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ADDITIONAL MATHEMATICS **0606/11**

Paper 1 Non-calculator **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.
- Calculators must **not** be used in this paper.
- You must show all necessary working clearly.

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.

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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. $A = \pi rl$

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

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

where n 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 ΔABC

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$
$$a^2 = b^2 + c^2 - 2bc\cos A$$
$$\Delta = \frac{1}{2}ab\sin C$$

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1 Solve the equation $|5x+4| = |3x-2|$. [3]

Two cases for | | = | |

$5x + 4 = 3x - 2$

or $5x + 4 = -(3x - 2) = -3x + 2$

Case 1: balance method

$5x - 3x + 4 = 3x - 3x - 2$

$2x + 4 - 4 = -2 - 4$

$2x \div 2 = -6 \div 2$

$x = -3$

Case 2: balance method

$5x + 3x + 4 = -3x + 3x + 2$

$8x + 4 - 4 = 2 - 4$

$8x \div 8 = -2 \div 8$

$x = -\frac{1}{4}$

$\therefore\ x = -3, \quad x = -\frac{1}{4}$

Examii Insight

01 Two cases for | | = | |
- If $|A| = |B|$, then $A = B$ or $A = -B$.
- Write BOTH equations — each one gives an answer.

02 Case 1: balance method
- To remove 3x from the right, we –3x on the right and, to be fair, –3x on the left too.
- Then –4 on both sides, then ÷2 on both sides.

03 Case 2: balance method
- +3x on both sides, –4 on both sides, ÷8 on both sides.
- Check: $x = -3$: $|-11| = 11$ and $|-11| = 11$ ✓

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2 A circle has equation $(x-3)^2+(y-4)^2=20$.

(a) Write down the coordinates of the centre of the circle. [1]

∴ (3, 4)

Examii Insight $(x-a)^2+(y-b)^2=r^2$ has centre (a,b) — change the signs.

(b) Write down the radius of the circle. [1]

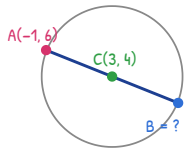
∴ $r = \sqrt{20} = 2\sqrt{5}$

Examii Insight The right side is $r^2=20$, so take the square root.

(c) The line AB is a diameter of this circle.
The point A has coordinates $(-1, 6)$.

Find the coordinates of the point B. [2]

The centre is the midpoint of AB



A → C : x + 4, y − 2

C → B : x + 4, y − 2

B = (3 + 4, 4 − 2)

Check with the midpoint formula

$\frac{-1+x}{2} = 3 \Rightarrow x = 7$

$\frac{6+y}{2} = 4 \Rightarrow y = 2$

∴ B = (7, 2)

Examii Insight

01 The centre is the midpoint of AB

- A diameter passes through the centre.
- So the centre C is exactly halfway from A to B.
- Make the same "step" again from C to reach B.

02 Check with the midpoint formula

- Midpoint $= \left(\frac{x_1+x_2}{2}, \frac{y_1+y_2}{2}\right)$.
- ×2 on both sides, then −(−1) i.e. +1, and −6.

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3 Show that $(3+5\cot\theta)^2+(3-5\cot\theta)^2-50\operatorname{cosec}^2\theta$, where $0<\theta<\frac{\pi}{2}$, can be simplified to a constant. [4]

Expand both brackets

$(3+5\cot\theta)^2 = 9+30\cot\theta+25\cot^2\theta$

$(3-5\cot\theta)^2 = 9-30\cot\theta+25\cot^2\theta$

Add, then subtract 50 cosec²θ

$9+\cancel{30\cot\theta}+25\cot^2\theta+9-\cancel{30\cot\theta}+25\cot^2\theta-50\operatorname{cosec}^2\theta$

$= 18+50\cot^2\theta-50\operatorname{cosec}^2\theta$

Use the identity

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

$18+50\cot^2\theta-50(1+\cot^2\theta) = 18+\cancel{50\cot^2\theta}-50-\cancel{50\cot^2\theta}$

$= -32$

$\therefore$ −32, a constant ✓

Examii Insight

01 Expand both brackets
- $(a+b)^2=a^2+2ab+b^2$
- $2\times3\times5\cot\theta=30\cot\theta$

02 Add, then subtract 50 cosec²θ
- The +30 cot θ and −30 cot θ cancel.
- 9 + 9 = 18 and 25 + 25 = 50.

03 Use the identity
- From the formula list: $\operatorname{cosec}^2A=1+\cot^2A$.
- So $\cot^2\theta-\operatorname{cosec}^2\theta=-1$.
- No θ is left, so the answer is a constant.

04 Trig rules toolbox
- $\sin^2\theta+\cos^2\theta=1$
- $1+\tan^2\theta=\sec^2\theta$
- $1+\cot^2\theta=\operatorname{cosec}^2\theta$ ← **used here**
- $\tan\theta=\frac{\sin\theta}{\cos\theta}$, $\cot\theta=\frac{\cos\theta}{\sin\theta}=\frac{1}{\tan\theta}$
- $\sec\theta=\frac{1}{\cos\theta}$, $\operatorname{cosec}\theta=\frac{1}{\sin\theta}$
- Positive: all (Q1), sin (Q2), tan (Q3), cos (Q4)
- sin, cos repeat every 360° (2π); tan every 180° (π)

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4 Given that $\int_0^a \frac{1}{3x+2}\,dx = \ln 4$, find the value of the constant a. [5]

Integrate

$$\int \frac{1}{3x+2}\,dx = \frac{1}{3}\ln(3x+2)$$

Put in the limits

$$\left[\frac{1}{3}\ln(3x+2)\right]_0^a = \frac{1}{3}\ln(3a+2) - \frac{1}{3}\ln 2$$

$$= \frac{1}{3}\ln\left(\frac{3a+2}{2}\right)$$

Solve = ln 4 (balance)

$$3 \times \frac{1}{3}\ln\left(\frac{3a+2}{2}\right) = 3 \times \ln 4$$

$$\ln\left(\frac{3a+2}{2}\right) = \ln 64$$

$$\frac{3a+2}{2} = 64$$

Finish

$$3a + 2 = 128$$

$$3a + 2 - 2 = 128 - 2$$

$$3a \div 3 = 126 \div 3$$

$$\therefore\ a = 42$$

Examii Insight

01 Integrate
- $\int \frac{1}{ax+b}\,dx = \frac{1}{a}\ln(ax+b)$
- Divide by 3, the number in front of x.

02 Put in the limits
- Top limit minus bottom limit.
- Log law: $\ln A - \ln B = \ln \frac{A}{B}$.

03 Solve = ln 4 (balance)
- ×3 on both sides to clear the $\frac{1}{3}$.
- $3\ln 4 = \ln 4^3 = \ln 64$.
- ln of both sides equal → the insides are equal.

04 Finish
- ×2 on both sides, −2 on both sides, ÷3 on both sides.

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5 The polynomial p is such that $p(x) = ax^3 + 4x^2 - ax - 28$, where a is a positive constant.

It is given that $p(a) = 0$.

(a) Find the value of a. [4]

Substitute x = a

$p(a) = a \cdot a^3 + 4a^2 - a \cdot a - 28$

$a^4 + 4a^2 - a^2 - 28 = 0$

$a^4 + 3a^2 - 28 = 0$

Quadratic in a^2

$(a^2 + 7)(a^2 - 4) = 0$

$a^2 = -7$ (no) or $a^2 = 4$

$\therefore a = 2$

Examii Insight

01 Substitute x = a
- "$p(a) = 0$" means put $x = a$ everywhere.

02 Quadratic in a^2
- Treat a^2 like one letter: $u^2 + 3u - 28 = (u + 7)(u - 4)$.
- A square cannot be negative, and a is positive, so $a = 2$ only.

(b) Using your value of a, find $p(x)$ as a product of a linear factor and a quadratic factor. [2]

Write p(x) and use the factor (x – 2)

$p(x) = 2x^3 + 4x^2 - 2x - 28$

$p(2) = 16 + 16 - 4 - 28 = 0$ ✓

$p(x) = (x - 2)(2x^2 + 8x + 14)$

$\therefore p(x) = (x - 2)(2x^2 + 8x + 14)$

Examii Insight

01 Write p(x) and use the factor (x – 2)
- $p(2) = 0$, so $(x - 2)$ is a factor (factor theorem).
- Match: $2x^2$ gives $2x^3$; $-2 \times 14 = -28$; then middle term 8x.

(c) Hence show that the equation $p(x) = 0$ has exactly one root. [2]

Discriminant of the quadratic

$b^2 - 4ac = 8^2 - 4 \times 2 \times 14$

$= 64 - 112 = -48 < 0$

$\therefore$ only one root, x = 2

Examii Insight

01 Discriminant of the quadratic
- $b^2 - 4ac < 0 \rightarrow$ the quadratic has no real roots.
- So the only root comes from $x - 2 = 0$.

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6 The function f is such that $f(x) = 3x^2 + 8x$ for $x \geqslant k$, where k is a constant.
It is given that f^{-1} exists.
k has the least possible value for which f^{-1} exists.

(a) Find the value of k. [2]

Find the turning point

$f'(x) = 6x + 8 = 0$

$6x + 8 - 8 = 0 - 8$

$6x \div 6 = -8 \div 6$

$x = -\frac{4}{3}$

$\therefore\ k = -\frac{4}{3}$

Examii Insight

01 Find the turning point
- f^{-1} exists only if f is one-one.
- A U-shaped curve is one-one only from its lowest point onwards.
- So k = x-coordinate of the turning point.

(b) Find the range of f. [2]

Lowest value of f

$f\left(-\frac{4}{3}\right) = 3\left(\frac{16}{9}\right) + 8\left(-\frac{4}{3}\right)$

$= \frac{16}{3} - \frac{32}{3} = -\frac{16}{3}$

$\therefore\ f(x) \geqslant -\frac{16}{3}$

Examii Insight

01 Lowest value of f
- Substitute k into f.
- Range = all the outputs, from the lowest point upwards.

(c) Find an expression for f^{-1}. [3]

Swap x and y

$y = 3x^2 + 8x$

$x = 3y^2 + 8y$

$3y^2 + 8y - x = 0$

Quadratic formula for y

$y = \frac{-8 \pm \sqrt{64 - 4(3)(-x)}}{2 \times 3}$

$= \frac{-8 \pm \sqrt{64 + 12x}}{6}$

Choose + or − $\therefore\ f^{-1}(x) = \frac{-8 + \sqrt{64 + 12x}}{6}$

Examii Insight

01 Swap x and y
- Write y = f(x), then swap x and y.
- Make it a quadratic in y (= 0).

02 Quadratic formula for y
- $a = 3,\ b = 8,\ c = -x$.

03 Choose + or −
- f^{-1} gives outputs $\geqslant -\frac{4}{3}$ (the domain of f).
- Only the + sign does this, so reject −.

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(d) The function g is such that $g(x) = 3^x$ for $x > -6$.

(i) Write down the domain of gf. [1]

Domain of gf $\therefore\ x \geqslant -\frac{4}{3}$

Examii Insight

01 Domain of gf
- gf: do f first, so use the domain of f.

(ii) Solve the equation $gf(x) = 27$. [4]

Write gf(x)

$gf(x) = 3^{3x^2+8x}$

$3^{3x^2+8x} = 27 = 3^3$

Equate the powers

$3x^2 + 8x = 3$

$3x^2 + 8x - 3 = 0$

$(3x - 1)(x + 3) = 0$

Check the domain

$x = \frac{1}{3}$ or $x = -3$

$\therefore\ x = \frac{1}{3}$

Examii Insight

01 Write gf(x)
- f first, then g: put f(x) into the power.
- Write 27 as a power of 3.

02 Equate the powers
- Same base → the powers are equal.
- –3 on both sides, then factorise.

03 Check the domain
- $-3 < -\frac{4}{3}$, so it is NOT in the domain of gf → reject.

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7 A curve has equation $y = \dfrac{4+\mathrm{e}^{2x}}{2+\mathrm{e}^{x}}$.

(a) Show that, when $\dfrac{\mathrm{d}y}{\mathrm{d}x} = 0$, $\mathrm{e}^{2x} + 4\mathrm{e}^{x} - 4 = 0$. [5]

Quotient rule

$u = 4 + e^{2x}$, $\dfrac{du}{dx} = 2e^{2x}$

$v = 2 + e^{x}$, $\dfrac{dv}{dx} = e^{x}$

Write dy/dx

$$\frac{dy}{dx} = \frac{(2 + e^{x})\,2e^{2x} - (4 + e^{2x})\,e^{x}}{(2 + e^{x})^{2}}$$

Set the top = 0 and simplify

$$(2 + e^{x})\,2e^{2x} - (4 + e^{2x})\,e^{x} = 0$$

$$4e^{2x} + 2e^{3x} - 4e^{x} - e^{3x} = 0$$

$$e^{3x} + 4e^{2x} - 4e^{x} = 0$$

Divide by e^x

$$e^{x}\left(e^{2x} + 4e^{x} - 4\right) = 0$$

$$e^{2x} + 4e^{x} - 4 = 0$$

$\therefore$ shown ✓

Examii Insight

01 Quotient rule

- $\dfrac{d}{dx}\left(\dfrac{u}{v}\right) = \dfrac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2}$
- Chain rule: $\dfrac{d}{dx}e^{2x} = 2e^{2x}$.

02 Write dy/dx

- Bottom × derivative of top, MINUS top × derivative of bottom.

03 Set the top = 0 and simplify

- A fraction is zero only when its top is zero.
- Expand the brackets carefully: watch the minus sign.

04 Divide by e^x

- e^x is never 0, so we may $\div e^x$ on both sides.
- Always say why you divide.

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(b) Hence find the x-coordinate of the stationary point on the curve.
Give your answer in the form $\ln\left(a\sqrt{b}+c\right)$, where a, b and c are integers. [4]

Solve the quadratic in e^x

$(e^x)^2 + 4e^x - 4 = 0$

$$e^x = \frac{-4 \pm \sqrt{16 - 4(1)(-4)}}{2}$$

$$= \frac{-4 \pm \sqrt{32}}{2} = -2 \pm 2\sqrt{2}$$

Reject the negative and take ln

$e^x = 2\sqrt{2} - 2$

$\ln e^x = \ln\left(2\sqrt{2} - 2\right)$

$\therefore\ x = \ln\left(2\sqrt{2} - 2\right)$

Examii Insight

01 Solve the quadratic in e^x
- Let $u = e^x$: $u^2 + 4u - 4 = 0$.
- $\sqrt{32} = 4\sqrt{2}$, then ÷2.

02 Reject the negative and take ln
- $e^x > 0$ always, so $-2 - 2\sqrt{2}$ is impossible.
- Take ln of both sides to keep it balanced.
- a = 2, b = 2, c = –2.

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8 **(a)** Write down the value of $\lg(10000)$. [1]

$\therefore \lg 10000 = 4$

Examii Insight $10000 = 10^4$, and lg means $\log_{10}$.

(b) Solve the equation $\log_2(\log_3 x) = 2$. [3]

Remove the outer log

$\log_2(\log_3 x) = 2$

$\log_3 x = 2^2 = 4$

Remove the inner log

$x = 3^4$

$\therefore x = 81$

Examii Insight

01 Remove the outer log
- $\log_2 N = 2$ means $N = 2^2$.

02 Remove the inner log
- $\log_3 x = 4$ means $x = 3^4$.

(c) Solve the equation $\log_x 5 = \log_5 x^4$. [4]

Change both to base 5

$\log_x 5 = \dfrac{1}{\log_5 x}$

$\log_5 x^4 = 4\log_5 x$

Let $u = \log_5 x$ and balance

$\dfrac{1}{u} = 4u$

$\dfrac{1}{u} \times u = 4u \times u$

$1 \div 4 = 4u^2 \div 4$

$u^2 = \dfrac{1}{4}, \quad u = \pm\dfrac{1}{2}$

Back to x

$\log_5 x = \dfrac{1}{2} \Rightarrow x = 5^{\frac{1}{2}} = \sqrt{5}$

$\log_5 x = -\dfrac{1}{2} \Rightarrow x = 5^{-\frac{1}{2}} = \dfrac{1}{\sqrt{5}}$

$\therefore x = \sqrt{5}, \quad x = \dfrac{1}{\sqrt{5}}$

Examii Insight

01 Change both to base 5
- Swap the base: $\log_a b = \dfrac{1}{\log_b a}$.
- Power law: $\log x^4 = 4\log x$.

02 Let u = $\log_5 x$ and balance
- ×u on both sides, then ÷4 on both sides.
- Square root gives + and −.

03 Back to x
- Both are positive and not 1, so both are allowed.

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9 **(a)** A geometric progression has common ratio r and first term a, where $a \neq 0$.
The 4th term is -8 times the 7th term.

(i) Find the value of r. [2]

Write the terms

$ar^3 = -8ar^6$

$r^3 = -\frac{1}{8}$

$\therefore\ r = -\frac{1}{2}$

Examii Insight

01 Write the terms
- 4th term $= ar^3$, 7th term $= ar^6$.
- $\div(-8ar^3)$ on both sides, then cube root.

(ii) The sum of the first 5 terms of this progression is $\frac{99}{32}$.

Find the value of a. [2]

Use S_5

$\frac{a\left(1-\left(-\frac{1}{2}\right)^5\right)}{1-\left(-\frac{1}{2}\right)} = \frac{99}{32}$

$\frac{a\left(\frac{33}{32}\right)}{\frac{3}{2}} = \frac{99}{32}$

$\frac{11}{16}a = \frac{99}{32}$

$\therefore\ a = \frac{99}{32} \times \frac{16}{11} = \frac{9}{2}$

Examii Insight

01 Use S_5
- $S_n = \frac{a(1-r^n)}{1-r}$
- $\left(-\frac{1}{2}\right)^5 = -\frac{1}{32}$
- $\times\frac{16}{11}$ on both sides.

(b) The first three terms of a different geometric progression are $\cos\theta\sin\theta$, $\cos\theta\sin^3\theta$ and $\cos\theta\sin^5\theta$, for $0 < \theta < \frac{\pi}{2}$.

Show that the sum to infinity of this progression is $\tan\theta$. [4]

Common ratio

$r = \frac{\cos\theta\sin^3\theta}{\cos\theta\sin\theta} = \sin^2\theta$

Sum to infinity

$S_\infty = \frac{a}{1-r} = \frac{\cos\theta\sin\theta}{1-\sin^2\theta}$

$= \frac{\cos\theta\sin\theta}{\cos^2\theta}$

Cancel

$= \frac{\sin\theta}{\cos\theta} = \tan\theta$

$\therefore$ shown ✓

Examii Insight

01 Common ratio
- Ratio = 2nd term ÷ 1st term.
- $0 < \theta < \frac{\pi}{2} \rightarrow 0 < \sin^2\theta < 1$, so S_∞ exists.

02 Sum to infinity
- $1 - \sin^2\theta = \cos^2\theta$.

03 Cancel
- Cancel one $\cos\theta$ from top and bottom.

04 Trig rules toolbox
- $\sin^2\theta + \cos^2\theta = 1$ ← **used here**
- $1 + \tan^2\theta = \sec^2\theta$
- $1 + \cot^2\theta = \operatorname{cosec}^2\theta$
- $\tan\theta = \frac{\sin\theta}{\cos\theta}$, $\cot\theta = \frac{\cos\theta}{\sin\theta} = \frac{1}{\tan\theta}$ ← **used here**
- $\sec\theta = \frac{1}{\cos\theta}$, $\operatorname{cosec}\theta = \frac{1}{\sin\theta}$
- Positive: all (Q1), sin (Q2), tan (Q3), cos (Q4)
- sin, cos repeat every $360°$ (2π); tan every $180°$ (π)

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10 A curve has equation $y = f(x)$, where $f''(x) = (2x+10)^{-\frac{1}{2}} - 2x$.

The curve has a stationary point at $\left(3, \frac{64}{3}\right)$.

Find the equation of the curve. [8]

Integrate once to get f′(x)

$$f'(x) = \int \left[(2x+10)^{-\frac{1}{2}} - 2x\right] dx$$

$$= \frac{(2x+10)^{\frac{1}{2}}}{\frac{1}{2} \times 2} - x^2 + c$$

$$= (2x+10)^{\frac{1}{2}} - x^2 + c$$

Stationary point → f′(3) = 0

$$(16)^{\frac{1}{2}} - 9 + c = 0$$

$$4 - 9 + c = 0$$

$$c = 5$$

Integrate again to get f(x)

$$f(x) = \int \left[(2x+10)^{\frac{1}{2}} - x^2 + 5\right] dx$$

$$= \frac{(2x+10)^{\frac{3}{2}}}{\frac{3}{2} \times 2} - \frac{x^3}{3} + 5x + d$$

$$= \frac{1}{3}(2x+10)^{\frac{3}{2}} - \frac{x^3}{3} + 5x + d$$

Use the point (3, 64/3)

$$\frac{1}{3}(16)^{\frac{3}{2}} - \frac{27}{3} + 15 + d = \frac{64}{3}$$

$$\frac{64}{3} - 9 + 15 + d = \frac{64}{3}$$

$$6 + d = 0 \Rightarrow d = -6$$

$$\therefore\ y = \frac{1}{3}(2x+10)^{\frac{3}{2}} - \frac{x^3}{3} + 5x - 6$$

Examii Insight

01 Integrate once to get f′(x)
- Add 1 to the power, divide by the new power AND by 2 (from 2x).

02 Stationary point → f′(3) = 0
- At a stationary point the gradient is 0.
- +5 on both sides.

03 Integrate again to get f(x)
- A new constant d appears — do not forget it.

04 Use the point (3, 64/3)
- $16^{\frac{3}{2}} = (\sqrt{16})^3 = 64$.
- $-\frac{64}{3}$ on both sides, then −6.

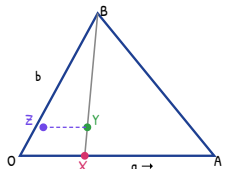
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11 A triangle OAB is such that $\overrightarrow{OA} = \mathbf{a}$ and $\overrightarrow{OB} = \mathbf{b}$.
The point X lies on OA such that $\overrightarrow{OA} = 3\overrightarrow{OX}$.
The point Y lies on XB such that $\overrightarrow{XB} = 5\overrightarrow{XY}$.
The point Z lies on OB such that $\overrightarrow{OB} = m\overrightarrow{OZ}$, where m is a scalar.
$\overrightarrow{OX} = n\overrightarrow{ZY}$, where n is a scalar.

Use a vector method to find the values of m and n. [8]

Vectors to X, along XB and to Y



$\overrightarrow{OX} = \frac{1}{3}\mathbf{a}$

$\overrightarrow{XB} = \mathbf{b} - \frac{1}{3}\mathbf{a}$

$\overrightarrow{XY} = \frac{1}{5}\left(\mathbf{b} - \frac{1}{3}\mathbf{a}\right)$

Vector to Z and then ZY

$\overrightarrow{OZ} = \frac{1}{m}\mathbf{b}$

$\overrightarrow{ZY} = \overrightarrow{ZO} + \overrightarrow{OX} + \overrightarrow{XY}$

$= -\frac{1}{m}\mathbf{b} + \frac{1}{3}\mathbf{a} + \frac{1}{5}\mathbf{b} - \frac{1}{15}\mathbf{a}$

$= \frac{4}{15}\mathbf{a} + \left(\frac{1}{5} - \frac{1}{m}\right)\mathbf{b}$

Use OX = n ZY

$\frac{1}{3}\mathbf{a} = n\left[\frac{4}{15}\mathbf{a} + \left(\frac{1}{5} - \frac{1}{m}\right)\mathbf{b}\right]$

Compare a, then b

a: $\frac{1}{3} = \frac{4n}{15} \Rightarrow n = \frac{15}{12} = \frac{5}{4}$

b: $0 = \frac{1}{5} - \frac{1}{m} \Rightarrow m = 5$

$\therefore\ m = 5,\quad n = \frac{5}{4}$

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01 Vectors to X, along XB and to Y

- $OA = 3OX \rightarrow$ X is $\frac{1}{3}$ of the way along OA.
- $\overrightarrow{XB} = \overrightarrow{XO} + \overrightarrow{OB}$.
- $XB = 5XY \rightarrow$ Y is $\frac{1}{5}$ of the way along XB.

02 Vector to Z and then ZY

- $OB = m\,OZ \rightarrow \overrightarrow{OZ} = \frac{1}{m}\mathbf{b}$.
- Go round the shape: Z → O → X → Y.
- Collect the a terms and the b terms.

03 Use OX = n ZY

- a and b point in different directions, so compare the a parts and the b parts separately.

04 Compare a, then b

- $\times\frac{15}{4}$ on both sides for n.
- There is no b on the left, so the b part on the right must be 0 ($n \neq 0$).

Question 12 is on the back page.

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12 Find the value of n such that ${}^{n+3}C_6 = 12 \times {}^{n+2}C_5$. [3]

Write with factorials

$$\frac{(n+3)!}{(n-3)!\,6!} = 12 \times \frac{(n+2)!}{(n-3)!\,5!}$$

Simplify

$$\frac{(n+3)!}{(n+2)!} = n+3$$

$$\frac{6!}{5!} = 6$$

$$\frac{n+3}{6} = 12$$

Balance

$$n+3 = 72$$

$$n+3-3 = 72-3$$

$$\therefore\ n = 69$$

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01 Write with factorials

- ${}^{n}C_r = \dfrac{n!}{(n-r)!\,r!}$
- Both have $(n-3)!$ at the bottom: $(n+3)-6 = n-3$ and $(n+2)-5 = n-3$.

02 Simplify

- $\times(n-3)!$ on both sides, then divide by $(n+2)!$.
- $(n+3)! = (n+3) \times (n+2)!$.

03 Balance

- $\times 6$ on both sides, then -3 on both sides.

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