

Mathematics

Paper 4

Algebra & Graphs

QUESTIONS

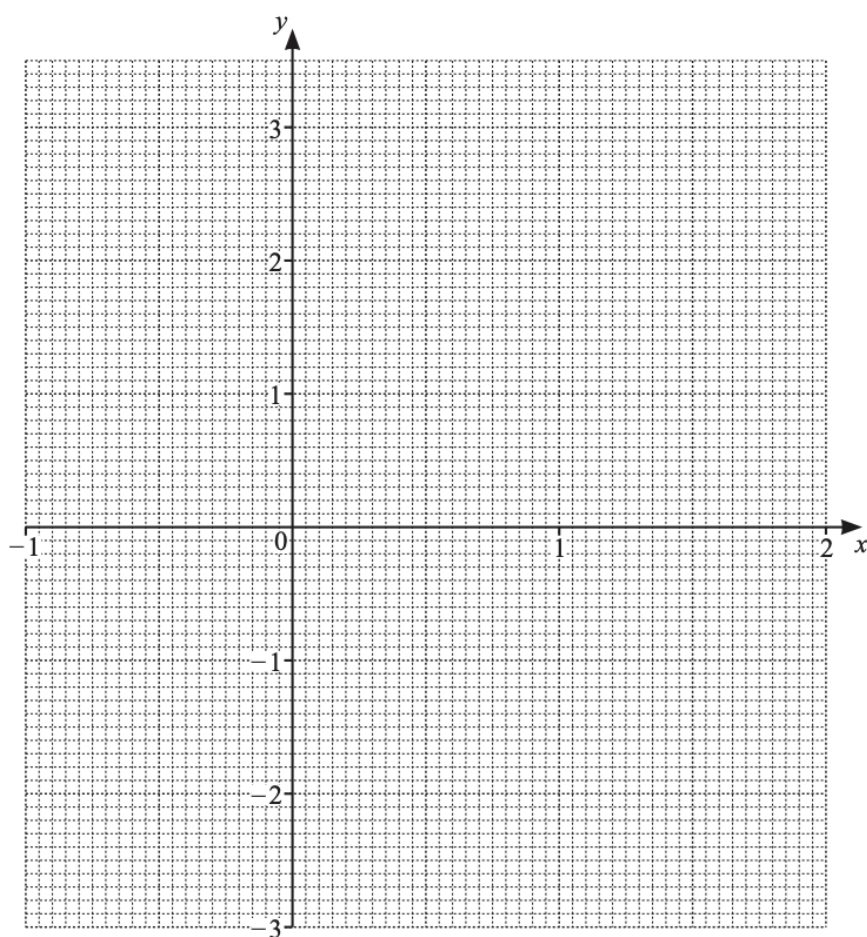
- 2 (a) The table shows some values for $y = 2x^3 - 4x^2 + 3$.

x	-1	-0.5	0	0.5	1	1.5	2
y	-3	1.75				0.75	3

(i) Complete the table.

[3]

(ii) On the grid, draw the graph of $y = 2x^3 - 4x^2 + 3$ for $-1 \leq x \leq 2$.



[4]

(iii) Use your graph to solve the equation $2x^3 - 4x^2 + 3 = 1.5$.

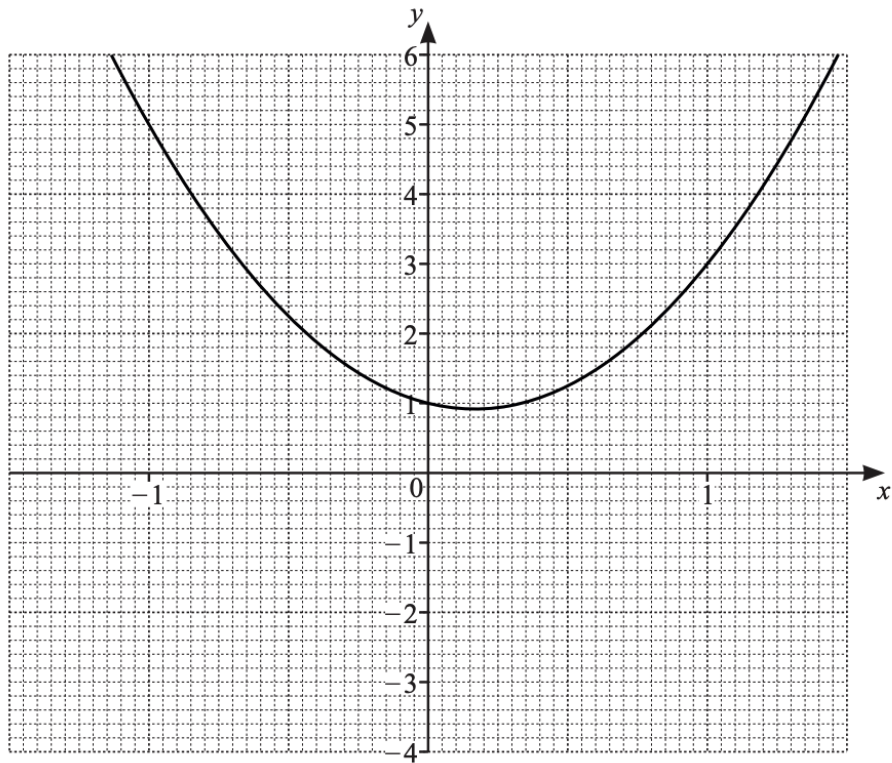
$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

(iv) The equation $2x^3 - 4x^2 + 3 = k$ has only one solution for $-1 \leq x \leq 2$.

Write down a possible integer value of k .

$\dots\dots\dots$ [1]

(b)



(i) On the grid, draw the tangent to the curve at $x = 1$. [1]

(ii) Use your tangent to estimate the gradient of the curve at $x = 1$.

..... [2]

(iii) Write down the equation of your tangent in the form $y = mx + c$.

$y =$ [2]

- 5 (a) Write as a single fraction in its simplest form.

$$\frac{x+3}{x-3} - \frac{x-2}{x+2}$$

..... [4]

(b) $2^{12} \div 2^{\frac{k}{2}} = 32$

Find the value of k .

$k =$ [2]

(c) Expand and simplify.

$$(y+3)(y-4)(2y-1)$$

..... [3]

(d) Make x the subject of the formula.

$$x = \frac{3+x}{y}$$

$x =$ [3]

- 7 (a) Naga has n marbles.
Panav has three times as many marbles as Naga.
Naga loses 5 marbles and Panav buys 10 marbles.
Together they now have more than 105 marbles.

Write down and solve an inequality in n .

..... [3]

- (b) y is inversely proportional to x^2 .
When $x = 4$, $y = 7.5$.

Find y when $x = 5$.

$y =$ [3]

10

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

$$g(x) = x^2$$

$$h(x) = 3^{-x}$$

(a) Find in its simplest form

(i) $f(x-3)$,

..... [1]

(ii) $g(5x)$.

..... [1]

(b) Find $f^{-1}(x)$.

$$f^{-1}(x) = \text{.....} [2]$$

(c) Find the value of $hh(l)$, correct to 4 significant figures.

..... [3]

(d) (i) Show that $g(3x-2) - h(-3)$ can be written as $9x^2 - 12x - 23$.

[2]

(ii) Use the quadratic formula to solve $9x^2 - 12x - 23 = 0$.
Give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

(e) Find x when $f(61) = h(x)$.

$x = \dots\dots\dots$ [2]

11 A curve has equation $y = x^3 - 3x + 4$.

(a) Work out the coordinates of the two stationary points.

(..... ,)

(..... ,) [5]

(b) Determine whether each stationary point is a maximum or a minimum.
Give reasons for your answers.

[3]

3 (a) $s = ut + \frac{1}{2}at^2$

Find the value of s when $u = 5.2$, $t = 7$ and $a = 1.6$.

$s = \dots\dots\dots$ [2]

(b) Simplify.

(i) $3a - 5b - a + 2b$

$\dots\dots\dots$ [2]

(ii) $\frac{5}{3x} \times \frac{9x}{20}$

$\dots\dots\dots$ [2]

(c) Solve.

(i) $\frac{15}{x} = -3$

$x = \dots\dots\dots$ [1]

(ii) $4(5 - 3x) = 23$

$x = \dots\dots\dots$ [3]

(d) Simplify.

$$(27x^9)^{\frac{2}{3}}$$

..... [2]

(e) Expand and simplify.

$$(3x - 5y)(2x + y)$$

..... [2]

- 6 Raheem makes baskets and mats.
Each week he makes x baskets and y mats.

He makes fewer than 10 mats.

The number of mats he makes is greater than or equal to the number of baskets he makes.

- (a) One of the inequalities that shows this information is $y < 10$.

Write down the other inequality.

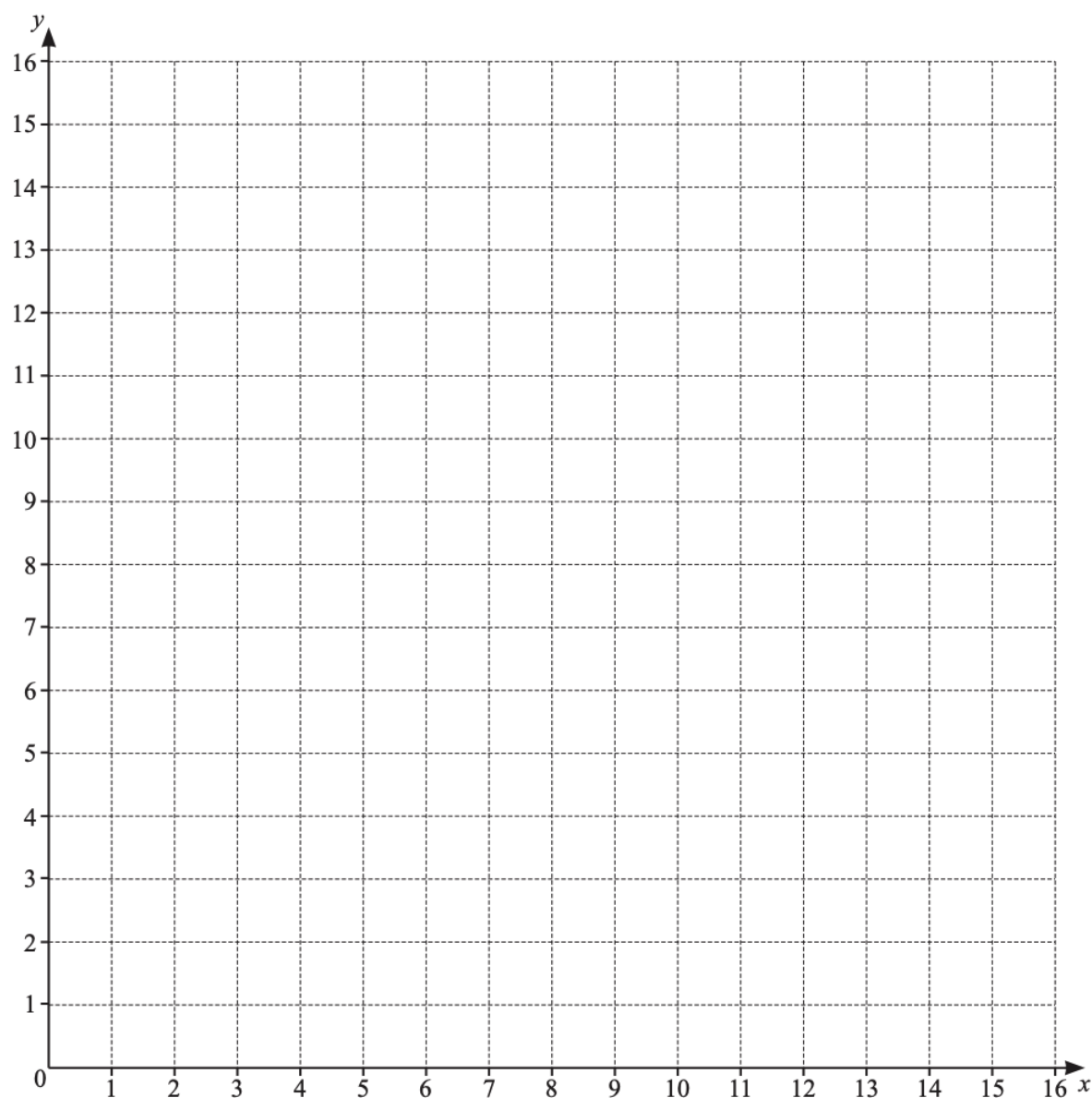
..... [1]

- (b) He takes $2\frac{1}{4}$ hours to make a basket and $1\frac{1}{2}$ hours to make a mat.
Each week he works for a maximum of 22.5 hours.

Show that $3x + 2y \leq 30$.

[2]

(c) On the grid, draw three straight lines and shade the **unwanted** regions to show these inequalities.



[5]

(d) He makes \$40 profit on each basket he sells and \$28 profit on each mat he sells.

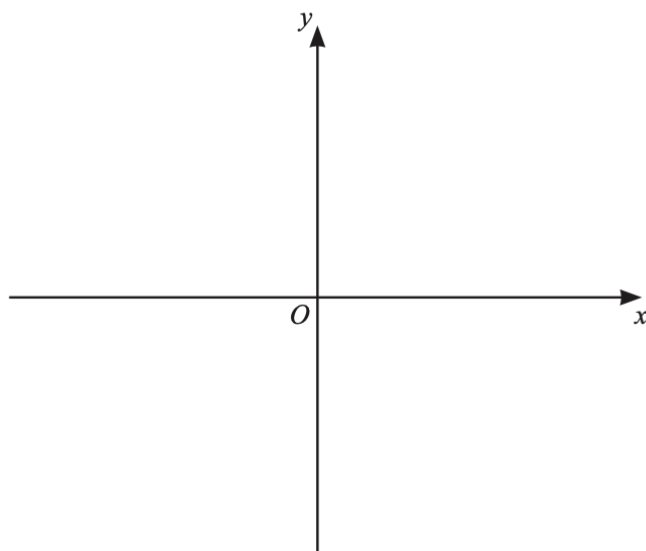
Calculate the maximum profit he can make each week.

\$ [2]

(c) (i) Write $x^2 + 10x + 14$ in the form $(x + a)^2 + b$.

..... [2]

(ii) On the axes, sketch the graph of $y = x^2 + 10x + 14$, indicating the coordinates of the turning point.



[3]

10 (a) A rhombus $ABCD$ has a diagonal AC where A is the point $(-3, 10)$ and C is the point $(4, -4)$.

(i) Calculate the length AC .

..... [3]

(ii) Show that the equation of the line AC is $y = -2x + 4$.

[2]

(iii) Find the equation of the line BD .

..... [4]

(b) A curve has the equation $y = x^3 + 8x^2 + 5x$.

(i) Work out the coordinates of the two turning points.

(..... ,) and (..... ,) [6]

(ii) Determine whether each of the turning points is a maximum or a minimum.
Give reasons for your answers.

[3]

6 $f(x) = 3x + 2$ $g(x) = x^2 + 1$ $h(x) = 4^x$

(a) Find $h(4)$.

..... [1]

(b) Find $fg(1)$.

..... [2]

(c) Find $gf(x)$ in the form $ax^2 + bx + c$.

..... [3]

(d) Find x when $f(x) = g(7)$.

$x =$ [2]

(e) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(f) Find $\frac{g(x)}{f(x)} + x$.

Give your answer as a single fraction, in terms of x , in its simplest form.

..... [3]

(g) Find x when $h^{-1}(x) = 2$.

$x =$ [1]

- 9 (a) (i) Write $x^2 + 8x - 9$ in the form $(x + k)^2 + h$.

..... [2]

- (ii) Use your answer to **part (a)(i)** to solve the equation $x^2 + 8x - 9 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

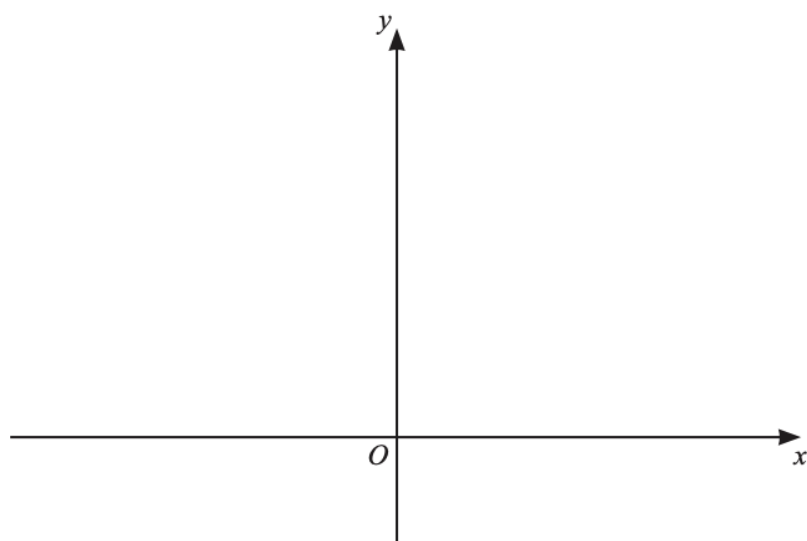
- (b) The solutions of the equation $x^2 + bx + c = 0$ are $\frac{-7 + \sqrt{61}}{2}$ and $\frac{-7 - \sqrt{61}}{2}$.

Find the value of b and the value of c .

$b = \dots\dots\dots$

$c = \dots\dots\dots$ [3]

(c) (i)



On the diagram,

(a) sketch the graph of $y = (x-1)^2$, [2]

(b) sketch the graph of $y = \frac{1}{2}x + 1$. [2]

(ii) The graphs of $y = (x-1)^2$ and $y = \frac{1}{2}x + 1$ intersect at A and B .

Find the length of AB .

$AB = \dots\dots\dots$ [7]

10 (a) $y = x^4 - 4x^3$

(i) Find the value of y when $x = -1$.

$y = \dots\dots\dots$ [2]

(ii) Find the two stationary points on the graph of $y = x^4 - 4x^3$.

$(\dots\dots\dots, \dots\dots\dots)$

$(\dots\dots\dots, \dots\dots\dots)$ [6]

(b) $y = x^p + 2x^q$

$\frac{dy}{dx} = 11x^{10} + 10x^4$, where $\frac{dy}{dx}$ is the derived function.

Find the value of p and the value of q .

$p = \dots\dots\dots$

$q = \dots\dots\dots$ [2]

- 4 (a) Solve the inequality.

$$3m + 12 \leq 8m - 5$$

..... [2]

- (b) Solve the equation.

$$\frac{2x+5}{3-x} = \frac{14}{15}$$

$x =$ [3]

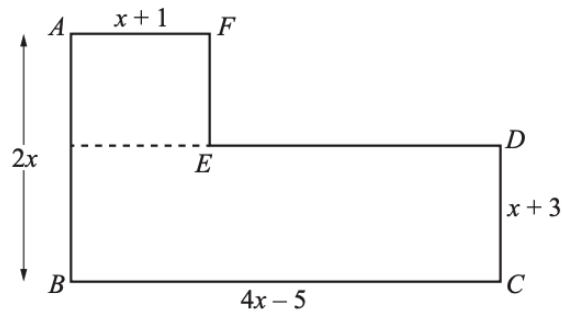
- (c) Solve the simultaneous equations.
You must show all your working.

$$\begin{aligned}y &= 4 - x \\ x^2 + 2y^2 &= 67\end{aligned}$$

$$x = \dots\dots\dots, y = \dots\dots\dots$$

$$x = \dots\dots\dots, y = \dots\dots\dots [6]$$

- 5 All the lengths in this question are in centimetres.



NOT TO
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The diagram shows a shape $ABCDEF$ made from two rectangles.
The total area of the shape is 342 cm^2 .

- (a) Show that $x^2 + x - 72 = 0$.

[5]

- (b) Solve by factorisation.

$$x^2 + x - 72 = 0$$

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots [3]$$

9 (a) The equation of line L is $3x - 8y + 20 = 0$.

(i) Find the gradient of line L .

..... [2]

(ii) Find the coordinates of the point where line L cuts the y -axis.

(..... ,) [1]

(b) The coordinates of P are $(-3, 8)$ and the coordinates of Q are $(9, -2)$.

(i) Calculate the length PQ .

..... [3]

(ii) Find the equation of the line parallel to PQ that passes through the point $(6, -1)$.

..... [3]

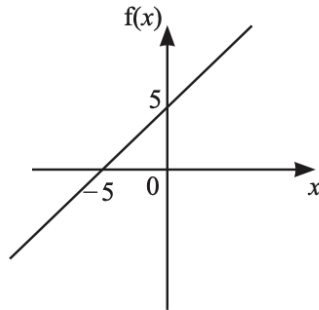
(iii) Find the equation of the perpendicular bisector of PQ .

..... [4]

10 (a) The diagrams show the graphs of two functions.

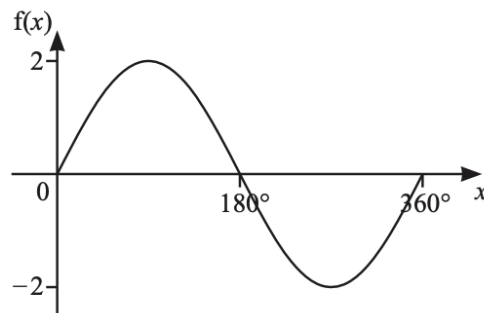
Write down each function.

(i)



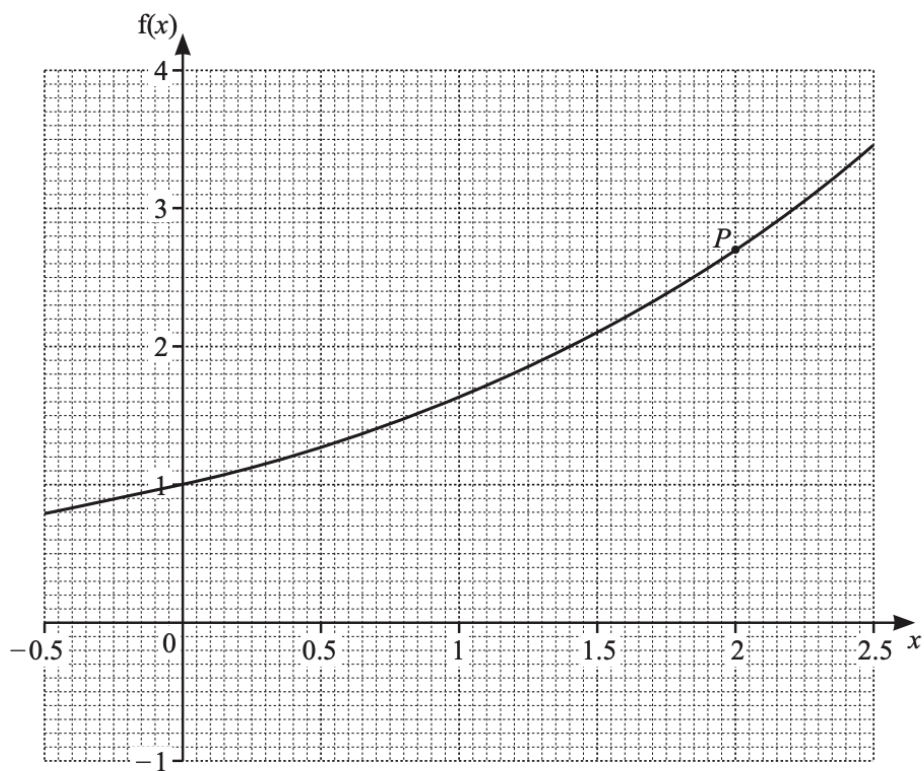
$f(x) = \dots\dots\dots$ [2]

(ii)



$f(x) = \dots\dots\dots$ [2]

(b)



The diagram shows the graph of another function.

By drawing a suitable tangent, find an estimate for the gradient of the function at the point P .

..... [3]

11 $f(x) = 7x - 4$ $g(x) = \frac{2x}{x-3}, x \neq 3$ $h(x) = x^2$

(a) Find $g(6)$.

..... [1]

(b) Find $fg(4)$.

..... [2]

(c) Find $fh(x)$.

..... [1]

(d) Find $\frac{f(x)}{2} + g(x)$.

Give your answer as a single fraction, in terms of x , in its simplest form.

..... [3]

(e) Find the value of x when $f(x+2) = -11$.

$x = \dots\dots\dots$ [2]

(f) Find the values of p that satisfy $h(p) = p$.

$\dots\dots\dots$ [2]

12 (a) A curve has equation $y = 4x^3 - 3x + 3$.

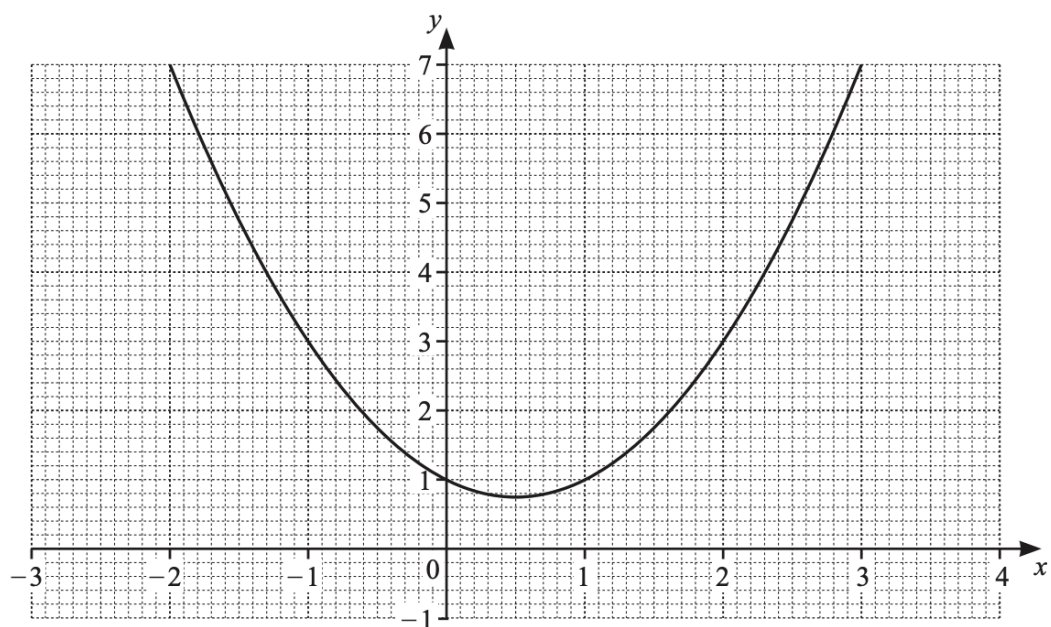
(i) Find the coordinates of the two stationary points.

(..... ,) and (..... ,) [5]

(ii) Determine whether each of the stationary points is a maximum or a minimum.
Give reasons for your answers.

[3]

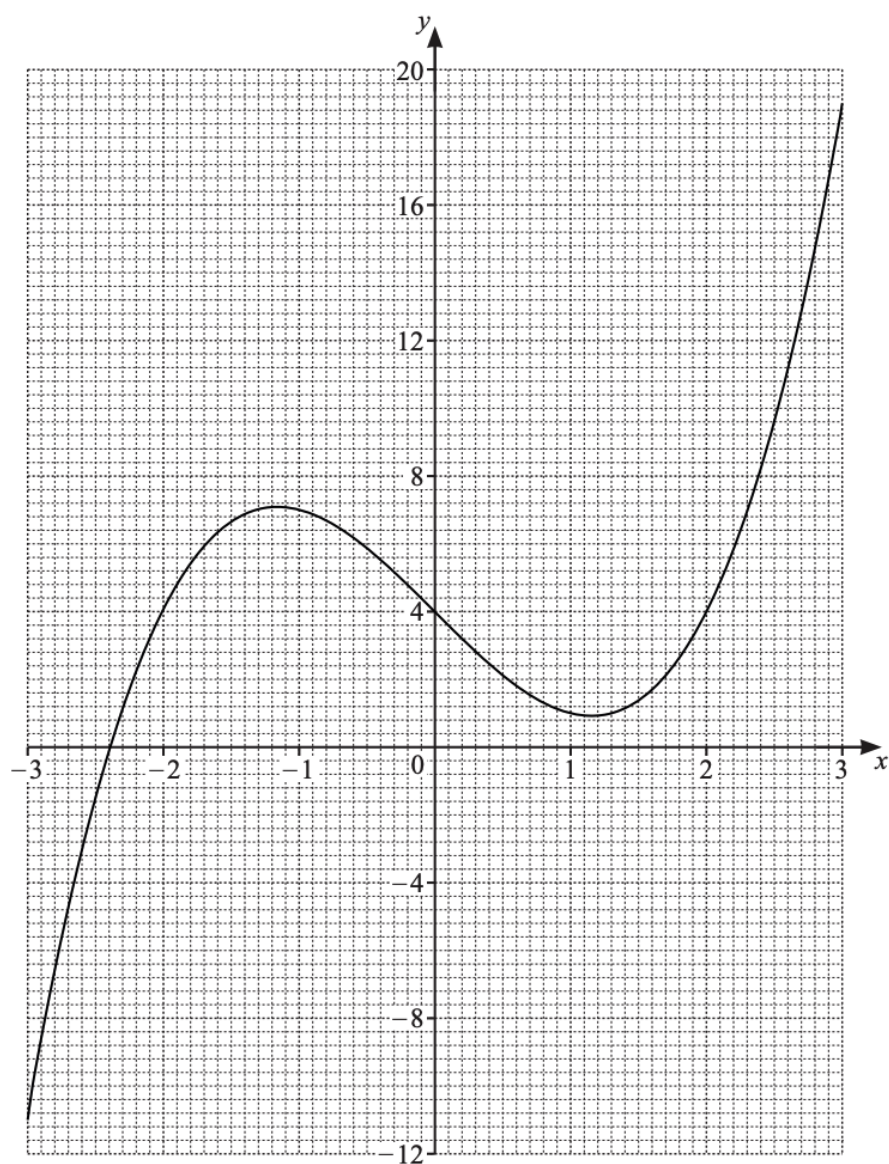
(b) The graph of $y = x^2 - x + 1$ is shown on the grid.



By drawing a suitable line on the grid, solve the equation $x^2 - 2x - 2 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

- 5 (a) The diagram shows the graph of $y = f(x)$ for $-3 \leq x \leq 3$.



- (i) Solve $f(x) = 14$.

$x = \dots\dots\dots$ [1]

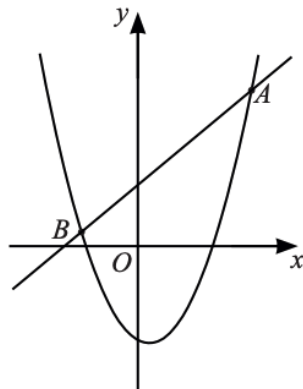
- (ii) By drawing a suitable tangent, find an estimate of the gradient of the graph at the point $(-2, 4)$.

$\dots\dots\dots$ [3]

(iii) By drawing a suitable straight line on the grid, solve $f(x) = 2x - 2$ for $-3 \leq x \leq 3$.

$x = \dots\dots\dots$ [3]

(b)



NOT TO
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The diagram shows a curve with equation $y = 2x^2 - 2x - 7$.
The straight line with equation $y = 3x + 5$ intersects the curve at the points A and B .

Find the coordinates of the points A and B .

A (..... ,)

B (..... ,) [5]

- 8 (a) Factorise completely.

$$3a^2b - ab^2$$

..... [2]

- (b) Solve the inequality.

$$3x + 12 < 5x - 3$$

..... [2]

- (c) Simplify.

$$(3x^2y^4)^3$$

..... [2]

- (d) Solve.

$$\frac{2}{x} = \frac{6}{2-x}$$

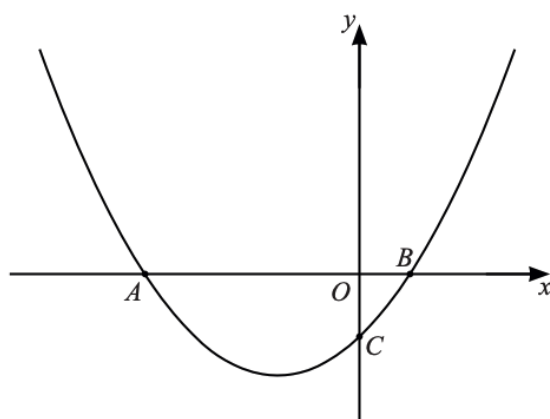
$x =$ [3]

- (e) Expand and simplify.

$$(x-2)(x+5)(2x-1)$$

..... [3]

10 (a)



NOT TO
SCALE

The diagram shows a sketch of the curve $y = x^2 + 3x - 4$.

(i) Find the coordinates of the points A , B and C .

A (.....,)

B (.....,)

C (.....,) [4]

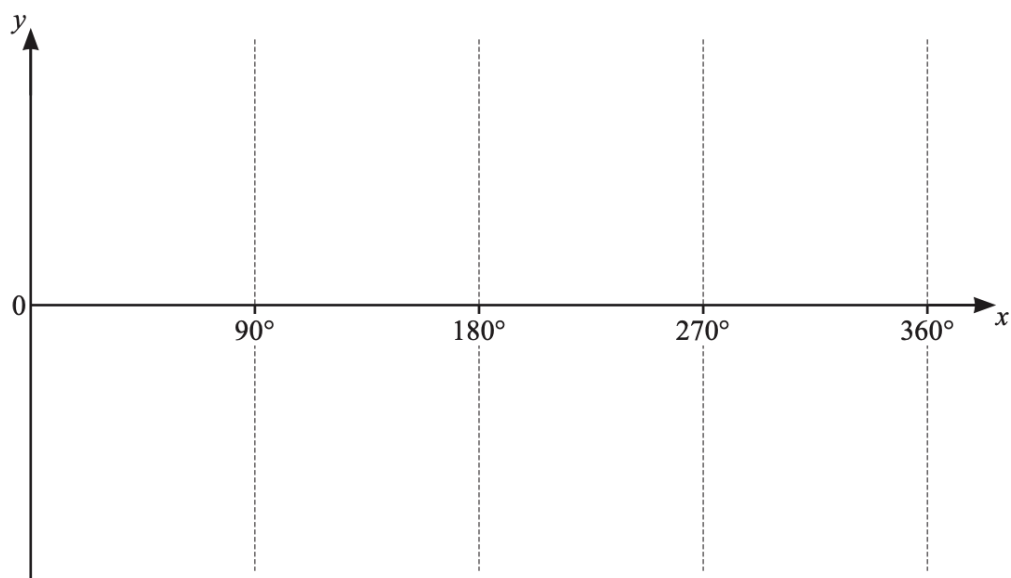
(ii) Differentiate $x^2 + 3x - 4$.

..... [2]

(iii) Find the equation of the tangent to the curve at the point $(2, 6)$.

..... [3]

(b)



(i) On the diagram, sketch the graph of $y = \tan x$ for $0^\circ \leq x \leq 360^\circ$. [2]

(ii) Solve the equation $5 \tan x = -7$ for $0^\circ \leq x \leq 360^\circ$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

- 5** Ahmed sells different types of cake in his shop.
The cost of each cake depends on its type and its size.

Every small cake costs $\$x$ and every large cake costs $\$(2x + 1)$.

- (a)** The total cost of 3 small lemon cakes and 2 large lemon cakes is \$12.36 .

Find the cost of a small lemon cake.

\$ [3]

- (b)** The cost of 18 small chocolate cakes is the same as the cost of 7 large chocolate cakes.

Find the cost of a small chocolate cake.

\$ [3]

- (c)** The number of small cherry cakes that can be bought for \$4 is the same as the number of large cherry cakes that can be bought for \$13.

Find the cost of a small cherry cake.

\$ [3]

- (d) Petra spends \$20 on small coffee cakes and \$10 on large coffee cakes.
The total number of cakes is 45.

Write an equation in terms of x .

Solve this equation to find the cost of a small coffee cake.

Show all your working.

\$ [7]

7 $y = x^2 + \frac{1}{x}, x \neq 0$

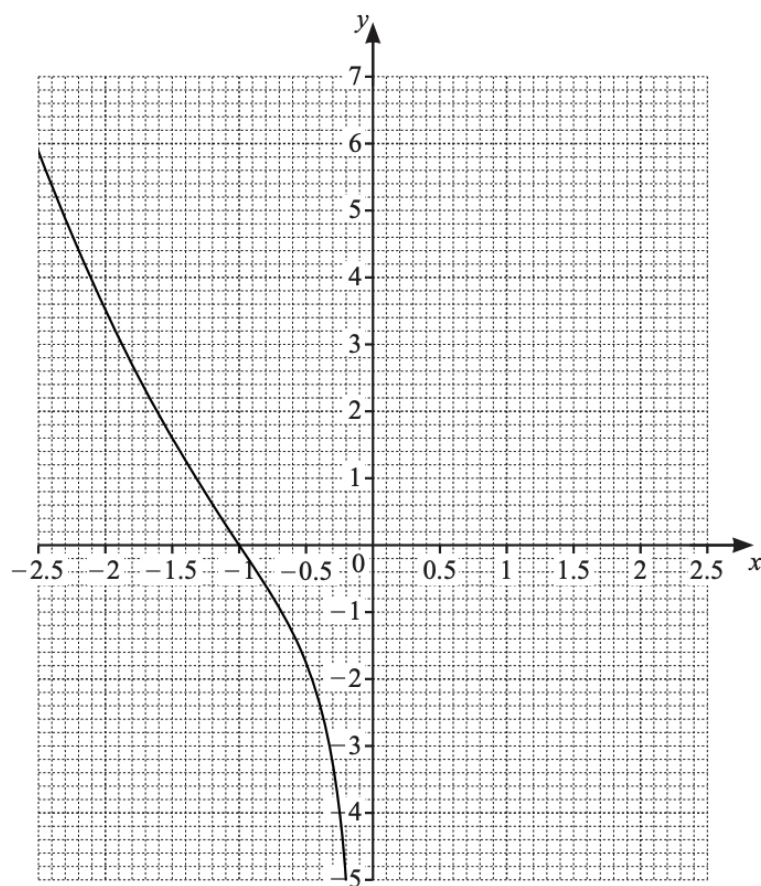
(a) Complete the table.

x	0.2	0.3	0.5	1	1.5	2	2.5
y	5.0	3.4	2.3		2.9		6.7

[2]

(b) On the grid, draw the graph of $y = x^2 + \frac{1}{x}$ for $0.2 \leq x \leq 2.5$.

The graph of $y = x^2 + \frac{1}{x}$ for $-2.5 \leq x \leq -0.2$ has been drawn for you.



[4]

(c) By drawing suitable straight lines on the grid, solve the following equations.

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

$x = \dots\dots\dots$ [1]

(ii) $x^2 + \frac{1}{x} + x - 1 = 0$

$x = \dots\dots\dots$ [2]

(d) k is an integer and the equation $x^2 + \frac{1}{x} = k$ has three solutions.

Write down a possible value of k .

$k = \dots\dots\dots$ [1]

10 $f(x) = x^2 + 1$ $g(x) = 1 - 2x$ $h(x) = \frac{1}{x}, x \neq 0$ $j(x) = 5^x$

(a) Find the value of

(i) $f(3)$,

..... [1]

(ii) $gf(3)$.

..... [1]

(b) Find $g^{-1}(x)$.

$g^{-1}(x) =$ [2]

(c) Find x when $h(x) = 2$.

$x =$ [1]

(d) Find $g(x)g(x) - gg(x)$, giving your answer in the form $ax^2 + bx + c$.

..... [4]

(e) Find $hh(x)$, giving your answer in its simplest form.

..... [1]

(f) Find $j(5)$.

..... [1]

(g) Find x when $j^{-1}(x) = 2$.

$x =$ [1]

(h) $j(x) = hg(-12)$

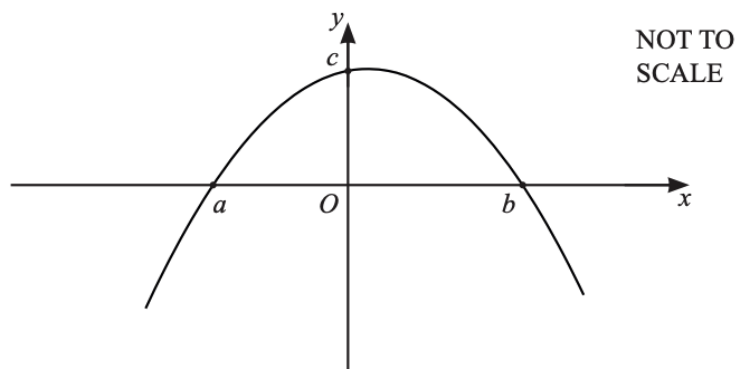
Find the value of x .

$x =$ [2]

- 7 (a) (i) Factorise $24 + 5x - x^2$.

..... [2]

- (ii) The diagram shows a sketch of $y = 24 + 5x - x^2$.



Work out the values of a , b and c .

$a =$

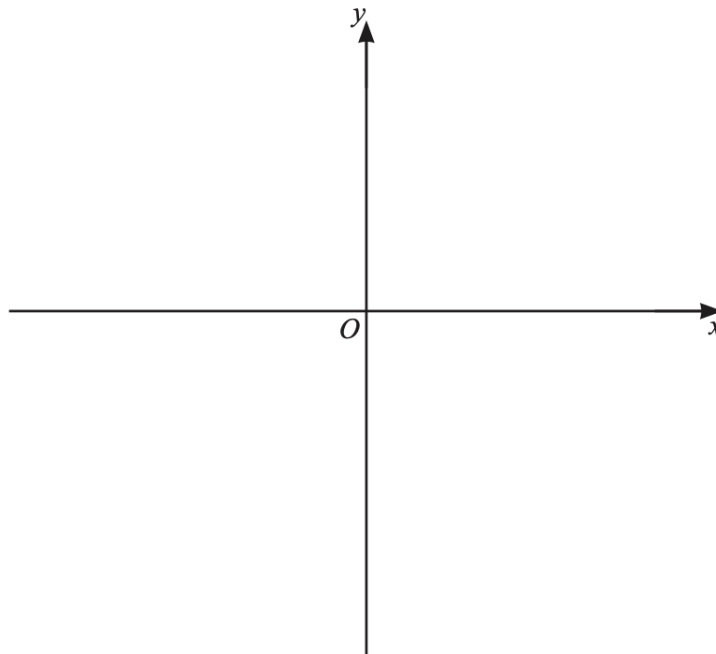
$b =$

$c =$ [3]

- (iii) Calculate the gradient of $y = 24 + 5x - x^2$ at $x = -1.5$.

..... [3]

- (b) (i) On the diagram, sketch the graph of $y = (x+1)(x-3)^2$.
Label the values where the graph meets the x -axis and the y -axis.



[4]

- (ii) Write $(x+1)(x-3)^2$ in the form $ax^3 + bx^2 + cx + d$.

..... [3]

- 9 (a) Find the integer values that satisfy the inequality $2 < 2x \leq 10$.

..... [2]

- (b) Factorise completely.

(i) $6y^2 - 15xy$

..... [2]

(ii) $y^2 - 9x^2$

..... [2]

- (c) Simplify.

$$\frac{3}{x-1} - \frac{2}{2x+1}$$

..... [3]

(d) The straight line $y = 3x + 2$ intersects the curve $y = 2x^2 + 7x - 11$ at two points.

Find the coordinates of these two points.

Give your answers correct to 2 decimal places.

(..... ,)

(..... ,) [6]

10 $f(x) = 4 - 3x$ $g(x) = x^2 + x$ $h(x) = 3^x$

(a) Find $fh(2)$.

..... [2]

(b) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(c) Simplify.

(i) $f(1 - 2x)$

..... [2]

(ii) $gf(x) - 9g(x)$

..... [4]

(d) $\frac{1}{h(x)} = 9^{kx}$

Find the value of k .

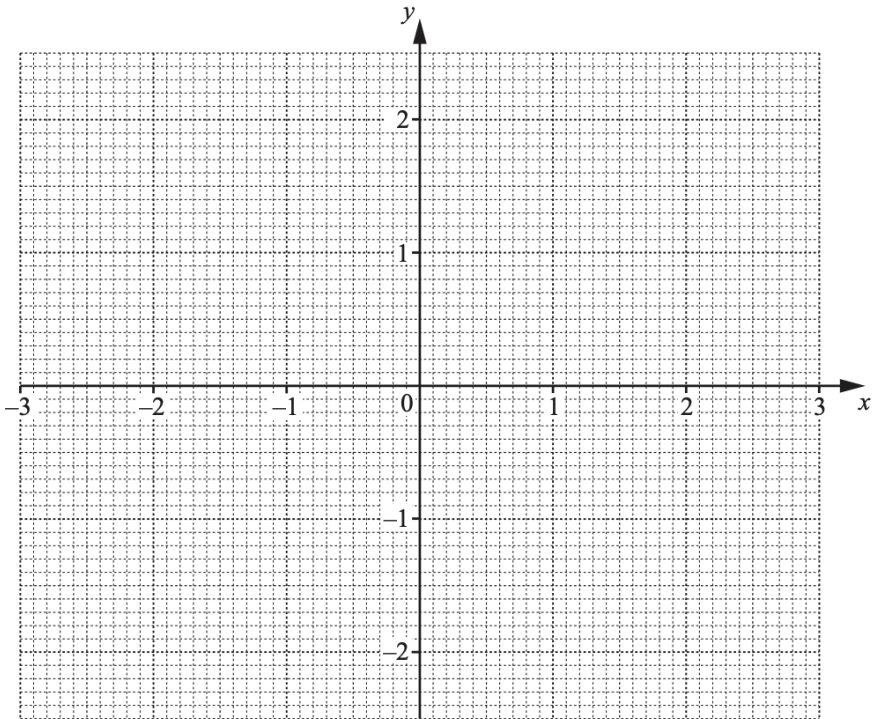
$k =$ [2]

5 The table shows some values for $y = \frac{3}{10}x^3 - 2x$ for $-3 \leq x \leq 3$.

x	-3	-2	-1.5	-1	0	1	1.5	2	3
y			2.0	1.7	0		-2.0	-1.6	

(a) Complete the table. [3]

(b) On the grid, draw the graph of $y = \frac{3}{10}x^3 - 2x$ for $-3 \leq x \leq 3$.



[4]

(c) On the grid opposite, draw a suitable straight line to solve the equation $\frac{3}{10}x^3 - 2x = \frac{1}{2}(1-x)$ for $-3 \leq x \leq 3$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

(d) For $-3 \leq x \leq 3$, the equation $\frac{3}{10}x^3 - 2x = 1$ has n solutions.

Write down the value of n .

$n = \dots\dots\dots$ [1]

8

$$f(x) = \frac{3}{x+2}, x \neq -2$$

$$g(x) = 8x - 5$$

$$h(x) = x^2 + 6$$

(a) Work out $g\left(\frac{1}{4}\right)$.

..... [1]

(b) Work out $ff(2)$.

..... [2]

(c) Find $gg(x)$, giving your answer in its simplest form.

..... [2]

(d) Find $g^{-1}(x)$.

$g^{-1}(x) =$ [2]

(e) Write $g(x) - f(x)$ as a single fraction in its simplest form.

..... [3]

- (f) (i) Show that $\lg(x) = 19$ simplifies to $16x^2 - 20x + 3 = 0$.

[3]

- (ii) Use the quadratic formula to solve $16x^2 - 20x + 3 = 0$.
Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- 10 (a)** Solve the simultaneous equations.
You must show all your working.

$$\begin{aligned}6x + 5y &= 27 \\ 5x - 3y &= 44\end{aligned}$$

$$x = \dots\dots\dots$$

$$y = \dots\dots\dots [4]$$

- (b)** y is inversely proportional to $(x + 3)^2$.
When $x = 2$, $y = 8$.

Find y when $x = 7$.

$$y = \dots\dots\dots [3]$$

- (c)** Solve the inequality.

$$3(x - 2) < 7(x + 2)$$

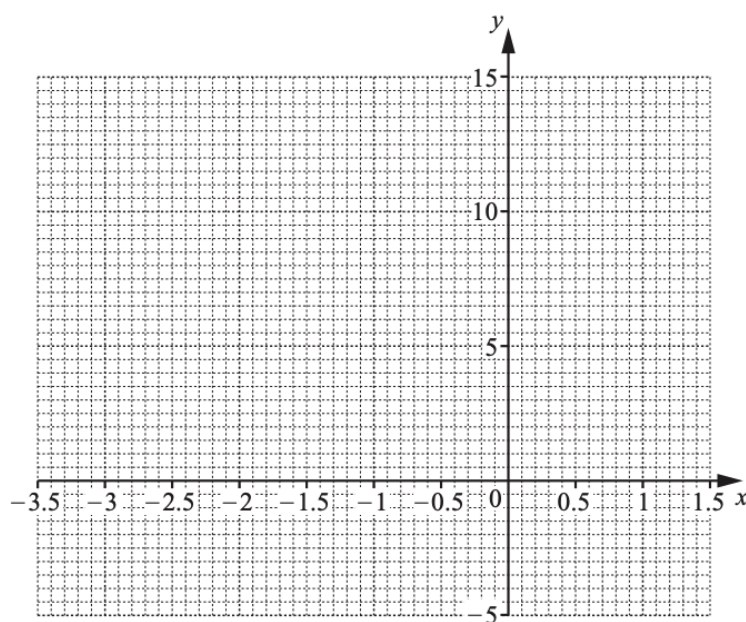
$$\dots\dots\dots [3]$$

- 2 The table shows some values for $y = x^3 + 3x^2 + 2$.

x	-3.5	-3	-2.5	-2	-1.5	-1	-0.5	0	0.5	1	1.5
y	-4.1		5.1	6	5.4	4	2.6		2.9		12.1

- (a) Complete the table. [3]

- (b) On the grid, draw the graph of $y = x^3 + 3x^2 + 2$ for $-3.5 \leq x \leq 1.5$.



[4]

- (c) Use your graph to solve the equation $x^3 + 3x^2 + 2 = 0$ for $-3.5 \leq x \leq 1.5$.

$x = \dots\dots\dots$ [1]

- (d) By drawing a suitable straight line, solve the equation $x^3 + 3x^2 + 2x + 2 = 0$ for $-3.5 \leq x \leq 1.5$.

$x = \dots\dots\dots$ [2]

- (e) For $-3.5 \leq x \leq 1.5$, the equation $x^3 + 3x^2 + 2 = k$ has three solutions and k is an integer.

Write down a possible value of k .

$k = \dots\dots\dots$ [1]

7 (a) $s = ut + \frac{1}{2}at^2$

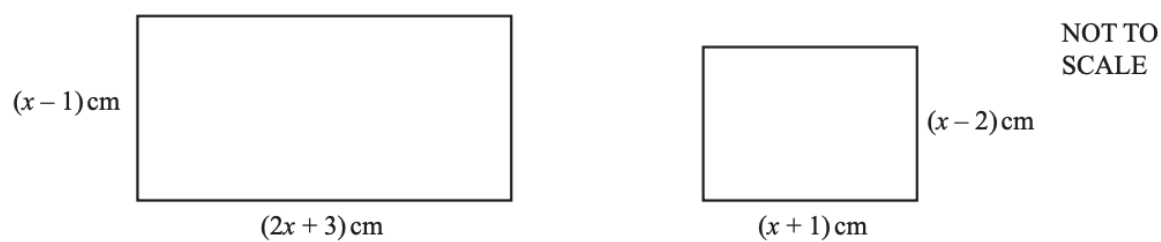
- (i) Find s when $t = 26.5$, $u = 104.3$ and $a = -2.2$.
Give your answer in standard form, correct to 4 significant figures.

$s = \dots\dots\dots$ [4]

- (ii) Rearrange the formula to write a in terms of u , t and s .

$a = \dots\dots\dots$ [3]

(b)



The difference between the areas of the two rectangles is 62 cm^2 .

(i) Show that $x^2 + 2x - 63 = 0$.

[3]

(ii) Factorise $x^2 + 2x - 63$.

..... [2]

(iii) Solve the equation $x^2 + 2x - 63 = 0$ to find the difference between the perimeters of the two rectangles.

..... cm [2]

9 $f(x) = 7x - 2$ $g(x) = x^2 + 1$ $h(x) = 3^x$

(a) Find $gh(2)$.

..... [2]

(b) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(c) $gg(x) = ax^4 + bx^2 + c$

Find the values of a , b and c .

$a =$

$b =$

$c =$ [3]

(d) Find x when $hf(x) = 81$.

$x =$ [3]

(iii) Solve by factorisation $10r^2 - 23r + 9 = 0$.

$r = \dots\dots\dots$ or $r = \dots\dots\dots$ [3]

- 4 (a) The equation of a straight line is $2y = 3x + 4$.

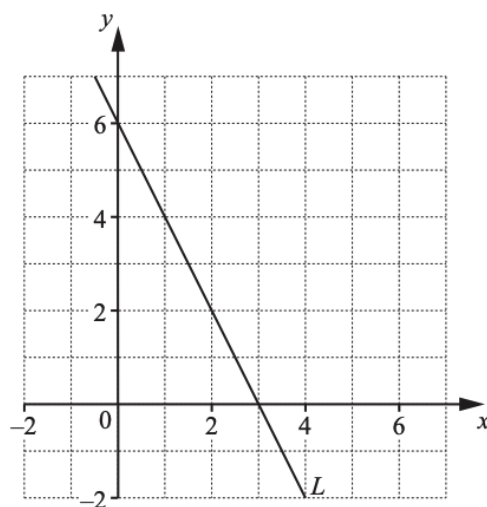
(i) Find the gradient of this line.

..... [1]

(ii) Find the co-ordinates of the point where the line crosses the y -axis.

(..... ,) [1]

- (b) The diagram shows a straight line L .



(i) Find the equation of line L .

..... [3]

(ii) Find the equation of the line perpendicular to line L that passes through $(9, 3)$.

..... [3]

(c) A is the point $(8, 5)$ and B is the point $(-4, 1)$.

(i) Calculate the length of AB .

..... [3]

(ii) Find the co-ordinates of the midpoint of AB .

(..... ,) [2]

- 5 The table shows some values of $y = \frac{1}{2x} - \frac{x}{4}$ for $0.15 \leq x \leq 3.5$.

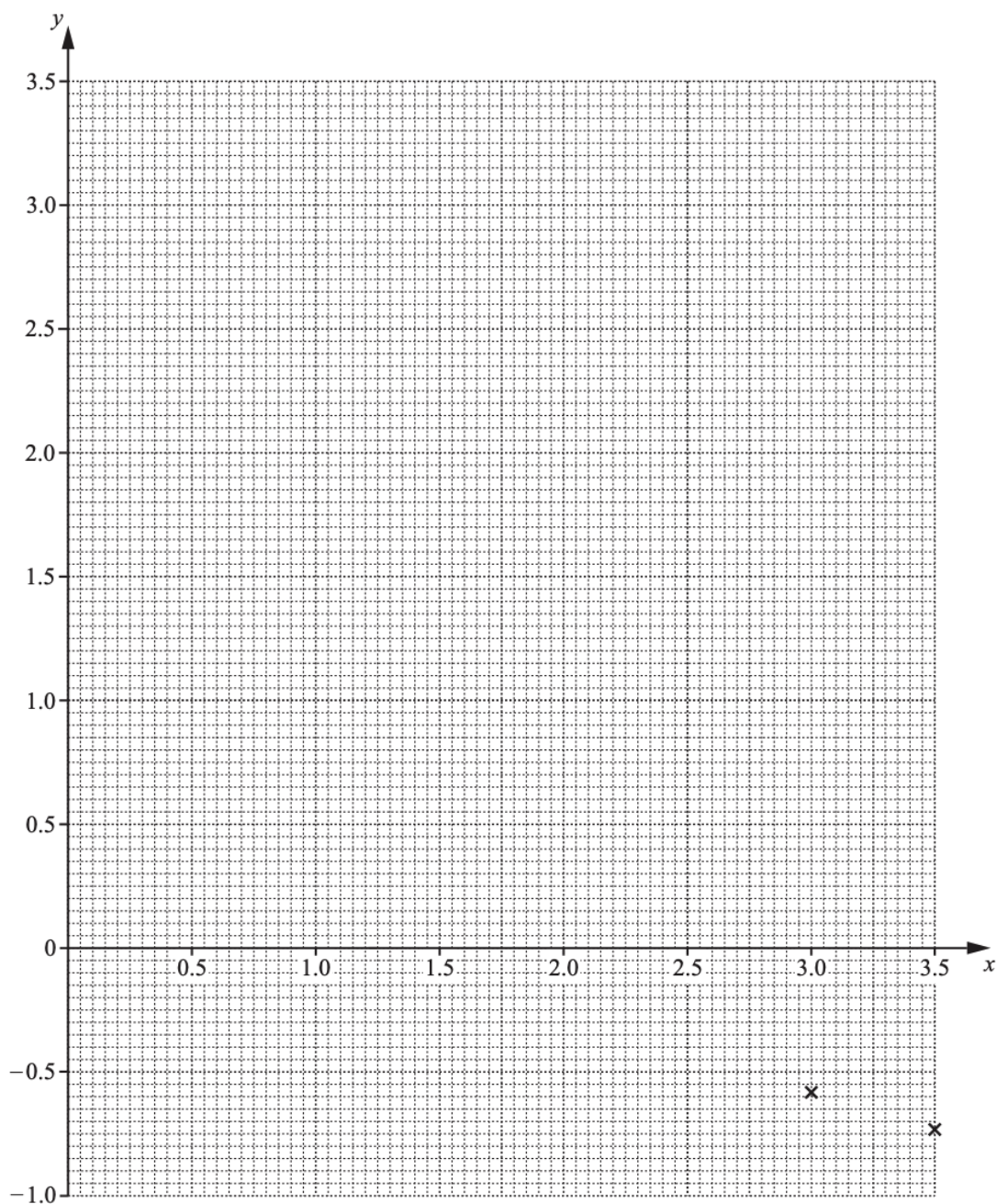
x	0.15	0.2	0.5	1	1.5	2	2.5	3	3.5
y	3.30		0.88		-0.04		-0.43	-0.58	-0.73

(a) Complete the table.

[3]

(b) On the grid, draw the graph of $y = \frac{1}{2x} - \frac{x}{4}$ for $0.15 \leq x \leq 3.5$.

The last two points have been plotted for you.



[4]

- (c) Use your graph to solve the equation $\frac{1}{2x} - \frac{x}{4} = \frac{1}{2}$ for $0.15 \leq x \leq 3.5$.

$x = \dots\dots\dots$ [1]

- (d) (i) On the grid, draw the line $y = 2 - x$. [2]

- (ii) Write down the x co-ordinates of the points where the line $y = 2 - x$ crosses the graph of

$$y = \frac{1}{2x} - \frac{x}{4} \text{ for } 0.15 \leq x \leq 3.5.$$

$x = \dots\dots\dots$ and $x = \dots\dots\dots$ [2]

- (e) Show that the graph of $y = \frac{1}{2x} - \frac{x}{4}$ can be used to find the value of $\sqrt{2}$ for $0.15 \leq x \leq 3.5$.

[2]

- 6 (a) Expand and simplify.
 $(x+7)(x-3)$

..... [2]

- (b) Factorise completely.

(i) $15p^2q^2 - 25q^3$

..... [2]

(ii) $4fg + 6gh + 10fk + 15hk$

..... [2]

(iii) $81k^2 - m^2$

..... [2]

- (c) Solve the equation.

$$3(x-4) + \frac{x+2}{5} = 6$$

$x =$ [4]

2 (a) Solve.

$$5x - 17 = 7x + 3$$

$$x = \dots\dots\dots [2]$$

(b) Find the integer values of n that satisfy this inequality.

$$-7 < 4n \leq 8$$

$$\dots\dots\dots [3]$$

(c) Simplify.

(i) $a^3 \times a^6$

$$\dots\dots\dots [1]$$

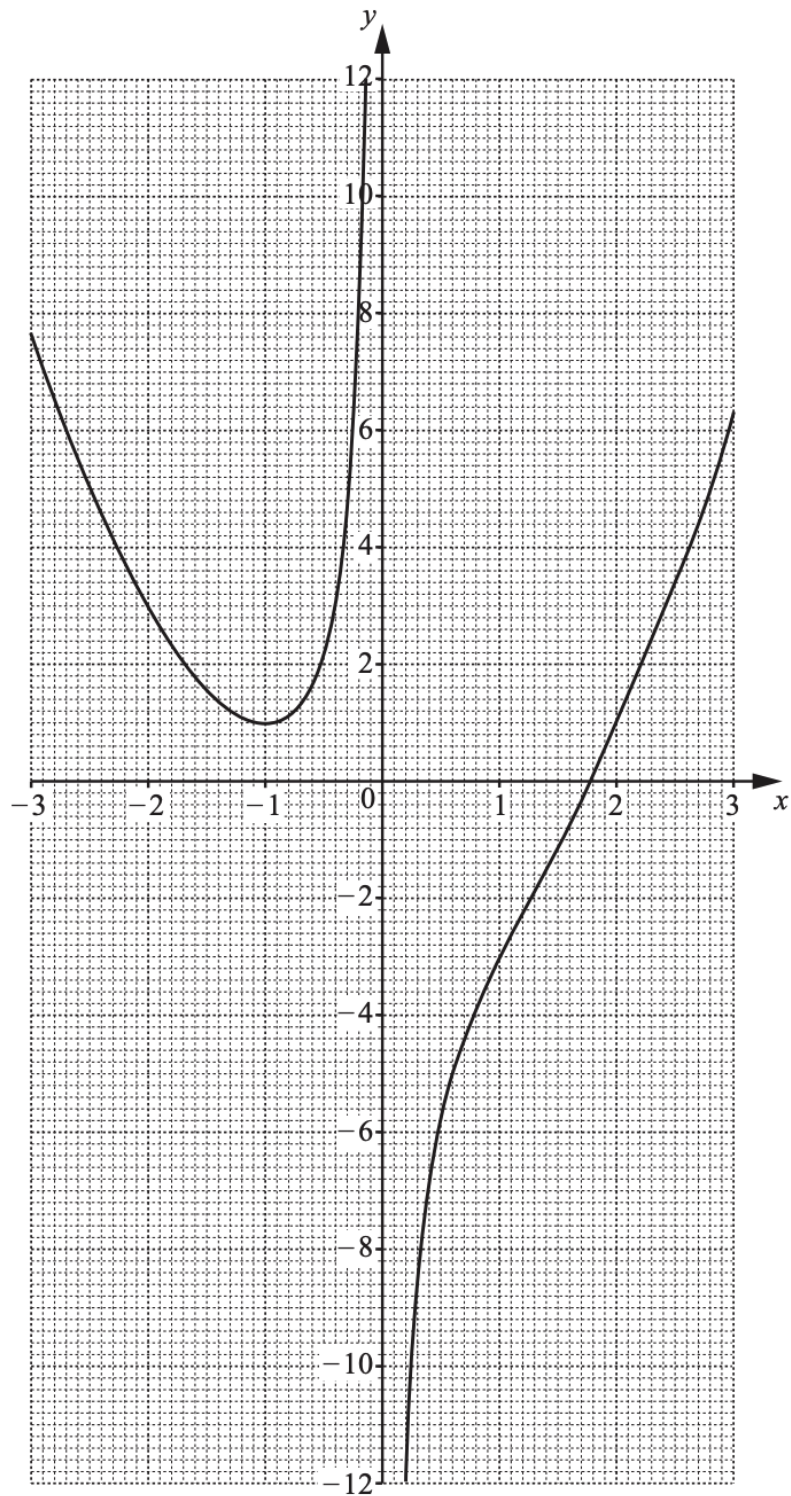
(ii) $(5xy^2)^3$

$$\dots\dots\dots [2]$$

(iii) $\left(\frac{27x^{12}}{64y^3}\right)^{-\frac{1}{3}}$

$$\dots\dots\dots [3]$$

- 5 The diagram shows the graph of $y = f(x)$ where $f(x) = x^2 - \frac{2}{x} - 2$, $x \neq 0$.



(a) Use the graph to find

(i) $f(1)$,

..... [1]

(ii) $ff(-2)$.

..... [2]

(b) On the grid opposite, draw a suitable straight line to solve the equation

$x^2 - \frac{2}{x} - 7 = -3x$ for $-3 \leq x \leq 3$.

$x =$ or $x =$ [4]

(c) By drawing a suitable tangent, find an estimate of the gradient of the curve at $x = -2$.

..... [3]

(d) (i) Complete the table for $y = g(x)$ where $g(x) = 2^{-x}$ for $-3 \leq x \leq 3$.

x	-3	-2	-1	0	1	2	3
y			2	1	0.5		0.125

[3]

(ii) On the grid opposite, draw the graph of $y = g(x)$.

[3]

(iii) Use your graph to find the **positive** solution to the equation $f(x) = g(x)$.

$x =$ [1]

7 A straight line joins the points $A(-2, -3)$ and $C(1, 9)$.

(a) Find the equation of the line AC in the form $y = mx + c$.

$y = \dots\dots\dots$ [3]

(b) Calculate the acute angle between AC and the x -axis.

$\dots\dots\dots$ [2]

(c) $ABCD$ is a kite, where AC is the longer diagonal of the kite.
 B is the point $(3.5, 2)$.

(i) Find the equation of the line BD in the form $y = mx + c$.

$y = \dots\dots\dots$ [3]

(ii) The diagonals AC and BD intersect at $(-0.5, 3)$.

Work out the co-ordinates of D .

$(\dots\dots\dots, \dots\dots\dots)$ [2]

(b) Solve by factorisation.

$$4x^2 - 25x - 21 = 0$$

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots [3]$$

- 7 (a) Oranges cost 21 cents each.
 Alex buys x oranges and Bobbie buys $(x + 2)$ oranges.
 The total cost of these oranges is \$4.20 .

Find the value of x .

$$x = \dots\dots\dots [3]$$

- (b) The cost of one ruler is r cents.
 The cost of one protractor is p cents.

The total cost of 5 rulers and 1 protractor is 245 cents.
 The total cost of 2 rulers and 3 protractors is 215 cents.

Write down two equations in terms of r and p and solve these equations to find the cost of one protractor.

$$\dots\dots\dots \text{ cents } [5]$$

- (c) Carol walks 12 km at x km/h and then a further 6 km at $(x - 1)$ km/h.
The total time taken is 5 hours.

(i) Write an equation, in terms of x , and show that it simplifies to $5x^2 - 23x + 12 = 0$.

[3]

(ii) Factorise $5x^2 - 23x + 12$.

..... [2]

(iii) Solve the equation $5x^2 - 23x + 12 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [1]

(iv) Write down Carol's walking speed during the final 6 km.

..... km/h [1]

- 9 A car hire company has x small cars and y large cars.
 The company has at least 6 cars in total.
 The number of large cars is less than or equal to the number of small cars.
 The largest number of small cars is 8.

(a) Write down three inequalities, in terms of x and/or y , to show this information.

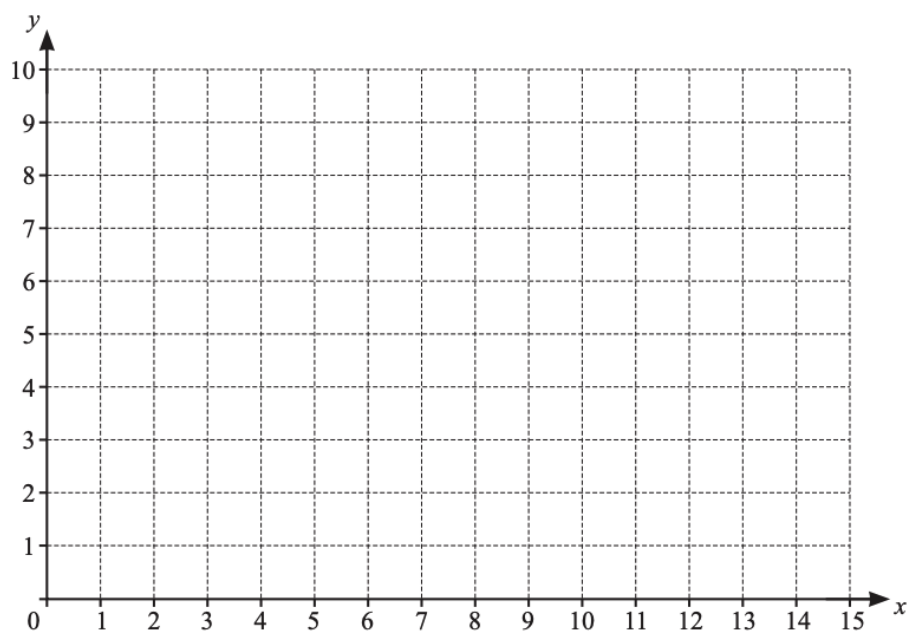
.....,, [3]

(b) A small car can carry 4 people and a large car can carry 6 people.
 One day, the largest number of people to be carried is 60.

Show that $2x + 3y \leq 30$.

[1]

(c)



By shading the **unwanted** regions on the grid, show and label the region R that satisfies all four inequalities. [6]

(d) (i) Find the number of small cars and the number of large cars needed to carry exactly 60 people.

..... small cars, large cars [1]

(ii) When the company uses 7 cars, find the largest number of people that can be carried.

..... [2]

3 A line joins $A(1, 3)$ to $B(5, 8)$.

(a) (i) Find the midpoint of AB .

(.....,) [2]

(ii) Find the equation of the line AB .
Give your answer in the form $y = mx + c$.

$y =$ [3]

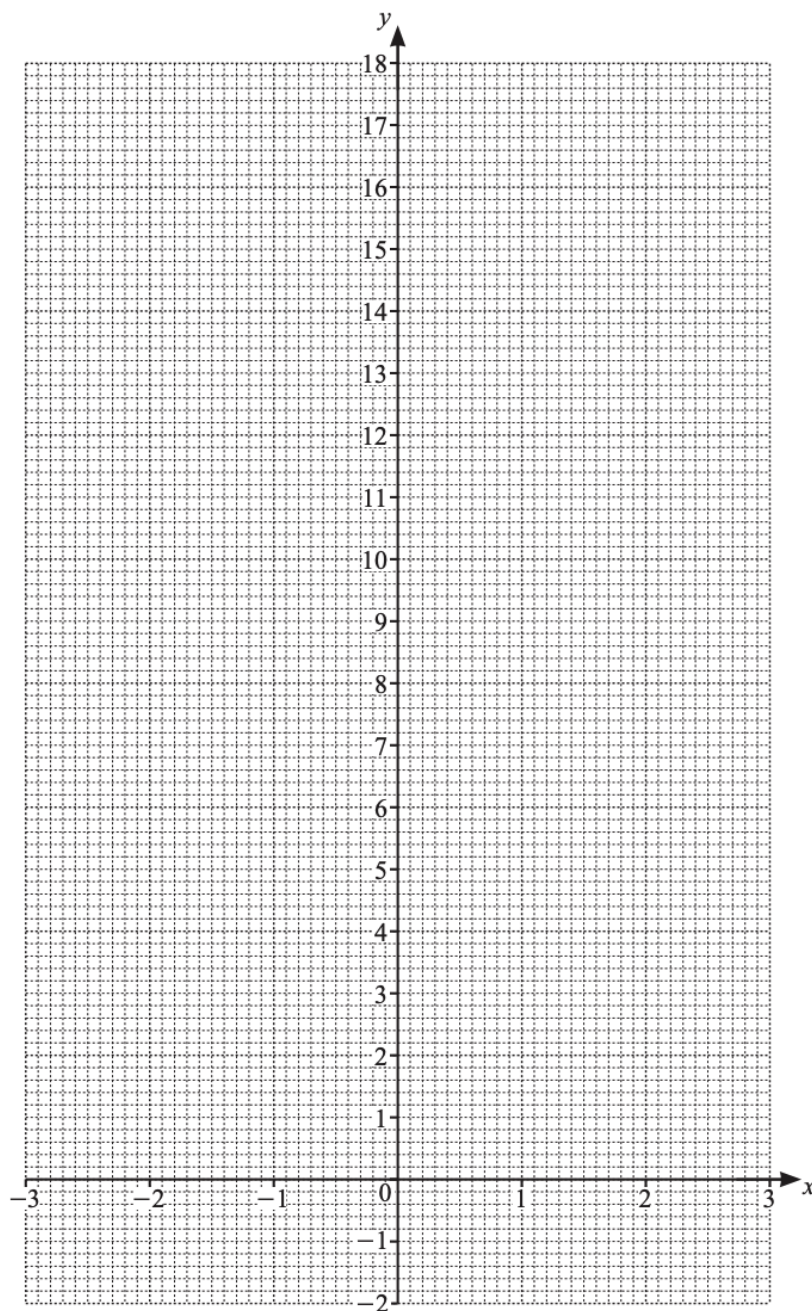
- 5 The table shows some values of $y = \frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x}$, $x \neq 0$.

x	-3	-2	-1	-0.5	-0.3		0.2	0.3	0.5	1	2	3
y	5.3	3.3		8.1	17.8			4.5	0.1	-0.5	1.3	

- (a) Complete the table.

[3]

- (b) On the grid, draw the graph of $y = \frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x}$ for $-3 \leq x \leq -0.3$ and $0.2 \leq x \leq 3$.



[5]

- (c) Use your graph to solve $\frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x} \leq 0$.

..... $\leq x \leq$ [2]

- (d) Find the smallest positive integer value of k for which $\frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x} = k$ has two solutions for $-3 \leq x \leq -0.3$ and $0.2 \leq x \leq 3$.

..... [1]

- (e) (i) By drawing a suitable straight line, solve $\frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x} = 3x + 1$ for $-3 \leq x \leq -0.3$ and $0.2 \leq x \leq 3$.

$x =$ [3]

- (ii) The equation $\frac{x^2}{2} + \frac{1}{x^2} - \frac{2}{x} = 3x + 1$ can be written as $x^4 + ax^3 + bx^2 + cx + 2 = 0$.

Find the values of a , b and c .

$a =$

$b =$

$c =$ [3]

7

$$f(x) = 7 - 2x$$

$$g(x) = \frac{10}{x}, \quad x \neq 0$$

$$h(x) = 27^x$$

(a) Find

(i) $f(-3)$,

..... [1]

(ii) $hg(30)$,

..... [2]

(iii) $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(b) Solve.

$$g(2x + 1) = 4$$

$x =$ [3]

(c) Simplify, giving your answer as a single fraction.

$$\frac{1}{f(x)} + g(x)$$

..... [3]

(d) Find $h^{-1}(19\,683)$.

..... [1]

8 (a) Make p the subject of

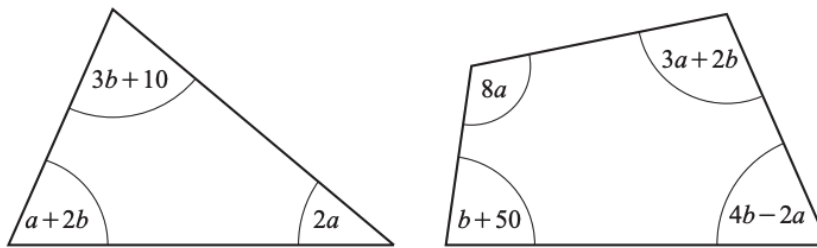
(i) $5p + 7 = m,$

$p =$ [2]

(ii) $y^2 - 2p^2 = h.$

$p =$ [3]

- 2 (a) The diagram shows a triangle and a quadrilateral.
All angles are in degrees.



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- (i) For the triangle, show that $3a + 5b = 170$.

[1]

- (ii) For the quadrilateral, show that $9a + 7b = 310$.

[1]

- (iii) Solve these simultaneous equations.
Show all your working.

$$a = \dots\dots\dots$$

$$b = \dots\dots\dots [3]$$

- (iv) Find the size of the smallest angle in the triangle.

$\dots\dots\dots [1]$

(b) Solve the equation $6x - 3 = -12$.

$x =$ [2]

(c) Rearrange $2(4x - y) = 5x - 3$ to make y the subject.

$y =$ [3]

(d) Simplify.

$$(27x^9)^{\frac{2}{3}}$$

..... [2]

(e) Simplify.

$$\frac{x^2 + 5x}{x^2 - 25}$$

..... [3]

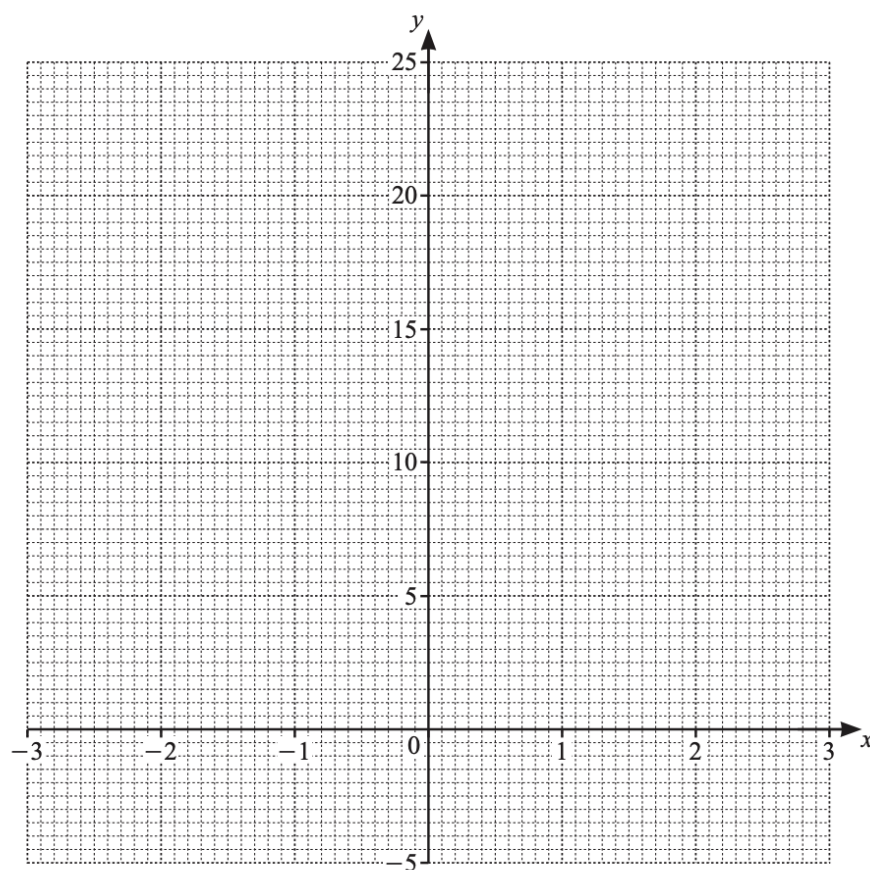
- 3 The table shows some values for $y = x^3 + x^2 - 5x$.

x	-3	-2	-1.5	-1	0	1	1.5	2	2.5	3
y	-3	6	6.4		0		-1.9	2	9.4	

(a) Complete the table.

[3]

(b) On the grid, draw the graph of $y = x^3 + x^2 - 5x$ for $-3 \leq x \leq 3$.



[4]

(c) Use your graph to solve the equation $x^3 + x^2 - 5x = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

(d) By drawing a suitable tangent, find an estimate of the gradient of the curve at $x = 2$.

$\dots\dots\dots$ [3]

(e) Write down the largest value of the integer, k , so that the equation $x^3 + x^2 - 5x = k$ has three solutions for $-3 \leq x \leq 3$.

$k = \dots\dots\dots$ [1]

9

$$f(x) = 2x - 3$$

$$g(x) = 9 - x^2$$

$$h(x) = 3^x$$

(a) Find

(i) $f(4)$,

..... [1]

(ii) $hg(3)$,

..... [2]

(iii) $g(2x)$ in its simplest form,

..... [1]

(iv) $fg(x)$ in its simplest form.

..... [2]

(b) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(c) Find x when $5f(x) = 3$.

$x =$ [2]

(d) Solve the equation $gf(x) = -16$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

(e) Find x when $h^{-1}(x) = -2$.

$x = \dots\dots\dots$ [1]

10 Solve.

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

Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [7]

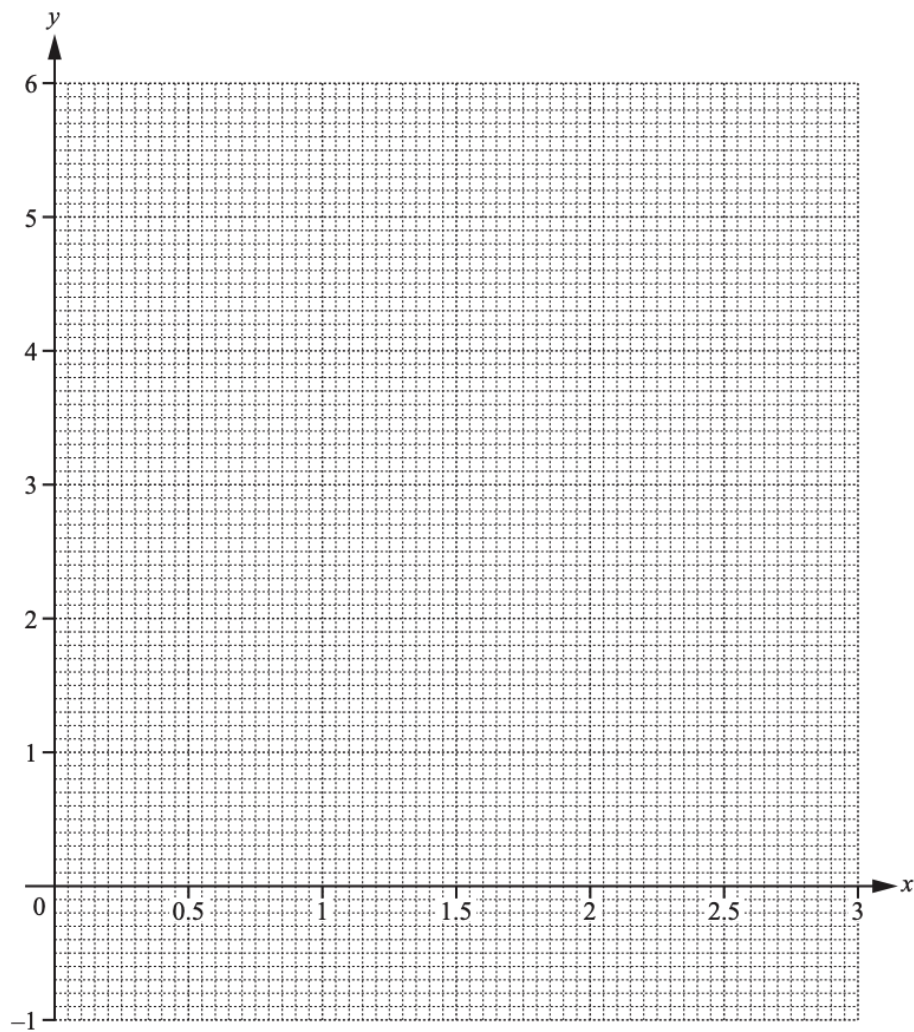
- 3 The table shows some values for $y = 2x + \frac{1}{x} - 3$ for $0.125 \leq x \leq 3$.

x	0.125	0.25	0.375	0.5	0.75	1	1.5	2	2.5	3
y	5.25	1.5	0.42			0	0.67	1.5		3.33

(a) Complete the table.

[3]

(b) On the grid, draw the graph of $y = 2x + \frac{1}{x} - 3$ for $0.125 \leq x \leq 3$.



[4]

- (c) Use your graph to solve $2x + \frac{1}{x} - 3 \geq 2$.

.....

..... [3]

- (d) The equation $\frac{1}{x} = 7 - 3x$ can be solved using your graph in **part (b)** and a straight line.

- (i) Write down the equation of this straight line.

..... [2]

- (ii) Draw this straight line and solve the equation $\frac{1}{x} = 7 - 3x$.

$x =$ or $x =$ [3]

- 4 (a) Make t the subject of the formula $s = k - t^2$.

$t = \dots\dots\dots$ [2]

- (b) (i) Factorise $x^2 - 25$.

$\dots\dots\dots$ [1]

- (ii) Simplify $\frac{x^2 - 25}{x^2 - 2x - 35}$.

$\dots\dots\dots$ [3]

- (c) Write as a single fraction in its simplest form.

$$\frac{x-8}{x} + \frac{3x}{x+1}$$

$\dots\dots\dots$ [3]

- (d) Find the **integer** values of n that satisfy the inequality.

$$18 - 2n < 6n \leq 30 + n$$

$\dots\dots\dots$ [3]

6 Klaus buys x silver balloons and y gold balloons for a party.

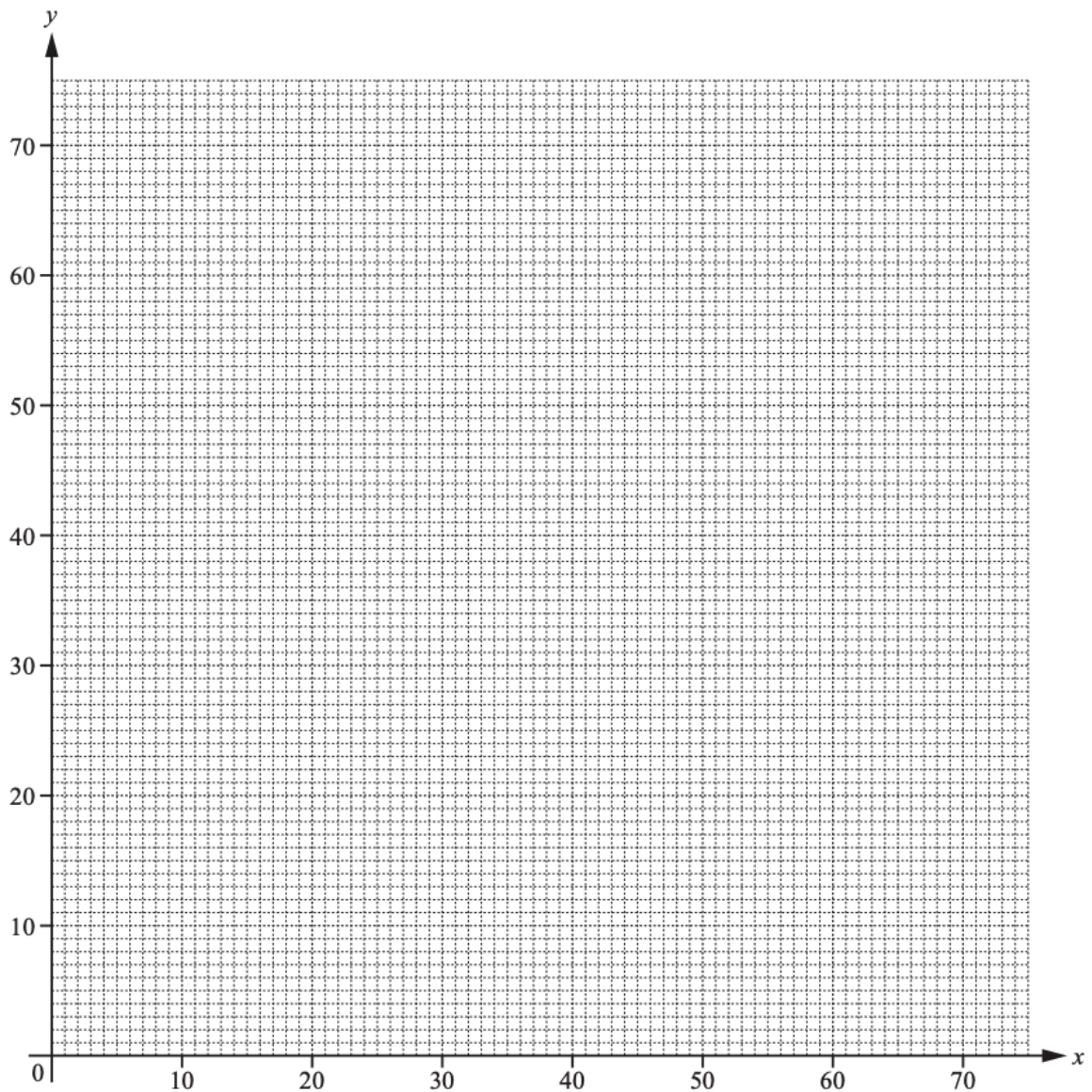
He buys

- more gold balloons than silver balloons
- at least 15 silver balloons
- less than 50 gold balloons
- a total of no more than 70 balloons.

(a) Write down four inequalities, in terms of x and/or y , to show this information.

.....
.....
.....
..... [4]

- (b) On the grid, show the information from **part (a)** by drawing four straight lines and shading the unwanted regions.



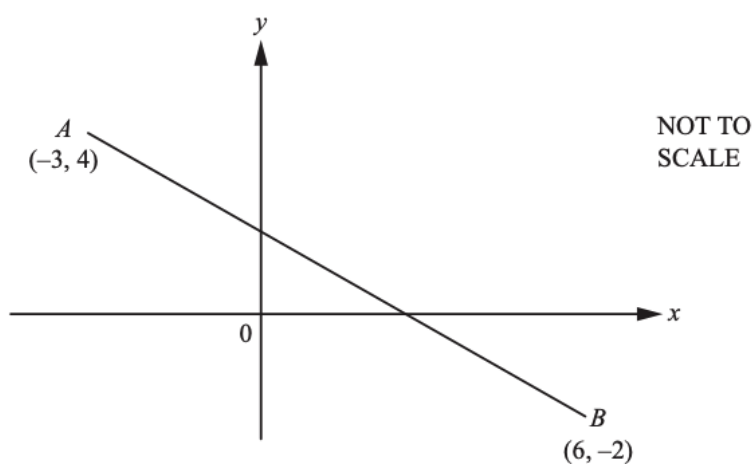
[5]

- (c) Silver balloons cost \$2 and gold balloons cost \$3.

Calculate the most that Klaus could spend.

\$ [2]

10 (a)



Calculate the length of AB .

..... [3]

(b) The point P has co-ordinates $(10, 12)$ and the point Q has co-ordinates $(2, -4)$.

Find

(i) the co-ordinates of the mid-point of the line PQ ,

(..... ,) [2]

(ii) the gradient of the line PQ ,

..... [2]

(iii) the equation of a line perpendicular to PQ that passes through the point $(2, 3)$.

..... [3]

5 (a) Factorise.

(i) $2mn + m^2 - 6n - 3m$

..... [2]

(ii) $4y^2 - 81$

..... [1]

(iii) $t^2 - 6t + 8$

..... [2]

(b) Rearrange the formula to make x the subject.

$$k = \frac{2m - x}{x}$$

$x =$ [4]

- (c) Solve the simultaneous equations.
You must show all your working.

$$\begin{aligned}\frac{1}{2}x - 3y &= 9 \\ 5x + y &= 28\end{aligned}$$

$$x = \dots\dots\dots$$

$$y = \dots\dots\dots [3]$$

(d) $\frac{3}{m+4} - \frac{4}{m} = 6$

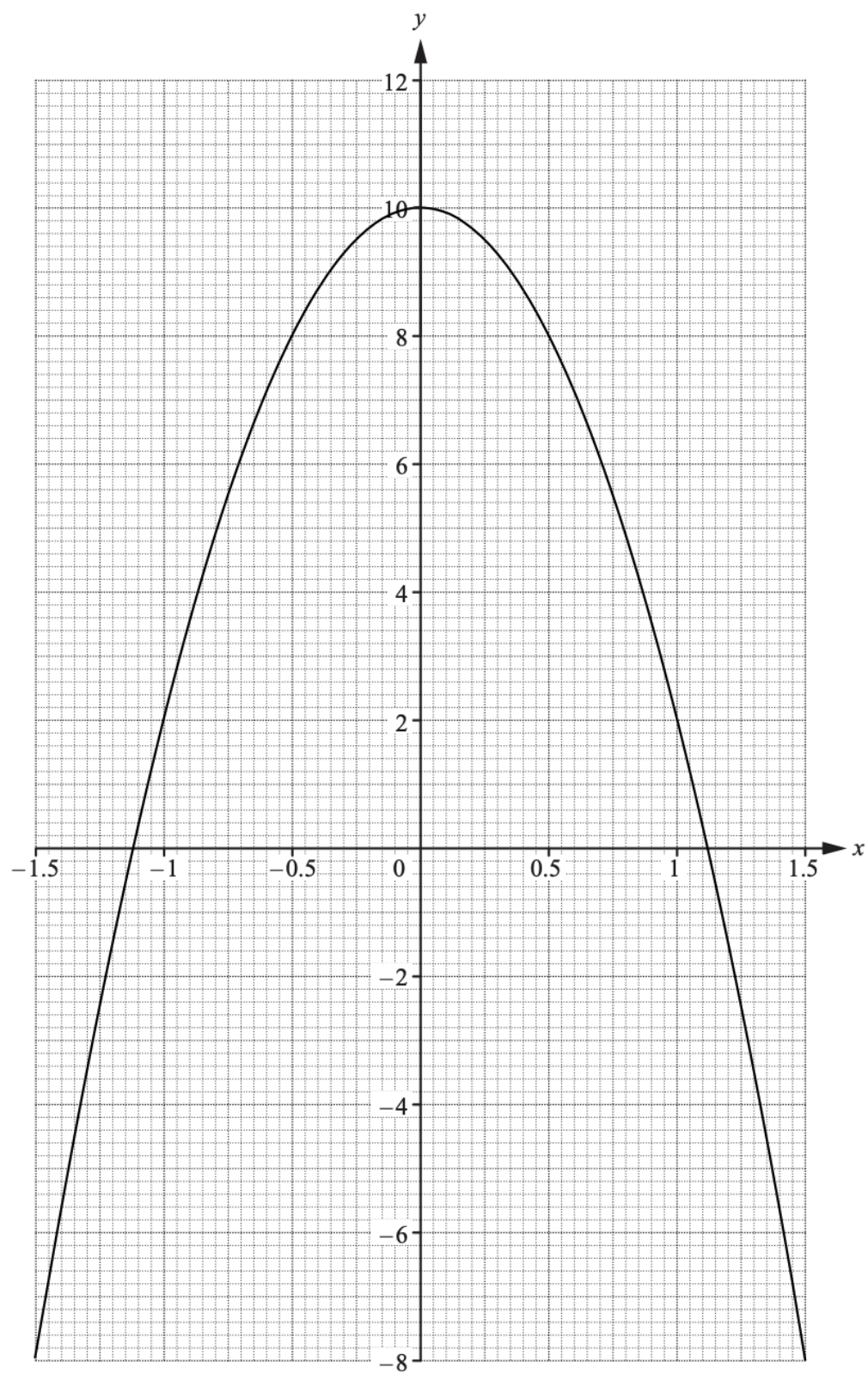
- (i) Show that this equation can be written as $6m^2 + 25m + 16 = 0$.

[3]

- (ii) Solve the equation $6m^2 + 25m + 16 = 0$.
Show all your working and give your answers correct to 2 decimal places.

$$m = \dots\dots\dots \text{ or } m = \dots\dots\dots [4]$$

- 7 The graph of $y = 10 - 8x^2$ for $-1.5 \leq x \leq 1.5$ is drawn on the grid.



- (a) Write down the equation of the line of symmetry of the graph.

..... [1]

- (b) On the grid opposite, draw the tangent to the curve at the point where $x = 0.5$.
Find the gradient of this tangent.

..... [3]

- (c) The table shows some values for $y = x^3 + 3x + 4$.

x	-1.5	-1	-0.5	0	0.5	1	1.5
y	-3.9				5.6	8	11.9

- (i) Complete the table. [3]

- (ii) On the grid opposite, draw the graph of $y = x^3 + 3x + 4$ for $-1.5 \leq x \leq 1.5$. [4]

- (d) Show that the values of x where the two curves intersect are the solutions to the equation $x^3 + 8x^2 + 3x - 6 = 0$.

[1]

- (e) By drawing a suitable straight line, solve the equation $x^3 + 5x + 2 = 0$ for $-1.5 \leq x \leq 1.5$.

$x =$ [3]

4 (a) Simplify.

(i) $(3p^2)^5$

..... [2]

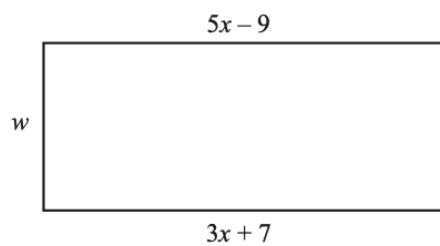
(ii) $18x^2y^6 \div 2xy^2$

..... [2]

(iii) $\left(\frac{5}{m}\right)^{-2}$

..... [1]

(b) In this part, all measurements are in metres.



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The diagram shows a rectangle.
The area of the rectangle is 310m^2 .

Work out the value of w .

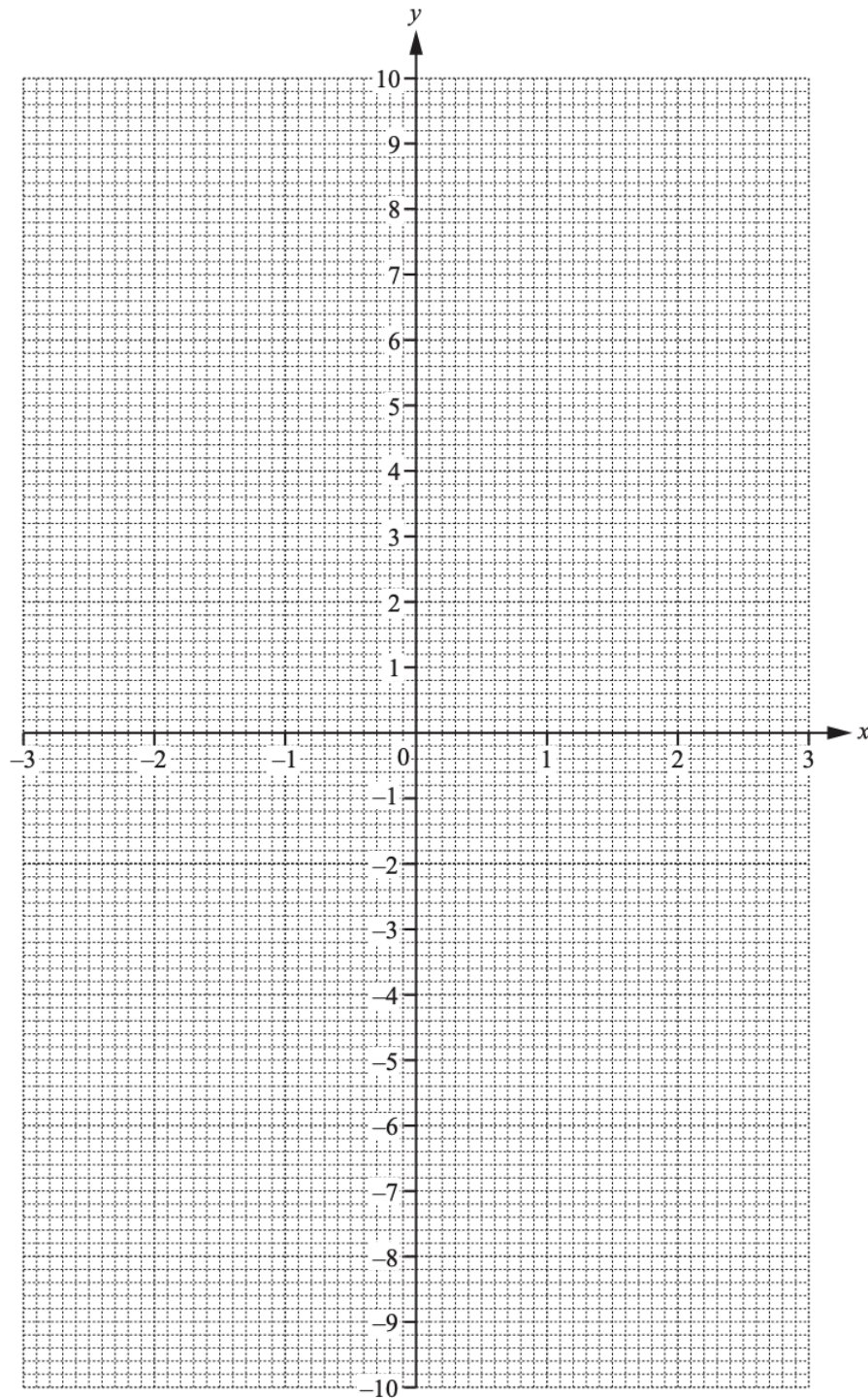
$w =$ [4]

- 6 (a) Complete the table of values for $y = \frac{x^3}{3} - \frac{1}{2x^2}$, $x \neq 0$.

x	-3	-2	-1	-0.5	-0.3		0.3	0.5	1	2	3
y	-9.1	-2.8	-0.8		-5.6		-5.5	-2.0			8.9

[3]

- (b) On the grid, draw the graph of $y = \frac{x^3}{3} - \frac{1}{2x^2}$ for $-3 \leq x \leq -0.3$ and $0.3 \leq x \leq 3$.



[5]

- (c) (i) By drawing a suitable tangent, find an estimate of the gradient of the curve at $x = -2$.

..... [3]

- (ii) Write down the equation of the tangent to the curve at $x = -2$.
Give your answer in the form $y = mx + c$.

$y =$ [2]

- (d) Use your graph to solve the equations.

(i) $\frac{x^3}{3} - \frac{1}{2x^2} = 0$

$x =$ [1]

(ii) $\frac{x^3}{3} - \frac{1}{2x^2} + 4 = 0$

$x =$ or $x =$ or $x =$ [3]

- (e) The equation $\frac{x^3}{3} - \frac{1}{2x^2} + 4 = 0$ can be written in the form $ax^n + bx^{n-3} - 3 = 0$.

Find the value of a , the value of b and the value of n .

$a =$

$b =$

$n =$ [3]

8 $f(x) = 8 - 3x$ $g(x) = \frac{10}{x+1}, x \neq -1$ $h(x) = 2^x$

(a) Find

(i) $hf\left(\frac{8}{3}\right),$

..... [2]

(ii) $gh(-2),$

..... [2]

(iii) $g^{-1}(x),$

$g^{-1}(x) = \dots\dots\dots [3]$

(iv) $f^{-1}f(5).$

..... [1]

(b) Write $f(x) + g(x)$ as a single fraction in its simplest form.

..... [3]

2 (a) (i) $y = 2^x$

Complete the table.

x	0	1	2	3	4
y		2	4	8	

[2]

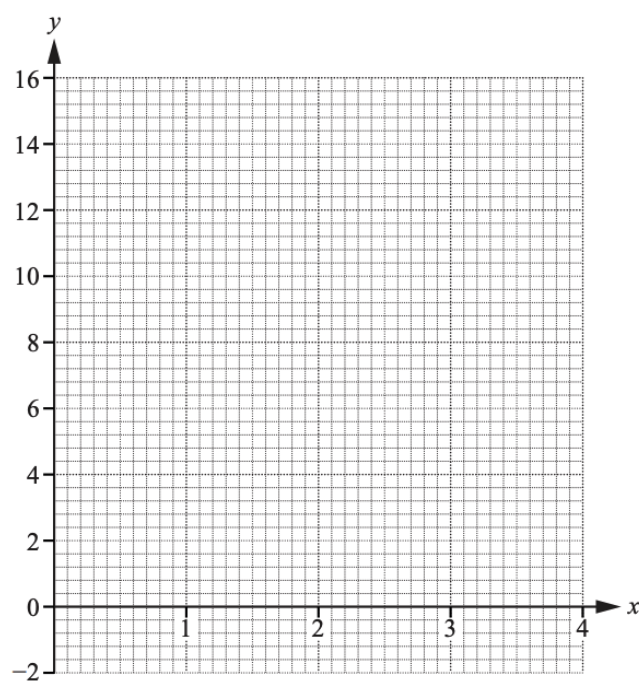
(ii) $y = 14 - x^2$

Complete the table.

x	0	1	2	3	4
y		13	10	5	

[2]

(b) On the grid, draw the graphs of $y = 2^x$ and $y = 14 - x^2$ for $0 \leq x \leq 4$.



[6]

(c) Use your graphs to solve the equations.

(i) $2^x = 12$

$x = \dots\dots\dots$ [1]

(ii) $2^x = 14 - x^2$

$x = \dots\dots\dots$ [1]

(d) (i) On the grid, draw the line from the point (4, 2) that has a gradient of -4 . [1]

(ii) Complete the statement.

This straight line is a $\dots\dots\dots$ to the graph of $y = 14 - x^2$

at the point ($\dots\dots\dots$, $\dots\dots\dots$). [2]

- 5 (a) At a football match, the price of an adult ticket is $\$x$ and the price of a child ticket is $\$(x - 2.50)$. There are 18 500 adults and 2400 children attending the football match. The total amount paid for the tickets is $\$320\,040$.

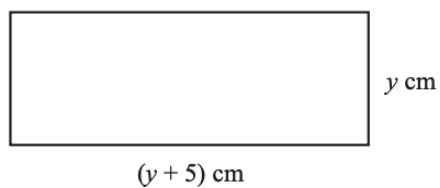
Find the price of an adult ticket.

$\$$ [4]

- (b) (i) Factorise $y^2 + 5y - 84$.

..... [2]

(ii)



NOT TO
SCALE

The area of the rectangle is 84 cm^2 .

Find the perimeter.

..... cm [3]

- (c) In a shop, the price of a monthly magazine is \$ m and the price of a weekly magazine is \$ $(m - 0.75)$.

One day, the shop receives

- \$168 from selling monthly magazines
- \$207 from selling weekly magazines.

The total number of these magazines sold during this day is 100.

- (i) Show that $50m^2 - 225m + 63 = 0$.

[3]

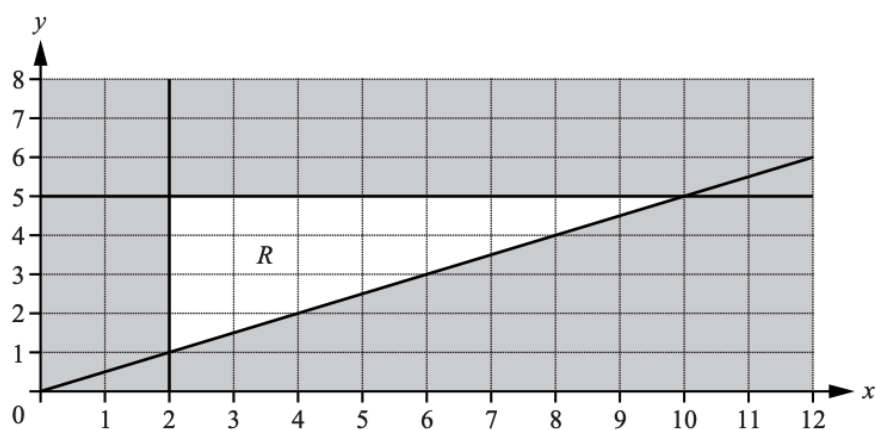
- (ii) Find the price of a monthly magazine.
Show all your working.

\$ [3]

- 9 (a) Find the equation of the straight line that is perpendicular to the line $y = \frac{1}{2}x + 1$ and passes through the point $(1, 3)$.

..... [3]

(b)



- (i) Find the three inequalities that define the region R .

.....

 [4]

- (ii) Find the point (x, y) , with integer co-ordinates, inside the region R such that $3x + 5y = 35$.

(..... ,) [2]

10 (a) $f(x) = 2x - 3$ $g(x) = x^2 + 1$

(i) Find $gg(2)$.

..... [2]

(ii) Find $g(x+2)$, giving your answer in its simplest form.

..... [2]

(iii) Find x when $f(x) = 7$.

$x =$ [2]

(iv) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(b) $h(x) = x^x, x > 0$

- (i) Calculate $h(0.3)$.
Give your answer correct to 2 decimal places.

..... [2]

- (ii) Find x when $h(x) = 256$.

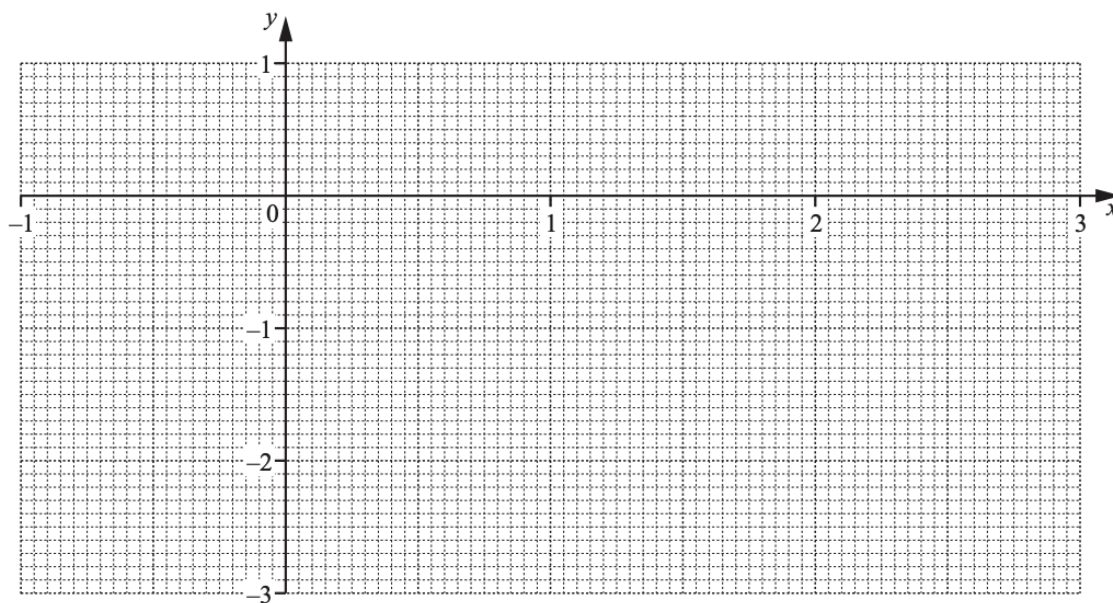
$x =$ [1]

- 3 The table shows some values of $y = x^3 - 3x^2 + x$.

x	-0.75	-0.5	-0.25	0	0.5	1	1.5	2	2.5	2.75
y	-2.9	-1.4	-0.5		-0.1	-1	-1.9		-0.6	

- (a) Complete the table. [3]

- (b) On the grid, draw the graph of $y = x^3 - 3x^2 + x$ for $-0.75 \leq x \leq 2.75$. [4]



- (c) Use your graph to complete the inequalities in x for which $y > -1$.

..... $< x <$ and $x >$ [3]

(d) The equation $x^3 - 3x^2 + 2x - 1 = 0$ can be solved by drawing a straight line on the grid.

(i) Write down the equation of this line.

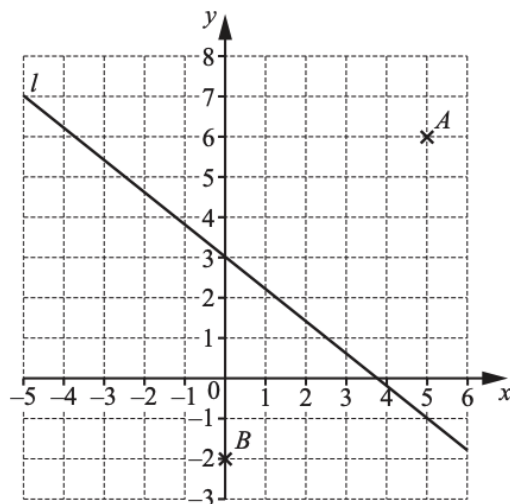
..... [2]

(ii) On the grid, draw this line and use it to solve the equation $x^3 - 3x^2 + 2x - 1 = 0$.

$x =$ [3]

(e) By drawing a suitable tangent, find an estimate for the gradient of the graph of $y = x^3 - 3x^2 + x$ at $x = -0.25$.

..... [3]



- (a) Write down the co-ordinates of A .

(..... ,) [1]

- (b) Find the equation of line l in the form $y = mx + c$.

$y =$ [3]

- (c) Write down the equation of the line parallel to line l that passes through the point B .

..... [2]

- (d) C is the point $(8, 14)$.

- (i) Write down the equation of the line perpendicular to line l that passes through the point C .

..... [3]

- (ii) Calculate the length of AC .

..... [3]

- (iii) Find the co-ordinates of the mid-point of BC .

(..... ,) [2]

- 9 Paulo and Jim each buy sacks of rice but from different shops.
 Paulo pays \$72 for sacks costing \$ m each.
 Jim pays \$72 for sacks costing \$ $(m + 0.9)$ each.

- (a) (i) Find an expression, in terms of m , for the number of sacks Paulo buys.

..... [1]

- (ii) Find an expression, in terms of m , for the number of sacks Jim buys.

..... [1]

- (b) Paulo buys 4 more sacks than Jim.

Write down an equation, in terms of m , and show that it simplifies to $10m^2 + 9m - 162 = 0$.

[4]

- (c) (i) Solve $10m^2 + 9m - 162 = 0$.

$m = \dots\dots\dots$ or $m = \dots\dots\dots$ [3]

- (ii) Find the number of sacks of rice that Paulo buys.

..... [1]

11 (a) Factorise $5m^2 - 20p^4$.

..... [3]

(b) Make P the subject of the formula $A = P + \frac{PRT}{100}$.

$P =$ [3]

- 2 (a) Solve $30 + 2x = 3(3 - 4x)$.

$x = \dots\dots\dots$ [3]

- (b) Factorise $12ab^3 + 18a^3b^2$.

$\dots\dots\dots$ [2]

- (c) Simplify.

(i) $5a^3c^2 \times 2a^2c^7$

$\dots\dots\dots$ [2]

(ii) $\left(\frac{16a^8}{c^{12}}\right)^{\frac{3}{4}}$

$\dots\dots\dots$ [2]

- (d) y is inversely proportional to the square of $(x + 2)$.
When $x = 3$, $y = 2$.

Find y when $x = 8$.

$y = \dots\dots\dots$ [3]

(e) Write as a single fraction in its simplest form.

$$\frac{5}{x-2} - \frac{x-5}{2}$$

..... [3]

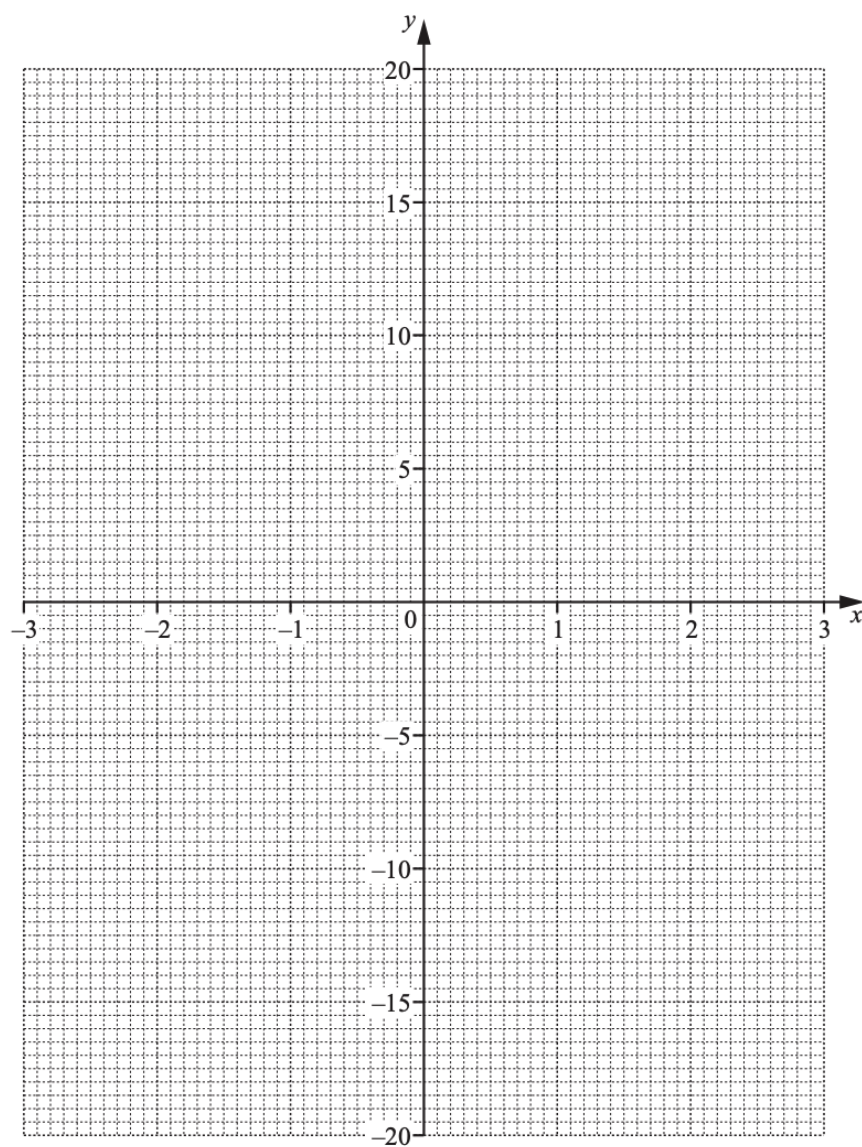
5 The table shows some values of $y = x^3 - 3x - 1$.

x	-3	-2.5	-2	-1.5	-1	0	1	1.5	2	2.5	3
y	-19	-9.1		0.1	1	-1	-3	-2.1	1	7.1	

(a) Complete the table of values.

[2]

(b) Draw the graph of $y = x^3 - 3x - 1$ for $-3 \leq x \leq 3$.



[4]

(c) A straight line through $(0, -17)$ is a tangent to the graph of $y = x^3 - 3x - 1$.

(i) On the grid, draw this tangent. [1]

(ii) Find the co-ordinates of the point where the tangent meets your graph.

(.....,) [1]

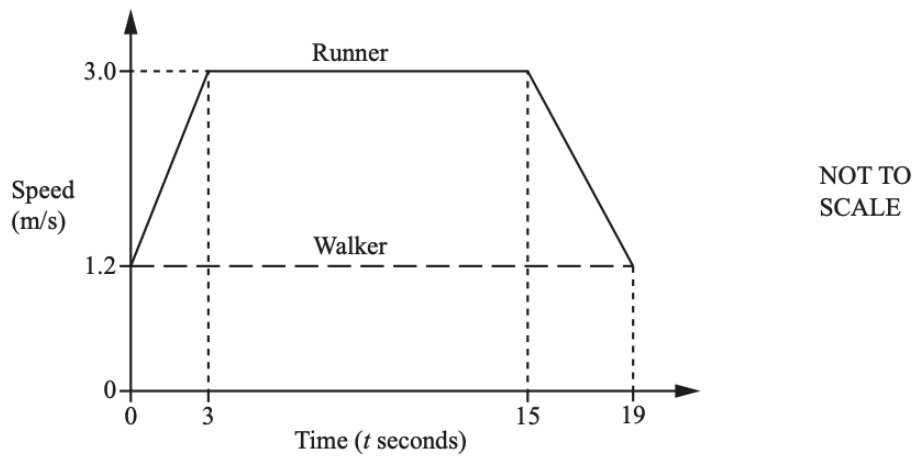
(iii) Find the equation of the tangent.
Give your answer in the form $y = mx + c$.

$y =$ [3]

(d) By drawing a suitable straight line on the grid, solve the equation $x^3 - 6x - 3 = 0$.

$x =$ or $x =$ or $x =$ [4]

- 6 The diagram shows the speed–time graph for part of a journey for two people, a runner and a walker.



- (a) Calculate the acceleration of the runner for the first 3 seconds.

..... m/s^2 [1]

- (b) Calculate the total distance travelled by the runner in the 19 seconds.

..... m [3]

- (c) The runner and the walker are travelling in the same direction along the same path.
When $t = 0$, the runner is 10 metres behind the walker.

Find how far the runner is ahead of the walker when $t = 19$.

..... m [3]

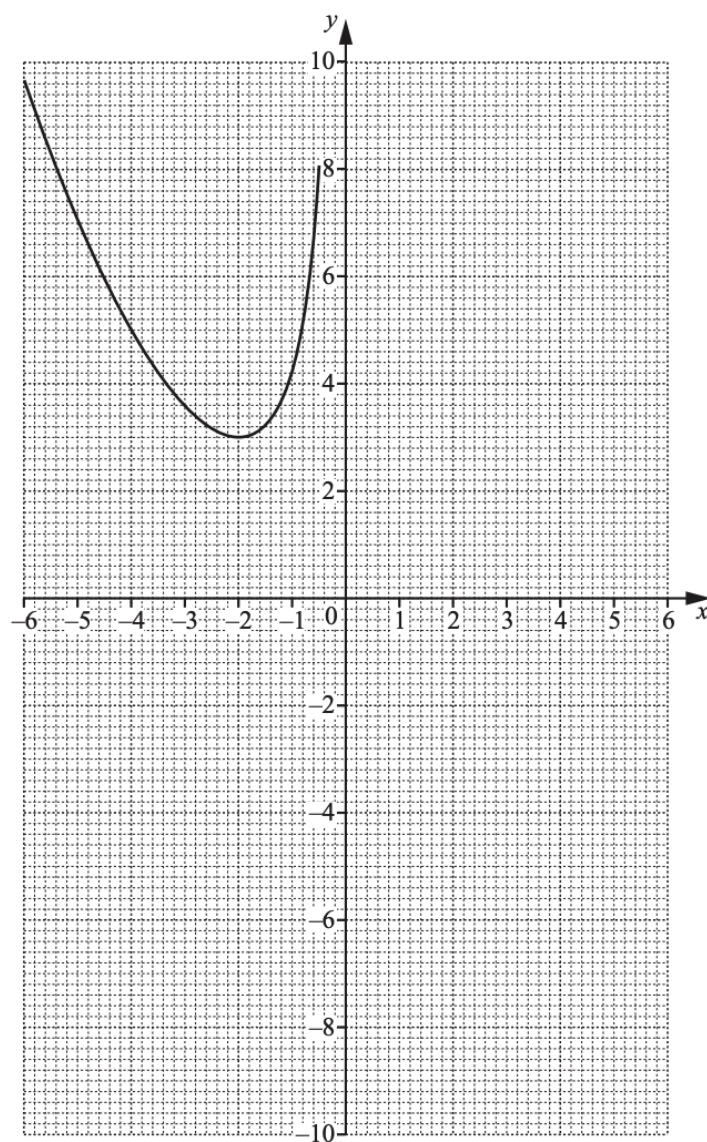
4 $f(x) = \frac{x^2}{4} - \frac{4}{x}, x \neq 0$

(a) Complete the table for $f(x)$.

x	0.5	1	2	3	4	5	6
$f(x)$	-7.9	-3.8		0.9		5.5	8.3

[2]

(b) The graph of $y = f(x)$ for $-6 \leq x \leq -0.5$ is drawn on the grid.



On the same grid, draw the graph of $y = f(x)$ for $0.5 \leq x \leq 6$.

[3]

- (c) By drawing a suitable tangent, estimate the gradient of the graph of $y = f(x)$ at the point $(-4, 5)$.

..... [3]

(d) $g(x) = \frac{9}{x}, x \neq 0$

Complete the table for $g(x)$.

x	-4	-3	-2	-1		1	2	3	4
$g(x)$	-2.3		-4.5	-9		9	4.5		2.3

[1]

- (e) On the same grid, draw the graph of $y = g(x)$ for $-4 \leq x \leq -1$ and $1 \leq x \leq 4$.

[4]

- (f) (i) Use your graphs to find the value of x when $f(x) = g(x)$.

$x =$ [1]

- (ii) Write down an inequality to show the **positive** values of x for which $f(x) > g(x)$.

..... [1]

- (g) The exact answer to **part (f)(i)** is $\sqrt[3]{k}$.

Use algebra to find the value of k .

$k =$ [2]

9 $f(x) = 3x + 4$ $g(x) = 2x - 1$ $h(x) = 3^x$

(a) Find $g\left(\frac{1}{2}\right)$.
 [1]

(b) Find $fh(-1)$.
 [2]

(c) Find $g^{-1}(x)$.
 $g^{-1}(x) =$ [2]

(d) Find $ff(x)$ in its simplest form.
 [2]

(e) Find $(f(x))^2$ in the form $ax^2 + bx + c$.
 [2]

(f) Find x when $h^{-1}(x) = g(2)$.
 $x =$ [2]

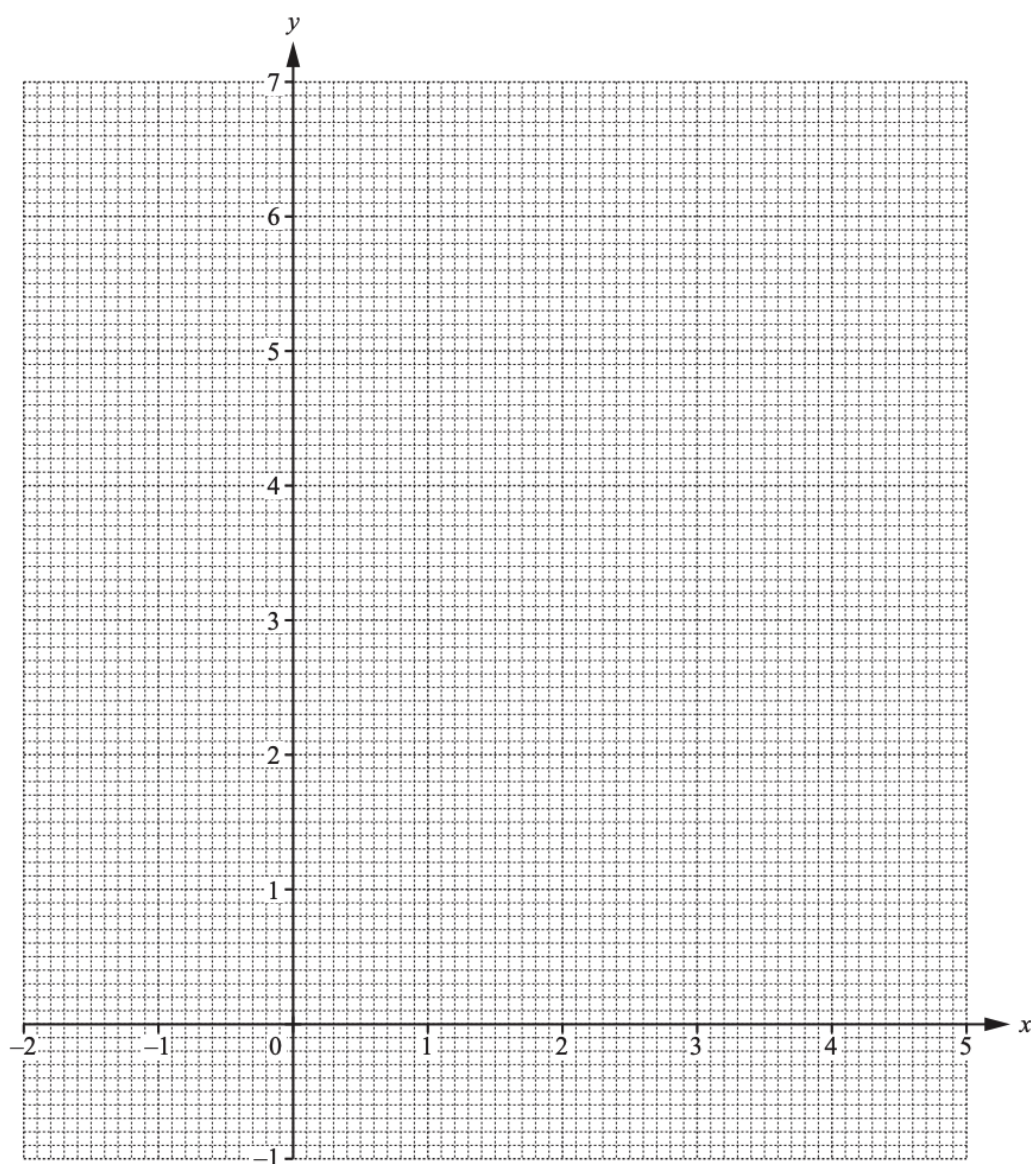
- 3 The table shows some values for $y = 1.5^x - 1$.

x	-2	-1	0	1	2	3	4	5
y	-0.56	-0.33				2.38	4.06	6.59

(a) Complete the table.

[3]

(b) Draw the graph of $y = 1.5^x - 1$ for $-2 \leq x \leq 5$.



[4]

(c) Use your graph to solve the equation $1.5^x - 1 = 3.5$.

$x = \dots\dots\dots$ [2]

(d) By drawing a suitable straight line, solve the equation $1.5^x - x - 2 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

(e) (i) On the grid, plot the point A at $(5, 5)$. [1]

(ii) Draw the tangent to the graph of $y = 1.5^x - 1$ that passes through the point A . [1]

(iii) Work out the gradient of this tangent.

$\dots\dots\dots$ [2]

5 (a) (i) Factorise $3x^2 + 11x - 4$.

..... [2]

(ii) Solve the equation $3x^2 + 11x - 4 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [1]

(b) (i) Show that $\frac{2}{2x+11} - \frac{1}{x-4} = \frac{1}{2}$ simplifies to $2x^2 + 3x - 6 = 0$.

[4]

(ii) Solve the equation $2x^2 + 3x - 6 = 0$.

You must show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- 9 Bernie buys x packets of seeds and y plants for his garden.
 He wants to buy more packets of seeds than plants.
 The inequality $x > y$ shows this information.

He also wants to buy

- less than 10 packets of seeds
- at least 2 plants.

- (a) Write down two more inequalities in x or y to show this information.

.....

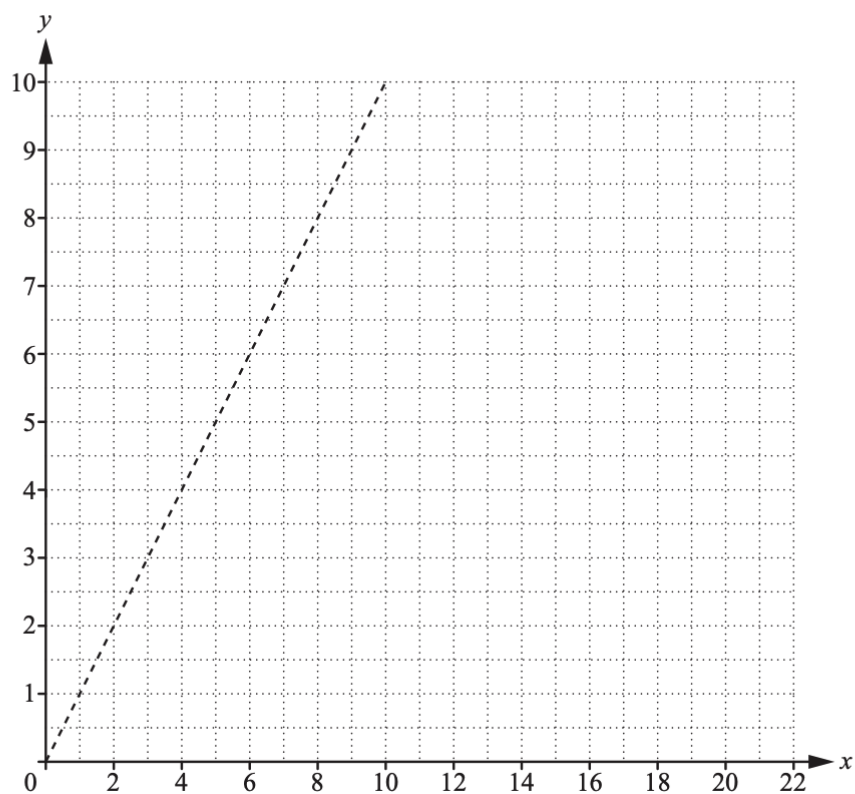
..... [2]

- (b) Each packet of seeds costs \$1 and each plant costs \$3.
 The maximum amount Bernie can spend is \$21.

Write down another inequality in x and y to show this information.

..... [1]

- (c) The line $x = y$ is drawn on the grid.
Draw three more lines to show your inequalities and shade the **unwanted** regions.



[5]

- (d) Bernie buys 8 packets of seeds.

- (i) Find the maximum number of plants he can buy.

..... [1]

- (ii) Find the total cost of these packets of seeds and plants.

\$..... [1]

- 11 On Monday, Ankuri sent this text message to two friends.

Today is Day Number 1.

Tomorrow, please add 1 to the Day Number and send this text message to two friends.

All the friends who receive a text message follow the instructions.

- (a) Complete the table.

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Day Number	1	2	3				
Number of text messages sent today	2	4					

[4]

- (b) Write down an expression for the number of text messages sent on Day Number n .

..... [1]

- (c) Ankuri thinks that, by the end of Day Number 3, the **total** number of text messages that have been sent is $2^4 - 2$.

- (i) Show that she is correct.

[2]

- (ii) Complete the statement.

The **total** number of text messages sent by the end of Day Number 5 is which is

equal to $2^k - 2$ where $k =$ [2]

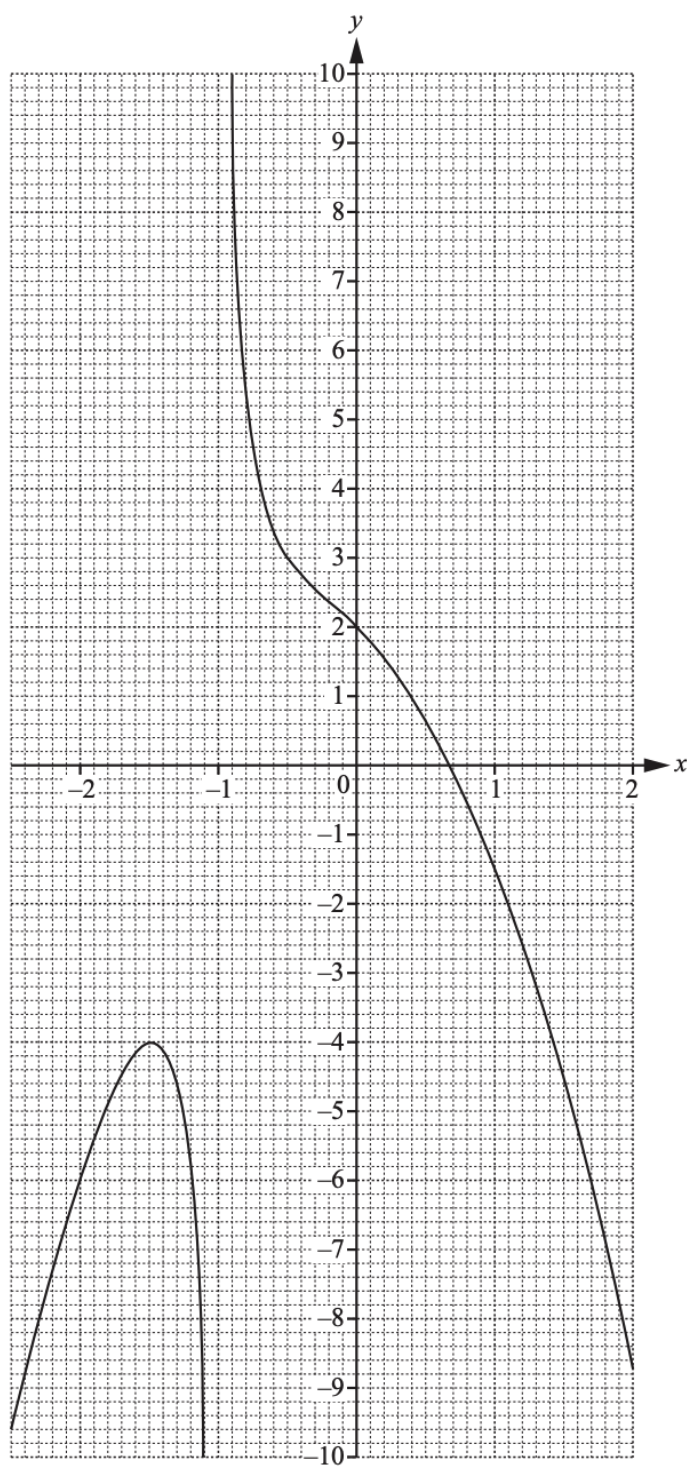
- (iii) Write down an expression for the **total** number of text messages sent by the end of Day Number n .

..... [1]

- (iv) Find the Day Number when the **total** number of text messages sent by the end of the day is 1022.

..... [1]

- 4 The diagram shows the graph of $y = f(x)$ for $-2.5 \leq x \leq 2$.



- (a) Find $f(1)$.

..... [1]

- (b) Solve $f(x) = 3$.

$x =$ [1]

- (c) The equation $f(x) = k$ has only one solution for $-2.5 \leq x \leq 2$.

Write down the range of values of k for which this is possible.

..... [2]

- (d) By drawing a suitable straight line, solve the equation $f(x) = x - 5$.

$x =$ or $x =$ or $x =$ [3]

- (e) Draw a tangent to the graph of $y = f(x)$ at the point where $x = 1$.

Use your tangent to estimate the gradient of $y = f(x)$ when $x = 1$.

..... [3]

6 (a) Expand the brackets and simplify.

(i) $4(2x + 5) - 5(3x - 7)$

..... [2]

(ii) $(x - 7)^2$

..... [2]

(b) Solve.

(i) $\frac{2x}{3} + 5 = -7$

$x =$ [3]

(ii) $4x + 9 = 3(2x - 7)$

$x =$ [3]

(iii) $3x^2 - 1 = 74$

$x =$ or $x =$ [3]

7 A line joins the points $A(-3, 8)$ and $B(2, -2)$.

(a) Find the co-ordinates of the midpoint of AB .

(.....,) [2]

(b) Find the equation of the line through A and B .
Give your answer in the form $y = mx + c$.

$y =$ [3]

(c) Another line is parallel to AB and passes through the point $(0, 7)$.

Write down the equation of this line.

..... [2]

(d) Find the equation of the line perpendicular to AB which passes through the point $(1, 5)$.
Give your answer in the form $ax + by + c = 0$ where a , b and c are integers.

..... [4]

- (b) Town A has a rectangular park.
The length of the park is x m.
The width of the park is 25 m shorter than the length.
The area of the park is 2200 m^2 .

(i) Show that $x^2 - 25x - 2200 = 0$.

[1]

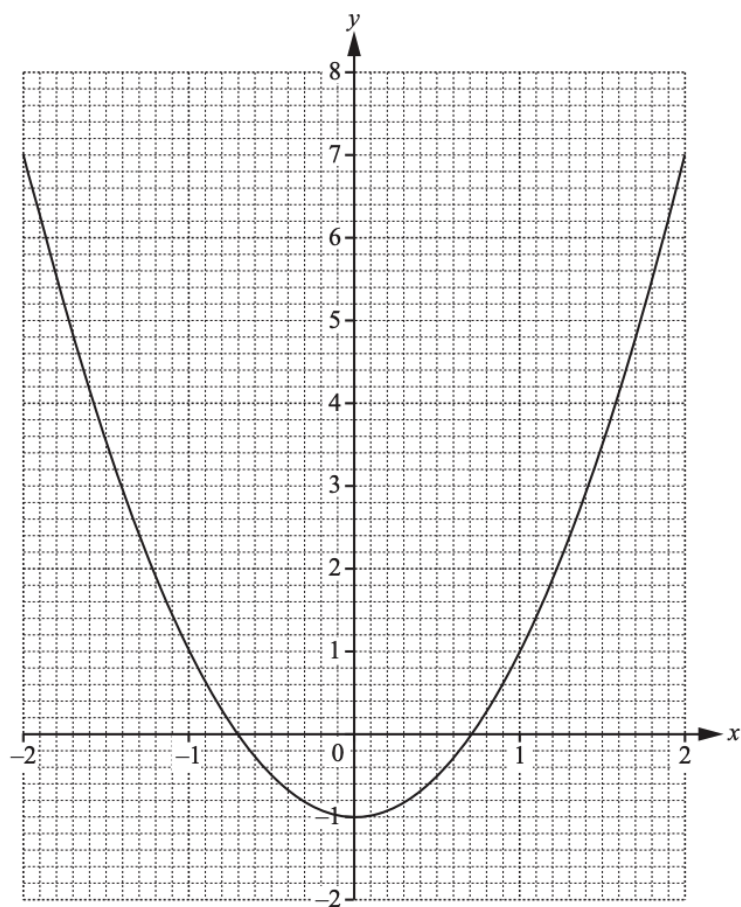
- (ii) Solve $x^2 - 25x - 2200 = 0$.
Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

4

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

The graph of $y = f(x)$, for $-2 \leq x \leq 2$, is drawn on the grid.



- (a) Use the graph to solve the equation $f(x) = 5$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

- (b) (i) Draw the tangent to the graph of $y = f(x)$ at the point $(-1.5, 3.5)$. [1]

- (ii) Use your tangent to estimate the gradient of $y = f(x)$ when $x = -1.5$.

$\dots\dots\dots$ [2]

(c) $g(x) = 2^x$

(i) Complete the table for $y = g(x)$.

x	-2	-1	0	1	2
y	0.25	0.5		2	4

[1]

(ii) On the grid opposite, draw the graph of $y = g(x)$ for $-2 \leq x \leq 2$.

[3]

(d) Use your graphs to solve

(i) the equation $f(x) = g(x)$,

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

(ii) the inequality $f(x) < g(x)$.

$\dots\dots\dots$ [1]

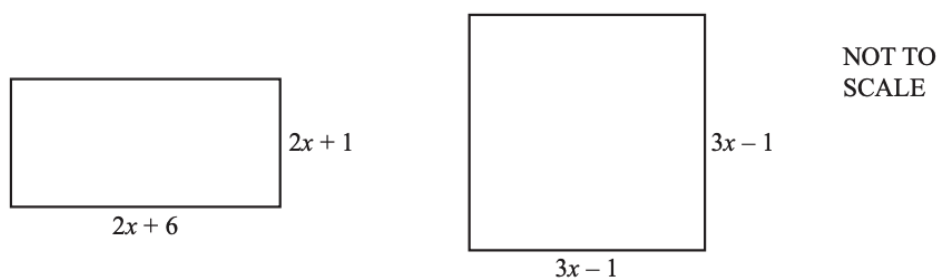
(e) (i) Write down the three values.

$g(-3) = \dots\dots\dots$ $g(-5) = \dots\dots\dots$ $g(-10) = \dots\dots\dots$ [1]

(ii) Complete the statement.

As x decreases, $g(x)$ approaches the value $\dots\dots\dots$ [1]

- 7 (a) In this part, all lengths are in centimetres.



- (i) Find the value of x when the perimeter of the rectangle is equal to the perimeter of the square.

$$x = \dots\dots\dots [3]$$

- (ii) Find the value of x when the area of the rectangle is equal to the area of the square.
Show all your working.

$$x = \dots\dots\dots [7]$$

(b) (i) Factorise $x^2 + 4x - 5$.

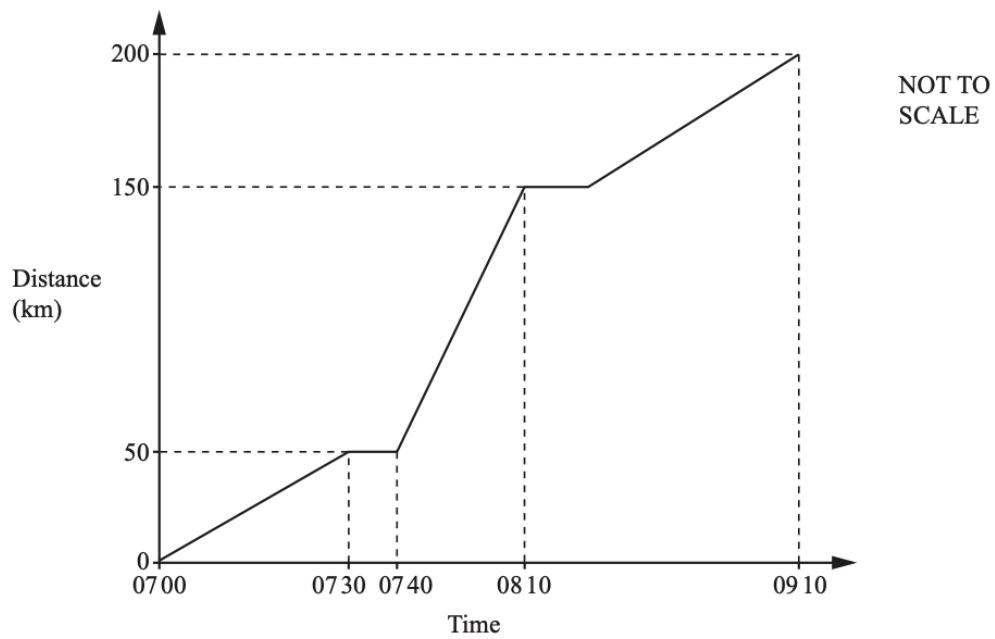
..... [2]

(ii) Solve the equation $\frac{5}{x} - \frac{8}{x+1} = 1$.

Show all your working.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

9 (a)



The distance-time graph shows the journey of a train.

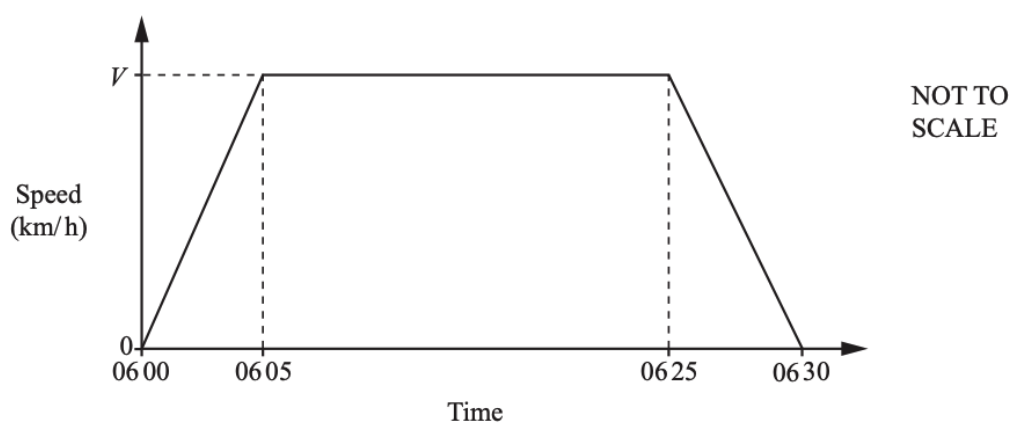
(i) Find the speed of the train between 07 00 and 07 30.

..... km/h [1]

(ii) Find the average speed for the whole journey.

..... km/h [3]

(b)



The speed-time graph shows the first 30 minutes of another train journey.

The distance travelled is 100 km.

The maximum speed of the train is V km/h.

(i) Find the value of V .

$V = \dots\dots\dots$ [3]

(ii) Find the acceleration of the train during the first 5 minutes.
Give your answer in m/s^2 .

$\dots\dots\dots \text{m/s}^2$ [2]

10 $f(x) = 3x - 2$ $g(x) = x^2$ $h(x) = 3^x$

(a) Find $f(-3)$.

..... [1]

(b) Find the value of x when $f(x) = 19$.

$x =$ [2]

(c) Find $fh(2)$.

..... [2]

(d) Find $gf(x) + f(x) + x$.
Give your answer in its simplest form.

..... [3]

(e) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

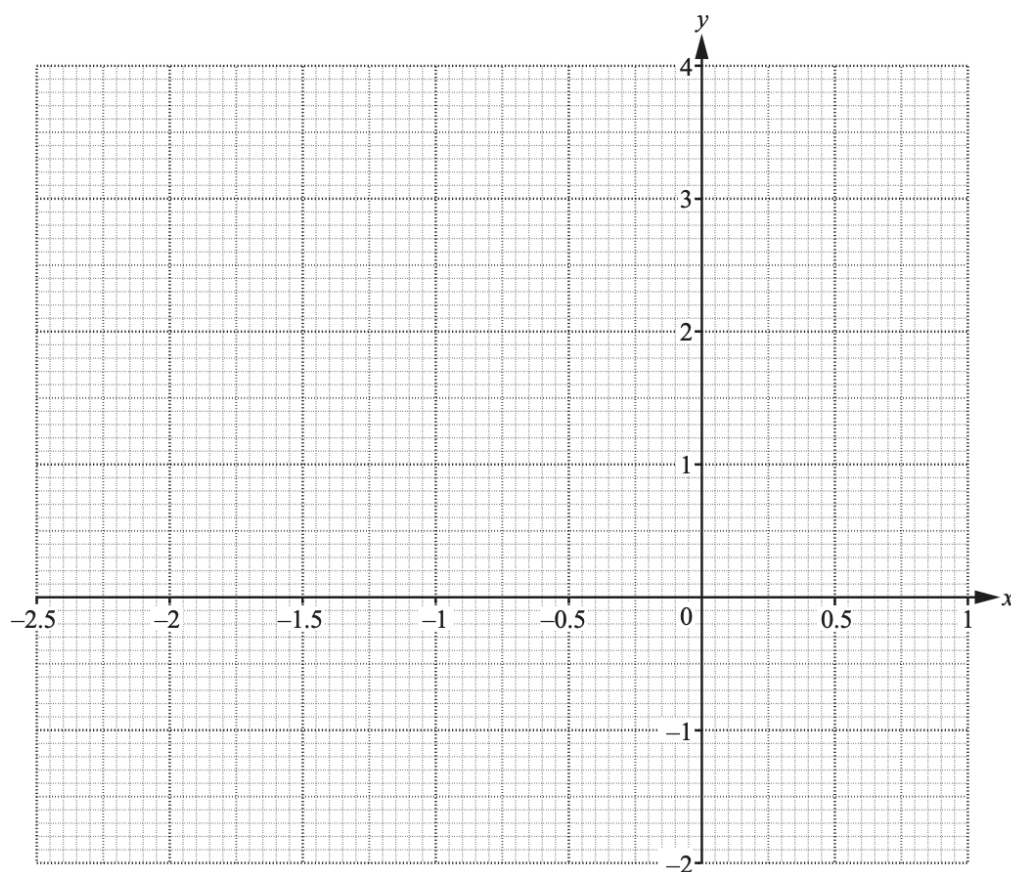
- 3 The table shows some values for $y = 2x^3 + 4x^2$.

x	-2.2	-2	-1.5	-1	-0.5	0	0.5	0.8
y	-1.94				0.75	0		3.58

- (a) Complete the table.

[4]

- (b) Draw the graph of $y = 2x^3 + 4x^2$ for $-2.2 \leq x \leq 0.8$.



[4]

- (c) Find the number of solutions to the equation $2x^3 + 4x^2 = 3$.

..... [1]

- (d) (i) The equation $2x^3 + 4x^2 - x = 1$ can be solved by drawing a straight line on the grid.

Write down the equation of this straight line.

$$y = \dots\dots\dots [1]$$

- (ii) Use your graph to solve the equation $2x^3 + 4x^2 - x = 1$.

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots \text{ or } x = \dots\dots\dots [3]$$

- (e) The tangent to the graph of $y = 2x^3 + 4x^2$ has a negative gradient when $x = k$.

Complete the inequality for k .

$$\dots\dots\dots < k < \dots\dots\dots [2]$$

- 7 (a) Solve the simultaneous equations.
You must show all your working.

$$\begin{aligned} 2x + 3y &= 11 \\ 3x - 5y &= -50 \end{aligned}$$

$$x = \dots\dots\dots$$

$$y = \dots\dots\dots [4]$$

(b) $x^2 - 12x + a = (x + b)^2$

Find the value of a and the value of b .

$$a = \dots\dots\dots$$

$$b = \dots\dots\dots [3]$$

- (c) Write as a single fraction in its simplest form.

$$\frac{x}{2x-5} + \frac{3x+2}{x-1}$$

$$\dots\dots\dots [4]$$

3 (a) Solve.

$$11x + 15 = 3x - 7$$

$$x = \dots\dots\dots [2]$$

(b) (i) Factorise.

$$x^2 + 9x - 22$$

$$\dots\dots\dots [2]$$

(ii) Solve.

$$x^2 + 9x - 22 = 0$$

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots [1]$$

(c) Rearrange $y = \frac{2(x-a)}{x}$ to make x the subject.

$$x = \dots\dots\dots [4]$$

(d) Simplify.

$$\frac{x^2 - 6x}{x^2 - 36}$$

$$\dots\dots\dots [3]$$

4

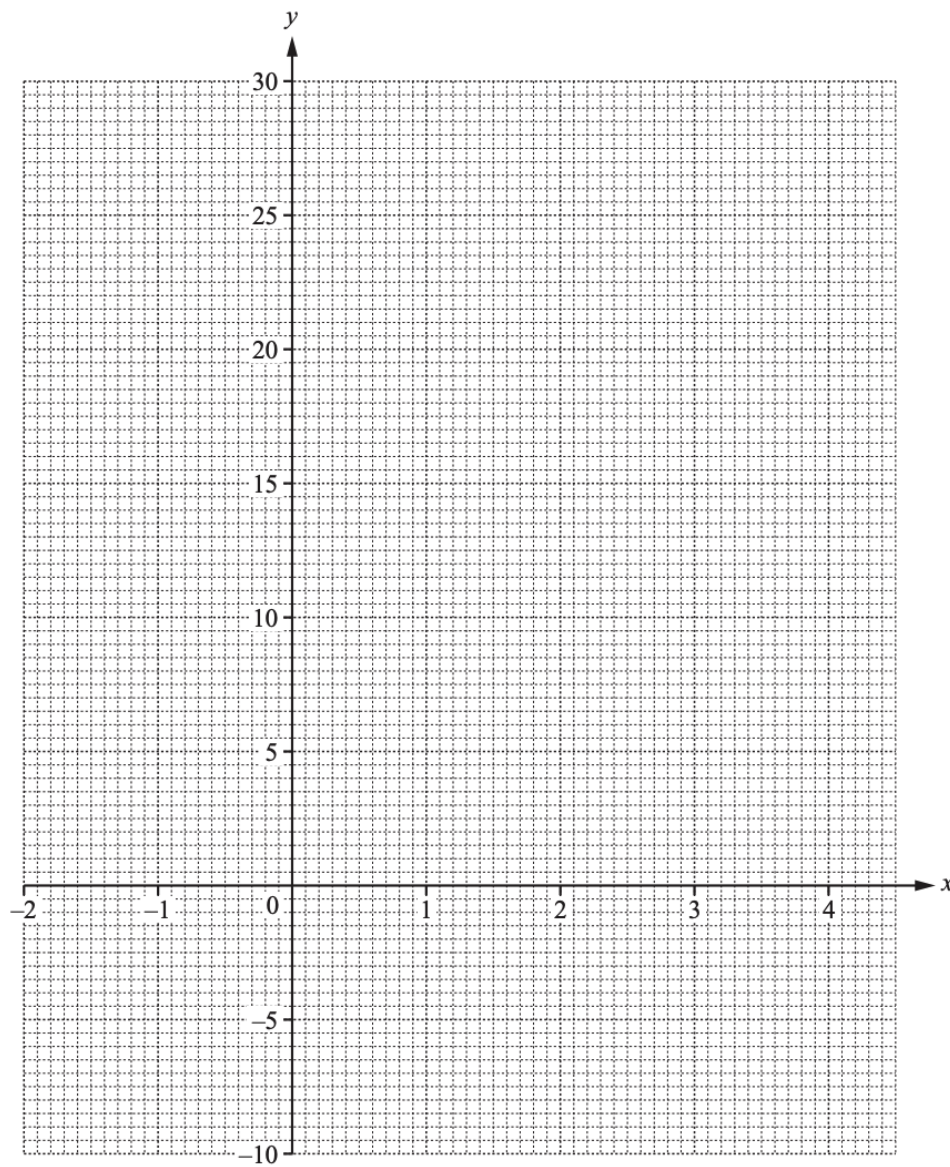
$$f(x) = x^3 - 4x^2 + 15$$

(a) Complete the table of values for $y = f(x)$.

x	-2	-1	-0.5	0	1	2	2.5	3	3.5	4	4.5
y	-9		13.9	15	12		5.6	6	8.9	15	25.1

[2]

(b) On the grid, draw the graph of $y = f(x)$ for $-2 \leq x \leq 4.5$.



[4]

(c) Use your graph to solve the equation $f(x) = 0$.

$x = \dots\dots\dots$ [1]

(d) By drawing a suitable tangent, estimate the gradient of the graph of $y = f(x)$ when $x = 3.5$.

$\dots\dots\dots$ [3]

(e) By drawing a suitable straight line on the grid, solve the equation $x^3 - 4x^2 - 2x + 5 = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

7 $f(x) = 3 - 2x$ $g(x) = \frac{4}{x}, x \neq 0$ $h(x) = 4^x$

(a) Find $f(5)$.

..... [1]

(b) Find $gh(3)$.

..... [2]

(c) Find $f^{-1}(x)$.

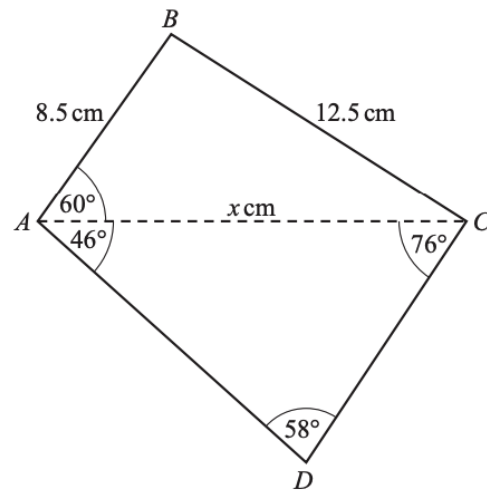
$f^{-1}(x) =$ [2]

(d) Show that $hf(x) = \frac{64}{16^x}$.

[3]

(e) Find the value of x when $h(x) = g(0.5)$.

$x =$ [2]



NOT TO
SCALE

The diagram shows a quadrilateral $ABCD$.

- (a) The length of AC is $x \text{ cm}$.

Use the cosine rule in triangle ABC to show that $2x^2 - 17x - 168 = 0$.

[4]

- (b) Solve the equation $2x^2 - 17x - 168 = 0$.
Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

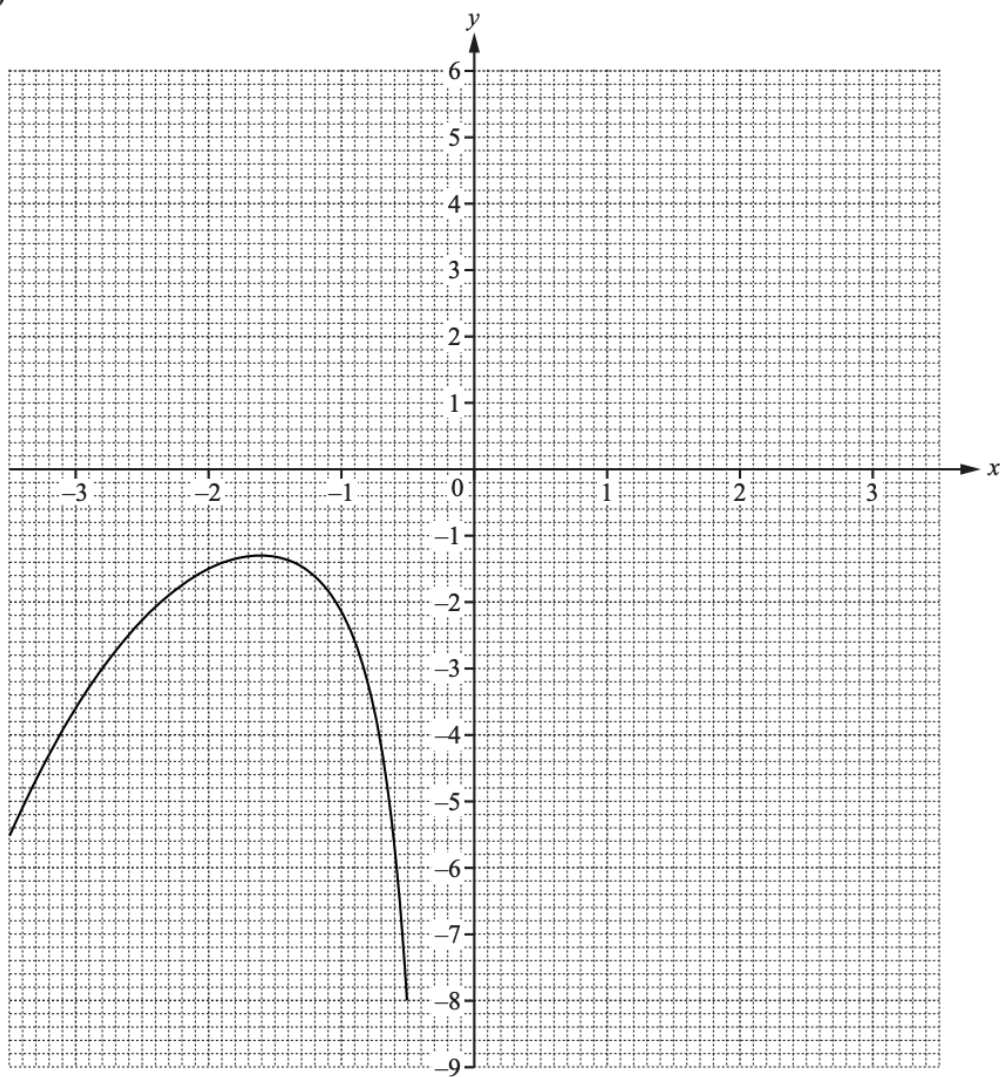
5 $y = \frac{x^3}{8} - \frac{2}{x^2}, x \neq 0$

(a) Complete the table of values.

x	0.5	1	1.5	2	2.5	3	3.5
y	-8.0	-1.9	-0.5	0.5	1.6		

[2]

(b)



The graph of $y = \frac{x^3}{8} - \frac{2}{x^2}$ for $-3.5 \leq x \leq -0.5$ has already been drawn.

On the grid, draw the graph of $y = \frac{x^3}{8} - \frac{2}{x^2}$ for $0.5 \leq x \leq 3.5$.

[4]

- (c) Use your graph to solve the equation $\frac{x^3}{8} - \frac{2}{x^2} = 0$.

$x = \dots\dots\dots$ [1]

- (d) $\frac{x^3}{8} - \frac{2}{x^2} = k$ and k is an integer.

Write down a value of k when the equation $\frac{x^3}{8} - \frac{2}{x^2} = k$ has

- (i) one answer,

$k = \dots\dots\dots$ [1]

- (ii) three answers.

$k = \dots\dots\dots$ [1]

- (e) By drawing a suitable tangent, estimate the gradient of the curve where $x = -3$.

$\dots\dots\dots$ [3]

- (f) (i) By drawing a suitable line on the grid, find x when $\frac{x^3}{8} - \frac{2}{x^2} = 6 - x$.

$x = \dots\dots\dots$ [3]

- (ii) The equation $\frac{x^3}{8} - \frac{2}{x^2} = 6 - x$ can be written as $x^5 + ax^3 + bx^2 + c = 0$.

Find the values of a , b and c .

$a = \dots\dots\dots$

$b = \dots\dots\dots$

$c = \dots\dots\dots$ [4]

- 8 (a) The cost of 1 apple is a cents.
The cost of 1 pear is p cents.
The total cost of 7 apples and 9 pears is 354 cents.

(i) Write down an equation in terms of a and p .

..... [1]

(ii) The cost of 1 pear is 2 cents more than the cost of 1 apple.

Find the value of a and the value of p .

$a =$

$p =$ [3]

(b) Rowena walks 2 km at an average speed of x km/h.

(i) Write down an expression, in terms of x , for the time taken.

..... h [1]

(ii) Rowena then walks 3 km at an average speed of $(x - 1)$ km/h.
The total time taken to walk the 5 km is 2 hours.

(a) Show that $2x^2 - 7x + 2 = 0$.

[3]

- (b) Find the value of x .
Show all your working and give your answer correct to 2 decimal places.

$$x = \dots\dots\dots [4]$$

9 $f(x) = 1 - 2x$ $g(x) = x + 4$ $h(x) = x^2 + 1$

(a) Find $f(-1)$.

..... [1]

(b) Solve the equation.

$$2f(x) = g(x)$$

$x =$ [2]

(c) Find $fg(x)$.

Give your answer in its simplest form.

..... [2]

(d) Find $hh(2)$.

..... [2]

(e) Find $f^{-1}(x)$.

$f^{-1}(x) =$ [2]

(f) $\text{hgf}(x) = 4x^2 + px + q$

Find the value of p and the value of q .

$$p = \dots\dots\dots$$

$$q = \dots\dots\dots [4]$$

2 (a) Solve.

$$\frac{x}{7} = 49$$

$x = \dots\dots\dots$ [1]

(b) Simplify.

(i) x^0

$\dots\dots\dots$ [1]

(ii) $x^7 \times x^3$

$\dots\dots\dots$ [1]

(iii) $\frac{(3x^6)^2}{x^{-4}}$

$\dots\dots\dots$ [2]

(c) (i) Factorise completely.

$$2x^2 - 18$$

$\dots\dots\dots$ [2]

(ii) Simplify.

$$\frac{2x^2 - 18}{x^2 + 7x - 30}$$

$\dots\dots\dots$ [3]

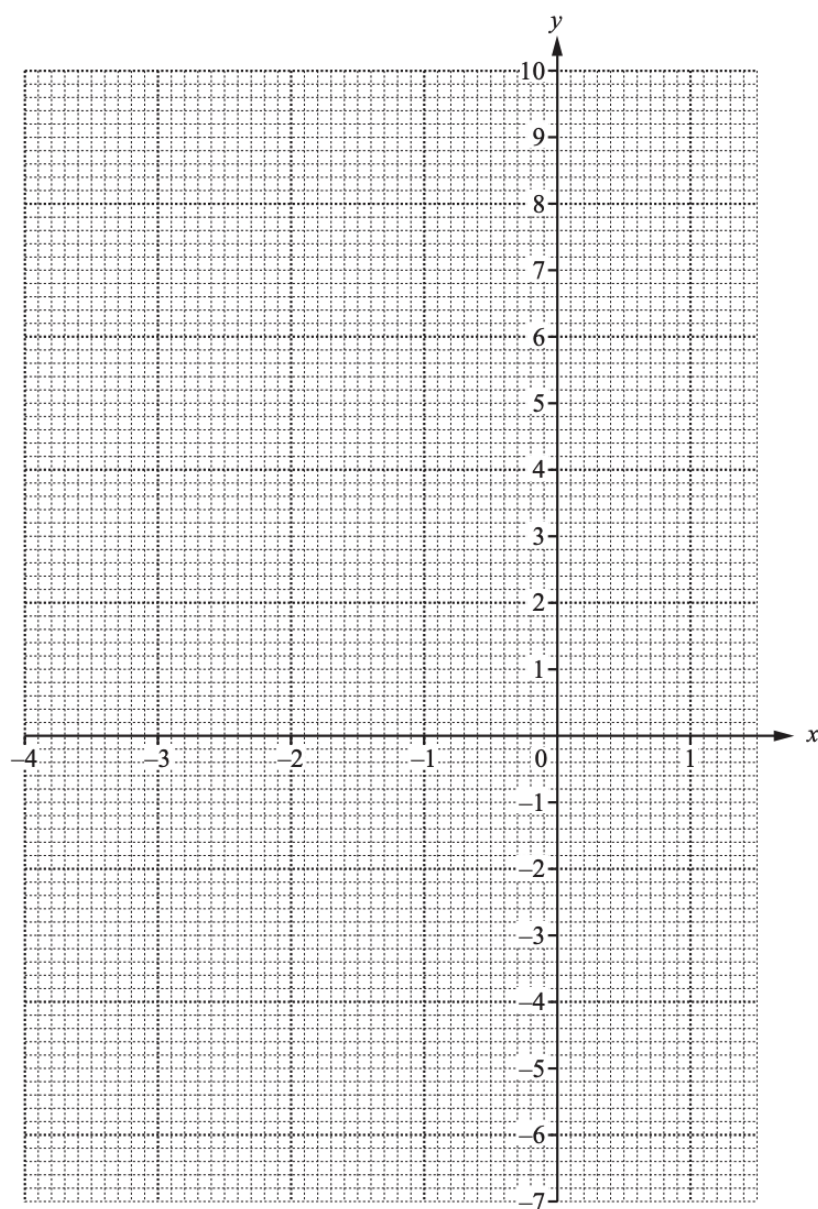
- 7 The table shows some values of $y = 2x^2 + 5x - 3$ for $-4 \leq x \leq 1.5$.

x	-4	-3	-2	-1	0	1	1.5
y		0	-5		-3	4	

(a) Complete the table.

[3]

(b) On the grid, draw the graph of $y = 2x^2 + 5x - 3$ for $-4 \leq x \leq 1.5$.



[4]

(c) Use your graph to solve the equation $2x^2 + 5x - 3 = 3$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

(d) $y = 2x^2 + 5x - 3$ can be written in the form $y = 2(x + a)^2 + b$.

Find the value of a and the value of b .

$a = \dots\dots\dots$

$b = \dots\dots\dots$ [3]

- 8** Line A has equation $y = 5x - 4$.
Line B has equation $3x + 2y = 18$.

(a) Find the gradient of

(i) line A ,

..... [1]

(ii) line B .

..... [1]

(b) Write down the co-ordinates of the point where line A crosses the x -axis.

(.....,) [2]

(c) Find the equation of the line perpendicular to line A which passes through the point $(10, 9)$.
Give your answer in the form $y = mx + c$.

$y =$ [4]

(d) Work out the co-ordinates of the point of intersection of line A and line B .

(.....,) [3]

(e) Work out the area enclosed by line A , line B and the y -axis.

..... [3]

- 9 Luigi and Alfredo run in a 10 km race.
 Luigi's average speed was x km/h.
 Alfredo's average speed was 0.5 km/h slower than Luigi's average speed.

- (a) Luigi took $\frac{10}{x}$ hours to run the race.

Write down an expression, in terms of x , for the time that Alfredo took to run the race.

..... h [1]

- (b) Alfredo took 0.25 hours longer than Luigi to run the race.

- (i) Show that $2x^2 - x - 40 = 0$.

[4]

- (ii) Use the quadratic formula to solve $2x^2 - x - 40 = 0$.
 Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- (iii) Work out the time that Luigi took to run the 10 km race.
 Give your answer in hours and minutes, correct to the nearest minute.

..... h min [3]

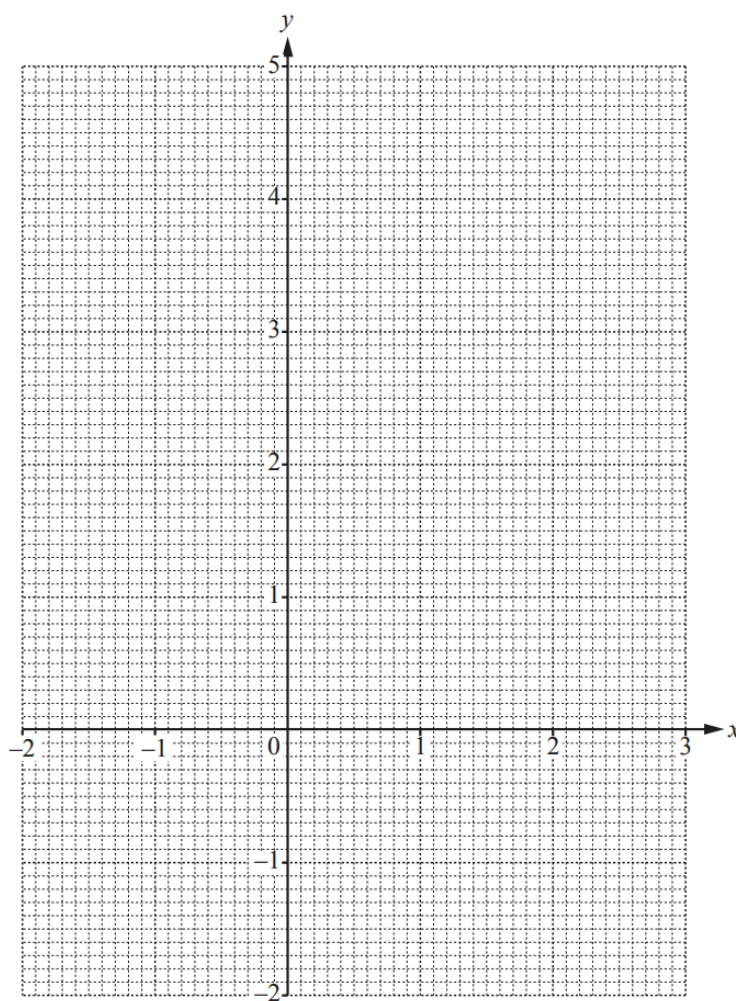
- 7 The table shows some values of $y = x + \frac{1}{x^2}$, $x \neq 0$.

x	-2	-1.5	-1	-0.75	-0.5		0.5	0.75	1	1.5	2	3
y	-1.75	-1.06	0	1.03			4.50	2.53	2		2.25	

(a) Complete the table of values.

[3]

(b) On the grid, draw the graph of $y = x + \frac{1}{x^2}$ for $-2 \leq x \leq -0.5$ and $0.5 \leq x \leq 3$.



[5]

(c) Use your graph to solve the equation $x + \frac{1}{x^2} = 1.5$.

$x =$ [1]

(d) The line $y = ax + b$ can be drawn on the grid to solve the equation $\frac{1}{x^2} = 2.5 - 2x$.

(i) Find the value of a and the value of b .

$a =$

$b =$ [2]

(ii) Draw the line $y = ax + b$ to solve the equation $\frac{1}{x^2} = 2.5 - 2x$.

$x =$ [3]

(e) By drawing a suitable tangent, find an estimate of the gradient of the curve at the point where $x = 2$.

..... [3]

- 8 (a)** y is directly proportional to the positive square root of $(x + 2)$.
When $x = 7$, $y = 9$.

Find y when $x = 23$.

$y = \dots\dots\dots$ [3]

- (b)** Simplify.

$$\frac{x^2 + 12x + 36}{x^2 + 4x - 12}$$

$\dots\dots\dots$ [5]

(c) $W = \sqrt{\frac{X-a}{a}}$

Make a the subject of the formula.

$a = \dots\dots\dots$ [5]

(d) Write as a single fraction in its simplest form.

$$\frac{x-2}{x+1} - \frac{x+3}{x-1}$$

$\dots\dots\dots$ [5]

11 $f(x) = 2 - 3x$ $g(x) = 7x + 3$

(a) Find

(i) $f(-3)$,

..... [1]

(ii) $g(2x)$.

..... [1]

(b) Find $gf(x)$ in its simplest form.

..... [2]

(c) Find x when $3f(x) = 7$.

$x =$ [3]

(d) Solve the equation.

$$f(x + 4) - g(x) = 0$$

$x =$ [3]

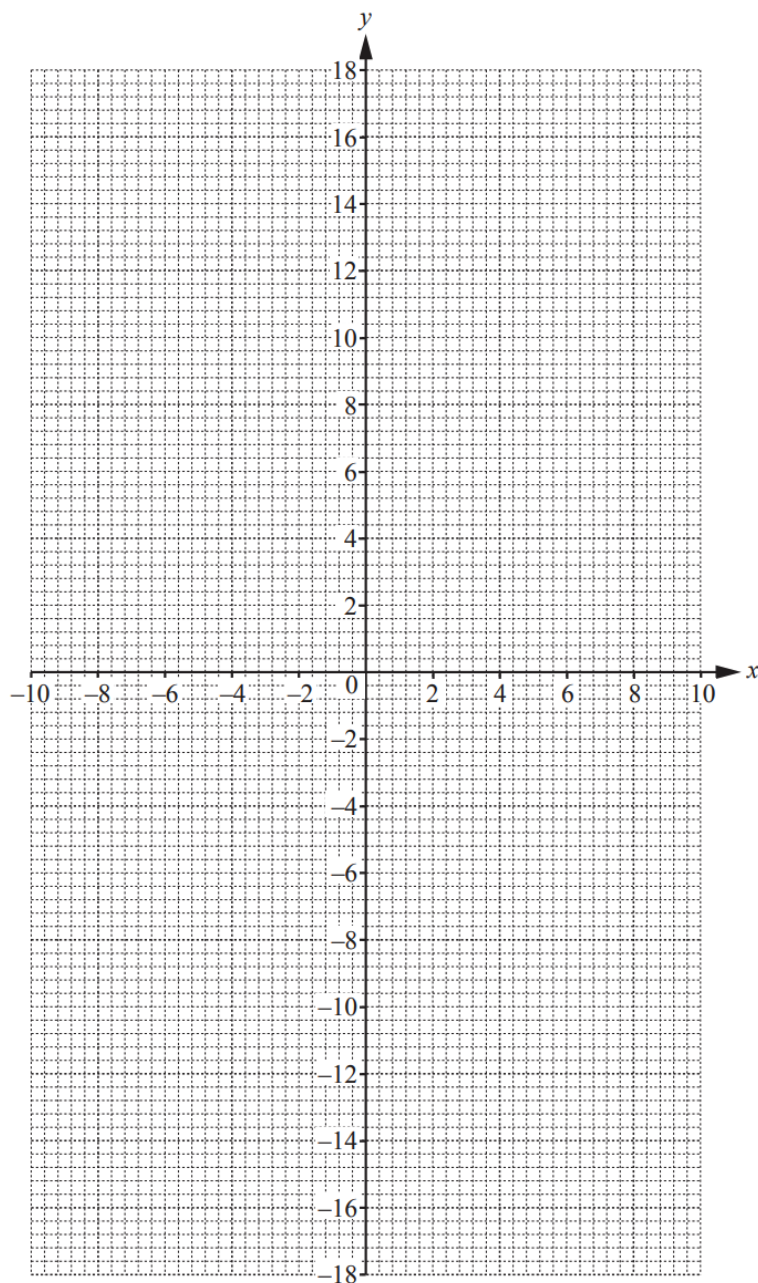
5 $f(x) = \frac{20}{x} + x, \quad x \neq 0$

(a) Complete the table.

x	-10	-8	-5	-2	-1.6		1.6	2	5	8	10
$f(x)$	-12	-10.5	-9	-12	-14.1		14.1	12			12

[2]

(b) On the grid, draw the graph of $y = f(x)$ for $-10 \leq x \leq -1.6$ and $1.6 \leq x \leq 10$.



[5]

- (c) Using your graph, solve the equation $f(x) = 11$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

- (d) k is a prime number and $f(x) = k$ has no solutions.

Find the possible values of k .

$\dots\dots\dots$ [2]

- (e) The gradient of the graph of $y = f(x)$ at the point $(2, 12)$ is -4 .

Write down the co-ordinates of the other point on the graph of $y = f(x)$ where the gradient is -4 .

$(\dots\dots\dots, \dots\dots\dots)$ [1]

- (f) (i) The equation $f(x) = x^2$ can be written as $x^3 + px^2 + q = 0$.

Show that $p = -1$ and $q = -20$.

[2]

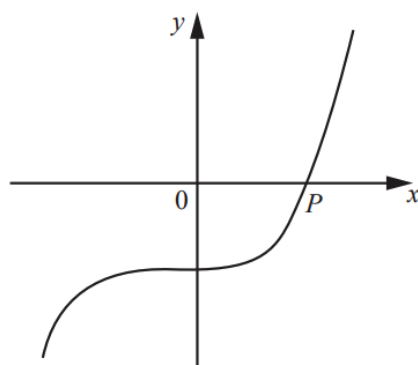
- (ii) On the grid opposite, draw the graph of $y = x^2$ for $-4 \leq x \leq 4$.

[2]

- (iii) Using your graphs, solve the equation $x^3 - x^2 - 20 = 0$.

$x = \dots\dots\dots$ [1]

- (iv)



NOT TO
SCALE

The diagram shows a **sketch** of the graph of $y = x^3 - x^2 - 20$.
 P is the point $(n, 0)$.

Write down the value of n .

$n = \dots\dots\dots$ [1]

6 (a)



x cm

NOT TO
SCALE

The perimeter of the rectangle is 80 cm.
The area of the rectangle is A cm².

- (i) Show that $x^2 - 40x + A = 0$.

[3]

- (ii) When $A = 300$, solve, by factorising, the equation $x^2 - 40x + A = 0$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

- (iii) When $A = 200$, solve, by using the quadratic formula, the equation $x^2 - 40x + A = 0$.
Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- (b) A car completes a 200 km journey with an average speed of x km/h.
 The car completes the return journey of 200 km with an average speed of $(x + 10)$ km/h.
- (i) Show that the difference between the time taken for each of the two journeys is $\frac{2000}{x(x+10)}$ hours.

[3]

- (ii) Find the difference between the time taken for each of the two journeys when $x = 80$.
 Give your answer in **minutes** and **seconds**.

..... min s [3]

8

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

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

$$h(x) = 2^x$$

(a) Solve the equation $f(x) = g(1)$.

$$x = \dots\dots\dots [2]$$

(b) Find the value of $fh(3)$.

$$\dots\dots\dots [2]$$

(c) Find $f^{-1}(x)$.

$$f^{-1}(x) = \dots\dots\dots [2]$$

(d) Find $gf(x)$ in its simplest form.

$$\dots\dots\dots [3]$$

- (e) Solve the equation $h^{-1}(x) = 0.5$.

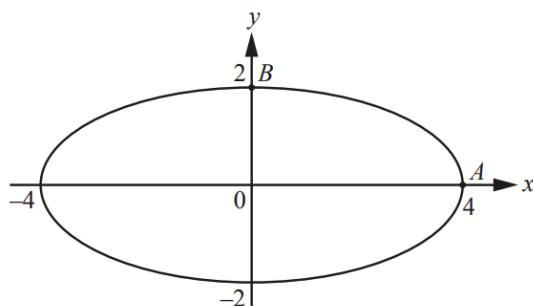
$x = \dots\dots\dots$ [1]

(f) $\frac{1}{h(x)} = 2^{kx}$

Write down the value of k .

$k = \dots\dots\dots$ [1]

9



NOT TO
SCALE

The diagram shows a curve with equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$.

- (a) A is the point $(4, 0)$ and B is the point $(0, 2)$.

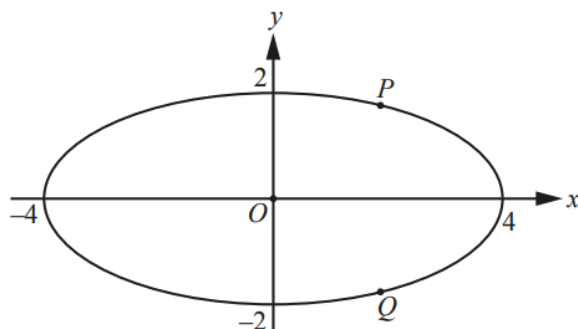
- (i) Find the equation of the straight line that passes through A and B .
Give your answer in the form $y = mx + c$.

$y = \dots\dots\dots$ [3]

- (ii) Show that $a^2 = 16$ and $b^2 = 4$.

[2]

(b)



NOT TO
SCALE

$P(2, k)$ and $Q(2, -k)$ are points on the curve $\frac{x^2}{16} + \frac{y^2}{4} = 1$.

(i) Find the value of k .

$k = \dots\dots\dots [3]$

(ii) Calculate angle POQ .

Angle $POQ = \dots\dots\dots [3]$

(c) The area enclosed by a curve with equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ is πab .

(i) Find the area enclosed by the curve $\frac{x^2}{16} + \frac{y^2}{4} = 1$.

Give your answer as a multiple of π .

$\dots\dots\dots [1]$

(ii) A curve, mathematically similar to the one in the diagrams, intersects the x -axis at $(12, 0)$ and $(-12, 0)$.

Work out the area enclosed by this curve, giving your answer as a multiple of π .

$\dots\dots\dots [2]$

2 (a) Work out the value of x in each of the following.

(i) $3^x = 243$

$x = \dots\dots\dots$ [1]

(ii) $16^x = 4$

$x = \dots\dots\dots$ [1]

(iii) $8^x = 32$

$x = \dots\dots\dots$ [2]

(iv) $27^x = \frac{1}{9}$

$x = \dots\dots\dots$ [2]

(b) Solve by factorisation.

$$y^2 - 7y - 30 = 0$$

Show your working.

$y = \dots\dots\dots$ or $y = \dots\dots\dots$ [3]

4

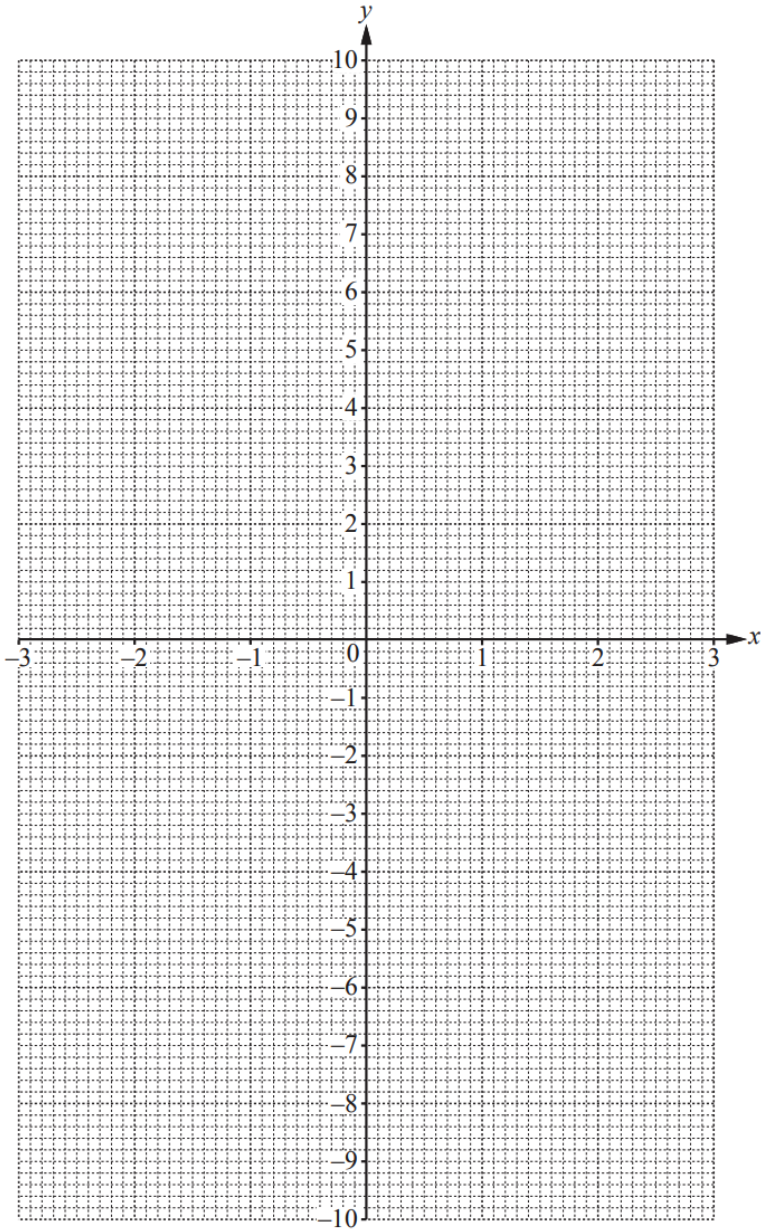
$f(x) = x^2 - \frac{1}{x} - 4, \quad x \neq 0$

(a) (i) Complete the table.

x	-3	-2	-1	-0.5	-0.1	0.2	0.5	1	2	3
$f(x)$	5.3	0.5		-1.8	6.0	-9.0	-5.8	-4		4.7

[2]

(ii) On the grid, draw the graph of $y = f(x)$ for $-3 \leq x \leq -0.1$ and $0.2 \leq x \leq 3$.



[5]

- (b) Use your graph to solve the equation $f(x) = 0$.

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots \text{ or } x = \dots\dots\dots [3]$$

- (c) Find an integer k , for which $f(x) = k$ has one solution.

$$k = \dots\dots\dots [1]$$

- (d) (i) By drawing a suitable straight line, solve the equation $f(x) + 2 = -5x$.

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots [4]$$

- (ii) $f(x) + 2 = -5x$ can be written as $x^3 + ax^2 + bx - 1 = 0$.

Find the value of a and the value of b .

$$a = \dots\dots\dots$$

$$b = \dots\dots\dots [2]$$

8 $f(x) = 5x + 7$ $g(x) = \frac{4}{x-3}, x \neq 3$

(a) Find

(i) $fg(1),$

..... [2]

(ii) $gf(x),$

..... [2]

(iii) $g^{-1}(x),$

$g^{-1}(x) =$ [3]

(iv) $f^{-1}f(2).$

..... [1]

(b) $f(x) = g(x)$

(i) Show that $5x^2 - 8x - 25 = 0$.

[3]

(ii) Solve $5x^2 - 8x - 25 = 0$.

Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- 9 A line joins the points $A(-2, -5)$ and $B(4, 13)$.

(a) Calculate the length AB .

$$AB = \dots\dots\dots [3]$$

(b) Find the equation of the line through A and B .
Give your answer in the form $y = mx + c$.

$$y = \dots\dots\dots [3]$$

(c) Another line is parallel to AB and passes through the point $(0, -5)$.

Write down the equation of this line.

$$\dots\dots\dots [2]$$

(d) Find the equation of the perpendicular bisector of AB .

$$\dots\dots\dots [5]$$

- 2 (a) Solve the inequality.

$$5x - 3 > 9$$

..... [2]

- (b) Factorise completely.

(i) $xy - 18 + 3y - 6x$

..... [2]

(ii) $8x^2 - 72y^2$

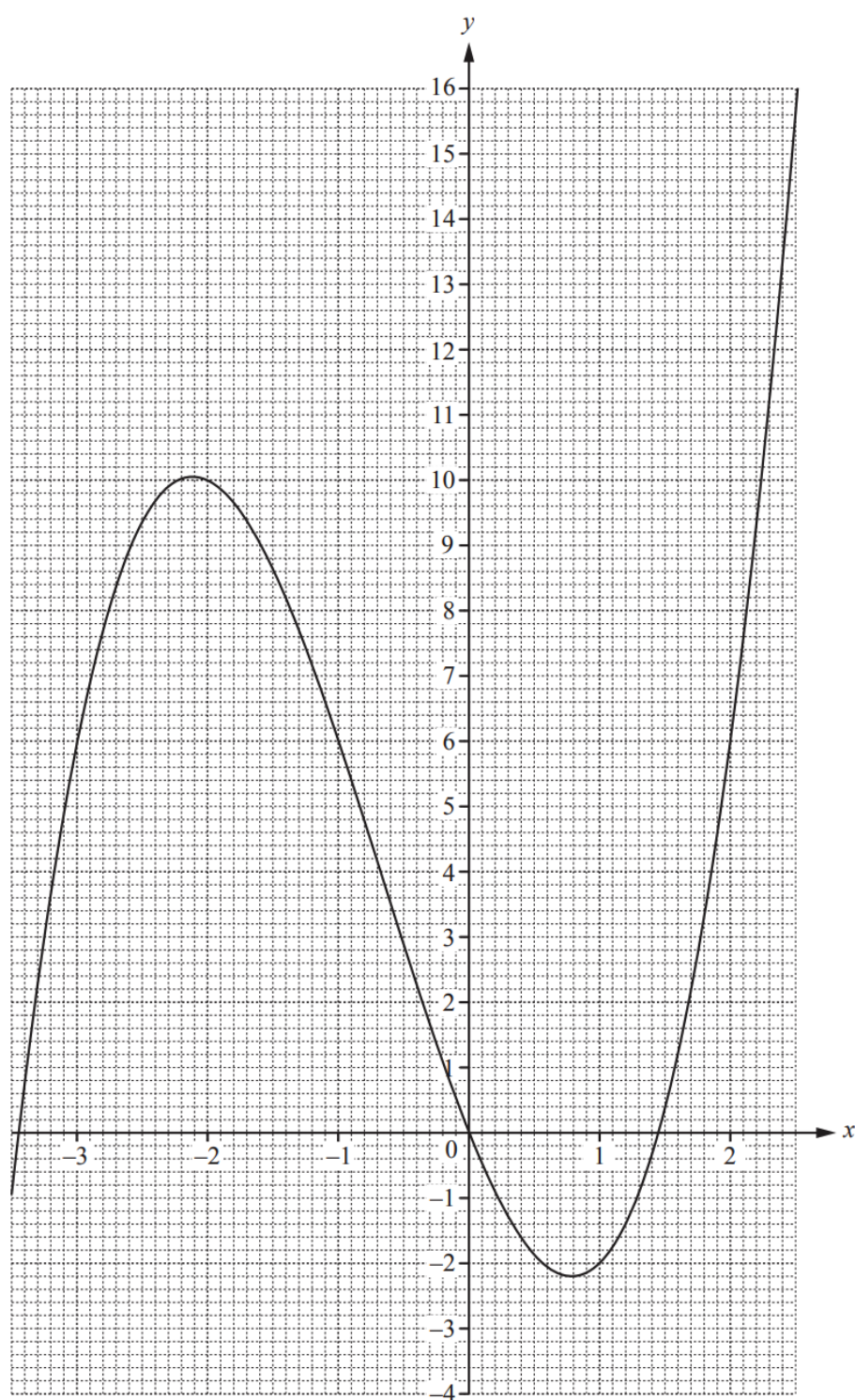
..... [3]

- (c) Make r the subject of the formula.

$$p + 5 = \frac{1 - 2r}{r}$$

$r =$ [4]

- 3 The diagram shows the graph of $y = f(x)$ for $-3.5 \leq x \leq 2.5$.



- (a) (i) Find $f(-2)$.

..... [1]

- (ii) Solve the equation $f(x) = 2$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

- (iii) Two tangents, each with gradient 0, can be drawn to the graph of $y = f(x)$.

Write down the equation of each tangent.

.....
..... [2]

- (b) (i) Complete the table for $g(x) = \frac{2}{x} + 3$ for $-3.5 \leq x \leq -0.5$ and $0.5 \leq x \leq 2.5$.

x	-3.5	-3	-2	-1	-0.5		0.5	1	2	2.5
$g(x)$	2.4	2.3		1			7	5		3.8

[3]

- (ii) On the grid opposite, draw the graph of $y = g(x)$.

[4]

- (iii) Use your graph to solve the equation $f(x) = g(x)$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [2]

- (c) Find $gf(-2)$.

..... [2]

- (d) Find $g^{-1}(5)$.

..... [1]

- 7 Alfonso runs 10 km at an average speed of x km/h.
The next day he runs 12 km at an average speed of $(x - 1)$ km/h.

The time taken for the 10 km run is 30 minutes less than the time taken for the 12 km run.

- (a) (i) Write down an equation in x and show that it simplifies to $x^2 - 5x - 20 = 0$.

[4]

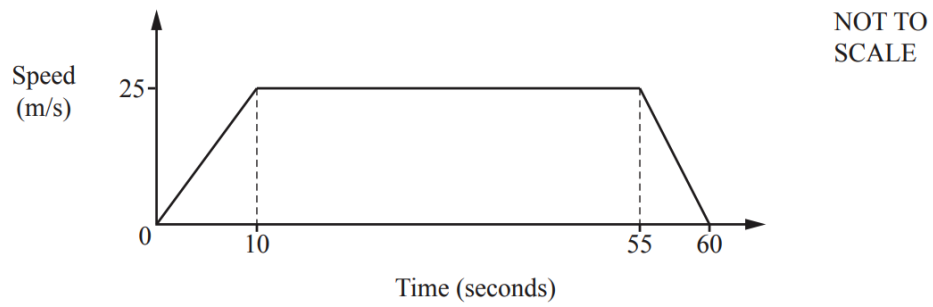
- (ii) Use the quadratic formula to solve the equation $x^2 - 5x - 20 = 0$.
Show your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- (iii) Find the time that Alfonso takes to complete the 12 km run.
Give your answer in hours and minutes correct to the nearest minute.

$\dots\dots\dots$ hours $\dots\dots\dots$ minutes [2]

- (b) A cheetah runs for 60 seconds.
The diagram shows the speed-time graph.



- (i) Work out the acceleration of the cheetah during the first 10 seconds.

.....m/s² [1]

- (ii) Calculate the distance travelled by the cheetah.

..... m [3]

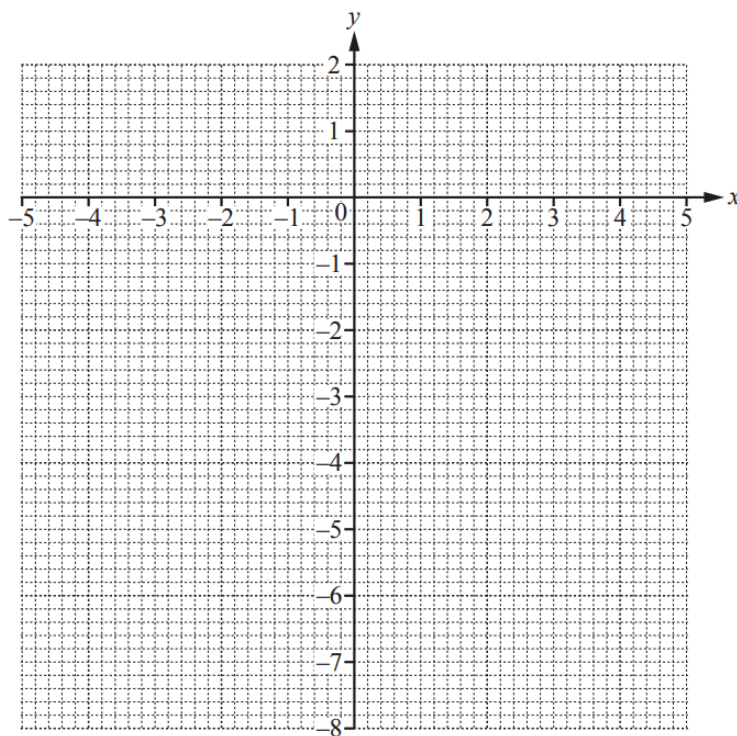
4 $y = 1 - \frac{2}{x^2}, x \neq 0$

(a) Complete the table.

x	-5	-4	-3	-2	-1	-0.5		0.5	1	2	3	4	5
y		0.88	0.78			-7		-7			0.78	0.88	

[3]

(b) On the grid, draw the graph of $y = 1 - \frac{2}{x^2}$ for $-5 \leq x \leq -0.5$ and $0.5 \leq x \leq 5$.



[5]

(c) (i) On the grid, draw the graph of $y = -x - 1$ for $-3 \leq x \leq 5$.

[2]

(ii) Solve the equation $1 - \frac{2}{x^2} = -x - 1$.

$x = \dots\dots\dots$ [1]

- (iii) The equation $1 - \frac{2}{x^2} = -x - 1$ can be written in the form $x^3 + px^2 + q = 0$.

Find the value of p and the value of q .

$$p = \dots\dots\dots$$

$$q = \dots\dots\dots [3]$$

- (d) The graph of $y = 1 - \frac{2}{x^2}$ cuts the positive x -axis at A .

B is the point $(0, -2)$.

- (i) Write down the co-ordinates of A .

$$(\dots\dots\dots, \dots\dots\dots) [1]$$

- (ii) On the grid, draw the straight line that passes through A and B . [1]

- (iii) Complete the statement.

The straight line that passes through A and B is a

at the point [2]

- 8 Apples cost x cents each and oranges cost $(x + 2)$ cents each.
 Dylan spends \$3.23 on apples and \$3.23 on oranges.
 The **total** of the number of apples and the number of oranges Dylan buys is 36.

(a) Write an equation in x and show that it simplifies to $18x^2 - 287x - 323 = 0$.

[4]

(b) (i) Find the two prime factors of 323.

.....,[1]

(ii) Complete the statement.

$$18x^2 - 287x - 323 = (18x \dots\dots\dots)(x \dots\dots\dots) \quad [2]$$

(iii) Solve the equation $18x^2 - 287x - 323 = 0$.

$$x = \dots\dots\dots \text{ or } x = \dots\dots\dots [1]$$

(c) Find the largest number of apples Dylan can buy for \$2.

.....[1]

9

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

$$g(x) = 3x - 2$$

$$h(x) = 3^x$$

(a) Find $hf(2) - fh(1)$.

.....[3]

(b) Find $gf(x)$, giving your answer in its simplest form.

..... [2]

(c) Solve the inequality $f(x) > g(x)$.

..... [2]

(d) Solve the equation $h(x) = \frac{1}{9}$.

$$x = \dots\dots\dots [1]$$

(e) Find $g^{-1}(x)$.

$$g^{-1}(x) = \dots\dots\dots [2]$$

(f) Find $\frac{5}{f(x)} + g(x)$.

Give your answer as a single fraction.

..... [3]

(g) Solve the equation $f^{-1}(x) = 4$.

$x =$ [1]

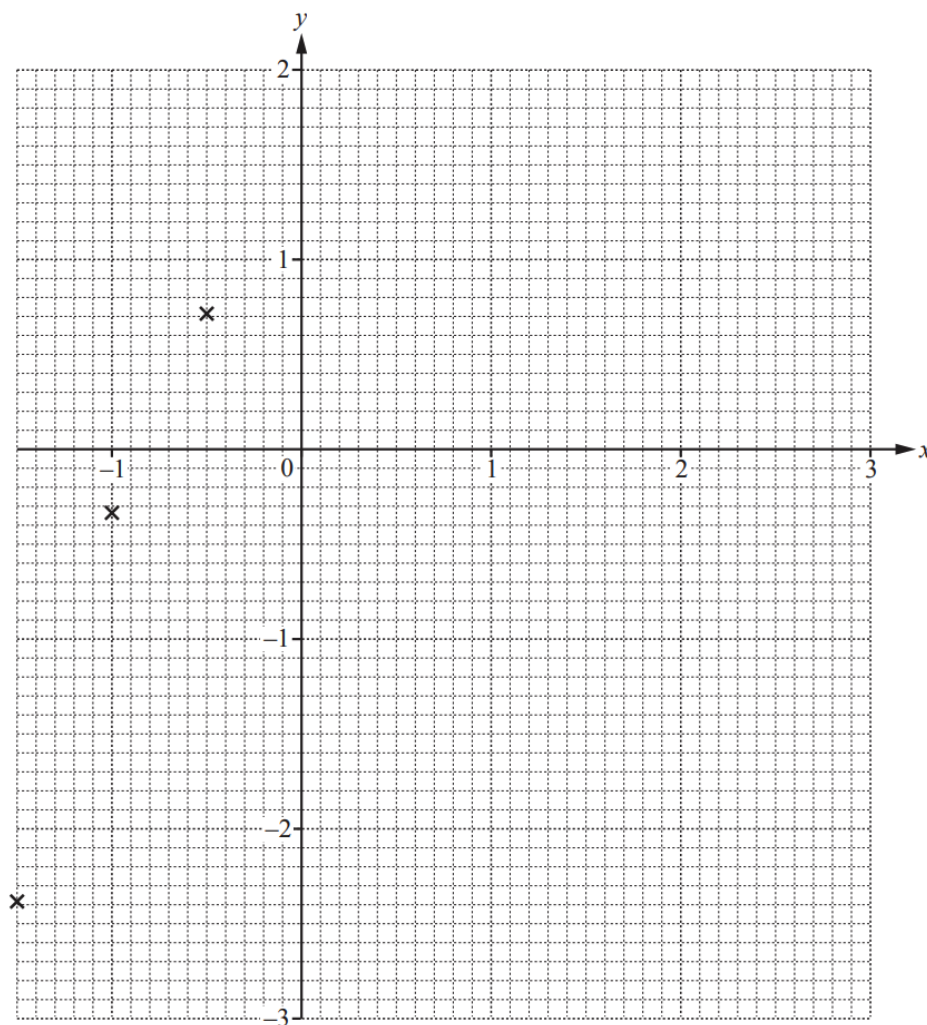
- 2 (a) Complete the table of values for $y = \frac{x^3}{3} - x^2 + 1$.

x	-1.5	-1	-0.5	0	0.5	1	1.5	2	2.5	3
y	-2.38	-0.33	0.71		0.79	0.33	-0.13	-0.33	-0.04	

[2]

- (b) Draw the graph of $y = \frac{x^3}{3} - x^2 + 1$ for $-1.5 \leq x \leq 3$.

The first 3 points have been plotted for you.



[4]

(c) Using your graph, solve the equations.

(i) $\frac{x^3}{3} - x^2 + 1 = 0$

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [3]

(ii) $\frac{x^3}{3} - x^2 + x + 1 = 0$

$x = \dots\dots\dots$ [2]

(d) Two tangents to the graph of $y = \frac{x^3}{3} - x^2 + 1$ can be drawn parallel to the x -axis.

(i) Write down the equation of each of these tangents.

$\dots\dots\dots$

$\dots\dots\dots$ [2]

(ii) For $0 \leq x \leq 3$, write down the smallest possible value of y .

$y = \dots\dots\dots$ [1]

- (b) A bag of sweets contains x orange sweets and y lemon sweets.
Each orange sweet costs 2 cents and each lemon sweet costs 3 cents.

The cost of a bag of sweets is less than 24 cents.

There are at least 9 sweets in each bag.

There are at least 2 lemon sweets in each bag.

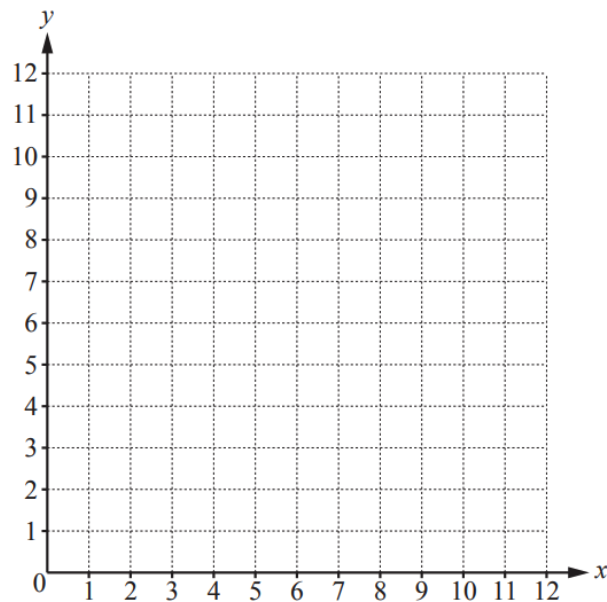
- (i) One of the inequalities that shows this information is $2x + 3y < 24$.

Write down the other two inequalities.

.....

..... [2]

- (ii) On the grid, by shading the unwanted regions, show the region which satisfies the three inequalities.



[4]

- (iii) Find the lowest cost of a bag of sweets.
Write down the value of x and the value of y that give this cost.

Lowest cost = cents

x =

y = [3]

- 7 (a) \$1 = 3.67 dirhams

Calculate the value, in dollars, of 200 dirhams.
Give your answer correct to 2 decimal places.

\$..... [2]

- (b) (i) Write as a single fraction, in its simplest form.

$$\frac{1000}{x} - \frac{1000}{x+1}$$

..... [3]

- (ii) One day in 2014, 1 euro was worth x rand.
One year later, 1 euro was worth $(x + 1)$ rand.

Winston changed 1000 rand into euros in both years.
In 2014 he received 4.50 euros more than in 2015.

Write an equation in terms of x and show that it simplifies to

$$9x^2 + 9x - 2000 = 0.$$

[3]

- (iii) Use the quadratic formula to solve the equation $9x^2 + 9x - 2000 = 0$.
Show all your working and give your answers correct to 2 decimal places.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- (iv) Calculate the number of euros Winston received in 2014.
Give your answer correct to 2 decimal places.

$\dots\dots\dots$ euros [2]

9 (a) $y = \frac{3}{x} + 2, \quad x \neq 0$

(i) Find the value of y when $x = -6$.

$y = \dots\dots\dots [1]$

(ii) Find x in terms of y .

$x = \dots\dots\dots [3]$

(b) $g(x) = 2 - x$ $h(x) = 2^x$

(i) Find $g(5)$.

$\dots\dots\dots [1]$

(ii) Find $hhh(2)$.

$\dots\dots\dots [2]$

(iii) Find x when $g(x) = h(3)$.

$x = \dots\dots\dots [2]$

(iv) Find x when $g^{-1}(x) = -1$.

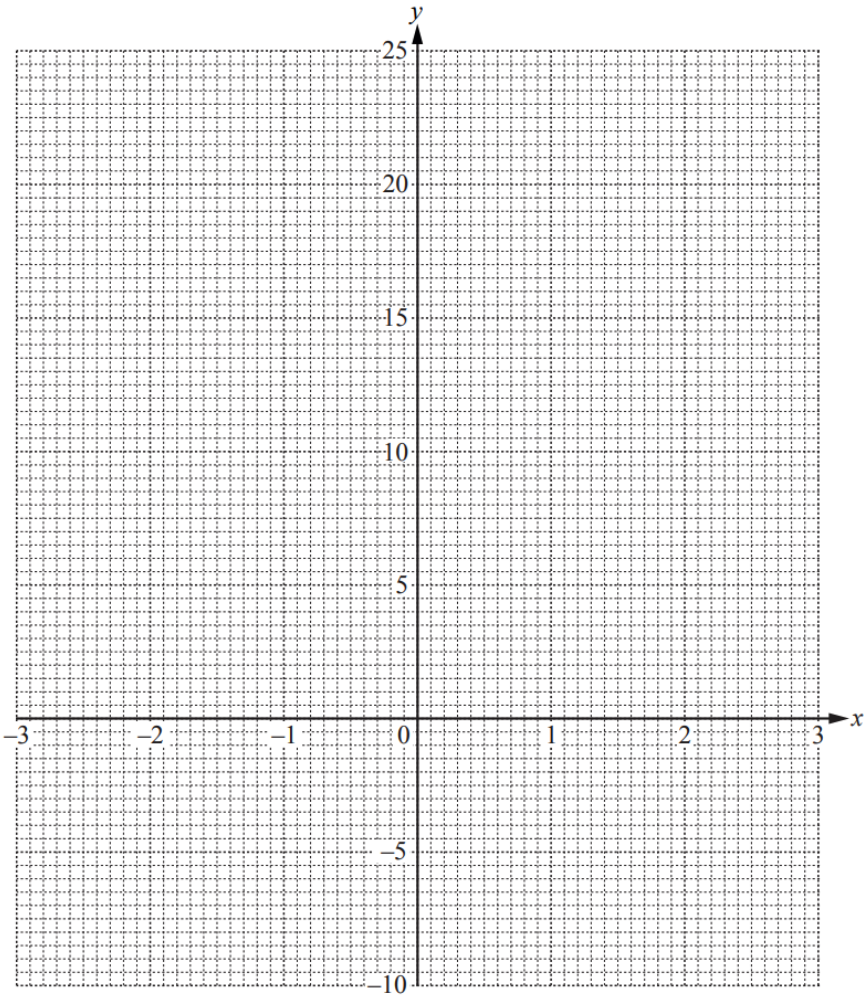
$x = \dots\dots\dots [1]$

2 (a) Complete the table for $y = 3x + \frac{2}{x^2} + 1$, $x \neq 0$.

x	-3	-2	-1	-0.5	-0.3		0.3	0.5	1	2	3
y	-7.8		0	7.5	22.3		24.1		6	7.5	10.2

[2]

(b) On the grid, draw the graph of $y = 3x + \frac{2}{x^2} + 1$ for $-3 \leq x \leq -0.3$ and $0.3 \leq x \leq 3$.



[5]

(c) Write down the value of the largest integer, k , so that the equation $3x + \frac{2}{x^2} + 1 = k$ has exactly one solution.

$k = \dots\dots\dots$ [1]

- (d) (i) By drawing a suitable straight line on the grid, solve $3x + \frac{2}{x^2} + 1 = 15 - 3x$.

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ or $x = \dots\dots\dots$ [4]

- (ii) The equation $3x + \frac{2}{x^2} + 1 = 15 - 3x$ can be written in the form $ax^3 + bx^2 + cx + 2 = 0$, where a , b and c are integers.

Find a , b and c .

$a = \dots\dots\dots$

$b = \dots\dots\dots$

$c = \dots\dots\dots$ [3]

3 (a) Solve.

$$8x - 5 = 22 - 4x$$

$$x = \dots\dots\dots [2]$$

(b) Solve.

$$6x \geq 2x + 14$$

$$\dots\dots\dots [2]$$

(c) Factorise.

$$x^2 - 4x - 21$$

$$\dots\dots\dots [2]$$

(d) Expand the brackets and simplify.

$$(3x - 2y)(4x + 3y)$$

$$\dots\dots\dots [3]$$

11 Solve.

$$\frac{2}{x+3} + \frac{1}{12} = \frac{3}{2x-1}$$

$x = \dots\dots\dots$ or $x = \dots\dots\dots$ [7]

Mathematics

Paper 4

Algebra & Graphs

ANSWERS

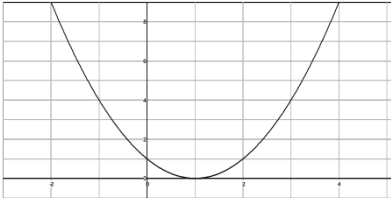
2(a)(i)	3 2.25 1	3	B1 for each
2(a)(ii)	Fully correct smooth curve	4	B3FT for 7 or 6 correct plots B2FT for 5 or 4 correct plots B1FT for 3 correct plots
2(a)(iii)	−0.6 to −0.51, 0.75 to 0.85, 1.7 to 1.85	3	B1 for each If 0 scored, SC1 for $y = 1.5$ drawn
2(a)(iv)	−3 or −2 or −1 or 0	1	
2(b)(i)	Tangent ruled at $x = 1$	1	
2(b)(ii)	4.4 to 5.6	2	Dep on tangent at $x = 1$ or close attempt M1 for rise/run for <i>their</i> line
2(b)(iii)	$y = (4.4 \text{ to } 5.6)x - (1.8 \text{ to } 2.2)$ or [$y =$] <i>their</i> (b)(ii) $x + \text{their}(y\text{-intercept})$	2	FT for any line but not horizontal or vertical line for 2 marks or B1 B1FT for [$m =$] <i>their</i> 5 or for <i>their</i> y -intercept
5(a)	$\frac{10x}{(x-3)(x+2)}$ or $\frac{10x}{x^2 - x - 6}$ final answer	4	M1 for common denominator $(x-3)(x+2)$ isw M1 for $(x+3)(x+2) - (x-2)(x-3)$ isw B1 for correct numerator in terms of x only
5(b)	14	2	M1 for $12 - \frac{k}{2} = 5$ or $2^{\frac{k}{2}} = \frac{2^{12}}{2^5}$ oe or $\frac{4096}{32}$ or $12 - 5$ or $2^{12} \div 2^{\frac{14}{2}}$ [= 32] seen
5(c)	$2y^3 - 3y^2 - 23y + 12$ final answer	3	B2 for correct unsimplified expanded expression or for simplified four-term expression of correct form with 3 terms correct or B1 for correct expansion of 2 of the brackets with at least 3 terms correct
5(d)	$[x =] \frac{3}{y-1}$ final answer	3	M1 for $xy = 3 + x$ M1 for $xy - x = 3$ or $x - \frac{x}{y} = \frac{3}{y}$ M1 for factorising and dividing
7(a)	$n - 5 + 3n + 10 > 105$ or better	B1	
	$n > 25$ final answer	B2	M1 for $4n > 100$

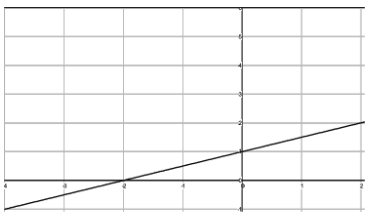
7(b)	4.8	3	M1 for $y = \frac{k}{x^2}$ or better M1 for $[y =] \frac{\text{their } k}{5^2}$ OR M2 for $y \times 5^2 = 7.5 \times 4^2$
10(a)(i)	$4x - 13$ final answer	1	
10(a)(ii)	$25x^2$ final answer	1	
10(b)	$\frac{x+1}{4}$ or $\frac{x}{4} + \frac{1}{4}$	2	M1 for correct first step $x = 4y - 1$ or $y + 1 = 4x$ or $\frac{y}{4} = x - \frac{1}{4}$
10(c)	0.6934 final answer	3	B2 for 0.69336... or $3^{-\frac{1}{3}}$ oe or 0.693 or M1 for $3^{-3^{-x}}$ oe
10(d)(i)	$(3x - 2)^2 - 3^{-(-3)}$	M1	
	$9x^2 - 6x - 6x + 4 - 27$ or $9x^2 - 12x + 4 - 27$ leading to $9x^2 - 12x - 23$	A1	with no errors seen
10(d)(ii)	$\frac{-(-12) \pm \sqrt{(-12)^2 - 4(9)(-23)}}{2 \times 9}$ or better	B2	B1 for $\sqrt{(-12)^2 - 4(9)(-23)}$ oe or $\frac{-(-12) + \sqrt{q}}{2 \times 9}$ oe or $\frac{-(-12) - \sqrt{q}}{2 \times 9}$ oe or both
	- 1.07, 2.40 final answers	B2	B1 for each If B0, SC1 for answers - 1.1 or -1.06 or -1.065... to - 1.065 and 2.4 or 2.39 or 2.398 to 2.398... or - 1.07 and 2.40 seen in working or for -2.40 and 1.07 as final answer
10(e)	-5 final answer	2	M1 for $243 = 3^{-x}$

11(a)	(1, 2) (-1, 6)	5	B2 for [derivative oe =] $3x^2 - 3$ or B1 for [derivative oe =] $3x^2$ or $f(x) - 3$ M1 for <i>their</i> derivative = 0 or recognition of $\frac{dy}{dx} = 0$ oe B1 for $[x =] -1, 1$ or for one coordinate pair
11(b)	(1, 2) minimum with reason (-1, 6) maximum with reason	3	Reasons could be e.g. a reasonable sketch correct use of 2nd derivative = $6x = 6$, $6 > 0$, so (1, 2) minimum oe 2nd derivative = $6x = -6$, $-6 < 0$ so (-1, 6) maximum oe, or finds gradient on each side of both correct stationary points with correct conclusion B2 for 1 correct with reason or M1 for showing [2nd derivative =] $6x$ or gradients for one value on either side of one correct stationary point or for reasonable sketch of cubic

3(a)	75.6	2	M1 for $5.2 \times 7 + \frac{1}{2} \times 1.6 \times 7^2$
3(b)(i)	$2a - 3b$ final answer	2	B1 for answer $2a + kb$ or $ka - 3b$ or for $2a - 3b$ seen in working
3(b)(ii)	$\frac{3}{4}$	2	B1 for $\frac{45x}{60x}$ oe single fraction
3(c)(i)	-5	1	
3(c)(ii)	-0.25 or $-\frac{1}{4}$	3	M1 for $20 - 12x = 23$ or for $5 - 3x = \frac{23}{4}$ M1 for correct completion to $ax = b$ FT <i>their</i> first step
3(d)	$9x^6$	2	B1 for $9x^k$ or kx^6
3(e)	$6x^2 - 7xy - 5y^2$	2	M1 for 3 terms out of 4 from $6x^2 - 10xy + 3xy - 5y^2$

6(a)	$y \geq x$ oe	1	
6(b)	$2.25x + 1.5y \leq 22.5$ oe	M1	
	One step shown to $3x + 2y \leq 30$	A1	
6(c)	$y = 10$ ruled	1	Broken line
	$3x + 2y = 30$ ruled	B2	Solid line B1 for line passing through (0, 15) or (10, 0)
	$y = x$ ruled	B1	Solid line
	Correct region indicated	B1	
6(d)	412	2	M1 for (4, 9) identified or for evaluation $40x + 28y$ for an integer point in the region ($x > 0$ and $y > 0$)
8(c)(i)	$(x + 5)^2 - 11$	2	M1 for $(x + 5)^2 + k$ or $(x + \text{their } 5)^2 + 14 - (\text{their } 5)^2$ or $a = 5$
8(c)(ii)	Sketch of U-shaped parabola with a minimum indicated at $(-5, -11)$ with no part of graph in 4 th quadrant	3	FT $\text{their } (x + 5)^2 - 11$ provided in that form B1 for U shape curve B1FT for turning point at $(-5, k)$ or $(k, -11)$
10(a)(i)	15.7 or 15.65...	3	M2 for $\sqrt{(4 - 10)^2 + (4 - -3)^2}$ oe or M1 for $(-4 - 10)^2 + (4 - -3)^2$ oe
10(a)(ii)	$\frac{-10 - 4}{4 - -3} [= -2]$ oe	M1	
	$10 = -2(-3) + c$ Or $-4 = -2(4) + c$ and correct completion to $y = -2x + 4$	A1	
10(a)(iii)	$y = \frac{1}{2}x + \frac{11}{4}$ oe	4	M1 for grad = $\frac{1}{2}$ soi M1 for [midpoint =] $(\frac{1}{2}, 3)$ M1 for substitution of $(1/2, 3)$ into $\text{their } y = mx + c$ oe
10(b)(i)	$\left(-\frac{1}{3}, -\frac{22}{27}\right)$ oe and $(-5, 50)$	6	B2 for $3x^2 + 16x + 5$ Or B1 for one correct M1 for derivative = 0 or $\text{their derivative} = 0$ M1 for $[x =] -\frac{1}{3}$ and $[x =] -5$ B1 for $-\frac{22}{27}$ and 50
10(b)(ii)	$\left(-\frac{1}{3}, -\frac{22}{27}\right)$ minimum $(-5, 50)$ maximum with correct reasons	3	B2 for one correct with reason or M1 for correct attempt e.g. 2 nd derivatives, gradients or sketching

6(a)	256	1	
6(b)	8	2	M1 for $3(x^2 + 1) + 2$ or for $3(2) + 2$
6(c)	$9x^2 + 12x + 5$	3	M1 for $(3x + 2)^2 + 1$ B1 for $[(3x + 2)^2 =] 9x^2 + 6x + 6x + 4$ oe
6(d)	16	2	M1 for $3x + 2 = 7^2 + 1$ or better
6(e)	$\frac{x-2}{3}$ oe final answer	2	M1 for $x = 3y + 2$ or for $y - 2 = 3x$ or for $\frac{y}{3} = x + \frac{2}{3}$
6(f)	$\frac{4x^2 + 2x + 1}{3x + 2}$ final answer	3	B1 for $x^2 + 1 + x(3x + 2)$ or better seen M1 for common denominator $3x + 2$
6(g)	16	1	
9(a)(i)	$(x+4)^2 - 25$	2	B1 for $(x+k)^2 - 9 - (their\ k)^2$ or $(x+4)^2 - h$ or $k = 4$
9(a)(ii)	$x + 4 = [\pm] 5$	M1	FT <i>their</i> (a)(i)
	-9 and 1	A1	
9(b)	$[b =] 7$ $[c =] -3$	3	B1 for $[b =] 7$ M1 for $b^2 - 4c = 61$
9(c)(i)(a)	Correct sketch 	2	B2 for correct quadratic curve with min touching x-axis or B1 for parabola vertex downwards

9(c)(i)(b)	Correct sketch 	2	B2 for correct straight line intersecting curve on y-axis or B1 for straight line with positive gradient and positive y-intercept
9(c)(ii)	2.8[0] or 2.795...	7	B3 for $x^2 - \frac{5}{2}x = 0$ oe or M1 for $(x-1)^2 = \frac{1}{2}x + 1$ B1 for $[(x-1)^2 =] x^2 - x - x + 1$ AND B2 for (0, 1) and $(\frac{5}{2}, \frac{9}{4})$ oe or B1 [$x =$] 0 and $\frac{5}{2}$ oe AND M1 for (difference in x) ² + (difference in y) ²
10(a)(i)	5	2	M1 for $(-1)^4 - 4(-1)^3$
10(a)(ii)	(0, 0) and (3, -27)	6	B2 for $4x^3 - 12x^2 [= 0]$ or B1 for $4x^3$ or $12x^2$ AND M1 for derivative = 0 or <i>their</i> derivative = 0 M1 for $4x^2(x-3)[= 0]$ B1 for [$x =$] 0 and [$x =$] 3 or [$y =$] 0 and [$y =$] -27 or for one correct coordinate pair
10(b)	[$p =$] 11 [$q =$] 5	2	B1 for each or M1 for $\frac{dy}{dx} = px^{p-1} + 2qx^{q-1}$
4(a)	$m \geq 3.4$ oe final answer	2	M1 for $12 + 5 \leq 8m - 3m$ or better or $3m - 8m \leq -5 - 12$ or better

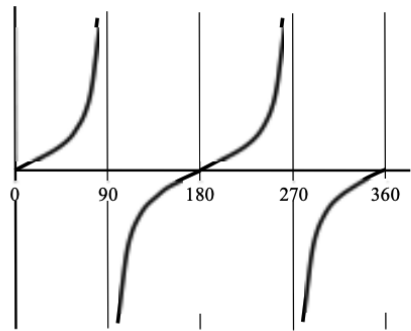
4(b)	$x = -0.75$ oe	3	M1 for $15(2x+5)=14(3-x)$ B1 for $30x+75=42-14x$ or better
4(c)	$3x^2 - 16x - 35 [= 0]$ or $3y^2 - 8y - 51 [= 0]$	M3	M1 for $x^2 + 2(4-x)^2 = 67$ or $(4-y)^2 + 2y^2 = 67$ seen B1 for $16 - 8x + x^2$ or $16 - 8y + y^2$
	$(3x+5)(x-7) [= 0]$ or $(3y-17)(y+3) [= 0]$	M1	or for correct factors for <i>their</i> equation or for correct use of quadratic formula or completing the square for <i>their</i> equation
	$x = 7, y = -3$ $x = -\frac{5}{3}, y = 5\frac{2}{3}$	B2	B1 for $x = 7, x = -\frac{5}{3}$ or for $y = -3, y = 5\frac{2}{3}$ or for a correct pair of x and y values
5(a)	$(4x-5)(x+3) + (x+1)(x-3) = 342$ or $2x(4x-5) - (3x-6)(x-3) = 342$	M2	M1 for $(4x-5)(x+3)$ or $(x+1)(x-3)$ or for $2x(4x-5)$ or $(3x-6)(x-3)$
	$4x^2 + 12x - 5x - 15$ oe and $x^2 + x - 3x - 3$ oe seen OR $8x^2 - 10x$ and $3x^2 - 15x + 18$ seen	M2	M1 for each
	$5x^2 + 5x - 18 = 342$ leading to $x^2 + x - 72 = 0$	A1	no errors or omission
5(b)	$(x+9)(x-8)$	M2	B1 for $(x+a)(x+b)$ where $ab = -72$ or $a+b = 1$ and a, b are integers
	8, -9	B1	

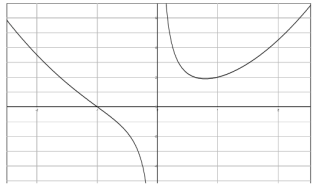
9(a)(i)	$\frac{3}{8}$	2	M1 for $8y = 3x + 20$ or better
9(a)(ii)	(0, 2.5) oe	1	
(b)(i)	15.6 or 15.62...	3	M2 for $\sqrt{(9 - -3)^2 + (-2 - 8)^2}$ oe seen or M1 for $(9 - -3)^2$ or $(-2 - 8)^2$ oe seen
9(b)(ii)	$y = -\frac{5}{6}x + 4$ oe	3	M1 for gradient $\frac{-2 - 8}{9 - -3}$ oe M1 for substituting (6, -1) into a linear equation oe
9(b)(iii)	$y = \frac{6}{5}x - \frac{3}{5}$ oe	4	M1 for gradient $-1 / \text{their}\left(-\frac{5}{6}\right)$ B1 for midpoint at (3, 3) M1 for <i>their</i> midpoint substituted into $y = \text{their } m \times x + c$ oe
10(a)(i)	$x + 5$	2	B1 for linear equation with positive gradient or intercept 5
10(a)(ii)	$2 \sin x$ oe	2	B1 for recognition of sin or $\cos(x - 90)$
10(b)	tangent ruled at P	B1	
	1.3 to 1.4	B2	dep on tangent drawn M1 for rise/run
11(a)	4	1	
11(b)	52	2	M1 for $f(8)$ seen or $7 \times \frac{2x}{x-3} - 4$
11(c)	$7x^2 - 4$	1	
11(d)	$\frac{7x^2 - 21x + 12}{2(x-3)}$ or $\frac{7x^2 - 21x + 12}{2x-6}$ final answer	3	M1 for $(7x-4)(x-3) + 2 \times 2x$ B1 for denominator $2(x-3)$ or $2x-6$
11(e)	-3	2	M1 for $7x + 14 - 4 = -11$
11(f)	$[p =] 0$ and $[p =] 1$	2	B1 for each
12(a)(i)	$\left(-\frac{1}{2}, 4\right)$ and $\left(\frac{1}{2}, 2\right)$	5	B2 for $12x^2 - 3 [= 0]$ or B1 for $12x^2$ or -3 M1 for their derivative $= 0$ or $dy/dx = 0$ B1 for $[x =] -\frac{1}{2}$ and $\frac{1}{2}$ or one coordinate pair correct

12(a)(ii)	$\left(-\frac{1}{2}, 4\right)$ Max with reason $\left(\frac{1}{2}, 2\right)$ Min with reason	3	B2 for one correct with reason or M1 for correct attempt to find e.g. 2nd derivative/gradients/sketch
12(b)	line $y = x + 3$ ruled	M2	B1 for $[y =]x + 3$ identified or rules $y = x + k$ or $y = px + 3$
	-0.7 to -0.8 2.7 to 2.8	A1	
5(a)(i)	2.7 to 2.8	1	

5(a)(ii)	tangent ruled at $x = -2$	B1	
	6 to 10	2	dep on B1 or a close attempt at tangent at $x = -2$ or M1 for rise/run for <i>their</i> tangent, or close attempt, at any point Must see correct or implied calculation from a drawn tangent After M0, SC1 for gradient of tangent (or close attempt) in range embedded in $y = mx + c$
5(a)(iii)	$y = 2x - 2$ ruled and $x = -2.9$ to -2.8 cao	3	B2 for correct ruled line or B1 for short line or for freehand line or broken line or ruled line with gradient 2 or with y-intercept at -2 (but not $y = -2$)
5(b)	$A(4, 17) B(-1.5, 0.5)$	5	B4 for $(-1.5, 0.5)$ and $(4, 17)$, or for $x = 4$ and $x = -1.5$ OR B3 for $A(4, 17)$ or $B(-1.5, 0.5)$ OR M1 for $2x^2 - 2x - 7 = 3x + 5$ oe AND either M2 for $(2x + 3)(x - 4)$ or M1 for $2x(x - 4) + 3(x - 4)$ or $x(2x + 3) - 4(2x + 3)$ or $(2x + c)(x + d)$ where $cd = -12$ or $c + 2d = -5$ [c and d are integers] OR M2 for $\frac{-\text{their } b \pm \sqrt{(\text{their } b)^2 - 4(\text{their } a)(\text{their } c)}}{2(\text{their } a)}$ or M1 for $\sqrt{(\text{their } b)^2 - 4(\text{their } a)(\text{their } c)}$ or for $p = -\text{their } b$, $r = 2(\text{their } a)$ if in the form $\frac{p + \sqrt{q}}{r}$ or $\frac{p - \sqrt{q}}{r}$

8(a)	$ab(3a - b)$ final answer	2	B1 for $a(3ab - b^2)$ or $b(3a^2 - ab)$ or $ab(3a - b)$ seen
8(b)	$x > 7.5$ final answer	2	B1 for $12+3 < 5x - 3x$ oe
8(c)	$27x^6y^{12}$	2	B1 for two of $27, x^6$ and y^{12} correct
8(d)	0.5 or $\frac{1}{2}$	3	M2 for $4 = 6x + 2x$ or better or M1 for $2(2 - x) = 6x$ oe
8(e)	$2x^3 + 5x^2 - 23x + 10$ final answer	3	B2 for correct expansion of three brackets unsimplified B1 for correct expansion of two brackets with at least 3 terms correct

10(a)(i)	$A(-4, 0)$ $B(1, 0)$ $C(0, -4)$	4	B3 for A and B correct Or B2 for B $(-4, 0)$ and A $(1, 0)$ Or B1 for $(x+4)(x-1)$ or for $\frac{-3 \pm \sqrt{3^2 - 4 \times 1 \times -4}}{2}$ oe and B1 for A or B correct B1 for C $(0, -4)$ OR SC2 for $-4, 1$ and -4 in correct positions on the graph
10(a)(ii)	$2x + 3 [\pm 0]$ final answer	2	B1 for answer $2x + c$ or for $ax + 3, a \neq 0$ or for correct answer seen
10(a)(iii)	$y = 7x - 8$ oe	3	B2 for answer $7x - 8$ OR M1 for [gradient =] $2(2) + 3$ FT <i>their</i> part (a)(ii) of the form $ax + b$ M1dep for substitution of $(2, 6)$ into $y = \text{their } mx + c$ oe
10(b)(i)	Correct sketch 	2	B1 for one correct section out of 4 OR B1 for two properties correct from • Crosses x-axis at $(0, 0)$ $(180, 0)$ and $(360, 0)$ only • Correct curvature in each section of 90° • Asymptotes at $x = 90$ and $x = 270$
10(b)(ii)	125.5 or 125.53 to 125.54 and 305.5 or 305.53 to 305.54	3	B2 for one correct angle or B1 for -54.5 or $-54.46\dots$ or for 2 angles with a difference of 180.
5(a)	1.48	3	B2 for $7x + 2 = 12.36$ or better or M1 for $3x + 2(2x + 1) [= 12.36]$ or better
5(b)	1.75 or $1\frac{3}{4}$	3	B2 for $18x - 14x = 7$ or better or M1 for $18x = 7(2x + 1)$
5(c)	$[0].8$ oe	3	B2 for $4(2x + 1) = 13x$ or M1 for $\frac{4}{x} = \frac{13}{2x+1}$ oe or correct equation to find number of cakes

5(d)	$\frac{20}{x} + \frac{10}{2x+1} = 45$ oe	M2	B1 for $\frac{20}{x}$ seen or $\frac{10}{2x+1}$ seen
	$90x^2 - 5x - 20 [= 0]$ oe	B2	B1 for $\frac{20(2x+1) + 10x}{x(2x+1)} = 45$ or better
	$(9x+4)(2x-1) [= 0]$ or for $\frac{- -1 \pm \sqrt{(-1)^2 - 4(18)(-4)}}{2(18)}$ oe	M2	FT <i>their</i> 3-term quadratic M1 for factors that give two correct terms when expanded or for correct discriminant or correct $\frac{-b}{2a}$ provided quadratic formula is in correct form
	$[0].5$ or $\frac{1}{2}$ final answer	B1	
7(a)	2, 4.5	2	B1 for each
7(b)	Correct graph 	4	B3 FT for 6 or 7 correct points FT <i>their</i> table or B2 FT for 4 or 5 correct points FT <i>their</i> table or B1 FT for 2 or 3 correct points FT <i>their</i> table
7(c)(i)	-0.5 to -0.4	1	
7(c)(ii)	$y = 1 - x$ ruled and -1.9 to -1.75	2	M1 for $[y =] 1 - x$ or $\left[x^2 + \frac{1}{x} = \right] 1 - x$ soi or B1 for -1.9 to -1.75
7(d)	Any integer ≥ 2	1	

10(a)(i)	10	1	
10(a)(ii)	-19	1	FT 1 – 2 <i>their (a)(i)</i>
10(b)	$\frac{1-x}{2}$ oe final answer	2	M1 for $x = 1 - 2y$ or $y + 2x = 1$ or $\frac{y}{2} = \frac{1}{2} - x$ or $y - 1 = -2x$ or better
10(c)	$\frac{1}{2}$ oe	1	
10(d)	$4x^2 - 8x + 2$ final answer	4	M1 for $(1 - 2x)(1 - 2x) - (1 - 2(1 - 2x))$ or better B1 for $1 - 2x - 2x + 4x^2$ B1 for $-(1 - 2 + 4x)$ or better or $[+] 1 - 4x$ or for correct answer seen then spoiled
10(e)	x final answer	1	
10(f)	3125	1	
10(g)	25	1	
10(h)	-2	2	B1 for $\frac{1}{25}$ or 0.04

7(a)(i)	$(8 - x)(3 + x)$	2	M1 for $8(3 + x) - x(3 + x)$ or $3(8 - x) + x(8 - x)$ or $(a - x)(b + x)$ where $ab = 24$ or $a - b = 5$
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7(a)(ii)	$[a =] -3$ $[b =] 8$ $[c =] 24$	3	FT <i>their (a)(i)</i> for a and b B1FT for each of a and b or both correct but reversed B1 for $[c =] 24$
7(a)(iii)	8	3	M2 for $5 - 2x$ or M1 for $-2x$ or $5 - kx$, $k \neq 0$
7(b)(i)	Correct sketch: positive cubic shape and max on the y -axis or to the right of y -axis with one root at $(-1, 0)$ and turning point at $(3, 0)$ and y -intercept at $(0, 9)$ all labelled	4	B1 for positive cubic shape with max on the y -axis or to the right of y -axis B1 for root at $(-1, 0)$ B1 for turning point at $(3, 0)$ B1 for y -intercept $(0, 9)$ If 0 score SC1 for all three intercepts on axes identified
7(b)(ii)	$x^3 - 5x^2 + 3x + 9$ final answer	3	B2 for correct expansion of three brackets unsimplified B1 for correct expansion of two brackets with at least 3 terms correct

9(a)	2, 3, 4, 5	2	B1 for 3 correct and no extra or 4 correct and one extra or M1 for $1 < x \leq 5$
9(b)(i)	$3y(2y - 5x)$	2	B1 for $3(2y^2 - 5xy)$ or $y(6y - 15x)$ or for the correct answer seen and then spoiled
9(b)(ii)	$(y - 3x)(y + 3x)$	2	B1 for $(y + 3)(y - 3)$
9(c)	$\frac{4x+5}{(x-1)(2x+1)}$ or $\frac{4x+5}{2x^2-x-1}$ final answer	3	M1 for $3(2x+1) - 2(x-1)$ oe isw M1 for $(x-1)(2x+1)$ oe isw
9(d)	(1.74 , 7.21 to 7.24) and (-3.74 , -9.20 to -9.22) cao	6	For the y values accept any value rounded to 2 decimal places in the given range B5 for (1.74 , 7.21 to 7.24) or (-3.74 , -9.20 to -9.22) or $x = 1.74$ and $x = -3.74$ OR M2 for $2x^2 + 4x - 13 = 0$ or $2y^2 + 4y - 13 = 0$ or M1 for $2x^2 + 7x - 11 = 3x + 2$ or $y = 2\left(\frac{y-2}{3}\right)^2 + 7\left(\frac{y-2}{3}\right) - 11$ AND FT their quadratic expression (not $2x^2 + 7x - 11$) M2FT for $\frac{-4 \pm \sqrt{4^2 - 4 \times 2 \times -13}}{2 \times 2}$ or $-1 \pm \sqrt{\frac{15}{2}}$ oe or M1FT for $\sqrt{4^2 - 4 \times 2 \times -13}$ oe or for $\frac{-4 + \sqrt{k}}{2 \times 2}$ or $\frac{-4 - \sqrt{k}}{2 \times 2}$ or $(x+1)^2 [-13/2 - 1 = 0]$
10(a)	-23	2	M1 for $4 - 3(3^x)$ oe soi
10(b)	$\frac{4-x}{3}$ oe final answer	2	M1 for $x = 4 - 3y$ or $y + 3x = 4$ or $x + 3y = 4$ or $\frac{y}{-3} = \frac{4}{-3} + x$ oe or $\frac{x}{-3} = \frac{4}{-3} + y$ oe
10(c)(i)	$1 + 6x$ final answer	2	M1 for $4 - 3(1 - 2x)$

10(c)(ii)	$20 - 36x$ or $4(5 - 9x)$ final answer	4	B3 for $20 - 36x$ seen in working then spoiled OR M1 for $(4 - 3x)^2 + 4 - 3x - 9(x^2 + x)$ or better B1 for $[(4 - 3x)^2 =] 16 - 12x - 12x + 9x^2$ or better B1 for answer $20 - kx$ or $k - 36x$ oe or answer $20 - 36x + kx^2$ $k \neq 0$
10(d)	$-\frac{1}{2}$ oe	2	M1 for $(3^2)^{kx}$ or $9^{kx} = 9^{-\frac{1}{2}x}$ oe

5(a)	-2.1, 1.6, -1.7, 2.1	3	B2 for 3 correct or B1 for 2 correct
5(b)	Fully correct curve	4	B3FT for 8 or 9 correct plots or B2FT for 6 or 7 correct plots or B1FT for 4 or 5 correct plots
5(c)	line $y = \frac{1}{2}(1 - x)$ ruled	M2	M1 for line with gradient $-\frac{1}{2}$ M1 for line through $(0, \frac{1}{2})$ but not $y = \frac{1}{2}$
	-2.15 to -2.01 -0.45 to -0.2 2.25 to 2.45	B2	B1 for two correct
5(d)	number of intersections of <i>their</i> curve and the line $y = 1$	1	strict FT for <i>their</i> curve

8(a)	-3	1	
8(b)	$\frac{12}{11}$ oe	2	M1 for $\frac{3}{\frac{3}{x+2} + 2}$ soi
8(c)	$64x - 45$ final answer	2	M1 for $8(8x - 5) - 5$ isw
8(d)	$\frac{x+5}{8}$ oe final answer	2	M1 for a correct first step $y + 5 = 8x$, $\frac{y}{8} = x - \frac{5}{8}$ or $x = 8y - 5$
8(e)	$\frac{8x^2 + 11x - 13}{x + 2}$ final answer	3	M1 for $(8x - 5)(x + 2) - 3$ oe isw B1 for common denominator $(x + 2)$

8(f)(i)	$(8x-5)^2 + 6 = 19$	M1	
	$64x^2 - 40x - 40x + 25$	B1	
	$64x^2 - 40x - 40x + 25 + 6 = 19$ oe leading to $16x^2 - 20x + 3 = 0$	A1	with no errors and must show $(8x-5)^2 + 6 = 19$ with no omissions after this
8(f)(ii)	$\frac{[-]20 \pm \sqrt{([-]20)^2 - 4(16)(3)}}{2 \times 16}$ oe	2	B1 for $\sqrt{([-]20)^2 - 4(16)(3)}$ or better or B1 for $\frac{[-]20 + \sqrt{q}}{2(16)}$ oe or $\frac{[-]20 - \sqrt{q}}{2(16)}$
	0.17 and 1.08 final ans	2	B1 for each If 0 scored, SC1 for answer 0.2 and 1.1 or answer - 0.17 and -1.08 or 0.174... and 1.075 to 1.076 seen or 0.17 and 1.08 seen in working
10(a)	correctly equating one set of coefficients	M1	or making x or y the subject of one equation correctly
	correct method to eliminate one variable	M1	or substitution for x or y for <i>their</i> rearranged formula
	$x = 7$ $y = -3$	A2	A1 for one correct value If A0 scored, SC1 for 2 values satisfying one of the original equations or if no working shown, but 2 correct answers given
10(b)	2	3	M1 for $y = \frac{k}{(x+3)^2}$ oe M1 for $y = \frac{\text{their } k}{(7+3)^2}$ oe OR M2 for $8(2+3)^2 = y(7+3)^2$ oe
10(c)	$x > -5$ final answer	3	M1 for $3x - 6 < 7x + 14$ M1 for <i>their</i> $(-6) - \text{their} 14 < 7x - 3x$ oe

2(a)	2, 2, 6	3	B1 for each
2(b)	Correct graph	4	B3FT for 10 or 11 correct plots or B2FT for 8 or 9 correct plots or B1FT for 6 or 7 correct plots
2(c)	−3.3 to −3.1	1	FT <i>their</i> graph
2(d)	$y = -2x$ ruled	M1	or B1 for $y = -2x$ stated
	−2.6 to −2.45	A1	
2(e)	3 or 4 or 5	1	FT <i>their</i> graph Allow more than one correct value

7(a)(i)	1.991×10^3	4	B3 for 1991 or 1.99×10^3 or $1.991... \times 10^3$ or B2 for 1990 or 1991. ... OR M1 for $104.3 \times 26.5 + \frac{1}{2} \times (-2.2) \times 26.5^2$ oe B1 for <i>their</i> seen value correctly rounded to 4 sf B1 for <i>their</i> seen value correctly converted into standard form
7(a)(ii)	$\frac{2(s-ut)}{t^2}$ oe final answer	3	M1 for correct multiplication by 2 oe M1 for correct rearrangement to isolate term with a M1 for correct division by t^2 for 3 marks e.g. cannot have a fraction in denominator nor $\div t^2$ in numerator
7(b)(i)	$(2x+3)(x-1) - (x+1)(x-2) = 62$	M1	
	$2x^2 + 3x - 2x - 3$ oe or $x^2 + x - 2x - 2$ oe	B1	
	$x^2 + 2x - 63 = 0$	A1	Established with no errors or omissions
7(b)(ii)	$(x+9)(x-7)$	2	B1 for $(x+a)(x+b)$ where $ab = -63$ or $a+b=2$ or for $x(x-7)+9(x-7)$ or for $x(x+9)-7(x+9)$
7(b)(iii)	20	2	FT $2 \times$ <i>their</i> positive root + 6 M1 for substituting <i>their</i> positive root into four lengths or for stating $2x+6$

9(a)	82	2	M1 for $(3^x)^2+1$ soi by $(3^2)^2+1$ or g(9) isw
9(b)	$\frac{x+2}{7}$ final answer	2	M1 for $y+2=7x$ or $\frac{y}{7}=x-\frac{2}{7}$ or $x=7y-2$
9(c)	$[a=] 1, [b=] 2, [c=] 2$	3	B2 for $x^4+x^2+x^2+1+1$ or M1 for $(x^2+1)^2+1$
9(d)	$\frac{6}{7}$ oe	3	M2 for $7x-2=4$ or M1 for $3^x=81$ soi $f(x)=4$ or for $3^{7x-2}=81$ or better

3(b)(iii)	$(5r-9)(2r-1) [= 0]$	B2	or B2 for e.g. $5r(2r-1)-9(2r-1)$ and then $5r-9=0$ and $2r-1=0$ or B1 for $5r(2r-1)-9(2r-1) [= 0]$ or $2r(5r-9)-1(5r-9) [= 0]$ or $(5r+a)(2r+b) [= 0]$ where a, b are integers and $ab=+9$ or $2a+5b=-23$ If 0 scored, SC1 for $5r-9$ and $2r-1$ seen but not in factorised form
	$[r=] \frac{9}{5}$ oe $[r=] \frac{1}{2}$ oe	B1	

4(a)(i)	1.5 oe	1	
4(a)(ii)	(0, 2)	1	
4(b)(i)	$y = -2x + 6$ oe final answer	3	B2 for $y = -2x + c$ oe or $y = mx + 6$ oe $m \neq 0$ or for answer $-2x + 6$ or B1 for [gradient =] $-\frac{6}{3}$ oe or $c = +6$ soi
4(b)(ii)	$y = 0.5x - 1.5$ oe final answer	3	B1 for [gradient =] -1 divided by <i>their</i> gradient from (b)(i) evaluated soi M1 for substitution of (9, 3) into $y = (\text{their } m)x + c$ seen in working
4(c)(i)	12.6 or 12.64 to 12.65	3	M2 for $\sqrt{(8 - -4)^2 + (5 - 1)^2}$ oe or M1 for $(8 - -4)^2 + (5 - 1)^2$ oe
4(c)(ii)	(2, 3)	2	B1 for each
5(a)	2.45, 0.25, -0.25	3	B1 for each
5(b)	Fully correct smooth curve	4	B3FT for 6 or 7 points or B2 FT for 4 or 5 points or B1 FT for 2 or 3 points
5(c)	0.7 to 0.8	1	FT <i>their</i> curve
5(d)(i)	Correct ruled line	2	M1 for good freehand, or ruled line with gradient -1.05 to -0.95 or ruled line through (0, 2) but not line $y = 2$

5(d)(ii)	Both intersections of <i>their</i> (b) and <i>their</i> (d)(i)	2	Strict FT intersection of <i>their</i> (b) and <i>their</i> (d)(i) B1FT for one correct OR B2 for 0.27 to 0.28 and 2.38 to 2.39
5(e)	Substitutes $x = \sqrt{2}$ into $\frac{1}{2x} - \frac{x}{4}$ OR Identifies $y = 0$ oe OR Correctly manipulates to a single fraction e.g. $\frac{2-x^2}{4x}$ oe seen	M1	
	Concludes 'read the graph at $y = 0$ ' oe OR Manipulates $0 = \frac{1}{2x} - \frac{x}{4}$ oe leading to $x^2 = 2$ OR States $\frac{2-x^2}{4x}$ oe = 0 leading to $x^2 = 2$	A1	
6(a)	$x^2 + 4x - 21$ final answer	2	B1 for three of x^2 , $+7x$, $-3x$, -21
6(b)(i)	$5q^2(3p^2 - 5q)$ final answer	2	B1 for $5(3p^2q^2 - 5q^3)$ or $q^2(15p^2 - 25q)$ or $q(15p^2q - 25q^2)$ or $5q(3p^2q - 5q^2)$ or for correct answer seen
6(b)(ii)	$(2g + 5k)(2f + 3h)$ final answer	2	B1 for $2g(2f + 3h) + 5k(2f + 3h)$ or $2f(2g + 5k) + 3h(2g + 5k)$ or for correct answer seen
6(b)(iii)	$(9k + m)(9k - m)$ final answer	2	M1 for $(9 + m)(9 - m)$ or for correct answer seen
6(c)	5.5	4	M1 for $5 \times 3(x - 4) + x + 2 = 5 \times 6$ M1 for $15x - 60 + x + 2 = 30$ FT <i>their</i> first step or $3x - 12 + \frac{x+2}{5} = 6$ If M0M0, SC1 for $3x - 12 + x + 2 = 30$ oe M1dep for $16x = 88$ FT <i>their</i> previous steps

2(a)	-10	2	M1 for $-17 - 3 = 7x - 5x$ oe or better
2(b)	-1, 0, 1, 2 final answer	3	B2 for 3 correct values and no incorrect values or 4 correct values and one incorrect value or M2 for $-\frac{7}{4} < n \leq 2$ oe or M1 for $-\frac{7}{4} < n \leq k$ or $k < n \leq 2$ oe
2(c)(i)	a^9	1	
2(c)(ii)	$125x^3y^6$ final answer	2	B1 for 2 correct elements if in form $kx^n y^m$
2(c)(iii)	$\frac{4y^{[1]}}{3x^4}$ final answer	3	B2 for $\left(\frac{3x^4}{4y^{[1]}}\right)^{[-1]}$ oe seen OR B1 for $3x^4$ or $4y^{[1]}$ and M1 for $\left(\frac{64y^3}{27x^{12}}\right)^{[\frac{1}{3}]}$ oe If 0 scored, SC1 for $\frac{64y^{[1]}}{27x^4}$ or $\frac{0.333x^{-4}}{0.25y^{-1}}$ seen
5(a)(i)	-3	1	
5(a)(ii)	6.2 to 6.4 oe	2	M1 for 3 seen or used
5(b)	$y = 5 - 3x$ ruled	2	B1 for $y = 5 - 3x$ soi or ruled line with gradient -3 or with y -intercept at 5 (but not $y = 5$) or B1FT for incorrect line equation/expression shown in working and <i>their</i> line correctly drawn
	-0.3 to -0.2 1.65 to 1.8	2	B1 for each, dep on $y = 5 - 3x$ drawn or FT <i>their</i> line provided equation/expression shown in working, dep on B1FT for line
5(c)	Tangent ruled at $x = -2$	1	B1 for correct tangent
	-4.5 to -2.5	2	Dep on B1 for tangent or close attempt at tangent at $x = -2$ M1 for rise/run also dep on tangent drawn or close attempt at correct tangent Must see correct or implied calculation from a drawn tangent
5(d)(i)	8, 4, 0.25 oe	3	B1 for each
5(d)(ii)	Correct graph	3	B2FT for 6 or 7 correct plots or B1FT for 4 or 5 correct plots
5(d)(iii)	1.8 to 1.9	1	

7(a)	$[y =] 4x + 5$	3	B2 for answer $[y =] 4x + c$ oe (c can be numeric or algebraic) OR M2 for $\frac{y-9}{x-1} = \frac{9-(-3)}{1-(-2)}$ oe OR M1 for $\frac{9--3}{1--2}$ oe or for M1 for correct substitution of $(-2, -3)$ or $(1, 9)$ into $y = (\text{their } m)x + c$ oe
7(b)	76[.0] or 75.96...	2	M1 for $\tan[] = 4$ oe
7(c)(i)	$[y =] -\frac{1}{4}x + \frac{23}{8}$ oe	3	B2FT for $[y =] -\frac{1}{\text{their gradient from (a)}}x + c$ oe (c can be numeric or algebraic) OR M2 for $\frac{y-2}{x-3.5} = -\frac{1}{\text{their gradient from (a)}}$ oe OR M1 for $-\frac{1}{\text{their gradient from (a)}}$ soi M1 for correct substitution of $(3.5, 2)$ into $y = (\text{their } m)x + c$ oe
7(c)(ii)	$(-4.5, 4)$	2	B1 for each value or for $\begin{pmatrix} -8 \\ 2 \end{pmatrix}$ seen
8(a)(ii)(b)	$(4x + 3)(x - 7) [= 0]$	M2	M1 for $4x(x - 7) + 3(x - 7)$ or $x(4x + 3) - 7(4x + 3)$ or for $(4x + a)(x + b)$ where either $ab = -21$ or $4b + a = -25$ If 0 scored, SC1 for $4x + 3$ and $x - 7$ seen but not in factorised form
	7 and $-\frac{3}{4}$	B1	

7(a)	9	3	M2 for $0.42x + 0.42 = 4.2$ oe or better or M1 for $0.21x + 0.21(x + 2)$ oe [= 420 or 4.20] or for $21x + 21(x + 2)$ oe [= 420 or 4.20] or for $420 \div 21$ oe [=20]
7(b)	$5r + p = 245$	B1	
	$2r + 3p = 215$	B1	
	45	3	Finds p M1 for correctly equating coefficients of r M1 for correct method to eliminate r OR M1 for correctly making r the subject of one of <i>their</i> equations M1 for correctly substituting <i>their</i> correct r to form an equation in p OR Finds r first M1 for correctly eliminating p from <i>their</i> equations M1 for correctly substituting <i>their</i> value of r to find p
7(c)(i)	$\frac{12}{x} + \frac{6}{x-1} [= 5]$	M1	
	$12(x-1) + 6x = 5x(x-1)$	M1	Dependent on previous M1 earned May be over common denominator
	$5x^2 - 23x + 12 = 0$ reached, with at least one more line of working and with no errors or omissions	A1	
7(c)(ii)	$(5x-3)(x-4)$ final answer	2	B1 for $(5x+a)(x+b)$ with $ab = 12$ or $a+5b = -23$ or for $5x(x-4) - 3(x-4)$ or $x(5x-3) - 4(5x-3)$
7(c)(iii)	$\frac{3}{5}$ oe and 4	1	FT from their two brackets in (c)(ii)
7(c)(iv)	3 cao	1	

9(a)	$x + y \geq 6$ oe $y \leq x$ oe $x \leq 8$	3	B1 for each
9(b)	$4x + 6y \leq 60$	1	
9(c)	Correct region indicated cao	6	B1 for $x + y = 6$ ruled and long enough B1 for $x = y$ ruled and long enough B1 for $x = 8$ ruled and long enough B2 for $2x + 3y = 30$ ruled and long enough or B1 for ruled line through (0, 10) or (15, 0) but not $y = 10$ or $x = 15$
9(d)(i)	6, 6	1	
9(d)(ii)	34	2	M1 for trying $4x + 6y$ with (4, 3) or (5, 2) or (6, 1) or (7, 0)
3(a)(i)	(3, 5.5)	2	B1 for either value correct
3(a)(ii)	$\frac{5}{4}x + \frac{7}{4}$ final answer	3	B2 for answer $\frac{5}{4}x + c$ oe or for correct equation in different form or M1 for $\frac{8-3}{5-1}$ oe and M1 for correct substitution shown of (1, 3) or (5, 8) or <i>their</i> (a)(i) into $y = (\text{their } m)x + c$ oe

5(a)	3.5, 15, 3.9	3	B1 for each
5(b)	Correct graph	5	B4 for correct curves but branches joined or touching y-axis or B3FT 10 or 11 points or B2FT for 8 or 9 points or B1FT for 6 or 7 points B1indep two separate branches not touching or crossing y-axis
5(c)	0.5 to 0.6 and 1.3 to 1.6	2	B1 for each or both correct but in reverse order
5(d)	1	1	
5(e)(i)	$y = 3x + 1$ ruled and 0.3 to 0.49	3	B2 for correct ruled line that crosses <i>their</i> curve or B1 for $y = 3x + 1$ soi or freehand line or ruled line with gradient 3 or with y – intercept at 1 (but not $y = 1$)
5(e)(ii)	$[a =] -6$ $[b =] -2$ $[c =] -4$	3	M2 for $x^4 + 2 - 4x = 6x^3 + 2x^2$ or better seen or B1 for each correct value to a maximum of 2 marks If 0 scored, SC1 for answer $[a =] 6, [b =] 2$ and $[c =] 4$ or for $x^5 + 2x - 4x^2 = 6x^4 + 2x^3$ or better
7(a)(i)	13	1	
7(a)(ii)	3	2	M1 for $h\left(\frac{10}{30}\right)$ oe soi or $27^{\frac{10}{x}}$
7(a)(iii)	$\frac{7-x}{2}$ oe final answer	2	M1 for $x = 7 - 2y$ or $y - 7 = -2x$ or $7 - y = 2x$ or $-\frac{y}{2} = -\frac{7}{2} + x$ oe
7(b)	0.75 oe final answer	3	M1 for $\frac{10}{2x+1} = 4$ M1 for $10 = 8x + 4$ or better
7(c)	$\frac{70-19x}{x(7-2x)}$ or $\frac{70-19x}{7x-2x^2}$ final answer	3	M1 for $x + 10(7-2x)$ or better isw B1 for common denominator $x(7-2x)$ oe isw
7(d)	3 final answer	1	
8(a)(i)	$\frac{m-7}{5}$ oe final answer	2	M1 for $5p = m - 7$ or $p + \frac{7}{5} = \frac{m}{5}$
8(a)(ii)	$[\pm]\sqrt{\frac{y^2-h}{2}}$ or $[\pm]\sqrt{\frac{h-y^2}{-2}}$ oe final answer	3	M1 for first correct step isolate term in p or divide by ± 2 M1 for second correct step FT <i>their</i> first step

2(a)(i)	$2a + a + 2b + 3b + 10 = 180$ leading to $3a + 5b = 170$ without error or omission	1	
2(a)(ii)	$8a + 3a + 2b + b + 50 + 4b - 2a = 360$ leading to $9a + 7b = 310$ without error or omission	1	
2(a)(iii)	Correct method to eliminate one variable	M1	
	$[a =]15$ $[b =]25$	A2	A1 for each correct value If 0 scored, SC1 for two values that satisfy one of the equations or for two correct answers with no/incorrect working
2(a)(iv)	30	1	
2(b)	-1.5 or $-1\frac{1}{2}$ or $-\frac{3}{2}$	2	M1 for $6x = -12 + 3$ or better
2(c)	$\frac{3x+3}{2}$ oe final answer	3	M1 for $8x - 2y = 5x - 3$ or $4x - y = \frac{1}{2}(5x - 3)$ M1FT for isolating the y term correctly
2(d)	$9x^6$	2	M1 for $(3x^3)^2$ or $(729x^{18})^{\frac{1}{3}}$ seen or for $9x^k$ or kx^6 as final answer
2(e)	$\frac{x}{x-5}$ final answer nfw	3	M1 for $x(x+5)$ M1 for $(x-5)(x+5)$
3(a)	5, -3, 21	3	B1 for each
3(b)	Fully correct curve	4	B3 FT for 9 or 10 points or B2 FT for 7 or 8 points or B1 FT for 5 or 6 points
3(c)	-2.9 to -2.7 0 1.7 to 1.9	2	B1 for 2 correct values
3(d)	Tangent ruled at $x = 2$	B1	
	10 to 14	B2	Dep on correct tangent or close attempt at tangent at $x = 2$ M1 for rise/run also dep on correct tangent drawn or close attempt at tangent Must see correct or implied calculation from a drawn tangent
3(e)	6	1	

9(a)(i)	5	1	
9(a)(ii)	1	2	M1 for $h(0)$ or 3^{9-x^2} or better
9(a)(iii)	$9 - 4x^2$ final answer	1	
9(a)(iv)	$15 - 2x^2$ final answer	2	M1 for $2(9 - x^2) - 3$ or better
9(b)	$\frac{x+3}{2}$ final answer	2	M1 for $x = 2y - 3$ or $y + 3 = 2x$ or better or $\frac{y}{2} = x - \frac{3}{2}$
9(c)	1.8 or $1\frac{4}{5}$ or $\frac{9}{5}$	2	M1 for $10x - 15 = 3$ or $2x - 3 = \frac{3}{5}$
9(d)	-1 and 4 nfw	4	M1 for $9 - (2x - 3)^2 = -16$ A1 for $4x^2 - 12x - 16 [= 0]$ oe M1 (dep on first M1) for correct factors or use of formula or completing the square for their 3-term quadratic OR M1 for $9 - y^2 = -16$ A1 for $y^2 = 25$ M1 (dep on first M1) for $2x - 3 = \pm 5$
9(e)	$\frac{1}{9}$	1	

10	$x + 1 - 2x = 3x(x + 1)$	M2	M1 for a common denominator of $x(x + 1)$ seen or attempt to multiply through by denominators or for $\frac{x+1-2x}{x(x+1)} = 3$
	$3x^2 + 4x - 1 [= 0]$ oe nfw	A1	
	$[x =] \frac{-4 \pm \sqrt{4^2 - 4 \times 3 \times (-1)}}{2 \times 3}$	B2	B1FT for $\sqrt{4^2 - 4 \times 3 \times (-1)}$ or better or for $\left(x + \frac{2}{3}\right)^2$ B1FT for $\frac{-4 + \sqrt{q}}{2 \times 3}$ or $\frac{-4 - \sqrt{q}}{2 \times 3}$ or for $-\frac{2}{3} \pm \sqrt{\frac{1}{3} + \left(\frac{2}{3}\right)^2}$
	-1.55 and 0.22 final answers	B2	B1 for each or B1 for -1.548 to -1.549 and 0.215... or for -1.55 and 0.22 seen in working or for -0.22 and 1.55 as final answer or for -1.5 or -1.54 and 0.2 or 0.21 as final answer

3(a)	0 -0.17 2.4	3	B1 for each
3(b)	Fully correct smooth curve	4	B3FT for 9 or 10 correct points or B2FT for 7 or 8 correct points or B1FT for 5 or 6 correct points
3(c)	$x \leq 0.17$ to 0.25 and $x \geq 2.25$ to 2.3	3	B2 for strict inequalities or one correct or B1 for 0.17 to 0.25 and 2.25 to 2.3 seen
3(d)(i)	$y = 4 - x$ oe final answer	2	B1 for $4 - x$ or $y = k - x$ or $y = 4 + kx$ oe
3(d)(ii)	correct ruled line	1	FT if in form $y = mx + c$ oe ($m, c \neq 0$)
	0.125 to 0.2 and 2.15 to 2.2	2	B1 for each
4(a)	$[\pm]\sqrt{k-s}$ final answer	2	M1 for $t^2 = k - s$
4(b)(i)	$(x-5)(x+5)$ final answer	1	
4(b)(ii)	$\frac{x-5}{x-7}$ nfwf final answer	3	M2 for $(x-7)(x+5)$ or M1 for $x(x+5) - 7(x+5)$ or $x(x-7) + 5(x-7)$ or $(x+a)(x+b)$ where $a+b = -2$ or $ab = -35$
4(c)	$\frac{4x^2 - 7x - 8}{x(x+1)}$ or $\frac{4x^2 - 7x - 8}{x^2 + x}$ final answer	3	M1 for $(x-8)(x+1) + 3x \times x$ oe isw B1 for common denominator $x(x+1)$ oe isw
4(d)	3, 4, 5, 6 nfwf	3	B2 for 3 correct or 4 correct and 1 extra or M2 for $n > \frac{18}{8}$ oe and $n \leq 6$ or M1 for $18 < 8n [\leq 30 + 3n]$ or $[18 - 3n <] 5n \leq 30$ seen
6(a)	$y > x$	1	
	$x \geq 15$	1	
	$y < 50$	1	
	$x + y \leq 70$	1	
6(b)	Four correct ruled lines and correct region indicated	5	all lines ruled B1 for $y = x$ broken B1 for $x = 15$ B1 for $y = 50$ broken B1 for $x + y = 70$
6(c)	189	2	M1 for (21, 49) seen or for $2x + 3y$ written for a point (x, y) in <i>their</i> region where x and y are integers

10(a)	10.8 or 10.81 to 10.82	3	M2 for $\sqrt{(6-3)^2 + (-2-4)^2}$ oe or M1 for $(6-3)^2 + (-2-4)^2$ oe
10(b)(i)	(6, 4)	2	B1 for each
10(b)(ii)	2	2	M1 for $\frac{12 - (-4)}{10 - 2}$ oe
10(b)(iii)	$y = -\frac{1}{2}x + 4$ oe final answer	3	M1 for gradient = $-\frac{1}{2}$ or $-\frac{1}{\text{their (b)(ii)}}$ M1 for (2, 3) substituted into <i>their</i> $y = mx + c$ or $y - y_1 = m(x - x_1)$ oe

5(a)(i)	$(2n + m)(m - 3)$ final answer	2	M1 for $m(2n + m) - 3(2n + m)$ or $2n(m - 3) + m(m - 3)$
5(a)(ii)	$(2y - 9)(2y + 9)$ final answer	1	
5(a)(iii)	$(t - 4)(t - 2)$ final answer	2	B1 for $(t - 4)(t - 2)$ seen and spoiled or M1 for $t(t - 2) - 4(t - 2)$ or $t(t - 4) - 2(t - 4)$ or $(t + a)(t + b)$ where $a + b = -6$ or $ab = +8$
5(b)	$[x =] \frac{2m}{k+1}$	4	M1 for $xk = 2m - x$ or $k = \frac{2m}{x} - 1$ M1 for $xk + x = 2m$ or $k + 1 = \frac{2m}{x}$ M1 for $x(k + 1) = 2m$

5(c)	correctly eliminating one variable	M1	
	$[x =] 6$	A1	
	$[y =] -2$	A1	If 0 scored SC1 for 2 values satisfying one of the original equations or SC1 if no working shown, but 2 correct answers given
5(d)(i)	$3m - 4(m + 4) = 6m(m + 4)$	M1	or $\frac{3m - 4(m + 4)}{m(m + 4)} [= 6]$ oe
	$3m - 4m - 16 = 6m^2 + 24m$	M1	removes brackets correctly
	$6m^2 + 25m + 16 = 0$	A1	with no errors or omissions
5(d)(ii)	$\frac{-25 \pm \sqrt{(25)^2 - 4(6)(16)}}{2 \times 6}$ or $\frac{-25}{12} \pm \sqrt{\left(\frac{25}{12}\right)^2 - \frac{16}{6}}$	2	B1 for $\sqrt{(25)^2 - 4(6)(16)}$ or better or B1 for $\left(m + \frac{25}{12}\right)^2$ and if in form $\frac{p + \sqrt{q}}{r}$ or $\frac{p - \sqrt{q}}{r}$ B1 for $p = -25$ and $r = 2(6)$
	-0.79 and -3.38 final ans cao	2	B1 for each SC1 for -0.8 and -3.4 or for -0.78 and -3.37 or -0.789... and -3.377... or 0.79 and 3.38 or -0.79 and -3.38 seen in working

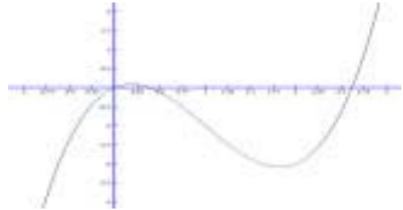
7(a)	$x = 0$	1	
7(b)	Tangent ruled at $x = 0.5$	B1	No daylight between tangent and curve at point of contact
	−9 to −6.5	2	dep on ruled tangent or close attempt at tangent at $x = 0.5$ M1 for rise/run also dep on tangent or close attempt at tangent at $x = 0.5$
7(c)(i)	0 2.4 or better 4	3	B1 for each
7(c)(ii)	Correct smooth curve	4	B3FT for 6 or 7 correct plots or B2 FT for 4 or 5 correct plots or B1 FT for 2 or 3 correct plots FT <i>their</i> table
7(d)	$x^3 + 3x + 4 = 10 - 8x^2$ and correctly completed	1	
7(e)	line $y = -2x + 2$ drawn and −0.45 to −0.35 nfw	3	B2 for ruled $y = -2x + 2$ or B1 for $-2x + 2$ seen or for line $y = -2x + c$ drawn or for $y = cx + 2$ ($c \neq 0$) drawn and B1 for −0.45 to −0.35 nfw
4(a)(i)	$243p^{10}$ final answer	2	B1 for answer $243p^k$ or kp^{10} ($k \neq 0$)
4(a)(ii)	$9xy^4$ final answer	2	B1 for answer with two correct elements in correct form of expression
4(a)(iii)	$\frac{m^2}{25}$ final answer	1	
4(b)	10	4	B2 for $x = 8$ or for [length of rectangle =] 31 or M1 for $5x - 9 = 3x + 7$ oe or better M1 for $\frac{310}{(3 \times \text{their } x + 7)}$ or $\frac{310}{(5 \times \text{their } x - 9)}$ <u>Alt method using simultaneous eqns</u> M1 for $5xw - 9w = 310$ and $3xw + 7w = 310$ M1 for equating coefficients of xw M1 for subtraction to eliminate term in xw

6(a)	$-2[.0], -0.2, 2.5$	3	B1 for each
6(b)	Fully correct curve	5	B4 for correct curve, but branches joined or B3FT for 9 or 10 correct plots or B2FT for 7 or 8 correct plots or B1FT for 5 or 6 correct plots and B1 indep two separate branches not touching or cutting y -axis
6(c)(i)	Correct tangent and $3 \leq \text{grad} \leq 5$	3	B2 for close attempt at tangent to curve at $x = -2$ and answer in range OR B1 for ruled tangent at $x = -2$, no daylight at $x = -2$ and M1dep (dep on B1 or close attempt at tangent) [at $x = -2$] for $\frac{\text{rise}}{\text{run}}$
6(c)(ii)	$[y =] \text{their(c)(i)} x + \text{their } y\text{-intercept}$ final answer	2	Strict FT $\text{their } y\text{-intercept}$ for their line M1 for $y = \text{their(c)(i)} x + \text{any value}$ or 'c' oe seen or for $y = \text{any value}(\text{non-zero}) x$ or 'mx' + $\text{their } y\text{-intercept}$ seen oe
6(d)(i)	1.05 to 1.25	1	
6(d)(ii)	-2.3 to -2.2 -0.4 to -0.3 0.3 to 0.4	3	B1 for each After 0 scored B1 for $y = -4$ ruled
6(e)	$[a =] 2$ $[b =] 24$ $[n =] 5$	3	B2 for 2 correct or for $2x^5 + 24x^2$ $[-3 = 0]$ or B1 for 1 correct or for $\frac{2x^5 - 3 + 4(6x^2)}{6x^2} [= 0]$ oe If 0 scored SC1 for $2x^5$ seen in final line of algebra
8(a)(i)	1	2	M1 for $h(0)$ or for 2^{8-3x}
8(a)(ii)	8	2	M1 for $g(\frac{1}{4})$ or for $\frac{10}{2^x + 1}$

8(a)(iii)	$\frac{10-x}{x}$ or $\frac{10}{x}-1$ final answer	3	M2 for $x = \frac{10-y}{y}$ or better or $xy = 10 - x$ or better or $y + 1 = \frac{10}{x}$ or M1 for $x(y + 1) = 10$ or $y(x + 1) = 10$ or $x = \frac{10}{y+1}$ or $x + 1 = \frac{10}{y}$
8(a)(iv)	5	1	
8(b)	$\frac{-3x^2 + 5x + 18}{x+1}$ final answer	3	M1 for $\frac{(8-3x)(x+1)+10}{x+1}$ B1 for $-3x^2 - 3x + 8x + 8$ [+10]
2(a)(i)	1,,,, 16	2	B1 for each
2(a)(ii)	14,,,, -2	2	B1 for each
2(b)	Fully correct smooth curves	6	B3 for correct curve of $y = 2^x$ or B2FT for 4 or 5 correct points or B1FT for 2 or 3 correct points B3 for correct curve of $y = 14 - x^2$ or B2FT for 4 or 5 correct points or B1FT for 2 or 3 correct points
2(c)(i)	3.5 to 3.7	1	
2(c)(ii)	2.65 to 2.8	1	
2(d)(i)	Correct line	1	Ruled, through (4, 2) and gradient -4
2(d)(ii)	Tangent (2, 10)	2	B1 for each

5(a)	15.6[0]	4	B3 for $20900x = 326040$ or better or M2 for $18500x + 2400(x - 2.5[0]) = 320040$ or M1 for $18500x$ or $2400(x - 2.5[0])$
5(b)(i)	$(y+12)(y-7)$ final answer	2	B1 for $(y+a)(y+b)$ where $ab = -84$ or $a+b = 5$ or $y(y+12) - 7(y+12)$ or $y(y-7) + 12(y-7)$
5(b)(ii)	38 cao	3	B2 for $y = 7$ or M1 for $y(y+5) = 84$ oe
5(c)(i)	$168(m - 0.75) + 207m = 100m(m - 0.75)$ oe OR $207 = 100m - 168 - 75 + \frac{126}{m}$	M2	May be all over common denominator M1 for $\frac{168}{m}$ or $\frac{207}{m-0.75}$ used
	at least one interim line leading to $50m^2 - 225m + 63 = 0$	A1	No errors or omissions
5(c)(ii)	$(10m-3)(5m-21)$ OR $m = \frac{-(-225) \pm \sqrt{(-225)^2 - 4(50)(63)}}{2(50)}$ oe OR $m = \frac{225}{100} \pm \sqrt{\left(\frac{225}{100}\right)^2 - \frac{63}{50}}$ oe	B2	M1 for $(10m+a)(5m+b)$ where $ab = 63$ or $5a + 10b = -225$ or $10m(5m-21) - 3(5m-21)$ or $5m(10m-3) - 21(10m-3)$ OR M1 for $\sqrt{(-225)^2 - 4(50)(63)}$ or for $p = -(-225)$, $r = 2(50)$ if in form $\frac{p+\sqrt{q}}{r}$ or $\frac{p-\sqrt{q}}{r}$ OR M1 for $\left(m - \frac{225}{100}\right)^2$ oe

9(a)	$y = -2x + 5$ oe	3	B2 for $-2x + 5$ or M1 for gradient $= -1 \div \frac{1}{2}$ or better M1 for substituting (1, 3) into $y = (\text{their } m)x + c$ oe If 0 scored SC1 for (1, 3) satisfying their wrong equation ($c \neq 0$) with gradient $\neq \frac{1}{2}$
9(b)(i)	$x \geq 2$ oe $y \leq 5$ oe $y \geq \frac{1}{2}x$ oe	4	SC3 for $x > 2$ and $y < 5$ and $y > \frac{1}{2}x$ OR B1 for $x \geq 2$ B1 for $y \leq 5$ B2 for $y \geq \frac{1}{2}x$ or M1 for $y \geq kx$ ($k > 0$) OR SC2 for all three boundary lines identified but with incorrect sign(s) If 0 scored SC1 for one or two correct boundary lines with incorrect sign(s)
9(b)(ii)	(5, 4)	2	M1 for one trial of an integer point inside region or for $3x + 5y = 35$ drawn
10(a)(i)	26	2	M1 for $g(5)$ or for $(x^2 + 1)^2 + 1$
10(a)(ii)	$x^2 + 4x + 5$	2	M1 for $(x + 2)^2 + 1$
10(a)(iii)	5	2	M1 for $2x - 3 = 7$
10(a)(iv)	$\frac{x+3}{2}$ oe	2	M1 for $x = 2y - 3$ or $y + 3 = 2x$ or $\frac{y}{2} = x - \frac{3}{2}$ oe
10(b)(i)	[0].70 cao	2	B1 for [0].696 to [0].697
10(b)(ii)	4 cao	1	

3(a)	0 -2 0.9	3	B1 for each
3(b)	Correct curve 	4	B3 FT for 9 or 10 points or B2 FT for 7 or 8 points or B1 FT for 5 or 6 points
3(c)	-0.45 to -0.35 1 2.35 to 2.45	3	FT <i>their</i> graph B1 for each in the correct position If zero scored, SC1FT for 3 correct values
3(d)(i)	$y = 1 - x$ oe	2	B1 for $y = 1 - kx$ oe, $k \neq 0$ or $y = k - x$ oe or $1 - x$
3(d)(ii)	Correct ruled line and 2.25 to 2.4	3	B2FTdep for correct ruled line or B1 dep for line through (0, 1) when extended but not $y = 1$ or with gradient -1.1 to -0.9 or correct line but freehand or SC2 for $y = x - 1$ ruled after answer [$y =$] $x - 1$ in (d)(i) and B1 for 2.25 to 2.4
3(e)	Correct tangent and 1.7 to 3.7	3	No daylight between tangent and curve at $x = -0.25$. Point of contact is the midpoint between two vertices of daylight and this point of contact must be between -0.35 and -0.15 B2 for close attempt at tangent at $x = -0.25$ and answer in range OR B1 for ruled tangent at $x = -0.25$, no daylight Consider point of contact as midpoint between two vertices of daylight, the midpoint must be between $x = -0.35$ and -0.15 and M1 dep on B1 or close attempt at tangent at $x = -0.25$ for $\frac{\text{rise}}{\text{run}}$
8(a)	(5, 6)	1	
8(b)	$[y =] -\frac{4}{5}x + 3$ nfw	3	B2 for $[y =] -\frac{4}{5}x + c$ nfw or M1 for $\frac{\text{rise}}{\text{run}}$ using any two of (-5, 7) (0, 3) and (5, -1) and B1 for $[y =]mx + 3$ ($m \neq 0$)

8(c)	$y = -\frac{4}{5}x - 2$ oe	2	FT <i>their</i> gradient from 8(b) B1 for $y = (\text{their gradient})x + c$ (c not 0) or for $y = mx - 2$ ($m \neq 0$) or for $-\frac{4}{5}x - 2$ alone
8(d)(i)	$y = \frac{5}{4}x + 4$ oe	3	M1 for $-\frac{1}{\text{their gradient}}$ from 8(b) M1 for (8, 14) substituted into <i>their</i> $y = mx + c$ or $\frac{y-14}{x-8} = m$ or better
8(d)(ii)	8.54 or 8.544...	3	M2 for $(14 - \text{their } 6)^2 + (8 - \text{their } 5)^2$ or better or M1 for $14 - \text{their } 6$ and $8 - \text{their } 5$ seen
8(d)(iii)	(4, 6)	2	B1 for each
9(a)(i)	$\frac{72}{m}$	1	
9(a)(ii)	$\frac{72}{m+0.9}$	1	
9 (b)	$\frac{72}{m} - \frac{72}{m+0.9} = 4$ oe	M1	FT <i>their</i> (a)(i) and (a)(ii) if expressions in m
	$72(m+0.9) - 72m = 4m(m+0.9)$ oe	M1	Dependent on M1 and correct fractions
	$[72m - 72m] + 64.8 = 4m^2 + 3.6m$ oe nfww	A1	
	Correct completion to $10m^2 + 9m - 162 = 0$	A1	
9(c)(i)	3.6 and -4.5 final answer	3	B2 for $(2m+9)(5m-18)$ or $\frac{-9 \pm \sqrt{(9)^2 - 4(10)(-162)}}{2 \times 10}$ or better or B1 for $(am+b)(cm+d)$ where $ac = 10$ and either $bd = -162$ or $ad + bc = 9$ or for $\sqrt{(9)^2 - 4(10)(-162)}$ or better or $\frac{-9 \pm \sqrt{q}}{2(10)}$ or better
9(c)(ii)	20	1	

11(a)	$5(m - 2p^2)(m + 2p^2)$ final answer	3	M2 for $(5m + k)(m + j)$ where $kj = -20p^4$ or $5j + k = 0$ or M1 for $5(m^2 - 4p^4)$ seen
11(b)	$[P =] \frac{100A}{100 + RT}$ final answer	3	M1 for $100A = 100P + PRT$ or for $A = P(1 + \frac{RT}{100})$ M1 for $100A = P(100 + RT)$ or for $\frac{A}{1 + \frac{RT}{100}} = P$ or for $100A = P(1 + RT)$ after $100A = P + PRT$ as first step
2(a)	-1.5	3	M1 for $30 + 2x = 9 - 12x$ or $10 + \frac{2}{3}x = 3 - 4x$ M1 for collecting <i>their</i> terms correctly to reach $ax = b$
2(b)	$6ab^2(2b + 3a^2)$ final answer	2	M1 for any correct partial factorisation seen or for correct answer seen
2(c)(i)	$10a^5c^9$ final answer	2	B1 for final answer with $10a^k c^9$ or $10a^5 c^k$ or $ka^5 c^9$
2(c)(ii)	$\frac{8a^6}{c^9}$ or $8a^6 c^{-9}$ final answer	2	B1 for final answer with $\frac{8a^6}{c^k}$ or $\frac{8a^k}{c^9}$ or $\frac{ka^6}{c^9}$ [$k \neq 0$] or for correct answer seen
2(d)	0.5 or $\frac{1}{2}$	3	M1 for $y = \frac{k}{(x+2)^2}$ oe B1 for $k = 50$ or M2 for $2(3 + 2)^2 = y(8 + 2)^2$ oe
2(e)	$\frac{7x - x^2}{2(x-2)}$ or $\frac{7x - x^2}{2x - 4}$ oe final answer	3	M1 for $5 \times 2 - (x - 5)(x - 2)$ oe seen M1 for common denominator $2(x - 2)$ oe isw

5(a)	-3, 17	2	B1 for each
5(b)	Fully correct curve	4	B3 FT for 10 or 11 points or B2 FT for 8 or 9 points or B1 FT for 6 or 7 points
5(c)(i)	Correct ruled tangent for <i>their</i> curve through (0, -17)	1	
5(c)(ii)	(1.7 to 2.2, -1 to 2.5)	1	
5(c)(iii)	[y =] 9x - 17 final answer	3	M2dep for answer [y =] 9x[+] - c OR M1dep for gradient = $\frac{\text{rise}}{\text{run}}$ for <i>their</i> tangent at any point B1 for answer [y =] kx[+] - 17 ($k \neq 0$)
5(d)	y = 3x + 2 ruled correctly and -2.2 ... to -2.1 -0.6 to -0.4 2.6 to 2.8	4	B2 for y = 3x + 2 ruled or B1 for [y =] 3x + 2 soi or y = 3x + k ruled or y = kx + 2 but not y = 2 B2 for all 3 values or B1 for 2 values
6(a)	0.6	1	
6(b)	50.7	3	M2 for $1.2 \times 19 + \frac{1}{2}(19 + 12) \times 1.8$ oe or M1 for method for finding any relevant area
6(c)	17.9	3	M2 for <i>their</i> 50.7 - 1.2 × 19 [- 10] oe or M1 for 1.2 × 19 oe seen isw
4(a)	-1, 3	2	B1 for each

4(b)	Correct graph	3	B2FT for 6 or 7 correct points or B1FT for 4 or 5 correct points
4(c)	Correct ruled tangent and $-2 \leq \text{gradient} \leq -1.5$	3	B2 for close attempt at tangent at $x = -4$ and answer in range OR B1 for ruled tangent at $x = -4$ with no daylight and M1 for rise/run also dep on close attempt at tangent. Must see correct or implied calculation from a drawn tangent.
4(d)	-3, 3	1	
4(e)	Correct graph	4	B3FT for 7 or 8 correct points or B2FT for 5 or 6 correct points or B1FT for 3 or 4 correct points
4(f)(i)	3.6 to 3.85	1	
4(f)(ii)	$x > \text{their (f)(i)}$	1	FT
4(g)	$\frac{x^2}{4} = \frac{9}{x} + \frac{4}{x}$ or $\frac{x^3}{4} - 4 = 9$	M1	Allow $\frac{13}{x}$ for $\frac{9}{x} + \frac{4}{x}$
	52	A1	
9(a)	0	1	
9(b)	5	2	M1 for $3(3^x) + 4$ or better or $f(\frac{1}{3})$ or $f(3^{-1})$
9(c)	$\frac{x+1}{2}$ oe final answer	2	M1 for $x = 2y - 1$ or $y + 1 = 2x$ or $\frac{y}{2} = x - \frac{1}{2}$ or better
9(d)	$9x + 16$	2	M1 for $3(3x + 4) + 4$ oe
9(e)	$9x^2 + 24x + 16$	2	B1 for three terms from $9x^2 + 12x + 12x + 16$ correct
9(f)	27	2	M1 for $x = h(\text{their } g(2))$

3	(a)	0 0.5 oe 1.25 oe	1, 1, 1	
	(b)	Fully correct smooth curve	4	B3 FT for 7 or 8 points or B2 FT for 5 or 6 points or B1 FT for 3 or 4 points
	(c)	3.6 to 3.8	2	M1 for $y = 3.5$ soi
	(d)	line $y = x + 1$ ruled -1.55 to -1.40 4.55 to 4.8	M1 A1 A1	If 0 scored SC1 for $y = x + 1$ stated or implied or for 2 correct values given
	(e) (i)	Point plotted at (5, 5)	1	
	(ii)	Tangent ruled from A	1	
	(iii)	1.2 to 1.4	B2	B2 and M1 dep on reasonable attempt at tangent from (5, 5) M1 for change in y / change in x of <i>their</i> ruled line
5	(a) (i)	$(3x - 1)(x + 4)$	2	M1 for $(3x + b)(x + c)$ with $bc = -4$ or $3c + b = 11$ or for $3x(x + 4) - 1(x + 4)$ or for $x(3x - 1) + 4(3x - 1)$
	(ii)	$\frac{1}{3}$ oe and -4	1	
	(b) (i)	$2 \times 2(x - 4) - 2(2x + 11) = (2x + 11)(x - 4)$ or better $2x^2 + 11x - 8x - 44$ or better $4x - 16 - 4x - 22 = 2x^2 - 8x + 11x - 44$ $2x^2 + 3x - 6 = 0$	M2 B1 A1	M1 for common denom $2(2x + 11)(x - 4)$ seen or attempt to multiply through by denoms or for $\frac{2(x - 4) - (2x + 11)}{(2x + 11)(x - 4)} \left[= \frac{1}{2} \right]$ or for other correct relevant 2 bracket expansion if alt method used correct solution reached with all brackets expanded and no errors or omissions seen
	(ii)	$\frac{-3 \pm \sqrt{(3)^2 - 4(2)(-6)}}{2 \times 2}$ -2.64 and 1.14 final ans cao	2 B1B1	B1 for $\sqrt{(3)^2 - 4(2)(-6)}$ or better or $\left(x + \frac{3}{4}\right)^2$ oe and B1 for $\frac{-3 + \sqrt{q}}{2(2)}$ or $\frac{-3 - \sqrt{q}}{2(2)}$ or better or $-\frac{3}{4} + \sqrt{\frac{57}{16}}$ oe or $-\frac{3}{4} - \sqrt{\frac{57}{16}}$ oe SC1 for -2.6 or -2.637... and 1.1 or 1.137... or -2.64 and 1.14 seen in working or 2.64 and -1.14 as final answers

9	(a)	$x < 10$ oe	1	Accept $x \leq 9$
		$y \geq 2$ oe	1	Accept $y > 1$
	(b)	$x + 3y \leq 21$ oe	1	Mark answer line isw
	(c)	ruled broken line $x = 10$	B1	or ruled line $x = 9$
		ruled line $y = 2$	B1	or ruled broken line $y = 1$
		ruled line from (0, 7) to (21, 0)	B2	SC1 for line with negative gradient correct only at (0, 7) or (21, 0)
(d)	(i)	4	1	
	(ii)	20	1	

11	(a)	4567 8163264128	1	B2 for 3 or 4 correct or B1 for first 2 correct If 0 scored, SC1 for 4 values correctly doubled FT one error
	(b)	2^n oe	1	
	(c)	$2 + 4 + 8 = 14$	1	
		$16 - 2 = 14$	1	
	(ii)	62 and 6	2	
	(iii)	$2^{n+1} - 2$ oe	1	
(iv)		9	1	

4(a)	-1.6 to -1.4	1	
4(b)	-0.5	1	
4(c)	$k > -4$	2	B1 for identifying the -4 or for horizontal line drawn $y = -4$
4(d)	$y = x - 5$ ruled and -2.3 to -2.1 -1.2 to -1.1 1.3 to 1.4	3	B2 for correct line and 2 correct values or no line and 3 correct values or B1 for no line and 2 correct values or B1 for correct line
4(e)	Tangent ruled at $x = 1$	B1	No daylight at point of contact. Consider point of contact as midpoint between two vertices of daylight, the midpoint must be between $x = 0.8$ and 1.2
	-6 to -4	2	Dep on B1 or close attempt at tangent at $x = 1$ M1 for rise/run for <i>their</i> tangent at $x = 1$

6(a)(i)	$-7x + 55$ final answer	2	M1 for $8x + 20$ or $-15x + 35$ or answer $-7x + k$ or $kx + 55$
6(a)(ii)	$x^2 - 14x + 49$ final answer	2	M1 for 3 of $x^2 - 7x - 7x + 49$
6(b)(i)	-18	3	M1 for a correct first step ie correctly multiplying by 3 or correctly dividing by 2 or for correctly subtracting 5 M1 for correctly reaching $ax = b$ from <i>their</i> first step
6(b)(ii)	15	3	M2 for $6x - 4x = 21 + 9$ oe or M1 for $6x - 21$ or correct division by 3 or for correctly reaching $ax = b$ from <i>their</i> first step
6(b)(iii)	5 and -5	3	B2 for 5 or -5 or M1 for $[x^2 =] (74 + 1) \div 3$ or better
7(a)	$(-0.5, 3)$	2	B1 for one correct value
7(b)	$[y =] -2x + 2$ final answer	3	M1 for $\frac{-2-8}{2--3}$ or better M1 for substitution of $(-3, 8)$ or $(2, -2)$ or <i>their</i> midpoint into $y = mx + c$ with <i>their m</i>
7(c)	$y = -2x + 7$ oe	2FT	FT their (b) M1 for $y = (their-2)x + k$ ($k \neq 2$) or $y = kx + 7$ ($k \neq 0$) If zero scored, SC1 for $(their - 2)x + 7$
7(d)	$x - 2y + 9 = 0$ or $2y - x - 9 = 0$ oe	4	B3 for any correct equivalent in wrong form Or M2 for $y = \frac{1}{2}x + k$ oe (FT negative reciprocal of <i>their</i> gradient in (b)) or M1 for grad = $\frac{1}{2}$ (FT negative reciprocal of <i>their</i> gradient in (b)) M1 for substitution of $(1, 5)$ into $y = mx + c$ oe with <i>their m</i>

8(b)(i)	$x(x - 25) = 2200$	1	and no errors seen
8(b)(ii)	$\frac{-(-25) \pm \sqrt{(-25)^2 - 4(1)(-2200)}}{2(1)}$ or better	B2	B1 for $\sqrt{(-25)^2 - 4(1)(-2200)}$ or better or for $\left(x - \frac{25}{2}\right)^2$ oe or B1 for $\frac{-(-25) + \sqrt{q}}{2(1)}$ or $\frac{-(-25) - \sqrt{q}}{2(1)}$ or both or for $\frac{25}{2} + \text{or} - \sqrt{\left(\frac{25}{2}\right)^2 + 2200}$
	-36.04 and 61.04 final answer	B1,B1	If B0B0 , SC1 for values in ranges -36.042 to -36.041 and 61.041 to 61.042 seen or for answers -36[.0] or -36.042 to -36.041 and 61[.0] or 61.041 to 61.042 or -36.04 and 61.04 seen in working or for -61.04 and 36.04 as final ans

4(a)	-1.75 to -1.7	1	
	1.7 to 1.75	1	
4(b)(i)	Correct ruled solid tangent at (-1.5, 3.5)	1	
4(b)(ii)	-7 to -5	2 dep	dep on close attempt at ruled solid tangent at $x = -1.5$ in part (b)(i) M1 for rise/run dep on close attempt at ruled solid tangent at $x = -1.5$
4(c)(i)	1	1	
4(c)(ii)	Correct curve	3	B2 for 4 or 5 correct points or B1 for 2 or 3 correct points

4(d)(i)	-0.95 to -0.8	1	
	1.1 to 1.45	1	
4(d)(ii)	<i>their</i> (-0.95 to -0.8) < x < <i>their</i> (1.1 to 1.45) oe	1FT	correct or FT their (d)(i)
4(e)(i)	0.125 oe and 0.03125 oe and 0.000976 to 0.000977 oe	1	
4(e)(ii)	0	1	accept zero, nought, etc

7(a)(i)	4.5 or $4\frac{1}{2}$ or $\frac{9}{2}$ final answer	3	M2 for $[2](4x + 7) = [2](6x - 2)$ oe or M1 for $2(2x + 6) + 2(2x + 1)$ oe or $4(3x - 1)$ oe or M1 for correctly reaching $ax = b$ from <i>their</i> linear equation
7(a)(ii)	$(2x + 6)(2x + 1) = (3x - 1)^2$	M1	May be seen in different stages
	$5x^2 - 20x - 5 [= 0]$ oe	B3	B1 for $4x^2 + 2x + 12x + 6$ or better B1 for $9x^2 - 3x - 3x + 1$ or better
	$\frac{-(-20) \pm \sqrt{(-20)^2 - 4(5)(-5)}}{2(5)}$ oe	M2	FT their 3 term quadratic provided formula used or complete the square M1 for $\sqrt{(-20)^2 - 4(5)(-5)}$ oe or if in form $\frac{-(-20) + \sqrt{q}}{2(5)}$ or $\frac{-(-20) - \sqrt{q}}{2(5)}$ FT $\pm$ <i>their</i> quadratic or for completing the square M2 for $2 \pm \sqrt{1 + 2^2}$ or M1 for $(x - 2)^2$
	4.24 or 4.236... cao	B1	
7(b)(i)	$(x + 5)(x - 1)$ final answer	2	B1 for $x(x - 1) + 5(x - 1)$ or $x(x + 5) - [1](x + 5)$ or for $(x + a)(x + b)$ where $ab = -5$ or $a + b = 4$
7(b)(ii)	$5(x + 1) - 8x = x(x + 1)$ or $5x + 5 - 8x = x^2 + x$	M2	Could be seen in different stages M1 for $5(x + 1) - 8x$ seen or for common denominator of $x(x + 1)$ for LHS or both sides soi
	-5 and 1 cao	A2	A1 for $x^2 + 4x - 5 [= 0]$ oe
9(a)(i)	100	1	
9(a)(ii)	92.3 or 92.29... to 92.31	3	M2 for $200 \div (2 + \frac{10}{60})$ oe or M1 for $200 \div$ <i>their</i> time interval or M1 for $\frac{10}{60}$ soi oe
9(b)(i)	240 nfwf	3	M2 for $\frac{V}{2} \left(\frac{30}{60} + \frac{20}{60} \right) = 100$ oe or M1 for any correct relevant area seen in terms of V
9(b)(ii)	$\frac{2}{9}$ oe	2FT	FT for <i>their</i> (b)(i) $\div 1080$ to 3 sf or better M1 for <i>their</i> (b)(i) $\times \frac{1000}{3600}$ soi

10(a)	-11	1	
10(b)	7	2	M1 for $3x - 2 = 19$ or better
10(c)	25	2	M1 for $3 \times 3^x - 2$ oe
10(d)	$9x^2 - 8x + 2$ final answer	3	M1 for $(3x - 2)^2 + 3x - 2 + x$ oe B1 for $\left[(3x - 2)^2 = \right] 9x^2 - 6x - 6x + 4$ oe
10(e)	$\frac{x+2}{3}$ oe final answer	2	M1 for $x = 3y - 2$ or $y + 2 = 3x$ or $\frac{y}{3} = x - \frac{2}{3}$ or better

3(a)	0 2.25 2 1.25	4	B1 for each
3(b)	Fully correct smooth curve	4	B3 FT for 7 or 8 points or B2 FT for 5 or 6 points or B1 FT for 3 or 4 points

3(c)	1	1	
3(d)(i)	$[y =] x + 1$	1	
3(d)(ii)	-2.2 to -2.1	1	
	-0.45 to -0.4	1	
	0.51 to 0.6	1	If zero scored, SC1 for <i>their</i> line in (d)(i) drawn. It must be of the form $y = mx + c$ ($m \neq 0$) and drawn 'fit for purpose'
3(e)	$-1.33 < k < 0$ to 0.1	2FT	FT Strict fit of <i>their</i> max point and min point dep on cubic graph or accept correct answer from calculus B1 for each If zero scored, SC1 for two correct values reversed

7(a)	$[x =] -5$ $[y =] 7$ with correct working	4	M1 for correctly equating one set of coefficients M1 for correct method to eliminate one variable OR M1 for correctly rearranging one equation M1 for correct method to eliminate one variable A1 $x = -5$ A1 $y = 7$ both dep on M2 If zero scored, SC1 for 2 values satisfying one of the original equations SC1 if no correct working shown, but 2 correct answers given
7(b)	$[a =] 36$ $[b =] -6$	3	B2 for either correct or M1 for $a = b^2$ or for $x^2 + bx + bx + b^2$ or better or for $(x - 6)^2$ seen and M1 for $2b = -12$ soi
7(c)	$\frac{7x^2 - 12x - 10}{(2x - 5)(x - 1)}$ oe final answer nfw	4	B1 for common denom $(2x - 5)(x - 1)$ seen oe isw M1 for $x(x - 1) + (3x + 2)(2x - 5)$ soi isw B1 for $6x^2 - 15x + 4x - 10$ soi

3(a)	-2.75 or $-2\frac{3}{4}$	2	M1 for $11x - 3x = -7 - 15$ or better
3(b)(i)	$(x + 11)(x - 2)$ final answer	2	M1 for $(x + a)(x + b)$ where $ab = -22$ or $a + b = 9$
3(b)(ii)	-11 and 2 final answer	1	
3(c)	$[x] = \frac{2a}{2 - y}$ or $\frac{-2a}{y - 2}$ nfw final answer	4	M1 for clearing the x term in the denominator M1 for correctly removing the bracket (expand or divide by 2) M1 for factorising to obtain single x term M1 for <i>their</i> factor and division Incorrect answer scores 3 out of 4 maximum
3(d)	$\frac{x}{x + 6}$ nfw final answer	3	M1 for $x(x - 6)$ M1 for $(x + 6)(x - 6)$

4(a)	10, 7	2	B1 for each value
4(b)	Correct curve	4	B3 FT for 10 or 11 correct points B2 FT for 8 or 9 correct points B1 FT for 6 or 7 correct points FT <i>their</i> table
4(c)	-1.7 to -1.55	1	FT <i>their</i> graph if one answer
4(d)	Tangent ruled at $x = 3.5$	B1	No daylight between tangent and curve at point of contact
	6.5 to 11	B2	dep on tangent drawn or close attempt at tangent at $x = 3.5$ M1 for rise/run also dep on tangent or close attempt at $x = 3.5$
4(e)	line $y = 2x + 10$ ruled <u>AND</u> -1.3 to -1.1 1 4.1 to 4.25	4	B3 for correct line (could be short) and 1 correct value or B2 for correct line (could be short) or B1 for $[y =] 2x + 10$ seen If zero scored, SC1 for no/wrong line and 3 correct values
7(a)	-7	1	
7(b)	$\frac{4}{64}$ or better	2	M1 for $g(4^3)$ soi or $\frac{4}{4^x}$ or better
7(c)	$\frac{3-x}{2}$ oe final answer	2	M1 for $x = 3 - 2y$ or $2x = 3 - y$ or $\frac{y}{2} = \frac{3}{2} - x$ or $\frac{y-3}{-2}$ oe as final answer
7(d)	4^{3-2x}	M1	
	Correctly interprets the indices	M1	Dep on previous M1 e.g. $4^3 \times 4^{-2x}$ or $4^3 \times \frac{1}{4^{2x}}$ or $\frac{4^3}{4^{2x}}$
	$\frac{64}{16^x}$ nfw	A1	Correct completion with no errors
7(e)	1.5	2	B1 for $4^x = 8$ or better

10(a)	$12.5^2 = x^2 + 8.5^2 - 2 \times x \times 8.5 \cos 60$ oe isw	M2	M1 for $\cos 60 = \frac{x^2 + 8.5^2 - 12.5^2}{2 \times x \times 8.5}$
	$156.25 = x^2 + 72.25 - 8.5x$	A1	or better
	$2x^2 - 17x - 168 = 0$	A1	with no errors or omissions
10(b)	$\frac{[-]17 \pm \sqrt{([-]17)^2 - 4(2)(-168)}}{2 \times 2}$	2	B1 for $\sqrt{([-]17)^2 - 4(2)(-168)}$ or better seen and if in form $\frac{p + or - \sqrt{q}}{r}$ B1 for $p = [-] 17$ and $r = 2 \times 2$
	14.35, -5.85 final answers	1, 1	SC1 for 14.352 to 14.353 and -5.853 to -5.852 seen or 14.3 or 14.4 and -5.8 or -5.9 as final answers or -14.35 and 5.85 as final answers or 14.35 and -5.85 seen in working
10(c)	12.2 or 12.17... nfw	3	M2 for $\frac{\text{their } 14.35 \times \sin 46}{\sin 58}$ or M1 for $\frac{\sin 46}{CD} = \frac{\sin 58}{\text{their } 14.35}$

5(a)	3.2 or 3.15 or 3.152 to 3.153 5.2 or 5.19 or 5.20 or 5.196...	2	B1 for each
5(b)	Correct graph for $0.5 \leq x \leq 3.5$	4	B3FT for 6 or 7 correct points or B2FT for 4 or 5 correct points or B1FT for 2 or 3 correct points
5(c)	1.7 to 1.8	1FT	FT <i>their</i> graph if one answer
5(d)(i)	Any integer $k \geq -1$	1	
5(d)(ii)	Any integer $k < -1$	1	
5(e)	Tangent ruled at $x = -3$	B1	
	2.5 to 4	B2	dep on tangent drawn at $x = -3$ or close attempt at tangent at $x = -3$ M1 for rise/run also dep on tangent at $x = -3$ or close attempt at tangent at $x = -3$

5(f)(i)	$y = 6 - x$ ruled accurately	M2	M1 for correct line but freehand or ruled line gradient -1.1 to -0.9 , or through $(0, 6)$ but not $y = 6$
	$2.85 \leq x \leq 3$	A1	
5(f)(ii)	$[a =] 8$ $[b =] -48$ $[c =] -16$	4	B3 for 2 correct or $x^5 + 8x^3 - 48x^2 - 16 = 0$ seen or $-x^5 - 8x^3 + 48x^2 + 16 = 0$ seen or M2 for correct multiplication by $8x^2$ or B1 for answers $\pm 8, \pm 48, \pm 16$ or M1 for $\frac{x^2 \times x^3 - 8 \times 2}{x^2 \times 8} = 6 - x$ or M1 for correct multiplication by 8 or M1 for correct multiplication by x^2
8(a)(i)	$7a + 9p = 354$ oe final answer	1	
8(a)(ii)	$[a =] 21$ $[p =] 23$	3	M1 for correctly eliminating one variable A1 for $a = 21$ A1 for $p = 23$
8(b)(i)	$\frac{2}{x}$	1	
8(b)(ii)(a)	$\frac{2}{x} + \frac{3}{x-1} = 2$	M1	
	$2(x-1) + 3x = 2x(x-1)$ oe	M1dep	Both sides of the equation could be over $x(x-1)$ at this stage Dep on M1 or 3 term equation with fractions but one sign error
	$2x - 2 + 3x = 2x^2 - 2x$ oe $2x^2 - 7x + 2 = 0$	A1	Answer reached with one correctly expanded line seen and no errors seen
8(b)(ii)(b)	$\sqrt{(-7)^2 - 4(2)(2)}$	B1	or for $\left(x - \frac{7}{4}\right)^2$
	$\frac{- -7 + \sqrt{q}}{2 \times 2}$ or $\frac{- -7 - \sqrt{q}}{2 \times 2}$	B1	or for $\frac{7}{4} + \text{or} - \sqrt{-1 + \left(\frac{7}{4}\right)^2}$
	3.19 only	B2	B1 for 3.19 with other root or for 3.2 or 3.186... isw other root or for 0.31 or 0.314 or 0.3138 to 0.3139

9(a)	3	1	
9(b)	$-\frac{2}{5}$ oe	2	M1 for $2(1-2x) = x+4$
9(c)	$-2x-7$ final answer	2	M1 for $1-2(x+4)$
9(d)	26	2	B1 for $h(5)$ soi or M1 for $(x^2+1)^2+1$
9(e)	$\frac{1-x}{2}$ oe final answer	2	M1 for $x=1-2y$ or $2x=1-y$ or $\frac{y}{2}=\frac{1}{2}-x$ or $y-1=-2x$
9(f)	$[p=]-20$ $[q=]26$	4	B3 for $[hgf(x)] = 4x^2 - 20x + 26$ seen and not spoilt by further working or M1 for $(1-2x)+4$ M1 dep for $(their (5-2x))^2+1$ B1FT dep for $25-10x-10x+4x^2$

2(a)	343	1	
2(b)(i)	1	1	
2(b)(ii)	x^{10} final answer	1	
2(b)(iii)	$9x^{16}$ final answer	2	B1 for x^{12} or x^{16} or $(3x^8)^2$ seen
2(c)(i)	$2(x-3)(x+3)$ final answer	2	M1 for $(2x+6)(x-3)$ or $(2x-6)(x+3)$ or $(x-3)(x+3)$
2(c)(ii)	$\frac{2(x+3)}{x+10}$ or $\frac{2x+6}{x+10}$ final answer nfw	3	M2 for $(x+10)(x-3)$ or M1 for $(x+a)(x+b)$ where $ab=-30$ or $a+b=7$

7(a)	9, -6, 9	3	B1 for each
7(b)	Correct graph	4	B3FT for 6 or 7 correct points or B2FT for 4 or 5 correct points or B1FT for 2 or 3 correct points
7(c)	-3.5 to -3.35 and 0.8 to 0.9..	2FT	FT <i>their</i> graph B1FT for either
7(d)	$a = \frac{5}{4}$ or $1\frac{1}{4}$ or 1.25 $b = -\frac{49}{8}$ or $-6\frac{1}{8}$ or -6.125	3	B2 for either correct or M1 for $[2]\left(x + \frac{5}{4}\right)^2$ seen isw or for $2x^2 + 4ax + 2a^2 + b$
8(a)(i)	5	1	
8(a)(ii)	$-\frac{3}{2}$ oe	1	
8(b)	$\left(\frac{4}{5}, 0\right)$ oe	2	M1 for $5x - 4 = 0$ soi
8(c)	$y = -0.2x + 11$ final answer	4	M2 for $y = -0.2x + c$ oe (any form) FT <i>their</i> (a) or B1FT for $\text{grad} = \frac{-1}{\text{their (a)(i)}}$ soi and M1 for substitution of (10, 9) into <i>their</i> equation
8(d)	(2, 6)	3	M1 for elimination of one variable A1 for $x = 2$ or $y = 6$
8(e)	13	3	M2 for $(4 + 9) \times \text{their } 2 \div 2$ oe or B1 for 9 oe or 4 or -4 seen

9(a)	$\frac{10}{x-0.5}$ oe final answer	1	Accept $\frac{20}{2x-1}$
9(b)(i)	$\frac{10}{x-0.5} - \frac{10}{x} = 0.25$ oe	M1	FT <i>their</i> (a)
	$10x - 10(x - 0.5) = 0.25x(x - 0.5)$ oe	M1	Clears algebraic denominators or collects as a single fraction FT <i>their</i> algebraic fractions dep on two fractions with algebraic denominators
	$10x - 10x + 5 = 0.25x^2 - 0.125x$ or better	B1	Expands brackets
	$2x^2 - x - 40 = 0$	A1	Dep on M1M1B1 and no errors seen
9(b)(ii)	$\frac{- -1 \pm \sqrt{(-1)^2 - 4 \times 2 \times -40}}{2 \times 2}$ oe	B2	B1 for $\sqrt{(-1)^2 - 4(2)(-40)}$ or better or B1 for $\frac{- -1 + \sqrt{q}}{2 \times 2}$ or $\frac{- -1 - \sqrt{q}}{2 \times 2}$ or both
	-4.23 and 4.73 final answers	B1 B1	SC1 for -4.229... and 4.729... or for -4.23 and 4.73 seen in working or for -4.73 and 4.23 as final answer or for -4.2 or -4.22 and 4.7 or 4.72 as final answer
9(b)(iii)	2 [hours] 7 [minutes]	3	B2 for 2.11 or 2.114 to 2.115 or 126.8 to 126.9 or 127 or M1 for $10 \div$ <i>their</i> positive root from (b)(ii)
7			
(a)	3.5[0] 1.94 3.11	3	B1 for each
(b)	Fully correct curve	5	B3 FT for 10 or 11 points or B2 FT for 8 or 9 points or B1 FT for 6 or 7 points B1 indep two separate branches not touching or cutting y-axis SC4 for correct curve, but branches joined
(c)	-0.7 to -0.6	1	

(d) (i) (ii) (e)	-1 2.5 -0.6 to -0.5 with correct ruled line Correct tangent and $0.5 \leq \text{grad} \leq 0.85$	1 1 3 3	If 0,0, M1 for $y = 2.5 - x$ oe seen in working B2FT for drawing <i>their</i> ruled line from (d)(i) or M1 for ruled line through (0, 2.5)FT or gradient -1 FT B2 for close attempt at tangent at $x = 2$ and answer in range OR B1 for ruled tangent at $x = 2$, no daylight at $x = 2$ Consider point of contact as midpoint between two vertices of daylight, the midpoint must be between $x = 1.8$ and 2.2 and M1 (dep on B1 or close attempt at tangent [at any point] for $\frac{\text{rise}}{\text{run}}$)
8 (a) (b) (c) (d)	15 nfw $\frac{x+6}{x-2}$ nfw final answer $\frac{X}{W^2+1}$ nfw final answer $\frac{-7x-1}{x^2-1}$ or $\frac{-7x-1}{(x-1)(x+1)}$ final answer	3 5 5 5	M1 for $y = k\sqrt{x+2}$ oe A1 for $k = 3$ B2 for $(x+6)^2$ oe or SC1 for $(x+a)(x+b)$ where $ab = 36$ or $a+b = 12$ or $x(x+6) + 6(x+6)$ B2 for $(x-2)(x+6)$ or SC1 for $(x+a)(x+b)$ where $ab = -12$ or $a+b = 4$ or $x(x+6) - 2(x+6)$ or $x(x-2) + 6(x-2)$ M1 for $W^2 = \frac{X-a}{a}$ or $W\sqrt{a} = \sqrt{X-a}$ M1 for next productive step M1 for 2nd productive step M1 for 3rd productive step M1 for final step leading to $a =$ M1 for common denominator $(x-1)(x+1)$ isw M1 for $(x-2)(x-1) - (x+3)(x+1)$ B2 for $x^2 - 2x - x + 2 - (x^2 + 3x + x + 3)$ oe or B1 for either expansion

11	(a) (i)	11	1	
	(ii)	$14x + 3$ final answer	1	
	(b)	$17 - 21x$ final answer	2	M1 for $7(2 - 3x) + 3$ oe
	(c)	$-\frac{1}{9}$	3	M1 for $3(2 - 3x) = 7$ oe M1 for correct first step
	(d)	-1.3	3	M1 for $2 - 3(x + 4) - (7x + 3) = 0$ M1 for $-10x - 13 = 0$ oe If 0 scored, SC1 for answer -0.7 oe after $2 - 3(x + 4) - 7x + 3 = 0$ shown previously
5	(a)	9 10.5	1 1	
	(b)	Fully correct curve	5	SC4 for correct curve, but branches joined B3 FT for 9 or 10 points plotted or B2 FT for 7 or 8 points plotted or B1 FT for 5 or 6 points plotted and B1 for two separate branches not touching or cutting y-axis
	(c)	2.1 to 2.6	1	
		8.5 to 9	1	
	(d)	2, 3, 5, 7	2	SC1 for correct 4 values and no more than one extra positive integer or $\pm 2, \pm 3, \pm 5, \pm 7$ or 3 correct values and no extras
	(e)	$(-2, -12)$	1	
	(f) (i)	$20 + x^2 = x^3$	M1	Multiplication by x
		$x^3 - x^2 - 20 = 0$	A1	No errors or omissions
	(ii)	Fully correct curve $y = x^2$	2	SC1 for U – shaped parabola, vertex at origin
	(iii)	2.5 to 3.5	1	
	(iv)	3.[0] to 3.1 or FT their answer to (iii)	1FT	FT dep on (iii) > 0

6	(a) (i)	$[y =] \frac{1}{2}(80 - 2x)$	M1	$40 - x$ is enough
		$A = \text{their} \frac{1}{2}(80 - 2x) \times x$ oe	M1	
		$A = 40x - x^2$ and $x^2 - 40x + A = 0$	A1	No errors or omissions
	(ii)	$(x - 30)(x - 10)$	B2	B1 for $x(x - 30) - 10(x - 30) [= 0]$ or $x(x - 10) - 30(x - 10) [= 0]$ or SC1 for $(x + a)(x + b)$ where $ab = 300$ or $a + b = -40$
	(iii)	30, 10	B1	
		$\sqrt{(-40)^2 - 4(1)(200)}$ or better	B1	or for $(x - 20)^2$
		$p = -40$ and $r = 2(1)$	B1	Must see $\frac{p + \sqrt{q}}{r}$ or $\frac{p - \sqrt{q}}{r}$ or both or for $20 \pm \sqrt{200}$
	(b) (i)	5.86 34.14	B1 B1	If B0 , SC1 for 5.9 or 5.857 to 5.858 and 34.1 or 34.14... or 5.86 and 34.14 seen in working or -5.86 and -34.14 as final answers
		$\frac{200}{x} - \frac{200}{x + 10}$	M2	or M1 for $\frac{200}{x}$ or $\frac{200}{x + 10}$ soi
		$\frac{200(x + 10) - 200x}{x(x + 10)} = \frac{2000}{x(x + 10)}$	A1	No errors or omissions
	(ii)	16 [min] 40 [s]	3	B2 for $0.2\dot{7}$ or 0.278 or 0.2777 to 0.2778 or $\frac{5}{18}$ [h] oe or $16.\dot{6}$ or 16.7 or 16.66 to 16.67 or $\frac{50}{3}$ [min] or M1 for $2000 \div 80(80 + 10)$ or $\frac{200}{80} - \frac{200}{90}$

8	(a)	2	2	M1 for $2x + 1 = 1 + 4$
	(b)	17	2	B1 for $[h(3) =] 8$ soi or $2 \times 2^x + 1$ oe
	(c)	$\frac{x-1}{2}$ oe final answer	2	M1 for $y - 1 = 2x$ or $\frac{y}{2} = x + \frac{1}{2}$ or $x = 2y + 1$
	(d)	$4x^2 + 4x + 5$ final answer	3	M1 for $(2x+1)^2 + 4$ and B1 for $[(2x+1)^2 =] 4x^2 + 2x + 2x + 1$ or better
	(e)	$\sqrt{2}$ or 1.41 or 1.414....	1	
	(f)	-1	1	
9	(a) (i)	$-\frac{1}{2}x + 2$ oe	3	SC2 for $y = -\frac{1}{2}x + c$ oe or SC1 for $y = kx + 2$ oe, $k \neq 0$ or M1 for [gradient =] $\frac{-2}{4}$ and M1 for substituting (4, 0) or (0, 2) into $y = (their\ m)x + c$
	(ii)	$\frac{16}{a^2} \left[+ \frac{0^{[2]}}{b^2} \right] = 1$ or $\frac{4^2}{a^2} \left[+ \frac{0^{[2]}}{b^2} \right] = 1$ and $a^{[2]} = 4^{[2]}$ $\left[\frac{0^{[2]}}{a^2} \right] + \frac{4}{b^2} = 1$ or $\left[\frac{0^{[2]}}{a^2} \right] + \frac{2^2}{b^2} = 1$ and $b^{[2]} = 2^{[2]}$	1 1	
	(b) (i)	1.73 or 1.732.. or $\sqrt{3}$	3	M2 for $\frac{k^2}{4} = \frac{3}{4}$ or better or M1 for $\frac{2^2}{16} + \frac{k^2}{4} = 1$ oe
	(ii)	81.8 or 81.78 to 81.79	3	M2 for $2 \times \tan^{-1} \left(\frac{their\sqrt{3}}{2} \right)$ oe or M1 for $\tan = \frac{their\sqrt{3}}{2}$ oe
	(c) (i)	8π final answer	1	
	(ii)	72π final answer	2FT	FT <i>their</i> (c)(i) $\times 9$ in terms of π M1 for area factor of 3^2 or 9 or [new a] = 12, [new b] = 6

(d) (i)	Correct line $y = -5x - 2$ ruled and – 0.4 to – 0.2 0.55 to 0.75	4	M2 for correct ruled line or M1 for correct line but freehand or for ruled line gradient – 5 or ruled line y-intercept – 2, but not $y = -2$ and A1 for each correct solution dependent on at least M1 If 0 scored, SC1 for both correct with no line drawn
(ii)	$[a =] 5$ and $[b =] -2$	2	B1 for one correct value or M1 for $x^3 + 5x^2 - 2x - 1 = 0$ seen

8 (a) (i) (ii) (iii) (iv) (b) (i) (ii)	-3 $\frac{4}{5x+4}$ final answer $\frac{4+3x}{x}$ or $\frac{4}{x}+3$ final answer 2 $(5x+7)(x-3) = 4$ $5x^2 - 15x + 7x - 21 = 4$ oe $5x^2 - 8x - 25 = 0$ $\sqrt{(-8)^2 - 4(5)(-25)}$ or better $p = -(-8)$ and $r = 5 \times 2$ oe -1.57 and 3.17	2 M1 for $[g(1)=] -2$ provided not used in a product or for $5\left(\frac{4}{x-3}\right) + 7$ or better 2 M1 for $\frac{4}{5x+7-3}$ 3 M2 for $xy = 4 + 3x$ or $y - 3 = \frac{4}{x}$ or $x = \frac{4}{y} + 3$ or $x = \frac{4+3y}{y}$ or M1 for $x = \frac{4}{y-3}$ or $y(x-3) = 4$ or $x-3 = \frac{4}{y}$ or $x(y-3) = 4$ 1 M1 B1 Condone omission of '=' for the B mark A1 Dep on M1B1 and no errors or omissions at any stage seen B1 or for $\left(x - \frac{4}{5}\right)^2$ oe B1 must see $\frac{p+\sqrt{q}}{r}$ or $\frac{p-\sqrt{q}}{r}$ or both or for $\frac{4}{5} + \sqrt{\left(\frac{4}{5}\right)^2 + 5}$ or $\frac{4}{5} - \sqrt{\left(\frac{4}{5}\right)^2 + 5}$ B1B1 SC1 for final answers -1.6 or -1.574 to -1.575 and 3.2 or 3.174 to 3.175 or -1.57 and 3.17 seen in working or for -3.17 and 1.57 as final ans
9 (a)	19[.0] or 18.97.. nfw	3 M2 for $\sqrt{(4--2)^2 + (13--5)^2}$ oe or M1 for $(4--2)^2 + (13--5)^2$ oe

(b)	$[y =] 3x + 1$	3	B2 for answer $[y =] 3x + c$ oe or answer $kx + 1$ ($k \neq 0$) or M1 for $\frac{13 - -5}{4 - -2}$ oe or 3 and M1 for correct substitution of $(-2, -5)$ or $(4, 13)$ into $y = (\text{their } m)x + c$ oe
(c)	$y = 3x - 5$ oe	2FT	FT <i>their</i> gradient from (b) M1 for $y = mx - 5$ with other $m, m \neq 0$ or $y = \{\text{their gradient from (b)}\}x + c$ If 0 scored, SC1 for answer $3x - 5$
(d)	$y = -\frac{1}{3}x + \frac{13}{3}$ oe isw	5	B2FT for $-\frac{1}{3}x + c$ (c can be numeric or algebraic) FT $-1/$ <i>their</i> gradient from (b) or M1 for $-1/$ <i>their</i> gradient from (b) soi and B1 for [midpoint of $AB =$] $(1, 4)$ and M1 for substitution of $(1, k)$ or $(k, 4)$ into a linear equation
2 (a)	$x > \frac{12}{5}$ oe final answer	2	B1 for $\frac{12}{5}$ oe in answer with incorrect or no sign or M1 for one correct step e.g. $5x > 9 + 3$
(b) (i)	$(y - 6)(x + 3)$ final answer	2	M1 for $y(x + 3) - 6(3 + x)$ or $x(y - 6) + 3(y - 6)$
(ii)	$8(x + 3y)(x - 3y)$ final answer	3	M2 for $2(2x + 6y)(2x - 6y)$ or $(8x + 24y)(x - 3y)$ or $(8x - 24y)(x + 3y)$ or $4(2x - 6y)(x + 3y)$ or $4(2x + 6y)(x - 3y)$ or $(4x - 12y)(2x + 6y)$ or $(4x + 12y)(2x - 6y)$ or M1 for $8(x^2 - 9y^2)$ or $(x + 3y)(x - 3y)$
(c)	$r = \frac{1}{p + 7}$ final answer nfw	4	M1 removes fraction correctly M1 collects terms in r M1 removes r as a factor from their terms in r M1dep divides by bracket to leave r and denominator simplified

3	(a) (i)	10	1	
	(ii)	−3.4 to −3.3 and −0.4 to −0.3 and 1.6 to 1.7	3	B1 for each
	(iii)	$y = -2.3$ to -2.1 oe $y = 10$ to 10.1 oe	2	B1 for each
	(b) (i)	2, −1, 4	3	B1 for each
	(ii)	Fully correct curve drawn	4	SC3 for correct curves but branches joined or touching y -axis or B2FT for 8 or 9 correct plots or B1FT for 6 or 7 correct plots and B1 indep for two separate branches not touching or crossing y - axis
	(iii)	−3.4 to −3.2 and 1.8 to 1.9	2	B1 for each
	(c)	3.2 oe	2FT	FT 2 ÷ <i>their</i> (a)(i) + 3 M1 for $f(-2) = 10$ or <i>their</i> (a)(i) used
	(d)	1	1	

7	(a) (i)	$\frac{12}{x-1} - \frac{10}{x} = 0.5 \text{ oe}$ $12x - 10(x-1) = 0.5x(x-1) \text{ or better}$ Brackets expanded $x^2 - 5x - 20 = 0 \text{ with no errors or omissions seen}$	M2 M1 A1	M1 for $\frac{12}{x-1}$ or $\frac{10}{x}$ FT $\frac{10}{x} - \frac{12}{x-1} = 0.5$ only Dep on M3 and brackets expanded
	(ii)	$\sqrt{(-5)^2 - 4(1)(-20)} \text{ or better}$ $p = -(-5), r = 2(1) \text{ or better}$ – 2.62, 7.62 final answers	B1 B1 B1B1	Seen anywhere or $(x - \frac{5}{2})^2$ oe Must be in the form $\frac{p + \sqrt{q}}{r}$ or $\frac{p - \sqrt{q}}{r}$ or for $\frac{5}{2} + \sqrt{\left(\frac{5}{2}\right)^2 + 20}$ or $\frac{5}{2} - \sqrt{\left(\frac{5}{2}\right)^2 + 20}$ SC1 for – 2.6 or – 2.623 to – 2.624 and 7.6 or 7.623 to 7.624 or – 2.62 and 7.62 seen in working or answers 2.62 and – 7.62
	(iii)	1 [hr] 49 [mins]	2FT	FT $12 \div (\text{their +ve root} - 1)$ or $0.5 + 10 \div (\text{their } 7.62)$ in hrs and mins, rounded to nearest min M1 for $12 \div (\text{their +ve root} - 1)$ or $0.5 + 10 \div (\text{their } 7.62)$
	(b) (i)	2.5	1	
	(ii)	1312.5 final answer	3	M2 for any complete correct method e.g $25 \times 10 \div 2 + 45 \times 25 + 5 \times 25 \div 2$ M1 for any correct method for a relevant area under the graph

4	(a)	0.92,, 0.5, -1,, -1, 0.5,, 0.92	3	B2 for 4 or 5 correct or B1 for 2 or 3 correct
	(b)	Fully correct graph	5	B4 for correct graph but branches joined OR B3FT for 11 or 12 correct points or B2FT for 9 or 10 correct points or B1FT for 7 or 8 correct points B1indep for a branch on each side of the y -axis, without touching it
	(c) (i)	Correct ruled line through $(-2, 1)$ and $(2, -3)$	2	B1 for straight line with gradient -1 or cutting y -axis at -1 or correct line but freehand or short correct ruled line
	(ii)	0.7 to 0.95	1	
	(iii)	$[p =] 2$ and $[q =] -2$	3	B2 for $x^3 + 2x^2 - 2 = 0$ oe or B1 for $x^2 - 2 = -x^3 - x^2$ oe or better or $1 + 1 - \frac{2}{x^2} + x [= 0]$ or better
	(d) (i)	$(1.3 \text{ to } 1.6, 0)$	1	
	(ii)	Ruled line from $(0, -2)$ to intersection of <i>their</i> graph with positive x -axis	1FT	
	(iii)	Tangent [to curve] A or $(1.3 \text{ to } 1.6, 0)$	1 1	

8	(a)	$\frac{323}{x} + \frac{323}{x+2} = 36$ oe three term equation $323(x+2) + 323x = 36x(x+2)$ oe or $\frac{323x + 646 + 323x}{x(x+2)} = 36$ oe $36x^2 - 574x - 646 = 0$ $18x^2 - 287x - 323 = 0$	B2	B1 for $\frac{323}{x}$ seen oe or $\frac{323}{x+2}$ seen oe
	(b) (i)	17, 19	1	
	(ii)	$(\dots\dots + 19)(\dots\dots - 17)$	2	SC1 for $(\dots\dots + a)(\dots\dots + b)$ where a, b are integers and $ab = -323$ or $a + 18b = -287$
	(iii)	$17, -\frac{19}{18}$ oe	1FT	FT <i>their</i> (b)(ii)
	(c)	11 cao	1	

9	(a)	236	3	B2 for 243 and 7 or M2 for $3^{2(2)+1} - (2(3^{[1]} + 1))$ oe B1 for h(5) or f(3) soi or M1 for $3^{2x+1} - (2(3^x) + 1)$ or better
	(b)	$6x + 1$ final answer	2	M1 for $3(2x + 1) - 2$
	(c)	$x < 3$ oe final answer	2	M1 for $1 + 2 > 3x - 2x$ or $2x - 3x > -2 - 1$ oe
	(d)	-2	1	
	(e)	$\frac{x+2}{3}$ oe final answer	2	M1 for $x = 3y - 2$ or $y + 2 = 3x$ or $\frac{y}{3} = x - \frac{2}{3}$
	(f)	$\frac{6x^2 - x + 3}{2x + 1}$ final answer	3	M1 for $5 + (2x + 1)(3x - 2)$ or better isw B1 for common denominator $2x + 1$ isw
	(g)	9	1	

2	(a)	1 1	1 1	
	(b)	Fully correct graph	4	B3FT for 6 or 7 points plotted or B2FT for 4 or 5 points plotted or B1FT for 2 or 3 points plotted
	(c) (i)	-1 < ans < -0.8 1.25 < ans < 1.45 2.5 < ans < 2.6	1 1 1	
	(ii)	-0.7 < ans < -0.5	2	M1 for evidence of $y = -x$ or $\frac{x^3}{3} - x^2 + 1 = -x$
	(d) (i)	$y = 1$ to 1.1 oe	1FT	FT only if a clear maximum point
		$y = -0.4$ to -0.33 oe	1FT	FT only if a clear minimum point
	(ii)	-0.4 to -0.33 oe	1FT	Correct or FT <i>their</i> graph

	(b) (i)	$x + y \geq 9$ oe $y \geq 2$ oe	1 1	If zero scored, SC1 for $x + y > 9$ and $y > 2$
	(ii)	Fully correct diagram with unwanted region shaded	4	B1 for $2x + 3y = 24$ ruled B1 for $x + y = 9$ ruled B1 for $y = 2$ ruled
	(iii)	20 [x =] 7 [y =] 2	1 1 1	If zero scored, SC1 for $2x + 3y$ evaluated from integers

7	(a)	54.50 final answer	2	B1 for 54.495 to 54.496 or 54.5 or M1 for $200 \div 3.67$
	(b) (i)	$\frac{1000}{x(x+1)}$ final answer	3	M1 for $1000(x+1) - 1000x$ M1 for denominator $x(x+1)$
	(ii)	$\frac{1000}{x} - \frac{1000}{x+1} = 4.5[0] \text{ oe}$ or $\frac{1000}{x(x+1)} = 4.5$ $1000 = 4.5x(x+1)$ $4.5x^2 + 4.5x - 1000 = 0$ $9x^2 + 9x - 2000 = 0$	M1	Allow <i>their</i> (b)(i) for first M1 only for a single fraction
	(iii)	$\frac{-9 \pm \sqrt{9^2 - 4(9)(-2000)}}{2(9)}$ -15.42 14.42	M1dep A1	Correctly multiplying by algebraic denominator Equation reached without any errors or omissions and at least one step after clearing the denominators of the fractions still with brackets included
	(iv)	69.34 to 69.37 final answer must be 2 dp	2	B1 for $\sqrt{9^2 - 4(9)(-2000)}$ If in form $\frac{p + \sqrt{q}}{r}$ or $\frac{p - \sqrt{q}}{r}$ then B1 for $p = -9$ and $r = 2(9)$
			B1 B1	SC1 for answers -15.4 or -15.42 to -15.41 and 14.4 or 14.41 to 14.42 or for -14.42 and 15.42 or -15.42 and 14.42 seen but not final answer Answers without working only score B1, B1 or SC1
			2FT	FT $1000 \div \text{their positive } x$ with final answer rounded up or down to 2 dp or M1 for $1000 \div \text{their positive } x$
9	(a) (i)	1.5 oe	1	
	(ii)	$\frac{3}{y-2}$ oe final answer	3	M1 for correct removal of fraction M1 for collection of terms in x and factorises OR M1 subtracts 2 from both sides M1 multiplies by x to remove fraction and M1 for correct division by expression of the form $ay + b$, a and $b \neq 0$
	(b) (i)	-3	1	
	(ii)	65 536 final answer	2	B1 for $h(16)$ oe e.g. $h(2^4)$
	(iii)	-6	2	M1 for $2 - x = 2^3$ oe
	(iv)	3	1	

2 (a) (b) (c) (d) (i) (ii)	–4.5 and 10.5 Correct curve 5 Line $y = 15 - 3x$ ruled and –0.4 to –0.31 0.35 to 0.45 2.2 to 2.3 $[a =] 6$ $[b =] -14$ $[c =] 0$	2 5 1 4 3	B1 for each value B4 for correct curve with branches joined OR B3 FT for 9 or 10 points or B2 FT for 7 or 8 points or B1 FT for 5 or 6 points and B1 independent for one branch on each side of the y-axis and not touching or crossing the y-axis B3 for correct line and 2 correct values or B2 for correct line or M1 for ruled line with gradient –3 or through (0, 15) or SC2 for no/wrong line and three correct values or SC1 for no/wrong line and two correct values or for correct freehand line B2 for $6x^3 - 14x^2 + 2 = 0$ oe or M1 for correct removal of denominator or collection of terms on one side
3 (a) (b) (c) (d)	2.25 oe $x \geq 3.5$ final answer $(x - 7)(x + 3)$ final answer $12x^2 + xy - 6y^2$ final answer	2 2 2 3	M1 for $8x + 4x = 22 + 5$ or better M1 for $6x - 2x \geq 14$ or better M1 for $x(x + 3) - 7(x + 3)$ or $x(x - 7) + 3(x - 7)$ or for $(x + a)(x + b)$ where $ab = -21$ or $a + b = -4$ M2 for $12x^2 + 9xy - 8xy - 6y^2$ or M1 for any two of the four terms correct

11	5 and $-\frac{27}{2}$ oe	7 M2 for $12 \times 2(2x - 1) + (x + 3)(2x - 1) = 12 \times 3(x + 3)$ oe or M1 for a common denominator with 2 or more of the terms and B2 for $2x^2 + 17x - 135 [= 0]$ oe or B1 for $48x - 24$ or $2x^2 - x + 6x - 3$ or $36x + 108$ or $2x^2 - x + 54x - 27$ or $132 - 12x$ or $37x + 111 - 2x^2 - 6x$ and M2 for $(2x + 27)(x - 5)$ or <i>their</i> correct factors or formula or M1 for $2x(x - 5) + 27(x - 5)$ or $x(2x + 27) - 5(2x + 27)$ or $(2x + a)(x + b)$ where $ab = -135$ or $a + 2b = 17$
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