0606 IGCSE Additional Maths
Summary Sheet
Assessment Test Prep

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The ReviseRoom Educator Team

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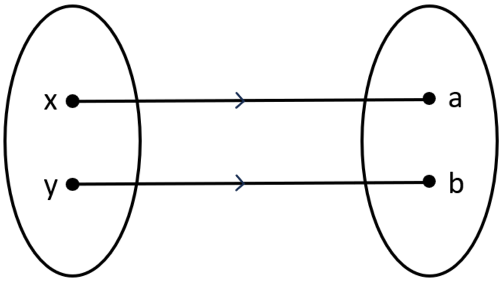
Chapter 1 – Functions

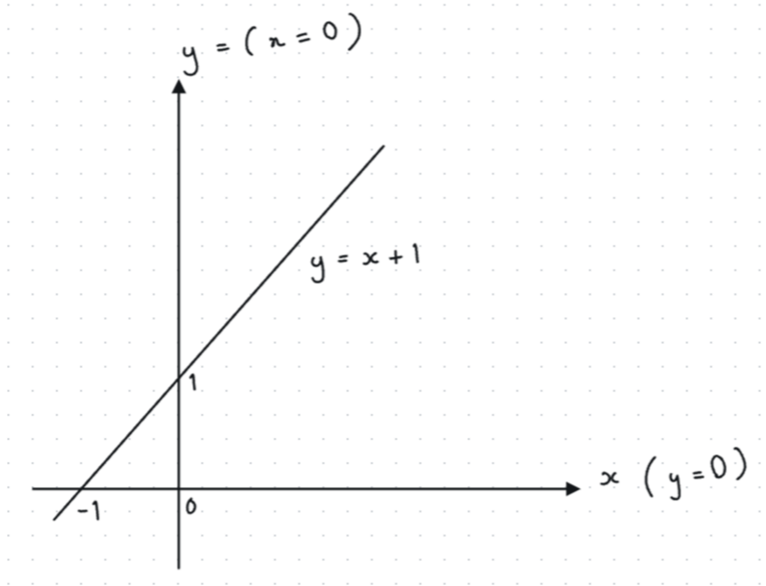
Mappings

1. One-one mapping

$y = x + 1, \ x \in \mathbb{R}$

x	0	-1
y	1	0
	(0,1)	(-1,0)

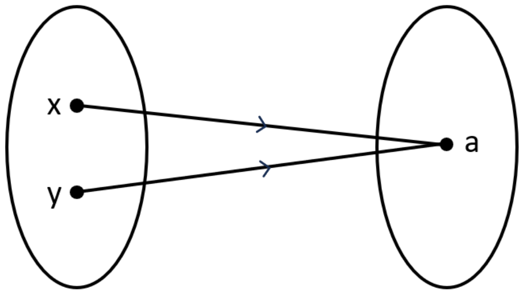


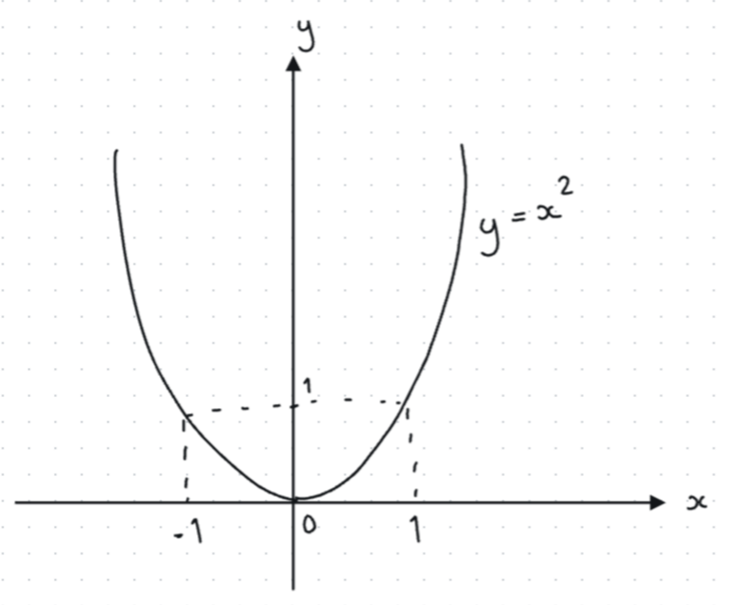


2. Many-one mapping

$y = x^2, \; x \in \mathbb{R}$

x	-1	0	1
y	1	0	1
	(-1,1)	(0,0)	(1,1)

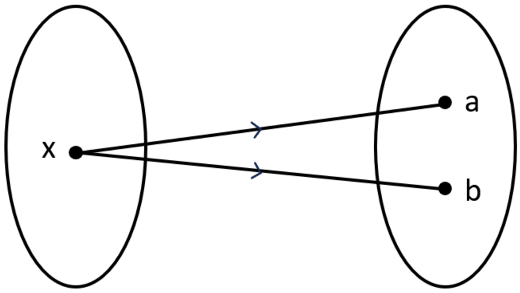


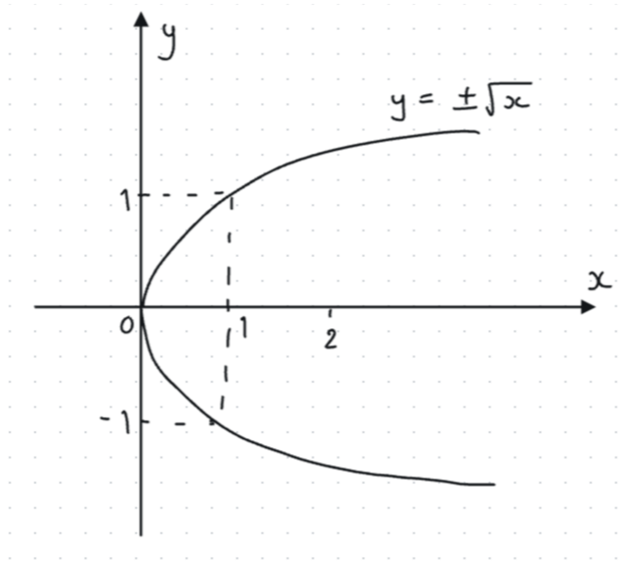


3. One-many mapping

$y = \pm\sqrt{x}, \; x > 0$

x	1	0	1
y	-1	0	1
	(1.-1)	(0,0)	(1,1)





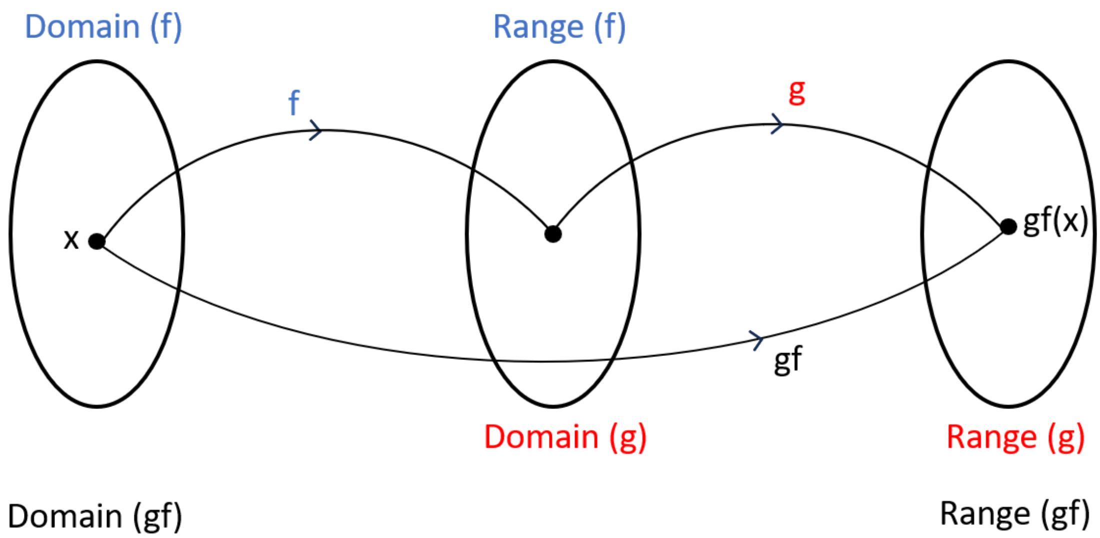
Function

Function: A rule that maps each x value to just one y value for a defined set of input values (only one y for every x)

❖ one-one mappings and many-one mappings are functions.

- ➢ domains = set of input values
- ➢ range = set of output values

Composite Function



gf(x) means the function of f acts on x first, then the function g acts on the result.

❖ Domain of gf(x) = Domain of f(x)

Modulus Function

When a number (whether positive or negative) is placed inside a modulus function, the sign is removed, and the result is always a non-negative value.

$|x| = x, \quad x \geq 0$

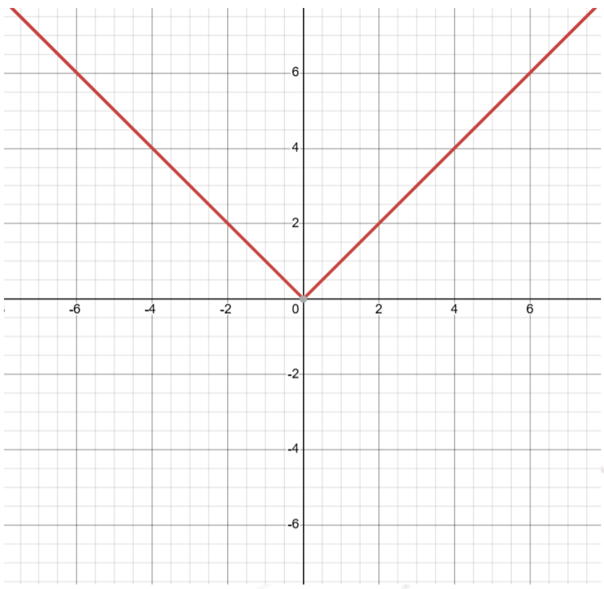
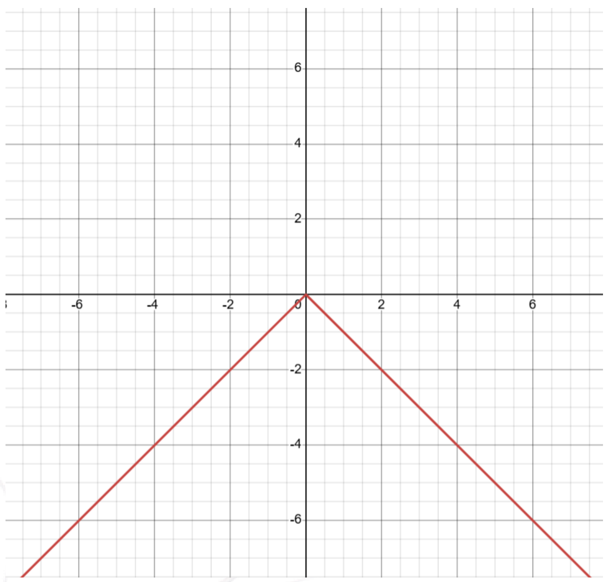
Eg. $|5| = 5$

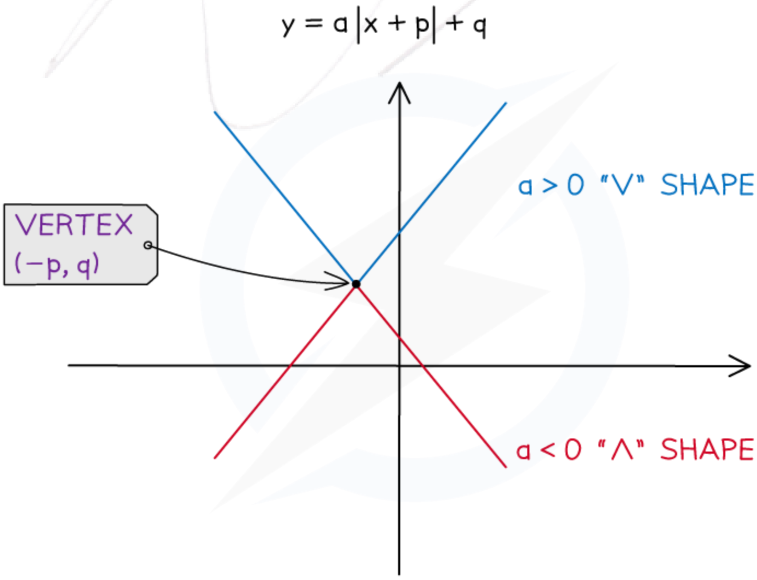
$|x| = -x, \quad x < 0$

Eg. $|-5| = -(-5) = 5$

Graph of y = | f(x) | where f(x) is linear

When a number (whether positive or negative) is placed inside a modulus function.

Positive modulus graph + | |	Negative modulus graph - | |
	
$y = \lvert x \rvert$	$y = -\lvert x \rvert$

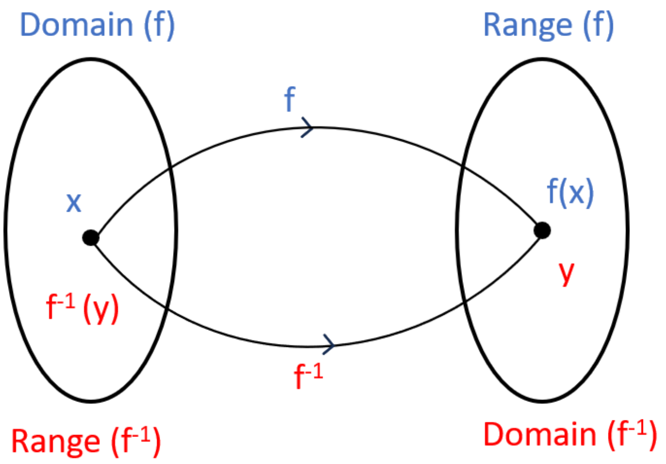


To get vertex:

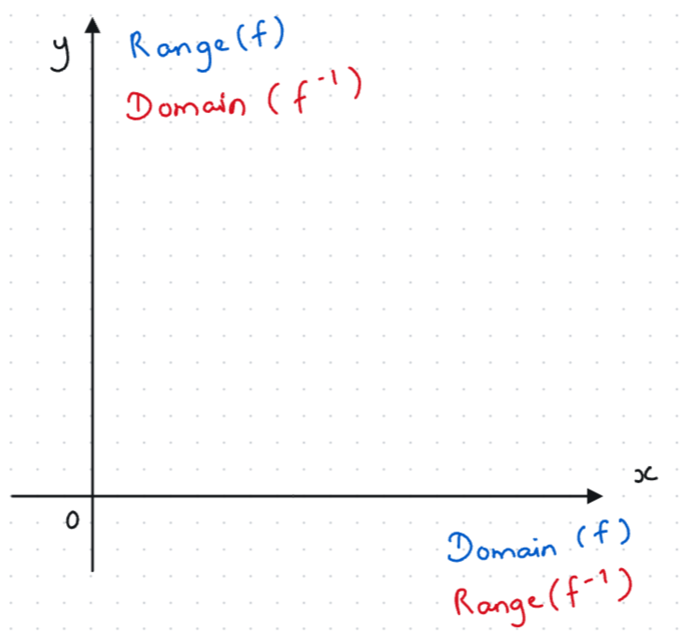
1) Do | f(x) | = 0.
2) find the value of x
3) find the value of y.

Inverse Function

An inverse function $f^{-1}(x)$ can exist, only if f(x) is a one-one mapping.



<u>Graph of a function and its inverse</u>



y = f(x): (a,b)

y = f^{-1}(x): (b,a)

- switch x and y values of the coordinates
- same scale
- symmetrical line: y = x (with dotted line)

Chapter 2 – Simultaneous equations and quadratics

Solving simultaneous equations

1. Elimination method

$$5x + 2y = 25 \quad \text{— (1)}$$
$$2x - y = 1 \quad \text{— (2)}$$

$$(1) \Rightarrow \quad 5x + \cancel{2y} = 25$$
$$(2) \times 2 \Rightarrow \quad 4x - \cancel{2y} = 2$$

$$9x = 27$$
$$x = 3$$

Sub $x = 3$ in eq (2),

$$2(3) - y = 1$$
$$6 - y = 1$$
$$y = 5$$

$$\therefore x = 3, \; y = 5$$

2. Substitution method

$$y = x - 1 \quad \text{——} \quad (1)$$
$$x^2 + y^2 = 25 \quad \text{——} \quad (2)$$

Sub (1) in (2),

$$x^2 + y^2 = 25$$
$$x^2 + (x-1)^2 = 25$$
$$x^2 + x^2 - 2x - 1 = 25$$
$$2x^2 - 2x - 24 = 0$$
$$x^2 - x - 12 = 0$$
$$(x-4)(x+3) = 0$$

$$(x-4)(x+3) = 0$$
$$x - 4 = 0 \quad (\text{or}) \quad x + 3 = 0$$
$$x = 4 \quad (\text{or}) \quad x = -3$$

Sub in (1) $\Rightarrow$ $y = 4 - 1 = 3$ (or) $y = -3 - 1 = -4$

$\therefore x = 4, y = 3$

$x = -3, y = 4$

3. Equaling two sides (if another side is same)

$$y = x^2 \text{ ——— (1)}$$
$$y = x + 6 \text{ ——— (2)}$$

$$x^2 = x + 6$$
$$x^2 - x - 6 = 0$$
$$(x - 3)(x + 2) = 0$$
$$x - 3 = 0 \quad (\text{or}) \quad x + 2 = 0$$
$$x = 3 \quad (\text{or}) \quad x = -2$$

Sub in (1) $\Rightarrow$ $y = 3^2 = 9$ (or) $y = (-2)^2 = 4$

$$\therefore x = 3,\ y = 9$$
$$x = -2,\ y = 4$$

Completing the square

$$(x + y)^2 = x^2 + 2xy + y^2$$
$$(x + y)^2 - y^2 = x^2 + 2xy$$

Eg.

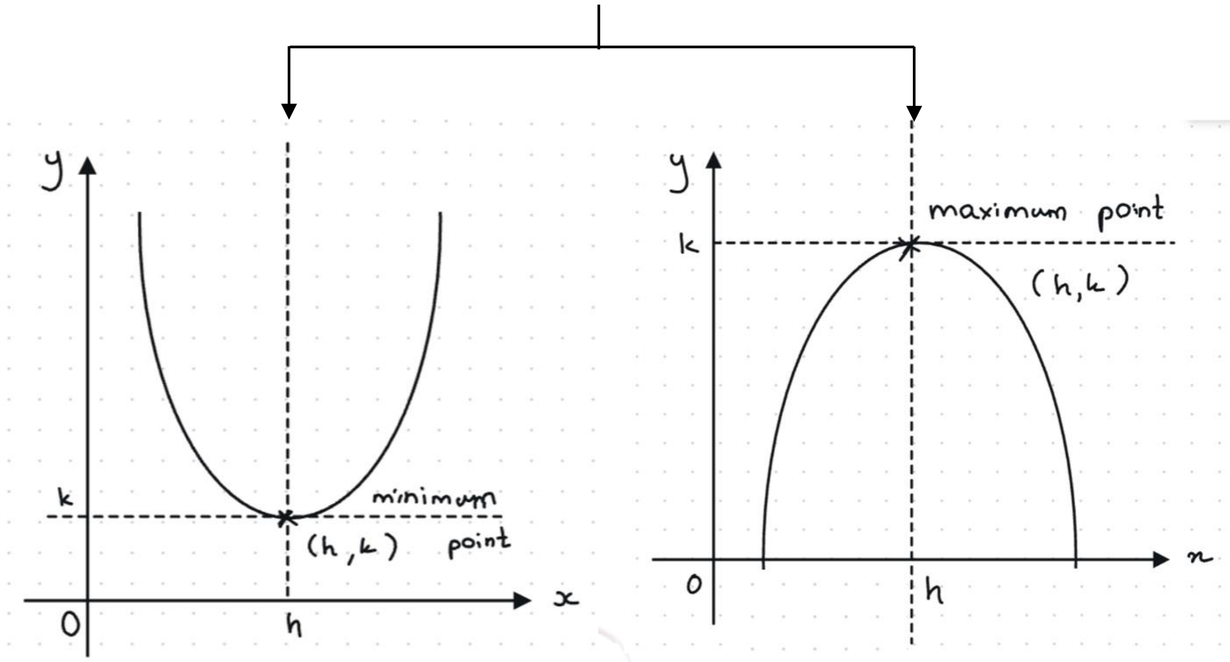
$$x^2 - 8x = (x \boxed{-4})^2 - (\boxed{-4})^2$$

$\div 2$

$$= (x - 4)^2 + 16$$

Maximum/ Minimum point

$$y = ax^2 + bx + c = a\,(x - h)^2 + k$$



If f^{-1} exists,

- the domain of f = $x \geq h$
- the range of f = $f(x) \geq k$

If f^{-1} exists,

- the domain of f^{-1} = $x \geq h$
- the range of f^{-1} = $f(x) \leq k$

❖ Stationary point = maximum (or) minimum point

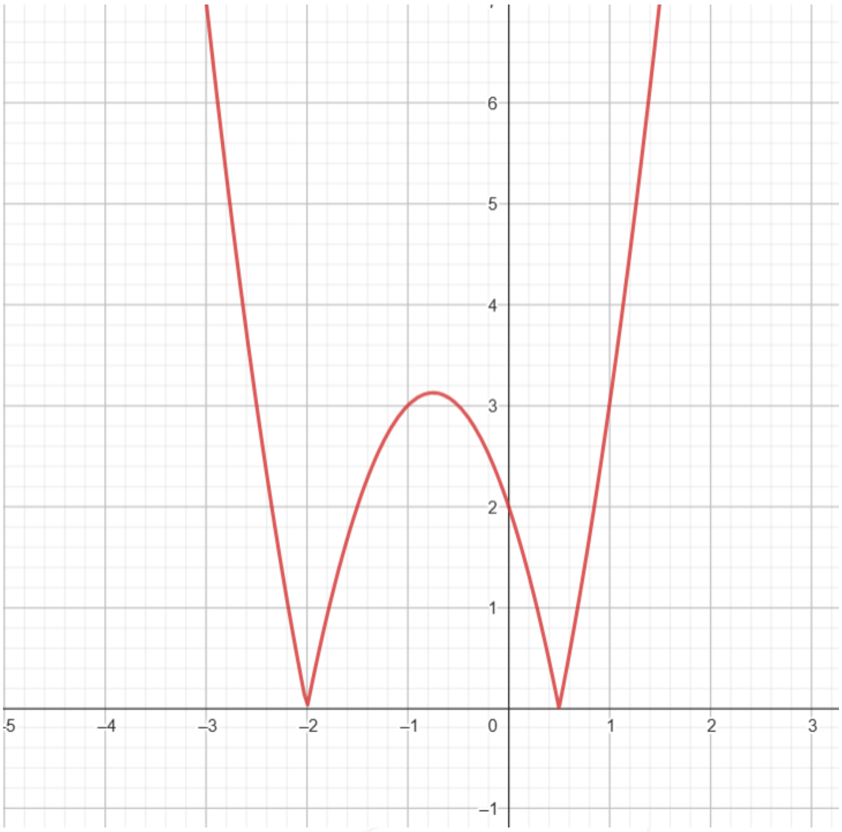
Graphs of y = | f(x) | where f(x) is quadratic

$y = |\,ax^2 + bx + c\,|$

Steps:

1. Draw $y = ax^2 + bx + c$.
2. Reflect the graph on x-axis.

❖ Be careful with the + and - values of the stationary points if included.



Quadratic Inequalities

Eg.

$(x+3)(x-4) > 0$

Critical values are $x = -3$ and $x = 4$.

$(x+3) = 0$ $\quad$ $(x-4) = 0$

$\therefore x < -3, \; x > 4$

Eg.

$$(x-5)(x-1) \le 0$$

Critical values are $x = 5$ and $x = 1$.

$$\uparrow \qquad\qquad \uparrow$$

$$(x-5) = 0 \qquad (x-1) = 0$$

$\therefore\ 1 < x < 5$

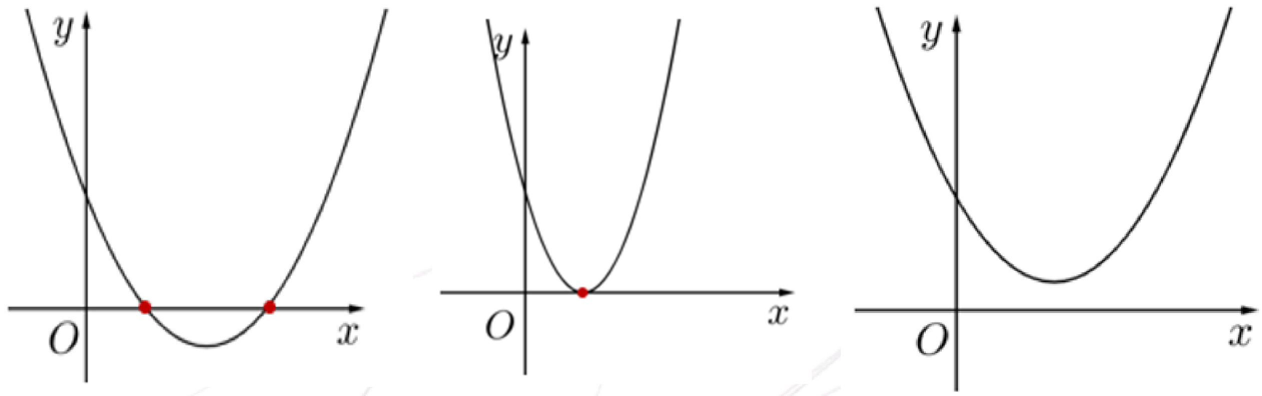
- ❖ $(x + p)(x - q) > 0 \implies x < -q$ (or) $x > q$
- ❖ $(x + p)(x - q) < 0 \implies -p < x < q$

Roots of quadratic equations

$$ax^2 + bx + c = 0$$

Discriminant = $b^2 - 4ac$

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



2 real and distant roots	2 real and equal roots (1 real root)	No real root (0 real root)

Intersections of a line and a curve

$$ax^2 + bx + c = 0,\ a > 0$$

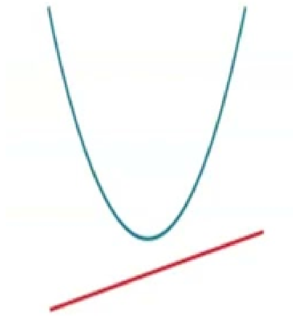
$b^2 - 4ac > 0$

The line cuts the curve at 2 distant points.

$b^2 - 4ac = 0$

The line is a tangent to a curve. (only 1 point)

$b^2 - 4ac < 0$



The line does not intercept the curve.

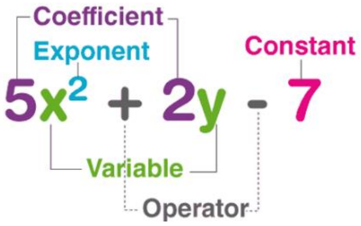
❖ The line meets the curve $\Rightarrow$ $b^2 - 4ac \geq 0$

Chapter 3 – Factors and polynomials

Polynomials

Polynomials – expressions composed of variables, constants and exponents, combined using mathematical operations (+ , - , × , ÷)

Eg.



$ax + b$	$\Longrightarrow$	Linear (degree 1)
$ax^2 + bx + c$	$\Longrightarrow$	Quadratic (degree 2)
$ax^3 + bx^2 + cx + d$	$\Longrightarrow$	Cubic (degree 3)
$ax^4 + bx^3 + cx^2 + dx + e$	$\Longrightarrow$	Quartic (degree 4)

❖ Degree = the highest power of x in the polynomial

Adding, subtracting & multiplying polynomials

Eg.

$$3x^4 + 2x^2 - 1 - 2(2x^3 + x^2 + 1)$$

$$= 3x^4 + 2x^2 - 1 - 4x^3 - 2x^2 - 2$$

$$= 3x^4 - 4x^2 - 3$$

Eg.

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

$$= (x^2+4x+4)(3x^3+x-1)$$

$$= x^2(3x^3+x-1) + 4x(3x^3+x-1) + 4(3x^3+x-1)$$

$$= 3x^5 + x^3 - x^2 + 12x^4 + 4x^2 - 4x + 12x^2 + 4x - 4$$

$$= 3x^5 + 12x^4 + 13x^3 + 3x^2 - 4$$

Division of polynomials (long division)

Eg.

$$(x^4 - 1) \div (x+1)$$

$$\begin{array}{r|l} & x^3 + x^2 + x - 1 \quad \leftarrow \text{Quotient} \\ \hline x + 1 & x^4 + 0x^3 + 0x^2 + 0x - 1 \quad \leftarrow \text{Dividend} \\ \uparrow & \ominus\, x^4 \ \ominus + x^3 \\ \text{Divisor} & \quad - x^3 + 0x^2 \\ & \quad \oplus - x^3 \ \oplus - x^2 \\ & \qquad x^2 + 0x \\ & \qquad \ominus\, x^2 \ \ominus + x \\ & \qquad\quad - x - 1 \\ & \qquad\quad \oplus - x \ \oplus - 1 \\ & \qquad\qquad 0 \end{array}$$

Factor Theorem

$\boxed{f(x) \div (x-k)} \Longleftrightarrow f(k) = 0 \Longleftrightarrow \boxed{x-k \text{ is a factor of } f(x).}$

Divisible

$\boxed{f(x) \div (ax-k)} \Longleftrightarrow f\left(\frac{k}{a}\right) = 0 \Longleftrightarrow \boxed{ax-k \text{ is a factor of } f(x).}$

$ax - k = 0$

$x = \frac{k}{a}$

The remainder theorem

$\boxed{f(x) \text{ is divided by } (x-k)} \Longrightarrow \boxed{\text{The remainder} = f(k)}$

$\boxed{f(x) \text{ is divided by } (ax-b)} \Longrightarrow \boxed{\text{The remainder} = f\left(\frac{b}{a}\right)}$

$ax - b = 0$

$x = \frac{b}{a}$

Eg. $f(x) = x^3 + 2x^2 - x + 3$

when $f(x)$ is divided by $x-1$,

the remainder $= f(1)$

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

$= 5$

❖ f(x) is divisible by x $\Longrightarrow$ f(0) = 0

Chapter 4 – Equations, inequalities, and graphs

Solving modulus equations

$$| ax + b | = | cx + d |$$

$$| p | = | q | \iff p^2 = q^2$$

Solving modulus inequalities

$$| p | \leq q \implies -q \leq p \leq q$$

$$| p | \geq q \implies p \leq -q \text{ (or) } p \geq q$$

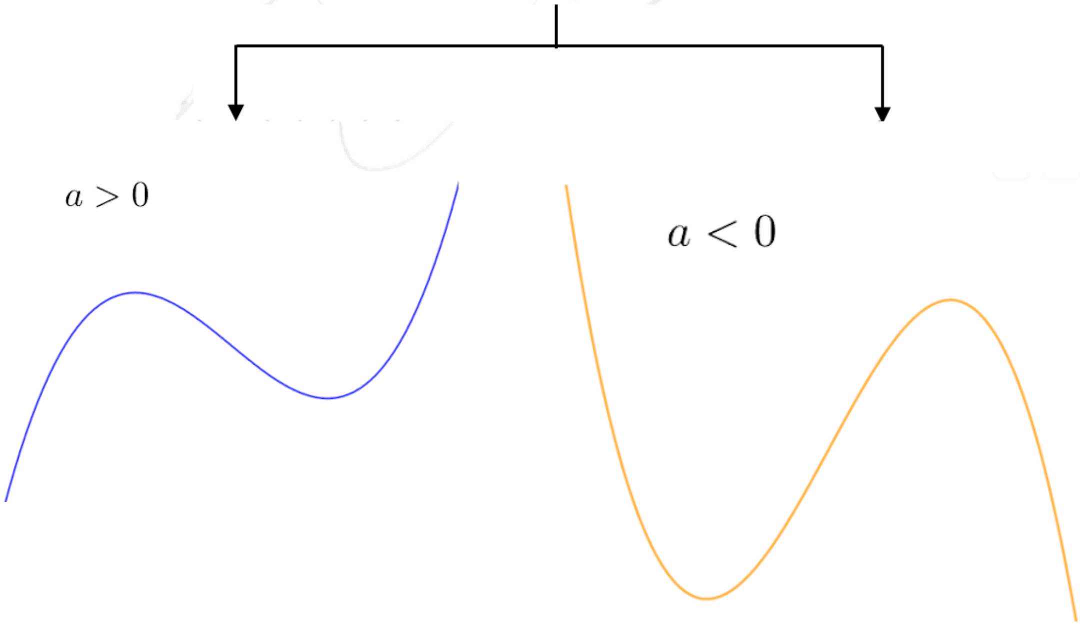
Modulus on both sides

$$| p | \leq | q | \implies p^2 < q^2$$

$$| p | \geq | q | \implies p^2 > q^2$$

Graphs of cubic polynomials and their modulus

$$f(x) = ax^3 + bx^2 + cx + d$$



To draw cubic graph,

1. Consider its shape.
2. Find x-intercept with y = 0.
3. Find y-intercept with x = 0.

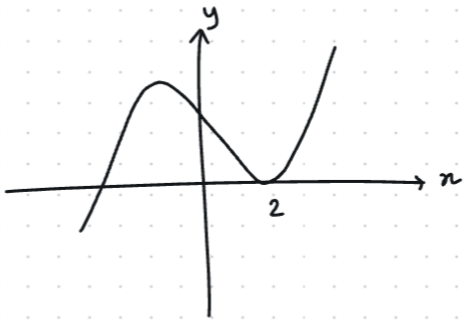
- If there is a repeated root $\Longrightarrow$ maximum point/ minimum point/ stationary point

Eg. $y = (x-2)^2(x+4)$

$\Downarrow$

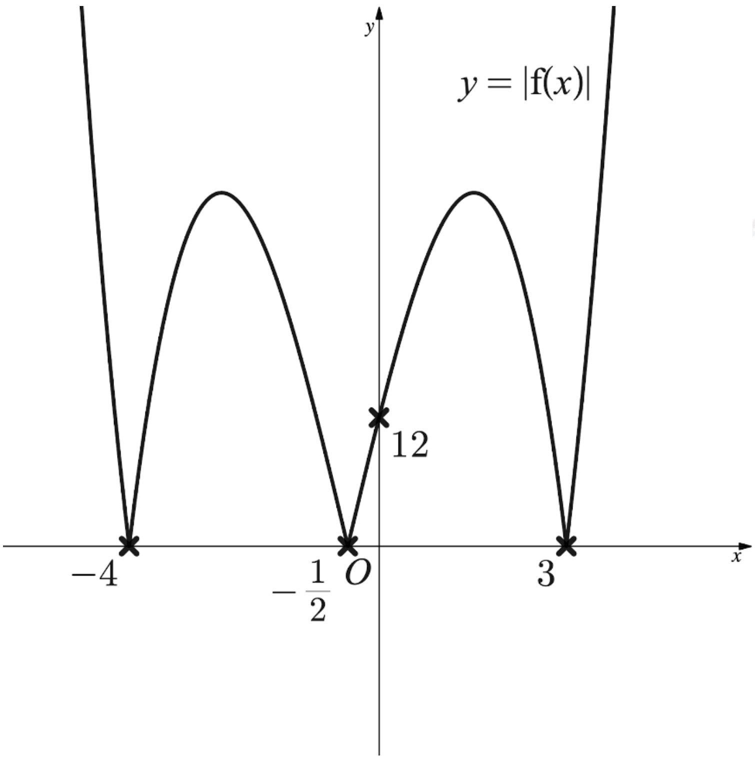
$x - 2 = 0$

$x = 2$

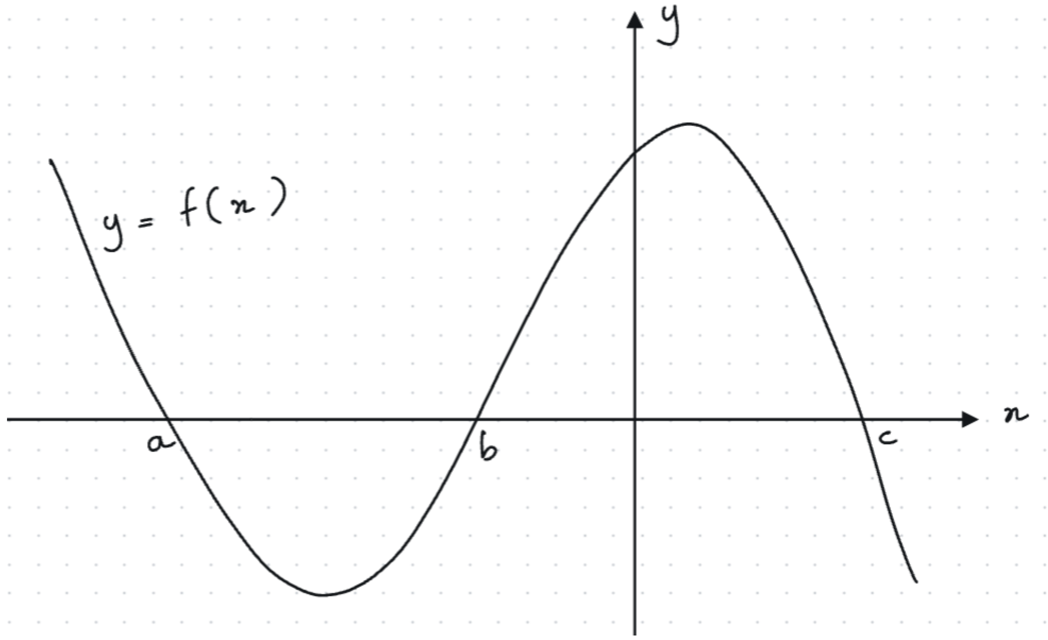


Cubic Modulus Graph

f(x) = ± k (x + a)(x + b)(x + c)



Solving cubic equalities graphically



$f(x) > 0 \implies \quad x < a, \quad b < x < c$

$f(x) < 0 \implies \quad a < x < b, \quad x > c$

Chapter 5 – Logarithmic and exponential functions

Logarithms to base 10

$$10^{x} = n \iff x = \log_{10} n$$

exponential form   log form

Eg. $10^{x} = 75$

$x = \log_{10} 75$

$x = \lg 75$

$x = 1.87506\ldots$

$x = 1.88$

$\log_a (b)$ $\Rightarrow$ $a > 1$ (base must be greater than 1)

$\Rightarrow$ $b > 0$ (number must be greater than 0)

- $a \neq 0, 1$
- $b \neq 0$

Logarithms to base a

$\log_a x = n \iff x = a^n,\ x \neq 1$

$\log_a 1 = 0,\quad a > 0$

Laws of logarithms

1) $\log_b (MN) = \log_b M + \log_b N$
2) $\log_b (M/N) = \log_b M - \log_b N$
3) $\log_b a^n = n \log_b a$

4) $\log_b 1/a^n = \log_b a^{-n} = -n \log_b a$

5) $\log_a a^n = n$

Change the base of logarithms

* $\log_b a = \dfrac{\log_k a}{\log_k b}$, $a, b, k > 0$
  $b, k \neq 1$

* $\log_b a = \dfrac{1}{\log_a b}$

* $\log_{b^n} a = \dfrac{1}{\log_a b^n}$

$$= \frac{1}{n \log_a b}$$

$$= \frac{1}{n} \times \frac{1}{\log_a b}$$

$$= \frac{1}{n} \log_b a$$

Natural logarithms

$\log_e x = \ln x$

$a^{\log_a x} = x$

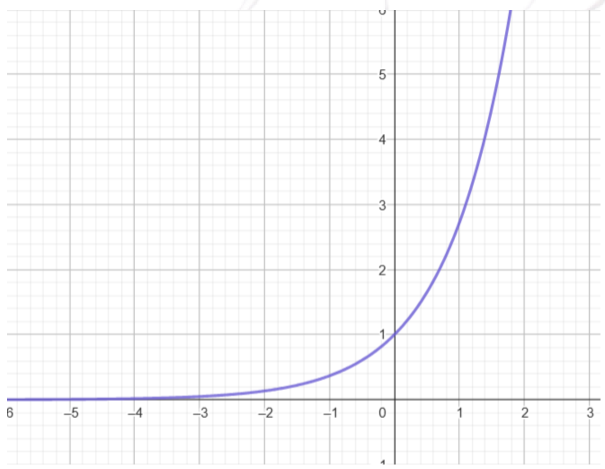
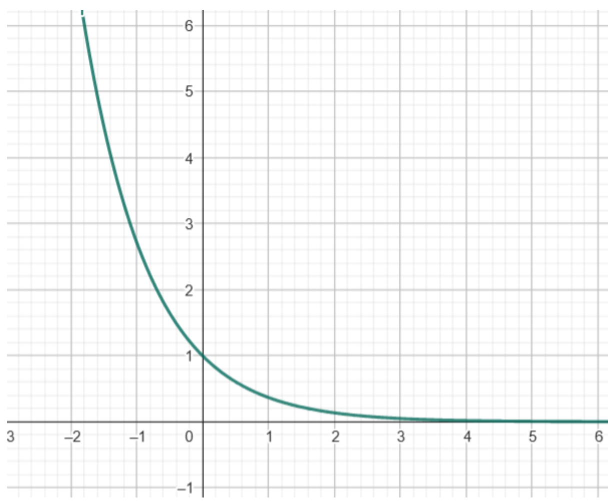
$e^{\ln x} = x$

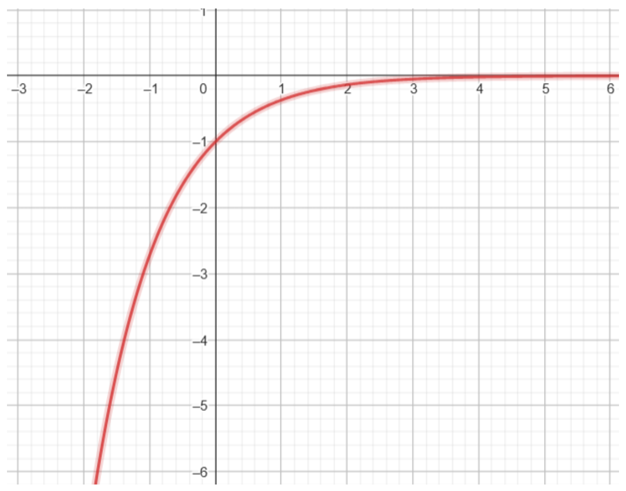
Eg.

$$\ln(2x-5) = 3$$
$$2x - 5 = e^{3}$$
$$2x = e^{3} + 5$$
$$x = \frac{1}{2}\left(e^{3} + 5\right)$$
$$x = 12.54276\ldots$$
$$x = 12.5$$

- $\ln(x)$, $x > 0$, $(x \neq 0)$
- e^{a}, a can be positive, negative or 0.
- $e^{a} > 0$ (always)

Graphs of exponential functions

$y = e^{x}$	$y = e^{-x}$
$x \to +\infty$, $y \to +\infty$ $x \to -\infty$, $y \to 0$	$x \to +\infty$, $y \to 0$ $x \to -\infty$, $y \to +\infty$
	



$y = -e^x$	$y = -e^{-x}$
$x \to +\infty, \quad y \to -\infty$	$x \to +\infty, \quad y \to 0$
$x \to -\infty, \quad y \to 0$	$x \to -\infty, \quad y \to -\infty$

❖ e^{-x} leans to 0 but never reach 0.

Steps:

1) x = 0, y = ?
2) y = 0, x = ?
3) Direction
4) Asymptote equation
5) Graph

Graphs of logarithmic functions

$$y = k \log_c (ax + b)$$

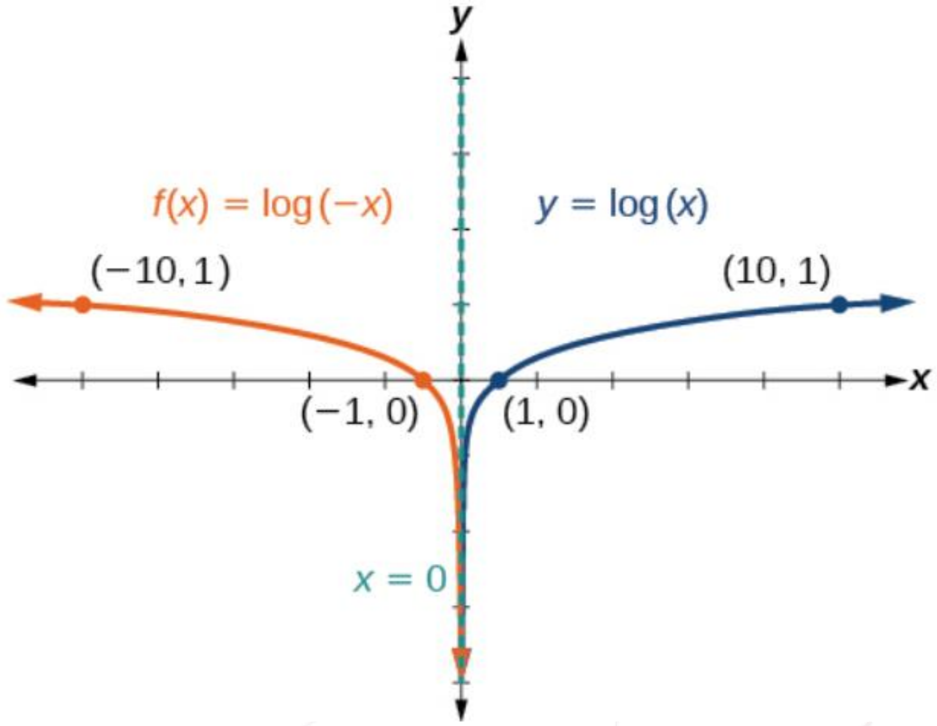
Steps:

1) x = 0, y = ?
2) y = 0, x = ?
3) Asymptote equation (vertical line)

$$ax + b > 0$$
$$x > -b/a$$

$\therefore$ Asymptote equation: $x = -b/a$

4) Direction
5) Graph



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