = 0$$

$$3x+1 = \sin^{-1}(0)$$

$$3x+1 = 0, \pi$$

$$3x = -1, \pi-1$$

$$x = -\frac{1}{3} \text{ rads}, \frac{\pi-1}{3} \text{ rads}$$

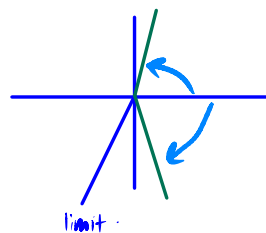
$$= -0.333 \text{ rads}, 0.714 \text{ rads} \quad \#$$



$$\frac{1}{\cos(3x+1)} - 5 = 0$$

$$\cos(3x+1) = \frac{1}{5}$$

$$3x+1 = \cos^{-1}\left(\frac{1}{5}\right)$$



$$3x+1 = \cos^{-1}\left(\frac{1}{5}\right), -\cos^{-1}\left(\frac{1}{5}\right)$$

$$x = \frac{\cos^{-1}\left(\frac{1}{5}\right)-1}{3}, \frac{-\cos^{-1}\left(\frac{1}{5}\right)-1}{3}$$

$$= 0.123 \text{ rads}, -0.790 \text{ rads} \quad \#$$

- 11 Solutions to this question by accurate drawing will not be accepted.

A circle C_1 has centre $(3, 5)$.

The point $P(1, 4)$ lies on circle C_1 .

A circle C_2 has centre $(12, 8)$.

The line with equation $y = 19 - 3x$ is the common chord of circles C_1 and C_2 .

Find the radius of circle C_2 .

[9]

$$C_1: (x-3)^2 + (y-5)^2 = r_1^2$$

$$\text{when } x=1, y=4$$

$$(1-3)^2 + (4-5)^2 = r_1^2$$

$$r_1^2 = 5$$

the intersection point of C_1 & C_2 :

$$(x-3)^2 + (y-5)^2 = 5, \quad y = 19 - 3x$$

$$x^2 - 6x + 9 + (19 - 3x - 5)^2 - 5 = 0$$

$$x^2 - 6x + 4 + (14 - 3x)^2 = 0$$

$$x^2 - 6x + 4 + 196 - 84x + 9x^2 = 0$$

$$10x^2 - 90x + 200 = 0$$

$$x^2 - 9x + 20 = 0$$

$$(x-5)(x-4) = 0$$

$$x_1 = 5 \quad x_2 = 4$$

Continuation of working space for Question 11.

$$\therefore y = 19 - 3(5) \\ = 4$$

$$\therefore (5, 4)$$

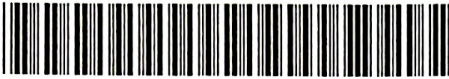
$$C_2: (x-12)^2 + (y-8)^2 = r_2^2$$

$$\text{when } x=5, y=4$$

$$49 + 16 = r_2^2$$

$$r_2 = \sqrt{65} \quad \text{unit} \times$$

Question 12 is on the back page.



- 12 A sphere has volume $V \text{ cm}^3$ and radius $r \text{ cm}$.

Given that r varies with time t , find V at the instant when $\frac{dV}{dt} = 9 \frac{dr}{dt}$. [4]

$$\frac{\frac{dV}{dt}}{\frac{dr}{dt}} = 9$$

$$\frac{dV}{dr} = 9$$

$$V_{\text{sphere}} = \frac{4}{3} \pi r^3$$

$$\frac{dV}{dr} = 4\pi r^2$$

$$9 = 4\pi r^2$$

$$r = \frac{3}{2\sqrt{\pi}}$$

$$\therefore V = \frac{4}{3} \pi \left(\frac{3}{2\sqrt{\pi}} \right)^3$$

$$= \frac{4}{3} \pi \left(\frac{27}{8\pi^{3/2}} \right)$$

$$= \frac{9\pi}{2\pi^{3/2}}$$

$$= \frac{9}{2\sqrt{\pi}} = 2.54 \text{ cm}^3$$

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