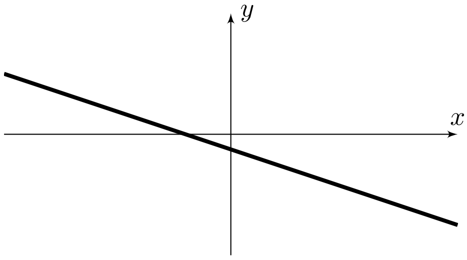
Chapter 4

Functions

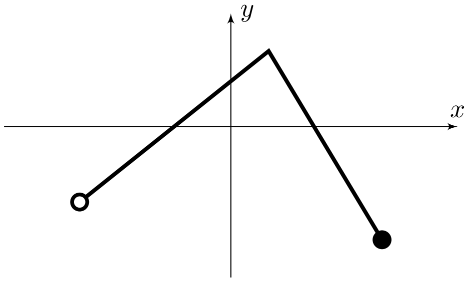
4.1 Basic properties

Q1. Does a diagram show a graph of a function? (where the domain is shown on the x-axis and the range on the y-axis)

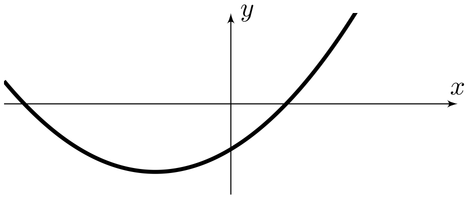
(1)



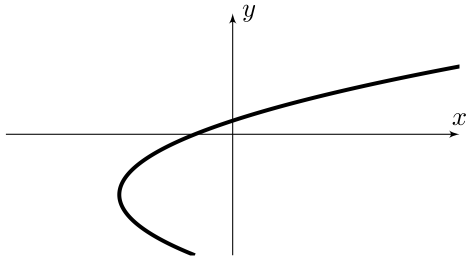
(2)



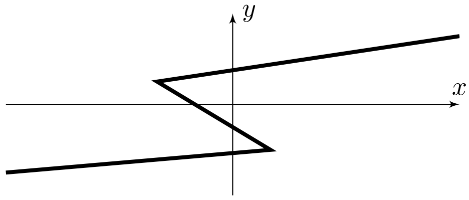
(3)



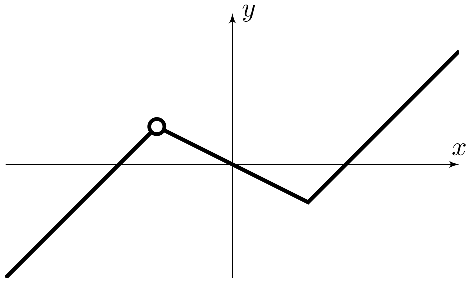
(4)



(5)



(6)



Q2. Each diagram below shows a graph of function f. From the graph read:

(i) the domain of f,

(ii) the range of f,

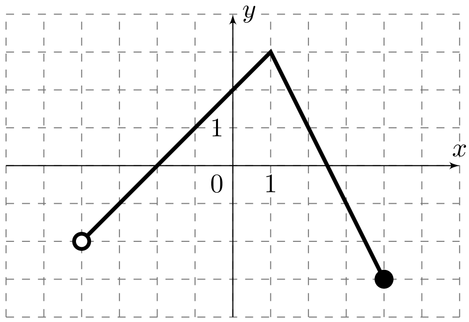
(iii) zeroes of f,

(iv) set(-s) of arguments for which f increases,

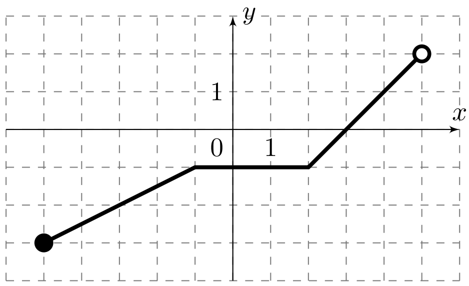
(v) set(-s) of arguments for which f decreases,

(vi) set(-s) of arguments for which f is constant,

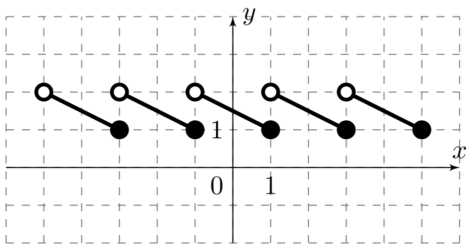
(vii) the set of arguments for which the values are...
(*note that the question finishes differently for each of the diagrams*)

(1) 

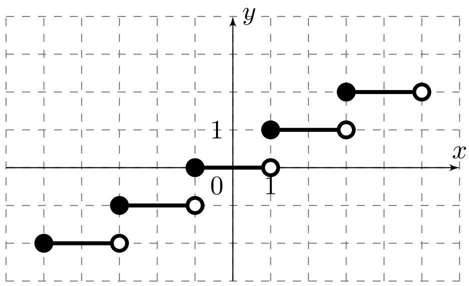
(vii) ... equal 2.

(2) 

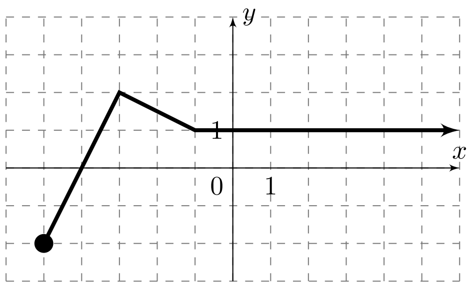
(vii) ... equal -1.

(3) 

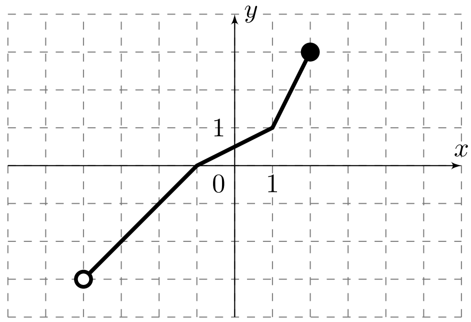
(vii) ... equal 3.

(4) 

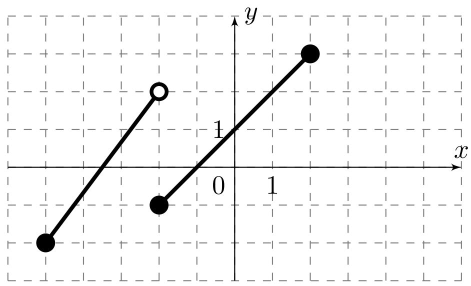
(vii) ... equal 1.5.

(5) 

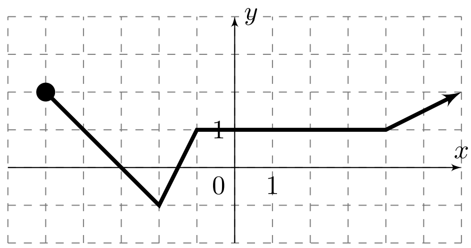
(vii) ... greater than 1.

(6) 

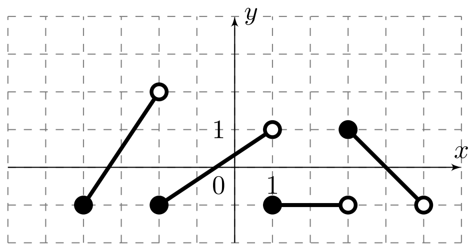
(vii) ... smaller or equal -1.

(7) 

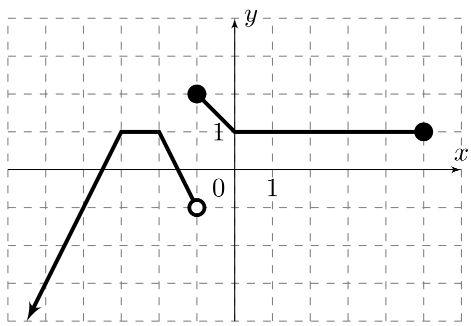
(vii) ... equal 2.

(8) 

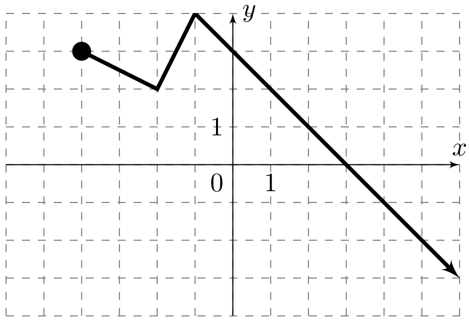
(vii) ... non-positive.

(9) 

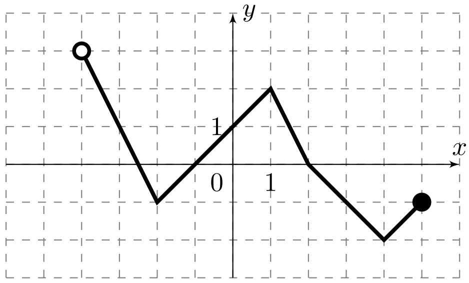
(vii) ... equal 1.

(10) 

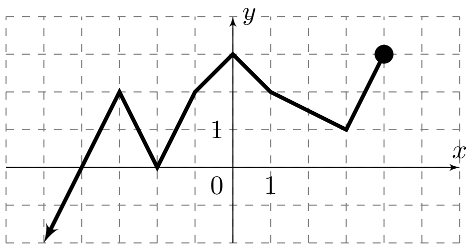
(vii) ... smaller or equal -1.

(11)


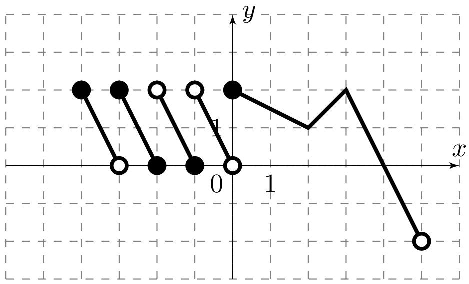
(vii) ... equal 3.

(12)


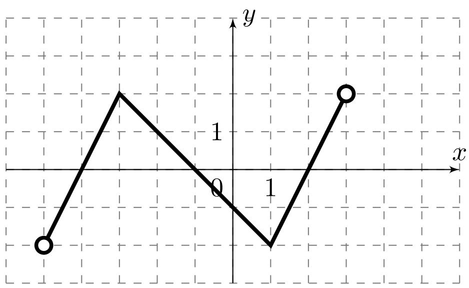
(vii) ... equal −1.

(13)


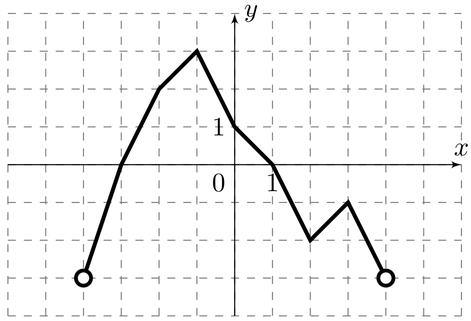
(vii) ... equal 2.

(14)


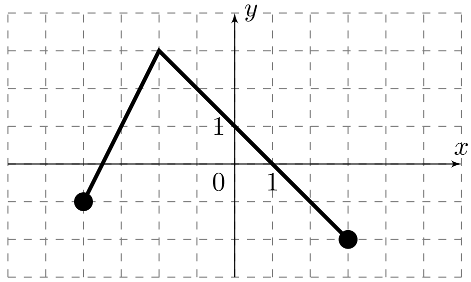
(vii) ... equal 2.

(15)


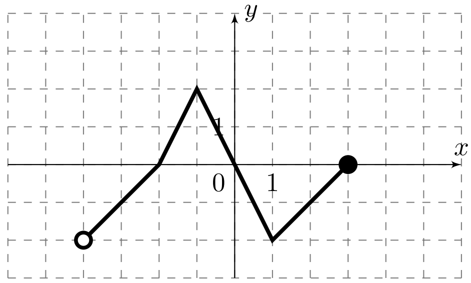
(vii) ... equal 2.

(16)


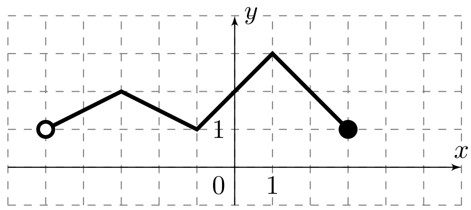
(vii) ... equal −3.

(17)


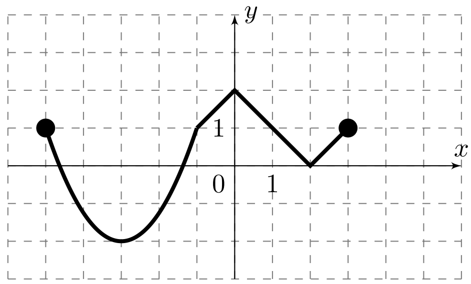
(vii) ... smaller than 1.

(18)


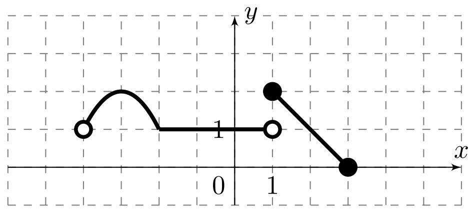
(vii) ... smaller than −1.

(19)


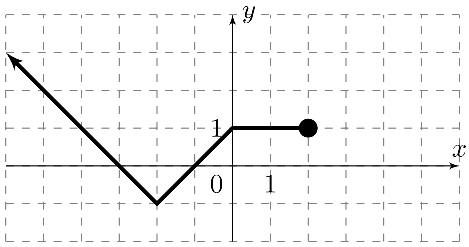
(vii) ... smaller than 2.

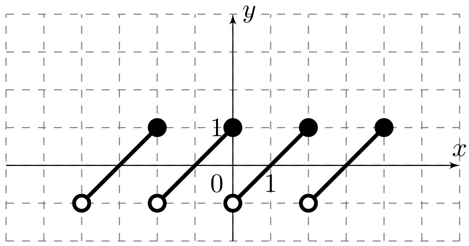
(20)


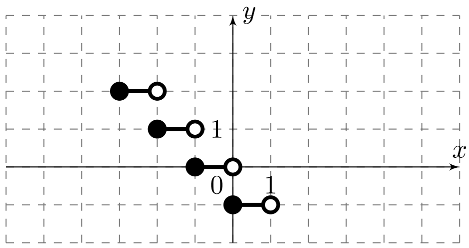
(vii) ... smaller than 1.

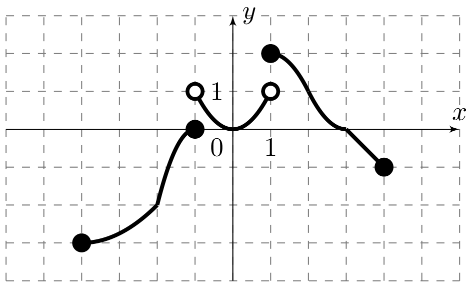
(21)


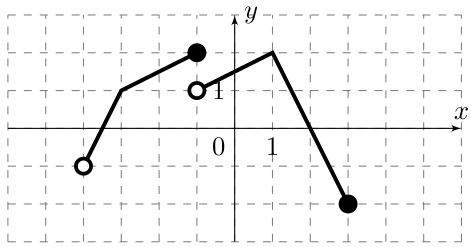
(vii) ... equal 1.

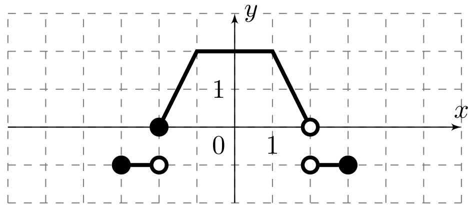
(22) 
(vii) ... negative.

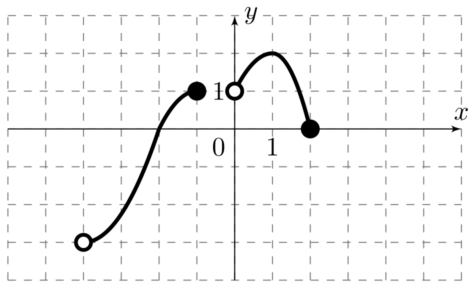
(23) 
(vii) ... larger or equal 1.

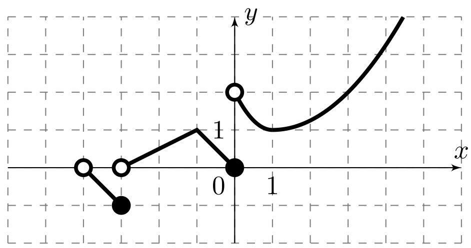
(24) 
(vii) ... smaller or equal 0.

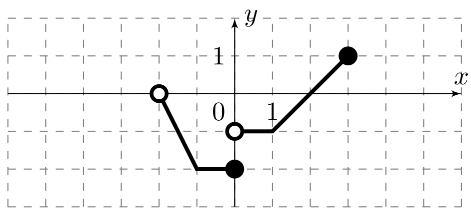
(25) 
(vii) ... smaller or equal 1.

(26) 
(vii) ... greater or equal -2.

(27) 
(vii) ... smaller or equal 0.

(28) 
(vii) ... positive.

(29) 
(vii) ... larger or equal 1.

(30) 
(vii) ... smaller or equal -2.

Q3. Write down the **domain** and the **range** of $y = f(x)$.

(1) $f(x) = x^2$
(2) $f(x) = x^3$
(3) $f(x) = \frac{1}{x}$
(4) $f(x) = \sqrt{x}$
(5) $f(x) = \frac{1}{2}x - 3$
(6) $f(x) = |x|$

Q4. Find the zeroes of the following functions. Do not use a calculator.

(1) $y = 2x + 5$
(2) $y = \sqrt{3 - x}$
(3) $y = 3 + \frac{2}{x-1}$
(4) $y = 9 - x^2$
(5) $y = (2x - 1)^2$
(6) $y = |x + 1| - 2$
(7) $y = \frac{2}{3}x + \pi$
(8) $y = \sqrt{3x + 1}$
(9) $y = \frac{-3}{x+4} - 2$
(10) $y = x^2 - 4$
(11) $y = (x + 1)^2 - 4$
(12) $y = 3 + |4 - 2x|$
(13) $y = \sqrt{3}x + 6$
(14) $y = \sqrt{2x} - 3$
(15) $y = x^3 - 8$
(16) $y = (x - 1)^3$
(17) $y = 3 - |2x - 4|$
(18) $y = \frac{\sqrt{x}-3}{2\sqrt{x}-1}$

Q5. Find the largest possible domain and the range of the following functions. You may use a calculator.

(1) $y = 2x + 5$
(2) $y = \sqrt{3 - x}$
(3) $y = 3 + \frac{2}{x-1}$
(4) $y = (x - 3)^2 - 4$
(5) $y = |x + 1| - 2$
(6) $y = \frac{2}{3}x + \pi$
(7) $y = \sqrt{3x + 1}$
(8) $y = \frac{-3}{x+4} - 2$
(9) $y = x^2 - 9$
(10) $y = 3 + |4 - 2x|$
(11) $y = \sqrt{3}x + 6$
(12) $y = \sqrt{2x} - 3$
(13) $y = (x - 3)^2$
(14) $y = 3 - |2x - 4|$
(15) $y = 4 - \frac{3}{2\sqrt{x}-1}$

Q6. Find $f(a)$ for given function f and the value of a.

(1) $f(x) = 2x + 5,\quad a = -2$
(2) $f(x) = \sqrt{3 - x},\quad a = -6$
(3) $f(x) = 3 + \frac{2}{x-1},\quad a = 5$
(4) $f(x) = 9 - x^2,\quad a = -7$
(5) $f(x) = (2x - 1)^2,\quad a = 2.5$
(6) $f(x) = |x + 1| - 2,\quad a = -3$
(7) $f(x) = \frac{2}{3}x + \pi,\quad a = 6\pi$
(8) $f(x) = \sqrt{3x + 1},\quad a = 8$
(9) $f(x) = \frac{-3}{x+4} - 2,\quad a = -1$
(10) $f(x) = x^2 - 4,\quad a = \frac{5}{3}$
(11) $f(x) = (x + 1)^2 - 4,\quad a = -\frac{10}{3}$
(12) $f(x) = 3 + |4 - 2x|,\quad a = 1.4$
(13) $f(x) = \sqrt{3}x + 6,\quad a = 4\sqrt{3}$
(14) $f(x) = \sqrt{2x} - 3,\quad a = 12$
(15) $f(x) = x^3 - 8,\quad a = -2$
(16) $f(x) = (x - 1)^3,\quad a = -2$
(17) $f(x) = 3 - |2x - 4|,\quad a = \frac{5}{6}$
(18) $f(x) = \frac{\sqrt{x}-3}{2\sqrt{x}-1},\quad a = 4$

Q7. Find the expression for $f(-x)$ for each of the functions given below. Write the answers in simplest form.

(1) $y = 2x + 5$
(2) $y = \sqrt{3 - x}$
(3) $y = 3 + \frac{2}{x-1}$
(4) $y = 9 - x^2$
(5) $y = (2x - 1)^2$
(6) $y = |x + 1| - 2$
(7) $y = \frac{2}{3}x + \pi$
(8) $y = \sqrt{3x + 1}$
(9) $y = \frac{-3}{x+4} - 2$
(10) $y = x^2 - 4$
(11) $y = (x + 1)^2 - 4$
(12) $y = 3 + |4 - 2x|$
(13) $y = \sqrt{3}x + 6$
(14) $y = \sqrt{2x} - 3$
(15) $y = x^3 - 8$
(16) $y = (x - 1)^3$
(17) $y = 3 - |2x - 4|$
(18) $y = \frac{\sqrt{x}-3}{2\sqrt{x}-1}$

Q8. Verify whether the given function is even, odd or neither.

(1) $f(x) = 6x$
(2) $f(x) = \sqrt{3 - x}$
(3) $f(x) = \frac{2}{3x}$
(4) $f(x) = 9 - x^2$
(5) $f(x) = 4x^2 + 16$
(6) $f(x) = |x + 1| - 2$
(7) $f(x) = \frac{2}{x^5-5x}$
(8) $f(x) = (4x)^3$
(9) $f(x) = \frac{x-3}{x+3}$
(10) $f(x) = x^2 - 4$
(11) $f(x) = (x + 1)^2$
(12) $f(x) = 3 - |2x|$
(13) $f(x) = \frac{x^2-13}{4-x^4}$
(14) $f(x) = \frac{x-2x^3}{4}$
(15) $f(x) = 2x^4 - 3x^2 + 5$
(16) $f(x) = (x - 1)^3$
(17) $f(x) = |5x^3| + 4$
(18) $f(x) = \sqrt{x} + 5$

4.2 Transformations of graphs of functions

Q9. Sketch in the same set of axes the graphs of $y = f(x)$ and $y = -f(x)$. Label the graphs.

(1) $f(x) = x^2$
(2) $f(x) = x^3$
(3) $f(x) = \frac{1}{x}$
(4) $f(x) = \sqrt{x}$
(5) $f(x) = \frac{1}{2}x - 3$
(6) $f(x) = |x|$

Q10. Sketch in the same set of axes the graphs of $y = f(x)$ and $y = f(-x)$. Label the graphs.

(1) $f(x) = x^2$
(2) $f(x) = x^3$
(3) $f(x) = \frac{1}{x}$
(4) $f(x) = \sqrt{x}$
(5) $f(x) = \frac{1}{2}x - 3$
(6) $f(x) = |x|$

Q11. Sketch in the same set of axes the graphs of $y = f(x)$, $y = 2f(x)$ and $y = \frac{1}{2}f(x)$. Label the graphs clearly.

(1) $f(x) = x^2$ (3) $f(x) = \frac{1}{x}$ (5) $f(x) = \frac{1}{2}x - 3$
(2) $f(x) = x^3$ (4) $f(x) = \sqrt{x}$ (6) $f(x) = |x|$

Q12. Sketch in the same set of axes the graphs of $y = f(x)$, $y = f(2x)$ and $y = f(\frac{1}{2}x)$. Label the graphs clearly.

(1) $f(x) = x^2$ (3) $f(x) = \frac{1}{x}$ (5) $f(x) = \frac{1}{2}x - 3$
(2) $f(x) = x^3$ (4) $f(x) = \sqrt{x}$ (6) $f(x) = |x|$

Q13. (i) Sketch the graph of $y = f(x)$.

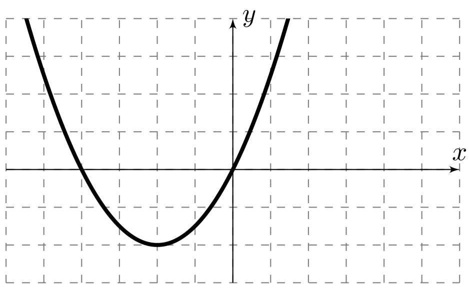
(ii) Sketch in the same set of axes the graph of $y = g(x)$ which is obtained from the graph of $y = f(x)$ by translating with vector $\begin{pmatrix} a \\ b \end{pmatrix}$.

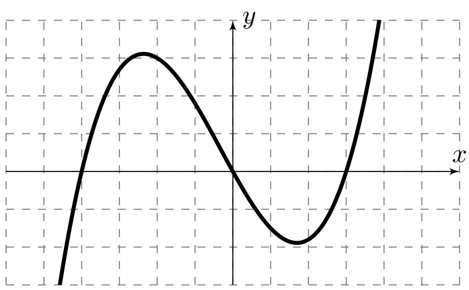
(iii) Write down the equation of $g(x)$.

(iv) Write down the domain and the range of g.

(1) $f(x) = x^2$,	$a = 3$,	$b = -1$	(7) $f(x) = x^2$,	$a = -4$,	$b = 2$
(2) $f(x) = x^3$,	$a = -2$,	$b = -3$	(8) $f(x) = x^3$,	$a = -2$,	$b = 1$
(3) $f(x) = \frac{1}{x}$,	$a = 4$,	$b = 1$	(9) $f(x) = \frac{1}{x}$,	$a = -1$,	$b = -2$
(4) $f(x) = \sqrt{x}$,	$a = -1$,	$b = 2$	(10) $f(x) = \sqrt{x}$,	$a = -4$,	$b = -2$
(5) $f(x) = -\frac{2}{3}x - 2$,	$a = -3$,	$b = 1$	(11) $f(x) = \frac{1}{2}x + 1$,	$a = 2$,	$b = 3$
(6) $f(x) = \lvert x\rvert$,	$a = -5$,	$b = 1$	(12) $f(x) = \lvert x\rvert$,	$a = -3$,	$b = -4$

Q14. The diagram shows the graph of $y = f(x)$. Copy the graph and sketch in the same set of axes the graph of $y = |f(x)|$. Label the graphs clearly.

(1)


(2)


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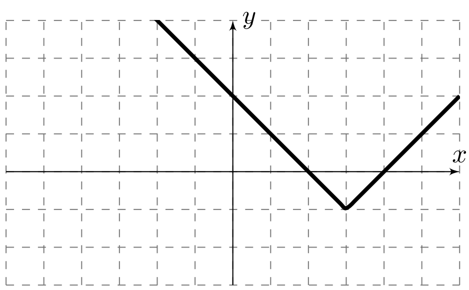
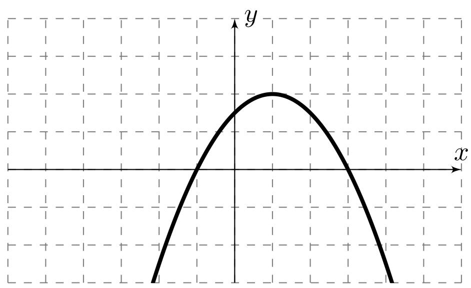
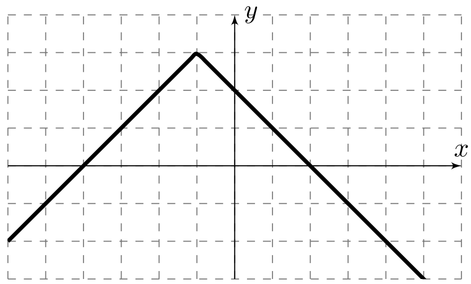
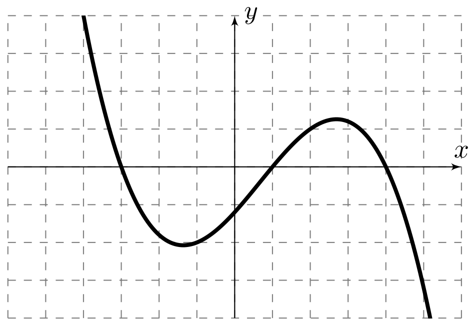
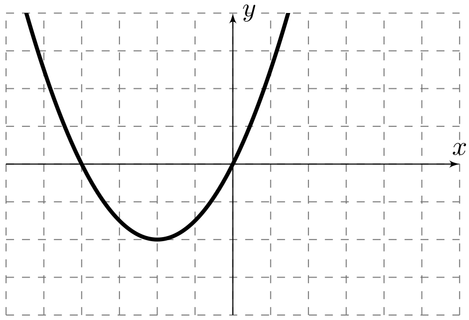


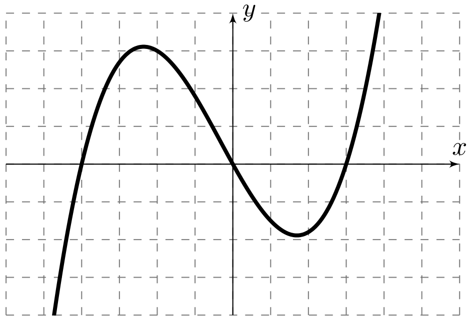
(4)


(5)


(6)


Q15. The diagram shows the graph of $y = f(x)$. Copy the graph and sketch in the same set of axes the graph of $y = f(|x|)$. Label the graphs clearly.

(1)


(2)


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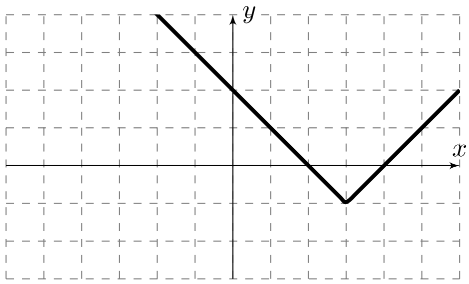

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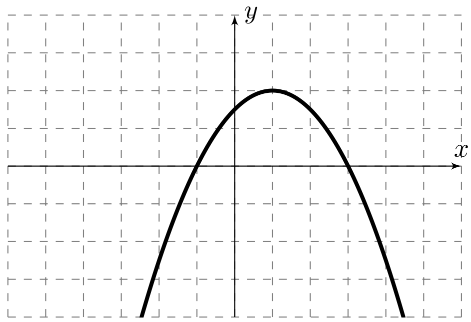

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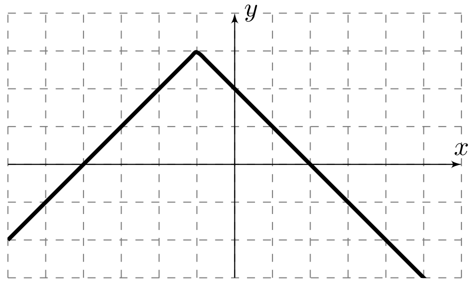

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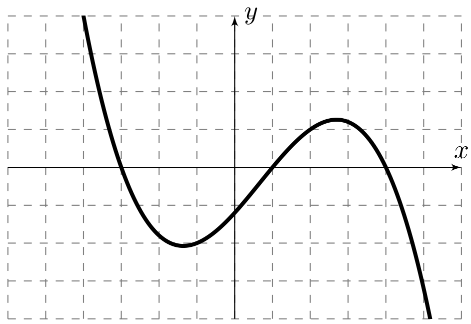
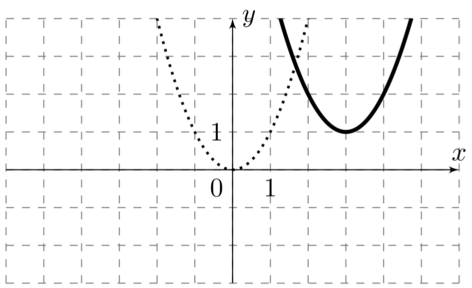


Q16. (i) Recognize the equations of the parent function (dotted line / curve).

(ii) State the single transformation or the sequence of transformations that have to be applied so that the parent function is transformed to the other one (solid line / curve).

(iii) Give the equation of the new function.

(1)


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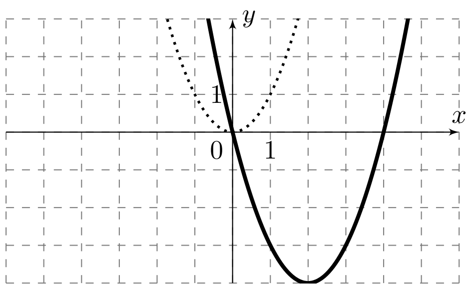

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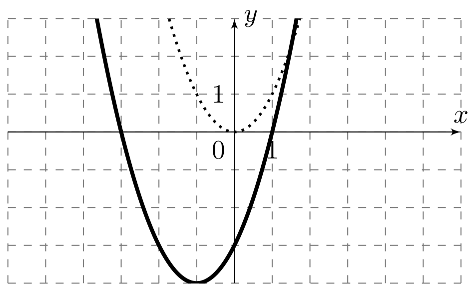

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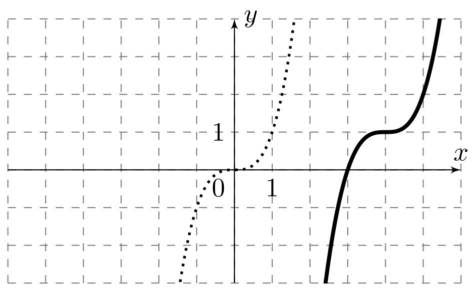

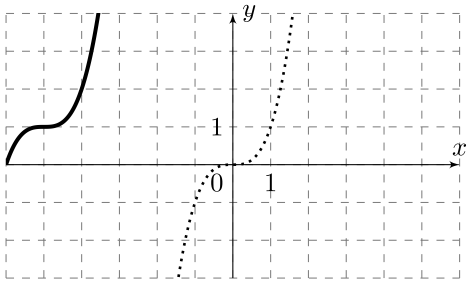

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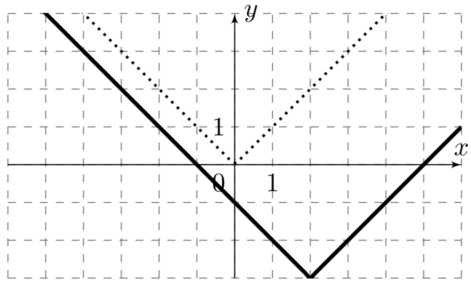

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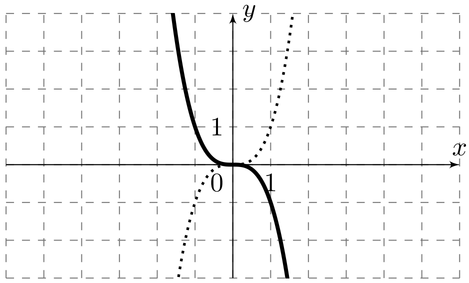

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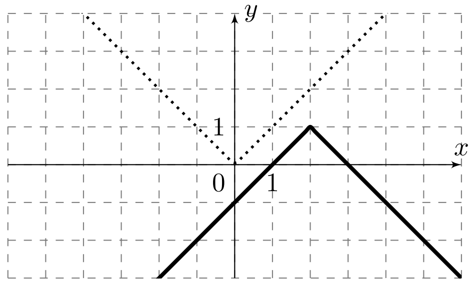

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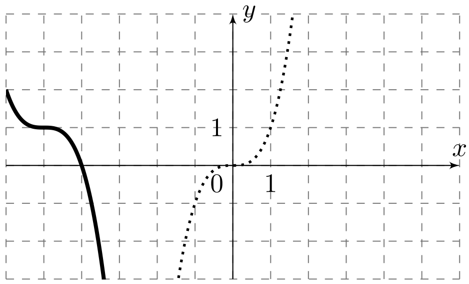

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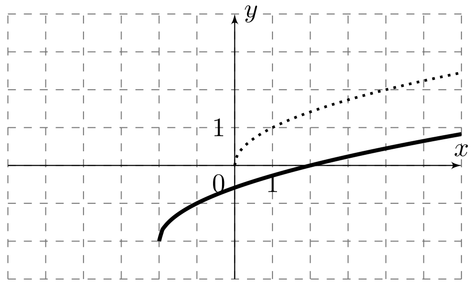

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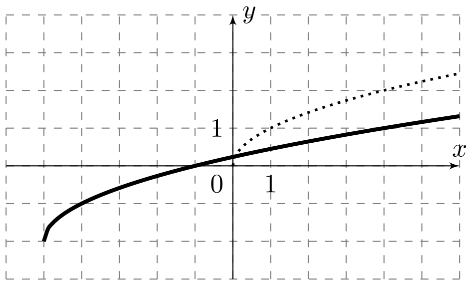

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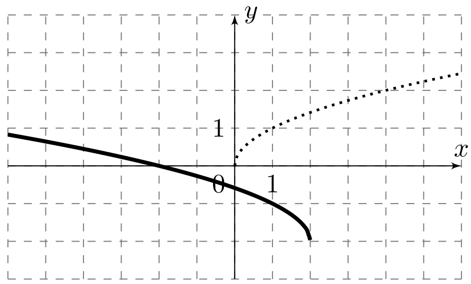

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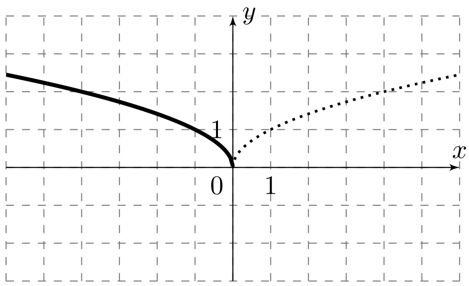

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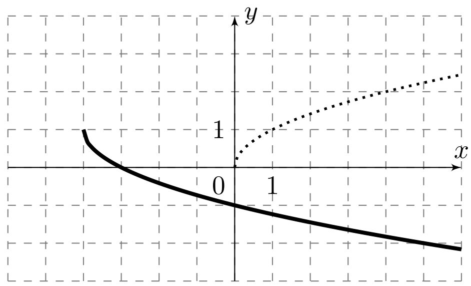

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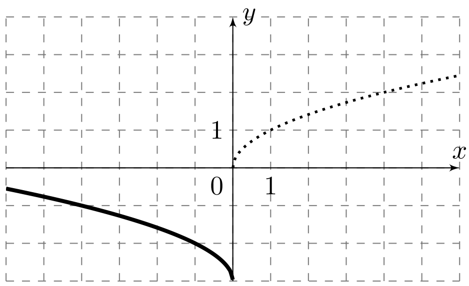

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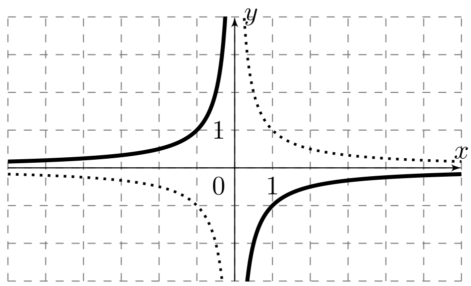

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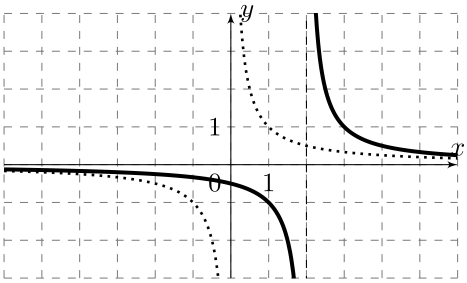

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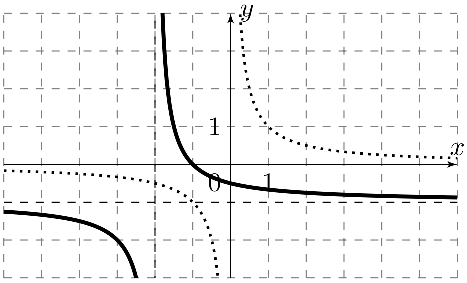

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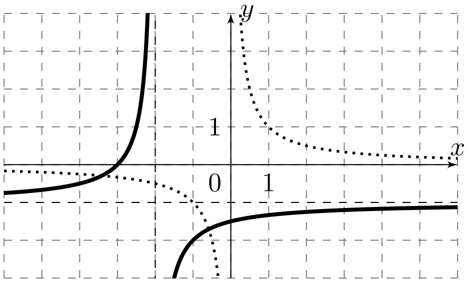

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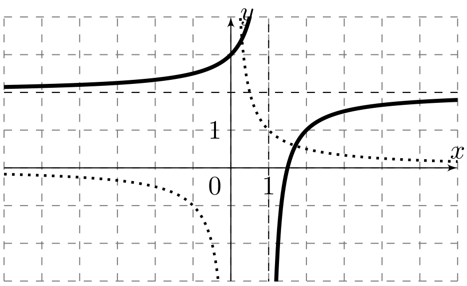

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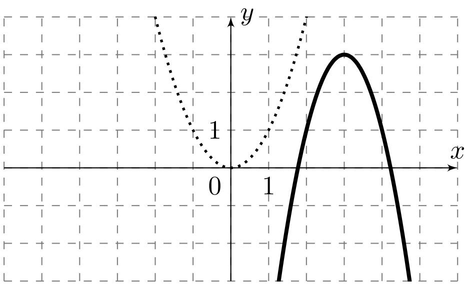

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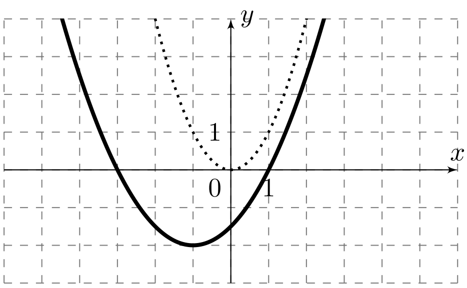

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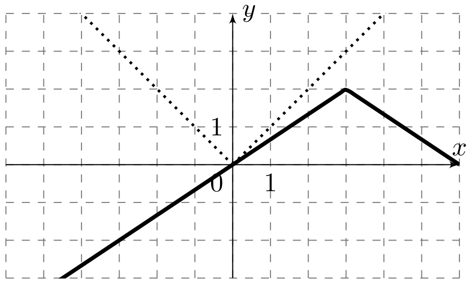

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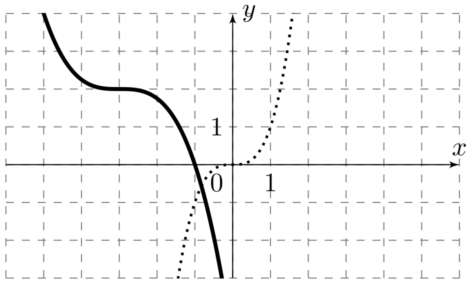

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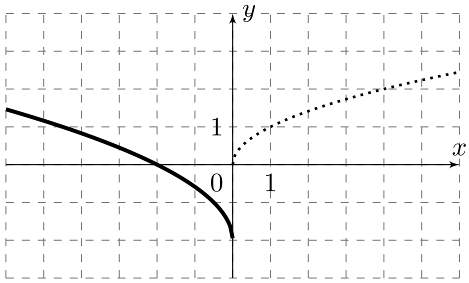

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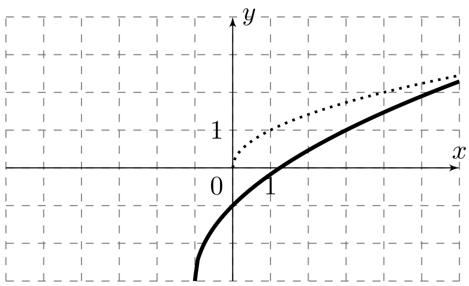

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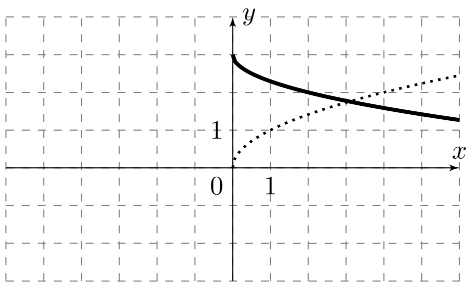

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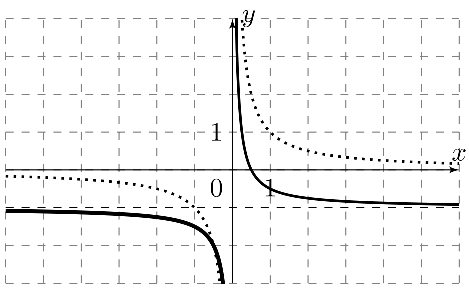

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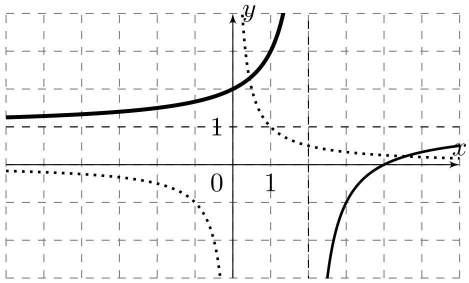
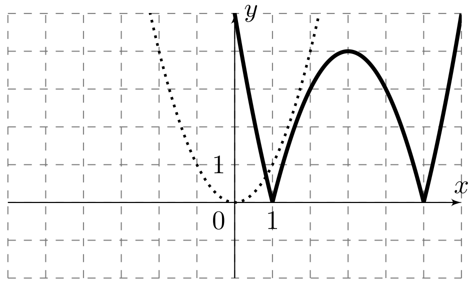
(29) 

(30) 

Q17. (i) Describe clearly the sequence of geometric transformations that transform the graph of $y = f(x)$ into the graph of $y = g(x)$.

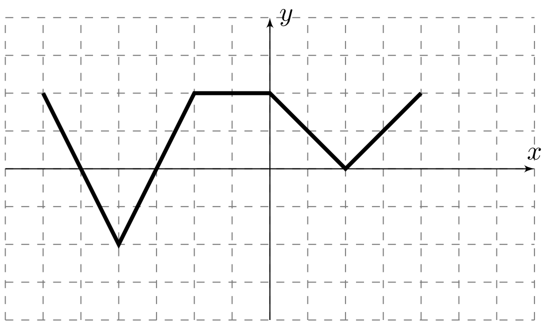
(ii) Graph both functions in the same set of axes.

(1) $f(x) = x^2$, $g(x) = 2(x-3)^2$,
(2) $f(x) = \frac{1}{x}$, $g(x) = \frac{3}{x+1}$,
(3) $f(x) = \sqrt{x}$, $g(x) = -\sqrt{x+2}$,
(4) $f(x) = x^3$, $g(x) = (x-2)^3 - 2$,
(5) $f(x) = 3x + 2$, $g(x) = 3|x| + 2$,
(6) $f(x) = |x|$, $g(x) = -2|x-3|$,
(7) $f(x) = x^2$, $g(x) = (2x)^2 + 1$,
(8) $f(x) = \frac{1}{x}$, $g(x) = \frac{1}{3x} + 2$,
(9) $f(x) = \sqrt{x}$, $g(x) = \sqrt{-x} - 1$,
(10) $f(x) = x^3$, $g(x) = -x^3 - 3$,
(11) $f(x) = 2 - x$, $g(x) = |2 - |x||$,
(12) $f(x) = |x|$, $g(x) = 2|x+1| - 3$,
(13) $f(x) = x^2$, $g(x) = -2(x+3)^2 + 2$,
(14) $f(x) = \frac{1}{x}$, $g(x) = -\frac{2}{x+1} + 1$,
(15) $f(x) = \sqrt{x}$, $g(x) = -2\sqrt{x-3} + 1$,
(16) $f(x) = x^3$, $g(x) = -(x-2)^3 - 2$,
(17) $f(x) = x + 2$, $g(x) = 3|x+2|$,
(18) $f(x) = |x|$, $g(x) = |2x| - 1$,
(19) $f(x) = x^2$, $g(x) = 3 - (x-3)^2$,
(20) $f(x) = \frac{1}{x}$, $g(x) = \frac{2}{x-1} + 2$,
(21) $f(x) = \sqrt{x}$, $g(x) = 2 - \sqrt{x-2}$,
(22) $f(x) = x^3$, $g(x) = \frac{1}{2}(x+1)^3 - 2$,
(23) $f(x) = 2x - 1$, $g(x) = -|2x-1|$,
(24) $f(x) = |x|$, $g(x) = 3 - |\frac{x}{2}|$,
(25) $f(x) = x^2$, $g(x) = \frac{1}{2}(x-3)^2 - 1$,
(26) $f(x) = x^2$, $g(x) = 2 - \frac{1}{2}(x+3)^2$,
(27) $f(x) = x^2$, $g(x) = 3(x+1)^2 - 3$,
(28) $f(x) = x^2$, $g(x) = 4 - 2(x+2)^2$,
(29) $f(x) = \frac{1}{2}x + 1$, $g(x) = \frac{1}{2}|x| + 1$,
(30) $f(x) = \frac{1}{2}x + 1$, $g(x) = |\frac{1}{2}x + 1|$,
(31) $f(x) = x^2$, $g(x) = 2(|x| - 2)^2 - 1$,
(32) $f(x) = x^2$, $g(x) = |2(x+2)^2 - 4|$.

Q18. Point A lies on the graph of function $y = f(x)$. When the graph of f was transformed the the graph of g, point A changed into point A'. Find the coordinates of A'.

(1) $A = (2, 1)$, $g(x) = f(x-2) + 3$,
(2) $A = (-2, 1)$, $g(x) = 2f(x+1)$,
(3) $A = (-3, -1)$, $g(x) = -f(2x) + 2$,
(4) $A = (3, -2)$, $g(x) = \frac{1}{2}f(-x) - 3$,
(5) $A = (-2, -4)$, $g(x) = |2f(-x) + 1|$,
(6) $A = (4, -2)$, $g(x) = 2f\left(-\frac{1}{2}x\right) - 1$.

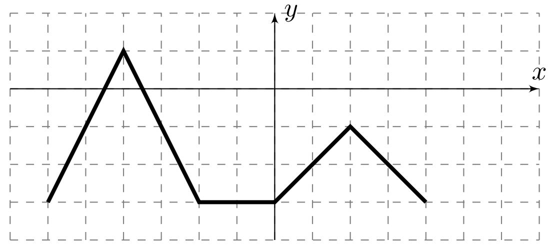
Q19. The diagram below shows the graph of $y = f(x)$.

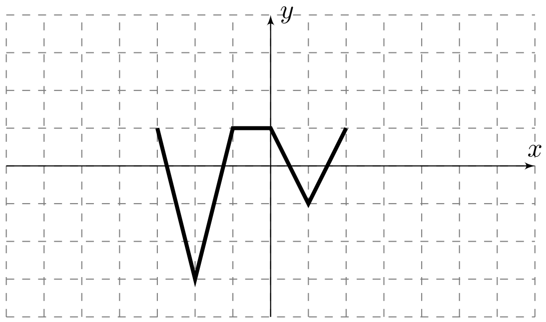


(i) Graph the functions with equations shown.

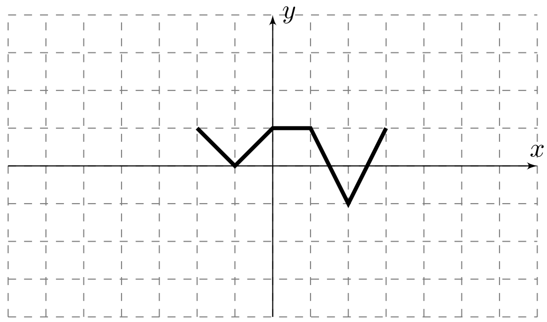
(1) $y = f(-x) - 2$
(2) $y = -f(x+1) - 1$
(3) $y = f(\frac{x}{2})$
(4) $y = \frac{1}{2}f(x-1) + 2$

(ii) Write down the equations of the graphs shown below.

(1) 



(2)



(3)

4.3 Equations and inequalities

Q20. Solve the equations.

(1) $|3x+1| = 2$

(2) $|1-2x| = 3$

(3) $|4x+2| = 5$

(4) $|-3x-2| = 6$

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

(6) $2 - \frac{2}{x+2} = 0$

(7) $\sqrt{x-2} = 3$

(8) $3 - \sqrt{3x} = 1$

(9) $\frac{1}{x+2} = \frac{4}{3-x}$

(10) $\frac{2}{x-2} = -\frac{4}{4x-2}$

(11) $\frac{1}{x-2} - 1 = 2 - \frac{2}{x-2}$

(12) $1 - \frac{4}{2x+1} = \frac{2}{2x+1} - 2$

Q21. (i) Solve the equation $x^2 = 4$. (ii) Hence solve $(x-2)^2 + 3 = 7$.

Q22. (i) Solve the equation $x^3 + 27 = 0$. (ii) Hence solve $\frac{1}{3}(x+2)^3 + 9 = 0$.

Q23. (i) Solve the equation $\frac{1}{x} = 2$. (ii) Hence solve $\frac{-2}{x-3} + 4 = 0$.

Q24. (i) Solve the equation $\sqrt{x} = 3$. (ii) Hence solve $\sqrt{2x} + 1 = 4$.

Q25. (i) Sketching the appropriate graphs manually state the **number** of solutions of the following equations.

(ii) Use a GDC to solve each equation. Give all answers correct to 3 significant figures.

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

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

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

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

(5) $\frac{1}{x} = -(x-4)^2 + 1$

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

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

(8) $-\frac{2}{x} = (x-2)^2 - 2$

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

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

(11) $\frac{1}{5}(x-4)^2 - 3 = 4 - (x-3)^2$

(12) $2(x+2)^2 - 4 = (x+1)^2 - 1$

Q26. Use a GDC to solve the following inequalities.

(1) $x^3 - 2x^2 - x + 2 \leq x^2$

(2) $\frac{1}{2}x^3 + x^2 - x - 2 > -x^2 + x + 1$

(3) $x^3 - 4x^2 + x + 1 \geq \frac{2x}{x^2+1}$

(4) $\frac{2x-3}{x-2} > x^2 - 1$

(5) $\frac{x^3}{x^2+x+1} > \frac{x}{2}$ for $-1 \leq x \leq 2$

(6) $\frac{x^3}{x^2+x+1} \leq \frac{x}{2}$ for $-0.5 \leq x \leq 1$

(7) $x - x^2 + 1 \geq \frac{2-x}{x+1}$

(8) $4 - 2x - x^2 \geq \frac{-x^2}{x+1}$

(9) $4 - 2x - x^2 \leq \frac{-x^2}{x+1}$ for $-3 < x < 3$

(10) $\frac{x^3+x+3}{x^2+1} > \frac{1}{2}x + 2$ for $-2 \leq x \leq 4$

(11) $\frac{x^3+x+3}{x^2+1} \leq \frac{1}{2}x + 2$ for $0 < x < 5$

(12) $2^{2+x-x^2} < 4 - 2(x+1)^2$

(13) $\left(\frac{3}{2}\right)^{3x-x^2} \geq x^2 - 4x + 5$

4.4 Chapter review

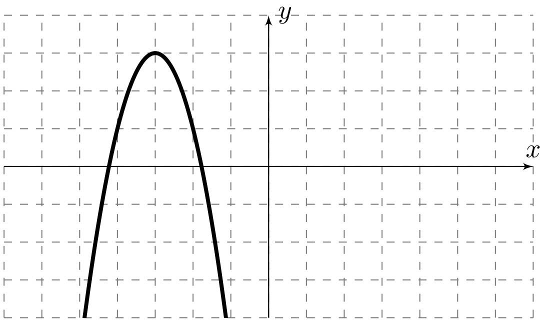
non-calculator questions

Q1. (i) Describe clearly the sequence of geometric transformations that transform the graph of $y = f(x)$ into the graph of $y = g(x)$. [1]

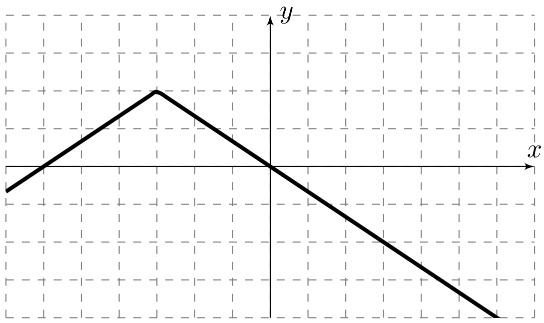
(ii) Sketch the graph of $y = g(x)$ showing clearly the position of at least three points.

(1) $f(x) = x^2$	$g(x) = \frac{1}{3}(x+3)^2 - 1$	(5) $f(x) = \frac{1}{x}$	$g(x) = \frac{-3}{x+2} - 1$
(2) $f(x) = \sqrt{x}$	$g(x) = \sqrt{-\frac{1}{2}x + 1}$	(6) $f(x) = \frac{1}{x}$	$g(x) = \frac{1}{2x} + 2$
(3) $f(x) = \sqrt{x}$	$g(x) = -\frac{1}{2}\sqrt{x-3} - 1$	(7) $f(x) = -\frac{2}{3}x + 2$	$g(x) = -\frac{2}{3}\lvert x\rvert + 2$
(4) $f(x) = \lvert x\rvert$	$g(x) = -3\lvert x+1\rvert + 2$	(8) $f(x) = x^2$	$g(x) = \lvert (x+3)^2 - 3\rvert$

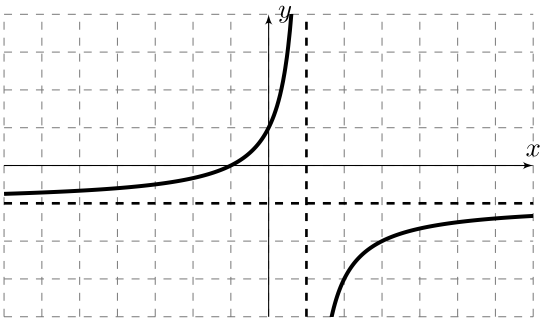
Q2. Write down an equation for each of the graphs shown.

(1)


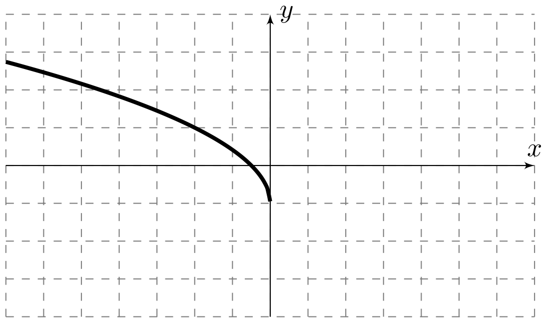
$y =$ ....

(4)


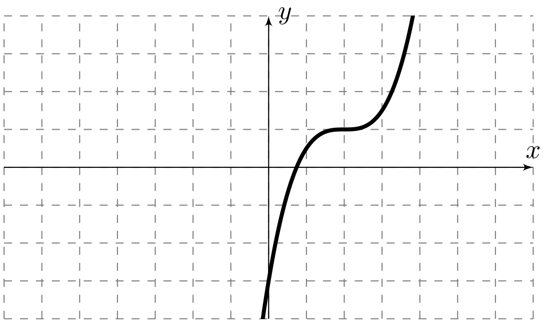
$y =$ ....

(2)


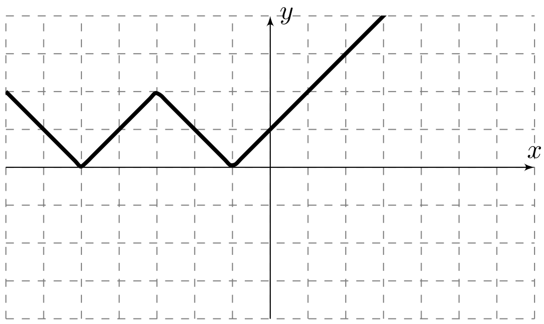
$y =$ ....

(5)


$y =$ ....

(3)


$y =$ ....

(6)


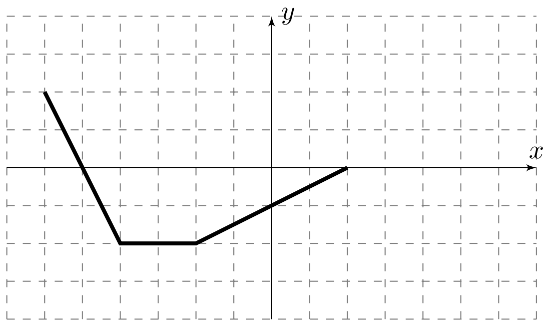
$y =$ ....

Q3. Verify if the given function is <u>even</u>, <u>odd</u> or <u>neither</u>. Justify your answer clearly.

(1) $f(x) = \frac{2x^2 - 3|x| + 1}{x^4 - 3x^2 + 2}$ (2) $g(x) = 2x^3 - \frac{3}{x - x^5}$ (3) $h(x) = \frac{3 - 2|x|}{|x^2 - 3x + 1|}$

[1] use simple terms like "shift by...", "reflection in...", "horizontal / vertical dilation by..."

Q4. The diagram below shows the graph of $y = f(x)$.

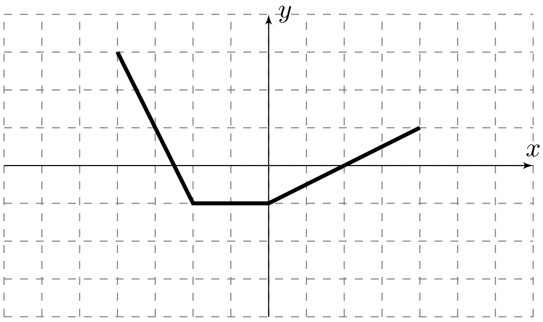


(i) Graph the functions with equations shown.

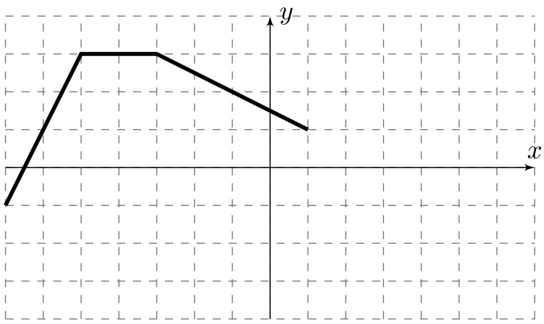
(1) $y = f(x-4)+1$
(2) $y = -f(x)+1$
(3) $y = f(2x)$
(4) $y = -2f(x-1)$
(5) $y = \frac{1}{2}f(-x)$
(6) $y = |f(x-1)|$
(7) $y = f(|x|)-1$

(ii) Write down the equations of the graphs shown below.

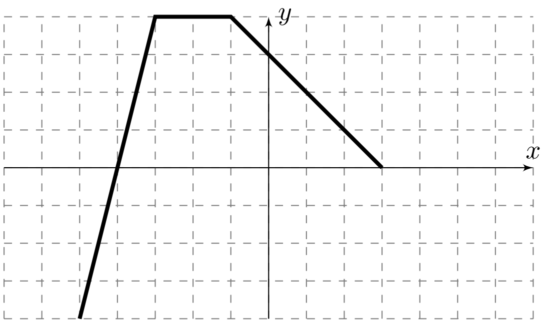
(1)



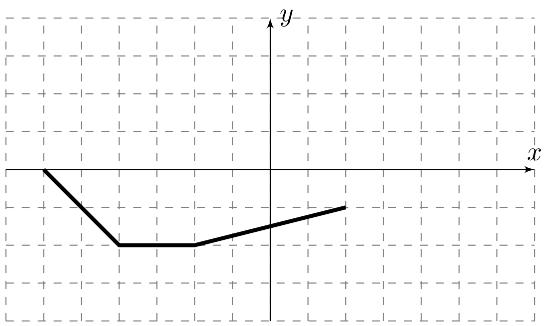
(2)



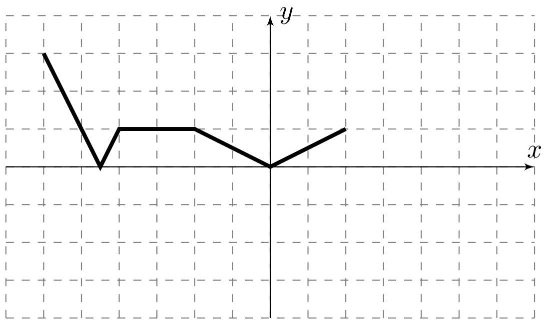
(3)



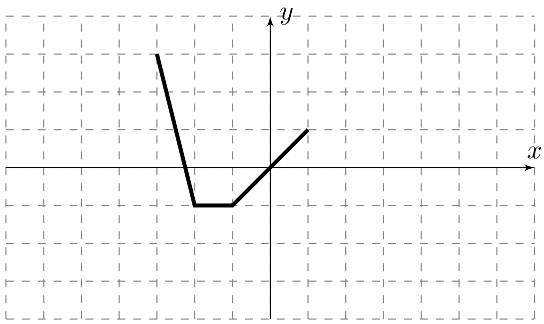
(4)



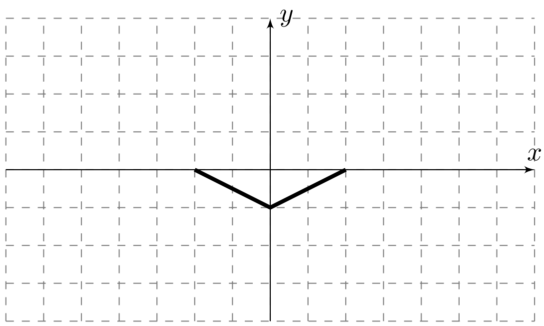
(5)



(6)



(7)



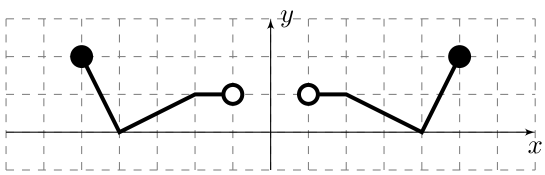
Q5. Consider the functions:

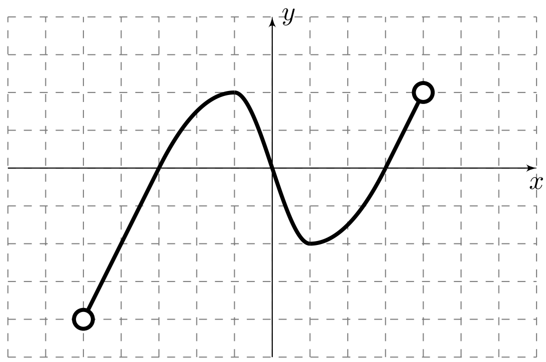
$$f_1(x) = -\sqrt{-3-2x} \qquad f_5(x) = \frac{-2}{x+1} + 3$$
$$f_2(x) = -2|x+3| + 4 \qquad f_6(x) = 2 - (x+1)^2$$
$$f_3(x) = 3|x| - 1 \qquad f_7(x) = \frac{3-x}{\sqrt{3+x}}$$
$$f_4(x) = 2(x+3)^2 - 5 \qquad f_8(x) = \frac{\sqrt{3-x}}{3+x}$$

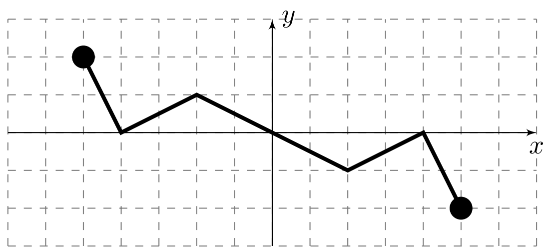
(i) State the domain of all functions defined above.
(ii) State the range of functions f_1 to f_6.

Q6. For each of the functions with graphs shown below read from the graph:

(i) the domain,
(ii) the range,
(iii) zeroes,
and sets of arguments
for which the function is:
(iv) decreasing,
(v) increasing,
(vi) constant.
State whether the function is:
(vii) even
(viii) odd
(ix) one-to-one

(1)


(2)


(3)


calculator questions

Q7. Find all points of intersection of the graphs of[2]:

(1) $y = \frac{1}{20}x^2 - \frac{3}{10}x - 2$ and $y = \frac{1}{x}$
(2) $y = 2x + 1$ and $y = |(x-6)^3 - 4|$
(3) $y = \frac{3-x}{2x-1}$ and $y = -0.1x^2 + 0.2x + 20$
(4) $y = 0.01x^3 - 2.2x + 1$ and $y = \frac{5x}{12}$

Q8. Solve the inequalities for $-20 \leq x \leq 20$.

(1) $\frac{1}{20}x^2 - \frac{3}{10}x - 2 > \frac{1}{x}$
(2) $2x + 1 < |(x-6)^3 - 4|$
(3) $\frac{3-x}{2x-1} \geq y = -0.1x^2 + 0.2x + 20$
(4) $0.01x^3 - 2.2x + 1 \leq y = \frac{5x}{12}$

[2] all x-coordinates of the points of intersection are between -20 and 20