Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS/A LEVEL

2300U10-1

S25-2300U10-1

WEDNESDAY, 14 MAY 2025 – MORNING

MATHEMATICS – AS unit 1
PURE MATHEMATICS A

2 hours 30 minutes

ADDITIONAL MATERIALS

In addition to this examination paper, you will need:

- a Formula Booklet;
- a calculator.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The maximum mark for this paper is 120.

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

Sufficient working must be shown to demonstrate the **mathematical** method employed.

Answers without working may not gain full credit.

Unless the degree of accuracy is stated in the question, answers should be rounded appropriately.

You are reminded of the necessity for good English and orderly presentation in your answers.

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1	5	
2	11	
3	6	
4	10	
5	6	
6	16	
7	6	
8	10	
9	5	
10	6	
11	9	
12	4	
13	4	
14	4	
15	11	
16	7	
Total	120	

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Reminder: Sufficient working must be shown to demonstrate the **mathematical** method employed.

1. Solve the inequality $(x-1)(x+6) < 9-2x-x^2$. [5]

$(x - 1)(x + 6) < 9 - 2x - x^2$

$x^2 + 5x - 6 < 9 - 2x - x^2$

$2x^2 + 7x - 15 < 0$

$(2x - 3)(x + 5) < 0$

Critical values: $x = -5$ and $x = \frac{3}{2}$

$2x^2 + 7x - 15$ is a positive quadratic, so it is negative between its roots.

$\therefore \quad -5 < x < \frac{3}{2}$

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2. The line L_1 passes through the points $A(-2, 0)$ and $B(3, 5)$.

(a) Find the equation of L_1. [3]

Gradient of $L_1 = \frac{5-0}{3-(-2)} = \frac{5}{5} = 1$

Equation of L_1: $y - 0 = 1(x - (-2))$

$y = x + 2$

The line L_2 is perpendicular to L_1, passes through B and intersects the x-axis at the point C.

(b) Find the coordinates of C. [3]

Gradient of $L_2 = -\frac{1}{1} = -1$ (perpendicular to L_1)

Equation of L_2: $y - 5 = -1(x - 3)$

$y = -x + 8$

At C, $y = 0$: $0 = -x + 8 \Rightarrow x = 8$

C is the point $(8, 0)$

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(c) Show that *ABC* is an isosceles triangle and calculate its area. [5]

$AB = \sqrt{((3 - (-2))^2 + (5 - 0)^2)} = \sqrt{(25 + 25)} = \sqrt{50} = 5\sqrt{2}$

$BC = \sqrt{((8 - 3)^2 + (0 - 5)^2)} = \sqrt{(25 + 25)} = \sqrt{50} = 5\sqrt{2}$

$AB = BC$, so triangle ABC is an isosceles triangle.

L_1 is perpendicular to L_2, so angle $ABC = 90°$.

Area of $ABC = \frac{1}{2} \times AB \times BC$

$= \frac{1}{2} \times \sqrt{50} \times \sqrt{50} = \frac{1}{2} \times 50$

Area of $ABC = 25$ (square units)

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3. Showing all your working, simplify the following expressions.

(a) $\dfrac{\left(a^2\right)^4\left(\sqrt{a}\right)^{-\frac{8}{3}}}{a^{-\frac{1}{3}}}$ [3]

$(a^2)^4 = a^8$

$(\sqrt{a})^{-8/3} = (a^{1/2})^{-8/3} = a^{-4/3}$

$\dfrac{(a^2)^4(\sqrt{a})^{-8/3}}{a^{-1/3}} = \dfrac{a^8 \times a^{-4/3}}{a^{-1/3}}$

$= a^{8 - 4/3 - (-1/3)}$

$= a^7$

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(b) $\dfrac{3-a\sqrt{3}}{2+3\sqrt{3}}$ [3]

$\dfrac{3 - a\sqrt{3}}{2 + 3\sqrt{3}} = \dfrac{(3 - a\sqrt{3})(2 - 3\sqrt{3})}{(2 + 3\sqrt{3})(2 - 3\sqrt{3})}$

$= \dfrac{6 - 9\sqrt{3} - 2a\sqrt{3} + 9a}{4 - 6\sqrt{3} + 6\sqrt{3} - 27}$

$= \dfrac{6 + 9a - (2a + 9)\sqrt{3}}{-23}$

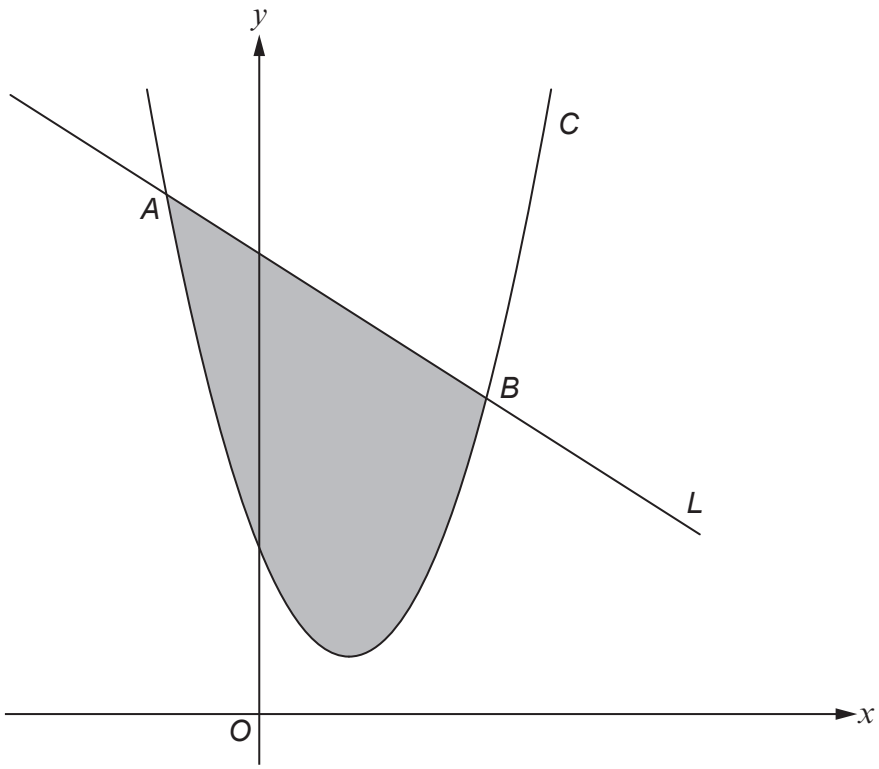
$= \dfrac{(2a + 9)\sqrt{3} - 6 - 9a}{23}$

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4. The diagram below shows a sketch of the curve *C* with equation $y = x^2 - 4x + 6$ and the line *L* with equation $y = -x + 16$. The curve and the line intersect at the points *A* and *B*.



(a) Find the coordinates of *A* and *B*. [4]

At A and B: $x^2 - 4x + 6 = -x + 16$

$x^2 - 3x - 10 = 0$

$(x - 5)(x + 2) = 0$

$x = -2$ or $x = 5$

$x = -2$: $y = -(-2) + 16 = 18$

$x = 5$: $y = -5 + 16 = 11$

A(−2, 18) and B(5, 11)

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(b) Calculate the area of the shaded region enclosed by C and L. [6]

$\text{Area} = \int_{-2}^{5} [(-x + 16) - (x^2 - 4x + 6)]\, dx$

$= \int_{-2}^{5} (-x^2 + 3x + 10)\, dx$

$= \left[-\frac{x^3}{3} + \frac{3x^2}{2} + 10x \right]_{-2}^{5}$

$= \left(-\frac{125}{3} + \frac{75}{2} + 50 \right) - \left(\frac{8}{3} + 6 - 20 \right)$

$= \frac{275}{6} - \left(-\frac{34}{3} \right)$

$= \frac{275}{6} + \frac{68}{6}$

$\text{Area} = \frac{343}{6} \quad (= 57.166\ldots)$

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5. Find the range of values of k for which the quadratic equation $x^2 + kx + k + 3 = 0$ has two distinct real roots. [6]

For two distinct real roots: $b^2 - 4ac > 0$

$a = 1, \quad b = k, \quad c = k + 3$

$k^2 - 4 \times 1 \times (k + 3) > 0$

$k^2 - 4k - 12 > 0$

$(k - 6)(k + 2) > 0$

Critical values: $k = -2, \quad k = 6$

$k^2 - 4k - 12$ is a positive quadratic, so it is positive

outside its roots:

$\therefore \quad k < -2 \quad \text{or} \quad k > 6$

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6. The function f is defined by $f(x) = x^3 - 3x^2 - 6x + 8$.

(a) Use an algebraic method to solve the equation $f(x) = 0$. Show all your working. [6]

$f(1) = 1 - 3 - 6 + 8 = 0$, so $(x - 1)$ is a factor

$x^3 - 3x^2 - 6x + 8 = (x - 1)(x^2 + ax + b)$

Comparing constants: $-b = 8 \Rightarrow b = -8$

Comparing x^2 terms: $a - 1 = -3 \Rightarrow a = -2$

$f(x) = (x - 1)(x^2 - 2x - 8)$

$f(x) = (x - 1)(x + 2)(x - 4)$

$f(x) = 0 \Rightarrow x = -2, \quad x = 1, \quad x = 4$

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The curve C has equation $y = f(x)$.

(b) Find the x-coordinates of the stationary points of C and determine their nature. [7]

$\frac{dy}{dx} = 3x^2 - 6x - 6$

At stationary points $\frac{dy}{dx} = 0$: $3x^2 - 6x - 6 = 0$

$x^2 - 2x - 2 = 0$

$x = \frac{2 \pm \sqrt{((-2)^2 - 4 \times 1 \times (-2))}}{2} = \frac{2 \pm \sqrt{12}}{2} = 1 \pm \sqrt{3}$

$x = 1 - \sqrt{3} = -0.732...$ and $x = 1 + \sqrt{3} = 2.732...$

$\frac{d^2y}{dx^2} = 6x - 6$

$x = 1 - \sqrt{3}$: $6(1 - \sqrt{3}) - 6 = -6\sqrt{3} < 0 \Rightarrow$ maximum

$x = 1 + \sqrt{3}$: $6(1 + \sqrt{3}) - 6 = 6\sqrt{3} > 0 \Rightarrow$ minimum

$\therefore$ $x = 1 - \sqrt{3}$ (−0.732) is a maximum point

$x = 1 + \sqrt{3}$ (2.732) is a minimum point

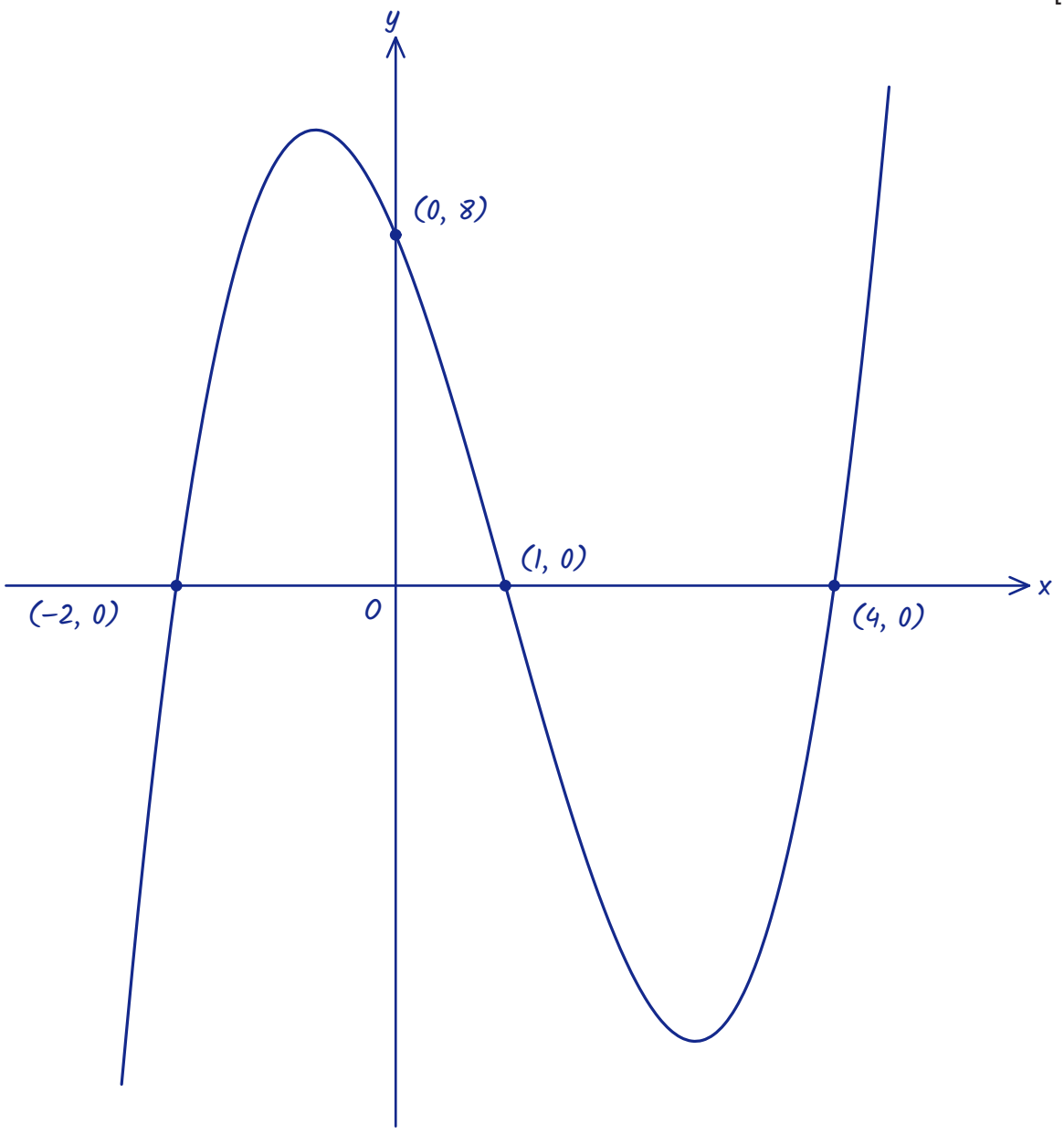
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(c) Sketch the curve *C*, clearly labelling the points where the curve crosses the x and y axes. [3]



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7. The triangle ABC is such that $AB = 20\sqrt{3}$ cm, $AC = 20$ cm, and angle $ABC = 30°$. Find the two possible **exact** values of the area of the triangle ABC. [6]

Sine rule in triangle ABC (C opposite AB):

$\frac{\sin C}{20\sqrt{3}} = \frac{\sin 30°}{20}$

$\sin C = \frac{20\sqrt{3} \times \sin 30°}{20} = \frac{\sqrt{3}}{2}$

$C = 60°$ or $C = 180° - 60° = 120°$

$C = 60°$: $A = 180° - 30° - 60° = 90°$

$C = 120°$: $A = 180° - 30° - 120° = 30°$

Area $= \frac{1}{2} \times AB \times AC \times \sin A$

$A = 90°$: Area $= \frac{1}{2} \times 20\sqrt{3} \times 20 \times \sin 90° = 200\sqrt{3}$ cm^2

$A = 30°$: Area $= \frac{1}{2} \times 20\sqrt{3} \times 20 \times \sin 30° = 100\sqrt{3}$ cm^2

Possible areas: $200\sqrt{3}$ cm^2 and $100\sqrt{3}$ cm^2

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8. A circle *C* has centre *A* and equation $x^2 + y^2 + 2x - 4y = 4$.

(a) Find the coordinates of *A* and the radius of *C*. [3]

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

$(x + 1)^2 - 1 + (y - 2)^2 - 4 = 4$

$(x + 1)^2 + (y - 2)^2 = 9 = 3^2$

Centre $A(-1, 2)$, radius = 3

(b) (i) A straight line *L*, with equation $y = 2x + 1$, intersects the circle *C* at the points *P* and *Q*. Determine the coordinates of *P* and *Q*. [4]

(ii) Find the gradient of the tangent at each of the points *P* and *Q*. [3]

(i) $x^2 + (2x + 1)^2 + 2x - 4(2x + 1) = 4$

$x^2 + 4x^2 + 4x + 1 + 2x - 8x - 4 = 4$

$5x^2 - 2x - 7 = 0$

$(5x - 7)(x + 1) = 0$

$x = -1$ or $x = \frac{7}{5} = 1.4$

$x = -1$: $y = 2(-1) + 1 = -1$

$x = 1.4$: $y = 2(1.4) + 1 = 3.8$

$P(-1, -1)$ and $Q(1.4, 3.8)$

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(ii) The tangent is perpendicular to the radius at each point.

At P(−1, −1): A(−1, 2) and P have the same x-coordinate,

so AP is vertical and the tangent at P is horizontal.

Gradient of tangent at P = 0

At Q(1.4, 3.8): gradient of AQ = $\frac{3.8 - 2}{1.4 - (-1)} = \frac{1.8}{2.4} = \frac{3}{4}$

Gradient of tangent at Q = $-1 \div \frac{3}{4} = -\frac{4}{3}$

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9. Given that $y = 2x^2 + x$, find $\frac{dy}{dx}$ from first principles. [5]

$y = f(x) = 2x^2 + x$

$f(x + h) = 2(x + h)^2 + (x + h) = 2x^2 + 4xh + 2h^2 + x + h$

$f(x + h) - f(x) = 2x^2 + 4xh + 2h^2 + x + h - (2x^2 + x)$

$= 4xh + 2h^2 + h$

$\frac{f(x + h) - f(x)}{h} = 4x + 2h + 1$

$\frac{dy}{dx} = \lim_{h \to 0} \frac{f(x + h) - f(x)}{h} = \lim_{h \to 0} (4x + 2h + 1)$

$\frac{dy}{dx} = 4x + 1$

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10. Solve the following equation for values of θ between 0° and 360°. [6]

$$15\sin^2\theta + 2\cos\theta = 14$$

$15(1 - \cos^2\theta) + 2\cos\theta = 14$

$15 - 15\cos^2\theta + 2\cos\theta = 14$

$15\cos^2\theta - 2\cos\theta - 1 = 0$

$(3\cos\theta - 1)(5\cos\theta + 1) = 0$

$\cos\theta = \frac{1}{3}$ or $\cos\theta = -\frac{1}{5}$

$\cos\theta = \frac{1}{3}$: $\theta = 70.528...° = 70.53°$

$\theta = 360° - 70.53° = 289.47°$

$\cos\theta = -\frac{1}{5}$: $\theta = 101.536...° = 101.54°$

$\theta = 360° - 101.54° = 258.46°$

$\therefore\ \theta = 70.53°,\ 101.54°,\ 258.46°,\ 289.47°$

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11. The function f is defined by $f(x) = x^3 - 9x^2 + 28x + 4$.

(a) Show that $f(x)$ is an increasing function. [4]

$f(x) = 3x^2 - 18x + 28$

$= 3(x^2 - 6x) + 28$

$= 3[(x - 3)^2 - 9] + 28$

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

Since $(x - 3)^2 \geq 0$ for all x, $f(x) \geq 1 > 0$ for all x.

$\therefore$ $f(x) > 0$ for all values of x, so $f(x)$ is an increasing function.

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(b) Two straight lines, both with gradient 4, are tangents to the curve $y = f(x)$.
Find the equation of each of these tangents. [5]

Gradient of tangent: $f'(x) = 4$

$3x^2 - 18x + 28 = 4$

$3x^2 - 18x + 24 = 0$

$x^2 - 6x + 8 = 0$

$(x - 2)(x - 4) = 0 \Rightarrow x = 2$ or $x = 4$

$f(2) = 2^3 - 9(2^2) + 28(2) + 4 = 32$

$f(4) = 4^3 - 9(4^2) + 28(4) + 4 = 36$

Tangent at $(2, 32)$: $y - 32 = 4(x - 2) \Rightarrow y = 4x + 24$

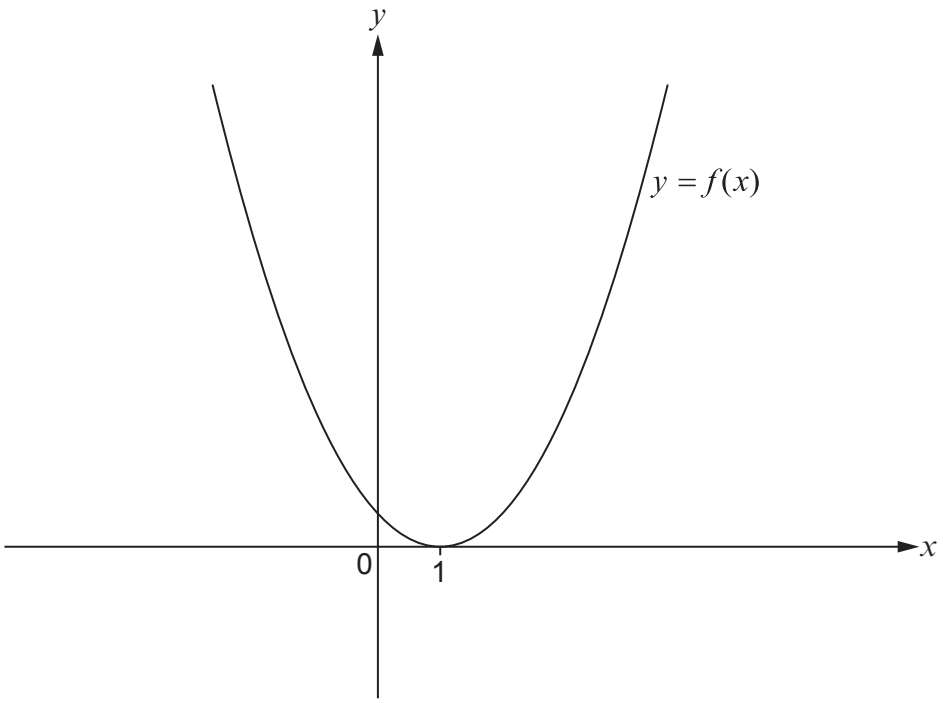
Tangent at $(4, 36)$: $y - 36 = 4(x - 4) \Rightarrow y = 4x + 20$

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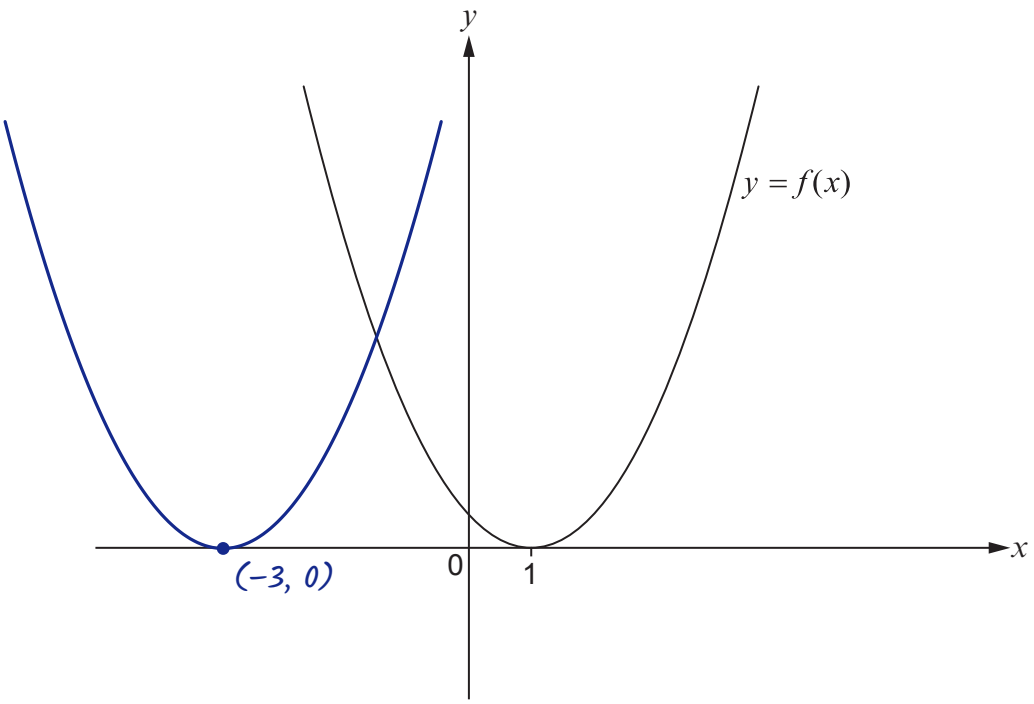
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12. The diagram below shows the graph of $y = f(x)$.



Draw a sketch of each of the following transformations on the diagrams provided. Clearly label the coordinates of the stationary point in each case.

(a) $y = f(x+4)$ [2]

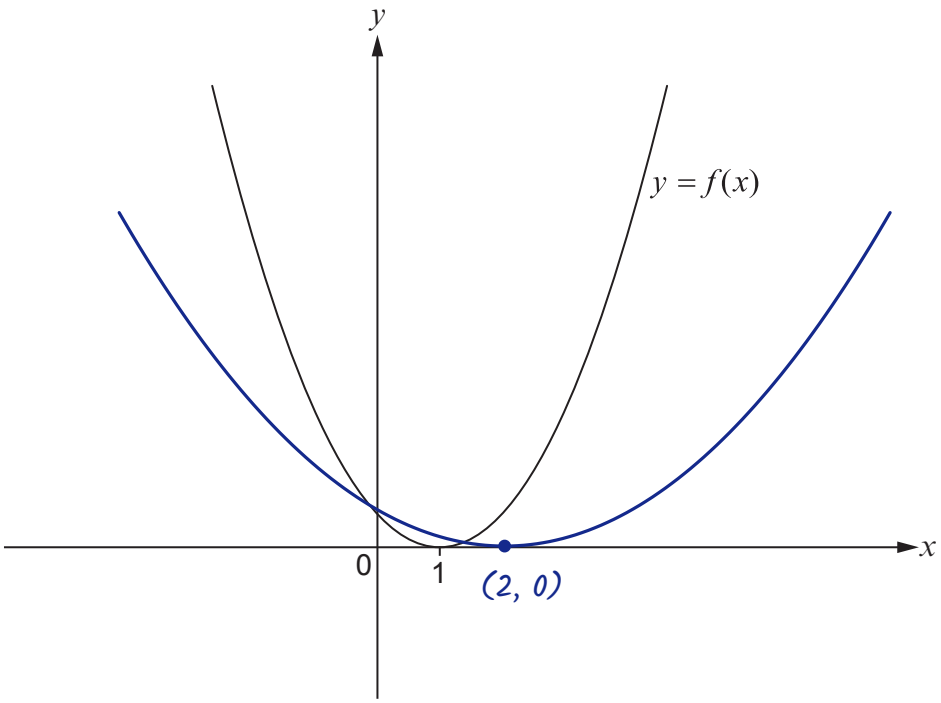


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(b) $y = f\left(\frac{1}{2}x\right)$ [2]



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13. Given that $3\sin^2 x - \cos^2 x = 2$, prove that $\sin^2 x = 3\cos^2 x$.

Hence, or otherwise, find the possible values of $\tan x$. [4]

$3\sin^2x - \cos^2x = 2$

$3\sin^2x - \cos^2x = 2(\sin^2x + \cos^2x)$ (using $\sin^2x + \cos^2x = 1$)

$3\sin^2x - \cos^2x = 2\sin^2x + 2\cos^2x$

$\therefore \sin^2x = 3\cos^2x$ as required

Dividing by $\cos^2x$:

$\frac{\sin^2x}{\cos^2x} = 3 \Rightarrow \tan^2x = 3$

$\tan x = \sqrt{3}$ or $\tan x = -\sqrt{3}$ ($\tan x = \pm 1.732\ldots$)

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14. The position vectors of the points *A* and *C*, relative to a fixed origin *O*, are given by $\mathbf{a} = (3\mathbf{i} + 4\mathbf{j})$ and $\mathbf{c} = (-5\mathbf{i} + 12\mathbf{j})$ respectively. The point *B* is such that *OABC* is a parallelogram. Find the position vector of *B* and hence calculate the length of *OB*. [4]

OABC is a parallelogram, so $OB = OA + AB = OA + OC$

$b = a + c$

$b = (3i + 4j) + (-5i + 12j)$

$b = -2i + 16j$

$OB = |b| = \sqrt{((-2)^2 + 16^2)} = \sqrt{(4 + 256)}$

$OB = \sqrt{260} = 2\sqrt{65} = 16.124\ldots = 16.1$ (3 s.f.)

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15. (a) Showing all your working, solve the following equation.

$$\log_3 36 - 2\log_3 18 + \log_3 180 + \log_3 x = 2$$ [5]

$\log_3 36 - \log_3 18^2 + \log_3 180 + \log_3 x = 2$

$\log_3 36 - \log_3 324 + \log_3 180 + \log_3 x = 2$

$\log_3 \left(\frac{36 \times 180 \times x}{324} \right) = 2$

$\log_3 \left(\frac{6480x}{324} \right) = 2$

$\log_3 (20x) = 2$

$20x = 3^2 = 9$

$x = \frac{9}{20} = 0.45$

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(b) Showing all your working, solve the following equation.

$$2 \times 4^x + 5 \times 2^x - 3 = 0$$ [6]

$2 \times 4^x + 5 \times 2^x - 3 = 0$

$4^x = (2^2)^x = (2^x)^2$

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

Let $y = 2^x$: $2y^2 + 5y - 3 = 0$

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

$2^x = \frac{1}{2}$ or $2^x = -3$

$2^x = \frac{1}{2} = 2^{-1} \Rightarrow x = -1$

$2^x = -3$ has no solution, since $2^x > 0$ for all x.

$\therefore x = -1$

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16. The binomial expansion of $\left(2-x^2\right)^7$ is given by

$$\left(2-x^2\right)^7 = a_0 + a_1x^2 + a_2x^4 + a_3x^6 + a_4x^8 + a_5x^{10} + a_6x^{12} + a_7x^{14}.$$

(a) Find the numerical values of a_0, a_2 and a_7. [4]

General term: ${}^7C_r\,(2)^{7-r}(-x^2)^r$

$a_0 = {}^7C_0\,(2)^7(-1)^0 = 128$

a_2 is the coefficient of x^4, so $r = 2$:

$a_2 = {}^7C_2\,(2)^5(-1)^2 = 21 \times 32 = 672$

$a_7 = {}^7C_7\,(2)^0(-1)^7 = -1$

$a_0 = 128, \quad a_2 = 672, \quad a_7 = -1$

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(b) Using a suitable numerical value for x, show that

$$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 = -126.$$ [3]

Let $x = 1$:

$(2 - 1^2)^7 = a_0 + a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7$

$1 = 128 + (a_1 + a_2 + a_3 + a_4 + a_5 + a_6) + (-1)$

$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 = 1 - 128 + 1$

$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 = -126$ as required

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