GCSE ONLINE TUTORING

ALGEBRA & GRAPHS / TOPIC GUIDE 12

12

Substitution and writing expressions

Shared GCSE foundations

Turn words into mathematics and evaluate expressions accurately. Careful substitution includes brackets around negative values and respects the original order of operations. Use expressions to model situations while keeping units and assumptions visible.

$$3(-4)^2 - 2(-4) = 56$$

Substitute in brackets, then follow operation order.

UNDERSTAND THE IDEA. EXPLAIN THE METHOD.

Detailed teaching • Worked examples • Discussion • Original practice • Full solutions

Name: _____

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Your learning guide

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Before you begin

Understand terms, coefficients, signed arithmetic and order of operations.

Your route through this notebook

1. Substitution with positive and negative inputs
2. Translating words into expressions
3. Building models from contexts

How to use it

Read a lesson, cover the worked solutions and try the examples yourself. Complete its practice page before checking the answers at the back. Finish with the mixed review, then return to any method you could not explain.

YOUR PROGRESS

After each lesson, ask: Can I explain the idea? Can I choose a method? Can I check my result? Record any questions you want to revisit.

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LESSON 1 / UNDERSTAND

Substitution with positive and negative inputs

Substitution replaces every occurrence of a variable by its assigned value. The structure of the expression stays the same: powers, brackets and operations must still be applied in the correct order. If a value is negative, enclose it in brackets to show exactly what is being substituted.

A coefficient multiplies the substituted value. In $4x^2$, square x first and multiply by 4 afterwards. In $(4x)^2$, the whole product is squared. When several variables are present, identify each value before calculating. Keep fractions exact when that makes the calculation cleaner.

A reliable method

1. Copy the expression and replace each letter using brackets.

2. Evaluate powers and brackets before multiplication and addition.

3. Check signs and whether the resulting size is plausible.

Worked example 1

Evaluate $3x^2 - 2x$ for $x = -4$.

STEP-BY-STEP SOLUTION

$3(-4)^2 - 2(-4) = 3 \times 16 + 8 = 56$.

Worked example 2

Evaluate $(a + 2b)/c$ when $a = 5$, $b = -3$, $c = 2$.

STEP-BY-STEP SOLUTION

The numerator is $5 + 2(-3) = -1$. Divide the whole numerator by 2: $-1/2$.

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LESSON 1 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

For $x = -3$, $x^2 = 9$ but $-x^2 = -9$. The minus in the input belongs inside the substitution brackets; a minus outside the original square remains outside.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

1.1 Evaluate $5x + 7$ for $x = 6$.

1.2 Evaluate $y^2 + 4y$ for $y = -5$.

1.3 Evaluate $2ab - b^2$ for $a = -2$, $b = 3$.

1.4 Evaluate $6t^2$ for $t = 1/2$.

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 2 / UNDERSTAND

Translating words into expressions

An expression describes a calculation without necessarily giving an answer. Choose a variable for the changing quantity, then translate the operations in their stated order. “Five more than twice n” is 2n + 5, while “twice the sum of n and five” is 2(n + 5). Brackets preserve grouped instructions.

Subtraction and division are sensitive to order. “Seven less than n” is n − 7, and “n divided by four” is n/4. Test a small input in your proposed expression and compare it with the verbal instructions. This catches many translation errors before any equation is formed.

A reliable method

1. Define the variable in words.

2. Identify the order and any grouped quantity.

3. Test the expression using a simple input.

Worked example 1

Write an expression for three less than four times k.

STEP-BY-STEP SOLUTION

Four times k is 4k; three less is 4k − 3.

Worked example 2

A number n is increased by 6, then the result is divided by 4. Write an expression.

STEP-BY-STEP SOLUTION

The whole increased amount is divided: (n + 6)/4. Without brackets, n + 6/4 describes a different operation.

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LESSON 2 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

The order of words can differ from the order of symbols. “Subtract p from 10” means start with 10 and remove p: 10 − p. Use a numerical test rather than following word order blindly.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

2.1 Write five more than three times x.

2.2 Write half the sum of a and b.

2.3 Write the square of the difference between n and 4.

2.4 Write the result of subtracting y from 12 and multiplying by 3.

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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LESSON 3 / UNDERSTAND

Building models from contexts

A mathematical model represents selected features of a situation. A fixed charge is a constant; a cost per item produces a variable term. If a taxi charges £4 plus £1.80 per kilometre, its model is C = 4 + 1.8d, with d in kilometres and C in pounds. The model assumes the same rate applies throughout and excludes additional charges.

Define units and valid inputs. A number of tickets should be a non-negative integer, whereas a distance can usually vary continuously. An expression can calculate the output; an equation can be formed when the output is known. Interpreting the answer is part of the mathematics, not an optional final sentence.

A reliable method

1. Separate fixed quantities from quantities that vary.

2. Define each variable and its unit.

3. State important assumptions and check whether the input is realistic.

Worked example 1

A delivery costs £6 plus £2.50 per parcel. Model the cost and find it for 8 parcels.

STEP-BY-STEP SOLUTION

Let n be the number of parcels. C = 6 + 2.5n pounds. For n = 8, C = 6 + 20 = £26.

Worked example 2

A rectangle has width x and length x + 3. Write its perimeter.

STEP-BY-STEP SOLUTION

P = 2x + 2(x + 3) = 4x + 6. If measurements are in cm, P is in cm and x must be positive.

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LESSON 3 / DISCUSS & PRACTISE

Explain it, then try it

DISCUSSION • TEST THE IDEA

A model can give a numerical output for an invalid input. A ticket-cost formula might accept n = 2.5 algebraically, but half a ticket may not be sold. The domain comes from the situation.

Say it in your own words

Explain the key idea to someone else. Use a small example to support your explanation. If you disagree with a claim, show why it fails.

3.1 A gym charges £15 joining fee and £8 per visit. Model total cost for v visits.

3.2 Use that model for 7 visits.

3.3 A rectangle has sides x and x + 5. Write its area.

3.4 A tank starts with 90 litres and loses 4 litres per minute. Model its content and state the valid time interval until empty.

Check before turning to the answers: is the size sensible, is the notation clear, and have you included any required units?

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MIXED REVIEW / ORIGINAL EXAM-STYLE PRACTICE

Apply your learning • 1

These questions are independently authored, not taken or adapted from past papers. Marks are suggested for self-assessment. Show your method and explain decisions. Use a calculator only where the arithmetic requires it.

R1. Evaluate $2x^2 - 5x + 1$ for $x = -3$. [3 marks]

R2. Evaluate $(3a - b)/(a + b)$ for $a = 4$, $b = -1$. [3 marks]

R3. Write three times the sum of n and 8. [1 mark]

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MIXED REVIEW / ORIGINAL EXAM-STYLE PRACTICE

Apply your learning • 2

These questions are independently authored, not taken or adapted from past papers. Marks are suggested for self-assessment. Show your method and explain decisions. Use a calculator only where the arithmetic requires it.

R4. Write five less than the square of p. [1 mark]

R5. A hire company charges £12 plus £7 per hour. Model the cost and calculate 5 hours. [3 marks]

R6. A rectangle has sides x + 2 and x + 7. Write its perimeter in simplest form. [3 marks]

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SOLUTIONS / LESSON PRACTICE

Check the reasoning

Your layout may differ. Compare the mathematical reasoning as well as the final answer. Correct any error, then reattempt the question without looking.

Lesson 1 • Substitution with positive and negative inputs

1.1 Evaluate $5x + 7$ for $x = 6$.

$5 \times 6 + 7 = 37$.

1.2 Evaluate $y^2 + 4y$ for $y = -5$.

$25 - 20 = 5$.

1.3 Evaluate $2ab - b^2$ for $a = -2$, $b = 3$.

$2(-2)(3) - 9 = -12 - 9 = -21$.

1.4 Evaluate $6t^2$ for $t = 1/2$.

$6 \times (1/2)^2 = 6/4 = 3/2$.

Lesson 2 • Translating words into expressions

2.1 Write five more than three times x.

$3x + 5$.

2.2 Write half the sum of a and b.

$(a + b)/2$.

2.3 Write the square of the difference between n and 4.

$(n - 4)^2$.

2.4 Write the result of subtracting y from 12 and multiplying by 3.

$3(12 - y)$.

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SOLUTIONS / LESSON PRACTICE

Check the reasoning • continued

Lesson 3 • Building models from contexts

3.1 A gym charges £15 joining fee and £8 per visit. Model total cost for v visits.

C = 15 + 8v, with v a non-negative integer and C in pounds.

3.2 Use that model for 7 visits.

C = 15 + 8 × 7 = £71.

3.3 A rectangle has sides x and x + 5. Write its area.

A = x(x + 5), or $x^2 + 5x$. For lengths, x > 0.

3.4 A tank starts with 90 litres and loses 4 litres per minute. Model its content and state the valid time interval until empty.

V = 90 − 4t litres. For this constant-rate model, 0 ≤ t ≤ 22.5 minutes.

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SOLUTIONS / MIXED REVIEW

Answers and marking guidance

Award the suggested method marks for valid working, even where a later arithmetic slip occurs. Do not count the same step twice. These are independent teaching allocations, not official exam-board mark schemes.

R1. Evaluate $2x^2 - 5x + 1$ for $x = -3$. [3 marks]

$2 \times 9 + 15 + 1 = 34$. [1 for substitution; 1 for signs/power; 1 for answer.]

R2. Evaluate $(3a - b)/(a + b)$ for $a = 4$, $b = -1$. [3 marks]

$(12 + 1)/(4 - 1) = 13/3$. [1 for substitution; 1 for numerator/denominator; 1 for quotient.]

R3. Write three times the sum of n and 8. [1 mark]

$3(n + 8)$. [1 for correct grouping.]

R4. Write five less than the square of p. [1 mark]

$p^2 - 5$. [1 for expression.]

R5. A hire company charges £12 plus £7 per hour. Model the cost and calculate 5 hours. [3 marks]

$C = 12 + 7h$; $C(5) = £47$. [1 for fixed term; 1 for hourly term; 1 for cost.]

R6. A rectangle has sides $x + 2$ and $x + 7$. Write its perimeter in simplest form. [3 marks]

$P = 2(x + 2) + 2(x + 7) = 4x + 18$. [1 for perimeter structure; 1 for expansion; 1 for collection.]

Reflect, repair and revisit

Record one secure method, one mistake you corrected and one question to retry. Reattempt the questions you missed in a few days. Explain why your new method works before you compare your answer.

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