



eClassroom

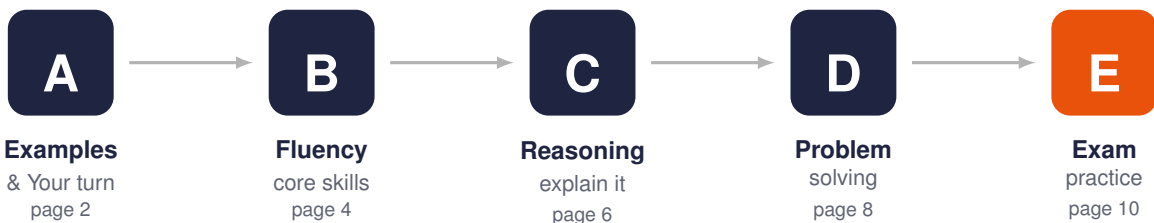
GCSE MATHEMATICS • ALGEBRA

Notation & Substitution

Worksheet

Pearson Edexcel GCSE (1MA1) & International GCSE (4MA1) • No calculator

Free Notation and Substitution worksheet for GCSE and iGCSE Maths, with full worked solutions



Tap a section to jump straight to it

By the end of this worksheet you can: write expressions using algebraic notation • form expressions and formulae from words • substitute positive and negative numbers into expressions • know the words term, expression, equation, formula and identity • *Higher*: identities with $\equiv$, substituting expressions, and counterexamples.

Which questions are for me?

FOUNDATION Everyone starts here. These skills appear on both tiers.

HIGHER Higher only: identities using the $\equiv$ symbol, substituting expressions into formulae, and counterexamples. Grades 6 to 9.

Every section has both, clearly labelled. Questions get harder as you go, and every skill in Sections A to D is needed in Section E.

Track your progress

Section	B	C	D	E
Foundation marks	23	10	13	17
Higher marks	16	14	17	14
My score				

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A**Worked examples & Your turn**

Read each example carefully. Cover it up, then answer the question beside it using the same method.

FOUNDATION*Everyone starts here***Worked example A1**

Write $4 \times a \times b \times a$ using algebraic notation.

Number first, then letters in order. $a \times a = a^2$

$$4a^2b$$

Your turn A1

Write $y \div 5 \times x \times 3$ using algebraic notation.

Worked example A2

$a = -2$ and $b = 5$. Work out the value of $3a^2 - 2b$

Square first: $a^2 = (-2)^2 = 4$, which is positive.

$$3 \times 4 - 2 \times 5 = 12 - 10$$

$$2$$

Your turn A2

$p = -3$ and $q = 2$. Work out the value of $q^3 - 4p$

Worked example A3

A gym charges a £30 joining fee and then £18 for each month. Write a formula for the total cost, C pounds, for m months.

A formula needs "C =". Fixed amount, plus the amount for each month.

$$C = 30 + 18m$$

Your turn A3

A cinema charges £8 for each ticket and £4 for each bag of popcorn. Write a formula for the total cost, T pounds, of a tickets and b bags of popcorn.



HIGHER*Higher only: identities, substituting expressions and counterexamples***Worked example A4: showing an identity with $\equiv$** Show that $2(x+5)+3(x-2) \equiv 5x+4$ *$\equiv$ means true for every value of x . Simplify one side until it matches the other.*

$$2x+10+3x-6=5x+4$$

$$\text{LHS} = \text{RHS}$$

Your turn A4Show that $4(2x-1)-3(x-3) \equiv 5x+5$ **Worked example A5: finding constants in an identity** $a(x+3)-2x \equiv 4x+b$. Find a and b .*Expand, then match the x terms and the numbers.*

$$ax+3a-2x: a-2=4 \text{ and } 3a=b$$

$$a=6, b=18$$

Your turn A5 $3(x+a)+b(x-2) \equiv 7x-2$. Find a and b .**Worked example A6: substituting an expression** $y=x^2-3x$. Find y in terms of t when $x=2t$.*Replace every x with $(2t)$, in brackets.*

$$(2t)^2-3(2t)$$

$$y=4t^2-6t$$

Your turn A6 $P=5q-2r$. Find P in terms of m when $q=2m$ and $r=3m-1$.**Worked example A7: a counterexample**Show that the statement " n^2+n+11 is always prime" is false.*One value that fails is enough. Try $n=10$*

$$100+10+11=121=11 \times 11$$

$$n=10 \text{ gives } 121$$

Your turn A7Show that the statement " x^2 is always bigger than x " is false.

B**Fluency**

Each question is a designed sequence. From one part to the next, ask yourself: what changed, and what did it do to the answer?

FOUNDATION*Everyone starts here*

B1 Write each using algebraic notation.

(a) $a \times b \times 3$

(b) $m \times m \times m$

(c) $x \div 4$

(d) $2 \times p \times q \times p \times q$

[4 marks]

B2 Write an expression for each of these.

(a) 5 more than n

(b) n multiplied by 10

(c) half of n , then subtract 3

(d) 3 less than n , then square the result

[4 marks]

B3 Work out the value of each expression.

(a) $3x + 2$ when $x = 4$

(b) $3x + 2$ when $x = -4$

(c) x^2 when $x = -4$

(d) $-x^2$ when $x = -4$

[4 marks]

B4 $a = -2$ and $b = 3$. Work out

(a) ab

(b) a^2b

(c) $(a+b)^2$

(d) $a^2 + b^2$

[4 marks]

B5 Choose from: expression, equation, formula. Which word describes each of these?

(a) $3x + 7$

(b) $3x + 7 = 22$

(c) $v = u + at$

[3 marks]

B6 $p = 10$ and $q = -5$. Work out

(a) $\frac{p}{q}$

(b) $\frac{p-q}{3}$

(c) $\frac{q^2}{p}$

(d) $(p+q)^3$

[4 marks]



HIGHER*Higher tier only*

B7 Is each statement an identity or an equation? If it is an equation, give the value or values of x that make it true.

(a) $2(x+3) = 2x+6$

(b) $2(x+3) = 14$

(c) $x^2 = 2x$

(d) $(x+1) - (x-1) = 2$

[4 marks]

B8 Find the value of each letter.

(a) $a(x+2) \equiv 3x+6$

(b) $4(x+b) \equiv 4x-12$

(c) $a(2x-1) \equiv 10x+b$

(d) $3(x+a) - (x-4) \equiv bx+10$

[4 marks]

B9 $y = 3x - 5$. Find y in terms of t when

(a) $x = 2t$

(b) $x = t + 1$

(c) $x = -t$

(d) $x = \frac{t}{3}$

[4 marks]

B10 Each statement is false. Give a value, or values, that show this.

(a) $x^2 > x$ for every number x

(b) $2n+1$ is always prime, for whole numbers n

(c) $a-b$ is always less than a

(d) $(a+b)^2 = a^2 + b^2$ for all numbers a and b

[4 marks]



C**Reasoning**

Show your working and explain your thinking. A correct answer without a reason does not score full marks.

FOUNDATION

Everyone starts here

- C1** A pencil is x cm long. Ali is asked for an expression for its length in millimetres. He writes x cm = 10 mm
Explain what is wrong, and write the correct expression. [2 marks]
- C2** Tom works out the value of $2x^2$ when $x = -3$. He writes $2x^2 = (-6)^2 = 36$
Explain Tom's mistake, and work out the correct value. [2 marks]
- C3** Sam says, " $3n$ is always bigger than $n + 3$ "
(a) Show that Sam is wrong. (b) For what value of n are $3n$ and $n + 3$ equal? [3 marks]
- C4** $a = 3$ and $b = -2$
Show that $a^2 - b^2$ and $(a + b)(a - b)$ have the same value. [3 marks]



HIGHER*Higher tier only***C5** Kai says, " $2(x+4) \equiv 2x+4$ "Use a value of x to show that Kai is wrong, and write the correct identity.**[3 marks]****C6** Explain why $x^2 + 1$ is positive for every value of x , but $x^2 - 1$ is not.**[3 marks]****C7** Explain why there are no values of a and b that make $a(x+2) \equiv 3x+5$ **[3 marks]****C8** $E = 2x^2 - 12x + 23$ **(a)** Substitute $x = 3 + t$ and show that $E = 2t^2 + 5$ **(b)** Hence explain why E is never less than 5, and write down the value of x that makes $E = 5$ **[5 marks]**

D**Problem solving**

You decide the method. Read the whole question first, and show every step.

FOUNDATION

Everyone starts here

- D1** A rectangle has length $(2x + 3)$ cm and width $(x - 1)$ cm.

Write an expression for its perimeter, and work out the perimeter when $x = 5$

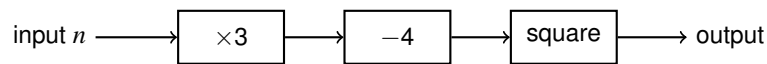
[3 marks]

- D2** An adult ticket costs $\pounds a$ and a child ticket costs $\pounds c$. A family buys 2 adult tickets and 3 child tickets, and gets $\pounds 5$ off the total.

(a) Write a formula for the total cost, T pounds. (b) Work out T when $a = 12.50$ and $c = 7.50$

[4 marks]

- D3** Here is a number machine.



Write an expression for the output. Work out the output when the input is -1

[3 marks]

- D4** The cost, C pounds, of hiring a bike for h hours is $C = 12 + 4h$

Kai has $\pounds 40$. What is the greatest number of whole hours he can hire a bike for?

[3 marks]



HIGHER*Higher tier only*

D5 A trapezium has parallel sides $(x + 2)$ cm and $3x$ cm, and height 4 cm.

$$\text{Area of a trapezium} = \frac{1}{2}(a + b)h$$

Show that the area is $(8x + 4)$ cm², and show that the area is 36 cm² when $x = 4$

[4 marks]

D6 The expression $4(x + k) - 2(x - 3)$ is equal to $2x + 20$ for every value of x .

Find the value of k .

[4 marks]

D7 Leonhard Euler noticed that $n^2 - n + 41$ is prime for $n = 1, 2, 3, \dots$ up to 40

(a) Show that it is prime when $n = 1$, $n = 2$ and $n = 3$

(b) Explain, without a calculator, why it is **not** prime when $n = 41$

[4 marks]

D8 a and b are positive whole numbers with $a + b = 10$

(a) Substitute $b = 10 - a$ and show that $a^2 - b^2 = 20a - 100$

(b) Find the greatest possible value of $a^2 - b^2$

[5 marks]

E**Exam practice**

Exam-style questions. Write your answers in the spaces. Aim for about one minute per mark.

FOUNDATION*Foundation and Higher crossover*

E1 Choose from: term expression equation formula

(a) x^2 is a in $x^2 + 4y$

(1)

(b) $5x - 3 = 12$ is an

(1)

(c) $A = \pi r^2$ is a

(1)

(Total for Question E1 is 3 marks)

E2 (a) Simplify $a \times a \times a$

.....

(1)

(b) Simplify $3 \times p \times q \times p$

.....

(1)

(Total for Question E2 is 2 marks)

E3 $a = -3$ and $b = 4$

(a) Work out the value of $2a + 3b$

.....

(2)

(b) Work out the value of $a^2 - b$

.....

(1)

(Total for Question E3 is 3 marks)



- E4** Sam has x sweets. Tom has 5 more sweets than Sam. Uma has twice as many sweets as Tom.

Write an expression, in terms of x , for the total number of sweets they have. Give your answer in its simplest form.

.....
(Total for Question E4 is 3 marks)

- E5** A taxi fare is £3 plus £2 for each mile.

(a) Write a formula for the fare, C pounds, for a journey of m miles.

.....
(2)

(b) Work out the fare for a journey of 7.5 miles.

£

(1)

(Total for Question E5 is 3 marks)

- E6** (a) Work out the value of $3x^2 - 5x$ when $x = -2$

.....
(2)

(b) When $x = 3$, explain why $-x^2$ and $(-x)^2$ have different values.

(1)

(Total for Question E6 is 3 marks)

HIGHER

Higher tier only

- E7** Show that $3(2x + 4) - 2(x - 1) \equiv 2(2x + 7)$

(Total for Question E7 is 3 marks)



E8 $a(x+b) + 3(x-2) \equiv 7x + 10$

Find the value of a and the value of b .

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

(Total for Question E8 is 3 marks)

E9 Aisha says, " $2n^2 + 1$ is always a prime number when n is a whole number."

Show that Aisha is wrong.

(Total for Question E9 is 3 marks)

E10 The sum of the whole numbers from 1 to n is given by the formula $S = \frac{n(n+1)}{2}$

(a) Work out the sum of the whole numbers from 1 to 40

.....
(1)

(b) Show that the sum of the whole numbers from $n+1$ to $2n$ is $\frac{n(3n+1)}{2}$

(3)

(c) Work out the sum of the whole numbers from 51 to 100

.....
(1)

(Total for Question E10 is 5 marks)

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