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GCSE to GCE TRANSITION WORKSHEETS – A LEVEL BRIDGING UNIT

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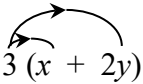


Chapter 1: REMOVING BRACKETS

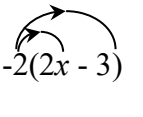
To remove a single bracket, we multiply every term in the bracket by the number or the expression on the outside:

Examples

1) $3(x + 2y) = 3x + 6y$



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



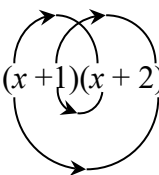
To expand two brackets, we must multiply everything in the first bracket by everything in the second bracket. We can do this in a variety of ways, including

- * the smiley face method
- * FOIL (Fronts Outers Inners Lasts)
- * using a grid.

Examples:

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

or



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

$$= x^2 + 3x + 2$$

or

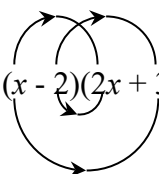
	x	1
x	x^2	x
2	$2x$	2

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

$$= x^2 + 3x + 2$$

2) $(x - 2)(2x + 3) = x(2x + 3) - 2(2x + 3)$
 $= 2x^2 + 3x - 4x - 6$
 $= 2x^2 - x - 6$

or



$$(x - 2)(2x + 3) = 2x^2 - 6 + 3x - 4x = 2x^2 - x - 6$$

$$(2x + 3)(x - 2) = 2x^2 + 3x - 4x - 6$$

$$= 2x^2 - x - 6$$

or

	x	-2
$2x$	$2x^2$	$-4x$
3	$3x$	-6

EXERCISE A Multiply out the following brackets and simplify.

1. $7(4x + 5)$
2. $-3(5x - 7)$
3. $5a - 4(3a - 1)$
4. $4y + y(2 + 3y)$
5. $-3x - (x + 4)$
6. $5(2x - 1) - (3x - 4)$
7. $(x + 2)(x + 3)$
8. $(t - 5)(t - 2)$
9. $(2x + 3y)(3x - 4y)$
10. $4(x - 2)(x + 3)$
11. $(2y - 1)(2y + 1)$
12. $(3 + 5x)(4 - x)$

Two Special Cases

Perfect Square:

$$(x + a)^2 = (x + a)(x + a) = x^2 + 2ax + a^2$$
$$(2x - 3)^2 = (2x - 3)(2x - 3) = 4x^2 - 12x + 9$$

Difference of two squares:

$$(x - a)(x + a) = x^2 - a^2$$
$$(x - 3)(x + 3) = x^2 - 3^2$$
$$= x^2 - 9$$

EXERCISE B Multiply out

1. $(x - 1)^2$
2. $(3x + 5)^2$
3. $(7x - 2)^2$
4. $(x + 2)(x - 2)$
5. $(3x + 1)(3x - 1)$
6. $(5y - 3)(5y + 3)$

Chapter 2: LINEAR EQUATIONS

When solving an equation, you must remember that whatever you do to one side must also be done to the other. You are therefore allowed to

- add the same amount to both side
- subtract the same amount from each side
- multiply the whole of each side by the same amount
- divide the whole of each side by the same amount.

If the equation has unknowns on both sides, you should collect all the letters onto the same side of the equation.

If the equation contains brackets, you should start by expanding the brackets.

A linear equation is an equation that contains numbers and terms in x . A linear equation does not contain any x^2 or x^3 terms.

Example 1: Solve the equation $64 - 3x = 25$

Solution: There are various ways to solve this equation. One approach is as follows:

Step 1: Add $3x$ to both sides (so that the x term is positive): $64 = 3x + 25$

Step 2: Subtract 25 from both sides: $39 = 3x$

Step 3: Divide both sides by 3: $13 = x$

So the solution is $x = 13$.

Example 2: Solve the equation $6x + 7 = 5 - 2x$.

Solution:

Step 1: Begin by adding $2x$ to both sides $8x + 7 = 5$
(to ensure that the x terms are together on the same side)

Step 2: Subtract 7 from each side: $8x = -2$

Step 3: Divide each side by 8: $x = -\frac{1}{4}$

Exercise A: Solve the following equations, showing each step in your working:

1) $2x + 5 = 19$

2) $5x - 2 = 13$

3) $11 - 4x = 5$

4) $5 - 7x = -9$

5) $11 + 3x = 8 - 2x$

6) $7x + 2 = 4x - 5$

Example 3: Solve the equation $2(3x - 2) = 20 - 3(x + 2)$

Step 1: Multiply out the brackets: $6x - 4 = 20 - 3x - 6$
(taking care of the negative signs)

Step 2: Simplify the right hand side: $6x - 4 = 14 - 3x$

Step 3: Add $3x$ to each side: $9x - 4 = 14$

Step 4: Add 4: $9x = 18$

Step 5: Divide by 9: $x = 2$

Exercise B: Solve the following equations.

1) $5(2x - 4) = 4$

2) $4(2 - x) = 3(x - 9)$

3) $8 - (x + 3) = 4$

4) $14 - 3(2x + 3) = 2$

EQUATIONS CONTAINING FRACTIONS

When an equation contains a fraction, the first step is usually to multiply through by the denominator of the fraction. This ensures that there are no fractions in the equation.

Example 4: Solve the equation $\frac{y}{2} + 5 = 11$

Solution:

Step 1: Multiply through by 2 (the denominator in the fraction): $y + 10 = 22$

Step 2: Subtract 10: $y = 12$

Example 5: Solve the equation $\frac{1}{3}(2x + 1) = 5$

Solution:

Step 1: Multiply by 3 (to remove the fraction) $2x + 1 = 15$

Step 2: Subtract 1 from each side $2x = 14$

Step 3: Divide by 2 $x = 7$

When an equation contains two fractions, you need to multiply by the lowest common denominator. This will then remove both fractions.

Example 6: Solve the equation $\frac{x+1}{4} + \frac{x+2}{5} = 2$

Solution:

Step 1: Find the lowest common denominator:

The smallest number that both 4 and 5 divide into is 20.

Step 2: Multiply both sides by the lowest common denominator

$$\frac{20(x+1)}{4} + \frac{20(x+2)}{5} = 40$$

Step 3: Simplify the left hand side:

$$\frac{\overset{5}{\cancel{20}}(x+1)}{\cancel{4}} + \frac{\overset{4}{\cancel{20}}(x+2)}{\cancel{5}} = 40$$

$$5(x+1) + 4(x+2) = 40$$

Step 4: Multiply out the brackets:

$$5x + 5 + 4x + 8 = 40$$

Step 5: Simplify the equation:

$$9x + 13 = 40$$

Step 6: Subtract 13

$$9x = 27$$

Step 7: Divide by 9:

$$x = 3$$

Example 7: Solve the equation $x + \frac{x-2}{4} = 2 - \frac{3-5x}{6}$

Solution: The lowest number that 4 and 6 go into is 12. So we multiply every term by 12:

$$12x + \frac{12(x-2)}{4} = 24 - \frac{12(3-5x)}{6}$$

Simplify

$$12x + 3(x-2) = 24 - 2(3-5x)$$

Expand brackets

$$12x + 3x - 6 = 24 - 6 + 10x$$

Simplify

$$15x - 6 = 18 + 10x$$

Subtract 10x

$$5x - 6 = 18$$

Add 6

$$5x = 24$$

Divide by 5

$$x = 4.8$$

Exercise C: Solve these equations

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

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

3) $\frac{y}{4} + 3 = 5 - \frac{y}{3}$

4) $\frac{x-2}{7} = 2 + \frac{3-x}{14}$

Exercise C (continued)

$$5) \quad \frac{7x-1}{2} = 13-x$$

$$6) \quad \frac{y-1}{2} + \frac{y+1}{3} = \frac{2y+5}{6}$$

$$7) \quad 2x + \frac{x-1}{2} = \frac{5x+3}{3}$$

$$8) \quad 2 - \frac{5}{x} = \frac{10}{x} - 1$$

FORMING EQUATIONS

Example 8: Find three consecutive numbers so that their sum is 96.

Solution: Let the first number be n , then the second is $n + 1$ and the third is $n + 2$.

$$\begin{aligned} \text{Therefore} \quad n + (n + 1) + (n + 2) &= 96 \\ 3n + 3 &= 96 \\ 3n &= 93 \\ n &= 31 \end{aligned}$$

So the numbers are 31, 32 and 33.

Exercise D:

- 1) Find 3 consecutive even numbers so that their sum is 108.
- 2) The perimeter of a rectangle is 79 cm. One side is three times the length of the other. Form an equation and hence find the length of each side.
- 3) Two girls have 72 photographs of celebrities between them. One gives 11 to the other and finds that she now has half the number her friend has. Form an equation, letting n be the number of photographs one girl had at the **beginning**. Hence find how many each has **now**.

Chapter 3: SIMULTANEOUS EQUATIONS

An example of a pair of simultaneous equations is $3x + 2y = 8$ ○
 $5x + y = 11$ ○

In these equations, x and y stand for two numbers. We can solve these equations in order to find the values of x and y by eliminating one of the letters from the equations.

In these equations it is simplest to eliminate y . We do this by making the coefficients of y the same in both equations. This can be achieved by multiplying equation ○ by 2, so that both equations contain $2y$:

$$\begin{array}{rcl} 3x + 2y = 8 & \text{○} & \\ 10x + 2y = 22 & 2 \times \text{○} = \text{○} & \end{array}$$

To eliminate the y terms, we subtract equation ○ from equation ○. We get: $7x = 14$
i.e. $x = 2$

To find y , we substitute $x = 2$ into one of the original equations. For example if we put it into ○:

$$\begin{array}{r} 10 + y = 11 \\ y = 1 \end{array}$$

Therefore the solution is $x = 2, y = 1$.

Remember: You can check your solutions by substituting both x and y into the original equations.

Example: Solve $2x + 5y = 16$ ○
 $3x - 4y = 1$ ○

Solution: We begin by getting the same number of x or y appearing in both equation. We can get $20y$ in both equations if we multiply the top equation by 4 and the bottom equation by 5:

$$\begin{array}{rcl} 8x + 20y = 64 & \text{○} & \\ 15x - 20y = 5 & \text{○} & \end{array}$$

As the SIGNS in front of $20y$ are DIFFERENT, we can eliminate the y terms from the equations by ADDING:

$$\begin{array}{rcl} 23x = 69 & \text{○} + \text{○} & \\ \text{i.e. } x = 3 & & \end{array}$$

Substituting this into equation ○ gives:

$$\begin{array}{r} 6 + 5y = 16 \\ 5y = 10 \end{array}$$

So... $y = 2$

The solution is $x = 3, y = 2$.

Exercise:

Solve the pairs of simultaneous equations in the following questions:

1) $x + 2y = 7$
 $3x + 2y = 9$

2) $x + 3y = 0$
 $3x + 2y = -7$

3) $3x - 2y = 4$
 $2x + 3y = -6$

4) $9x - 2y = 25$
 $4x - 5y = 7$

5) $4a + 3b = 22$
 $5a - 4b = 43$

6) $3p + 3q = 15$
 $2p + 5q = 14$

Chapter 4: FACTORISING

Common factors

We can factorise some expressions by taking out a common factor.

Example 1: Factorise $12x - 30$

Solution: 6 is a common factor to both 12 and 30. We can therefore factorise by taking 6 outside a bracket:

$$12x - 30 = 6(2x - 5)$$

Example 2: Factorise $6x^2 - 2xy$

Solution: 2 is a common factor to both 6 and 2. Both terms also contain an x . So we factorise by taking $2x$ outside a bracket.

$$6x^2 - 2xy = 2x(3x - y)$$

Example 3: Factorise $9x^3y^2 - 18x^2y$

Solution: 9 is a common factor to both 9 and 18.
The highest power of x that is present in both expressions is x^2 .
There is also a y present in both parts.
So we factorise by taking $9x^2y$ outside a bracket:

$$9x^3y^2 - 18x^2y = 9x^2y(xy - 2)$$

Example 4: Factorise $3x(2x - 1) - 4(2x - 1)$

Solution: There is a common bracket as a factor.
So we factorise by taking $(2x - 1)$ out as a factor.
The expression factorises to $(2x - 1)(3x - 4)$

Exercise A

Factorise each of the following

1) $3x + xy$

2) $4x^2 - 2xy$

3) $pq^2 - p^2q$

4) $3pq - 9q^2$

5) $2x^3 - 6x^2$

6) $8a^5b^2 - 12a^3b^4$

7) $5y(y - 1) + 3(y - 1)$

Factorising quadratics

Simple quadratics: Factorising quadratics of the form $x^2 + bx + c$

The method is:

Step 1: Form two brackets $(x \dots)(x \dots)$

Step 2: Find two numbers that multiply to give c and add to make b . These two numbers get written at the other end of the brackets.

Example 1: Factorise $x^2 - 9x - 10$.

Solution: We need to find two numbers that multiply to make -10 and add to make -9. These numbers are -10 and 1.

Therefore $x^2 - 9x - 10 = (x - 10)(x + 1)$.

General quadratics: Factorising quadratics of the form $ax^2 + bx + c$

The method is:

Step 1: Find two numbers that multiply together to make ac and add to make b .

Step 2: Split up the bx term using the numbers found in step 1.

Step 3: Factorise the front and back pair of expressions as fully as possible.

Step 4: There should be a common bracket. Take this out as a common factor.

Example 2: Factorise $6x^2 + x - 12$.

Solution: We need to find two numbers that multiply to make $6 \times -12 = -72$ and add to make 1. These two numbers are -8 and 9.

Therefore,
$$\begin{aligned} 6x^2 + x - 12 &= \underbrace{6x^2 - 8x} + \underbrace{9x - 12} \\ &= 2x(3x - 4) + 3(3x - 4) && \text{(the two brackets must be identical)} \\ &= (3x - 4)(2x + 3) \end{aligned}$$

Difference of two squares: Factorising quadratics of the form $x^2 - a^2$

Remember that $x^2 - a^2 = (x + a)(x - a)$.

Therefore: $x^2 - 9 = x^2 - 3^2 = (x + 3)(x - 3)$

$$16x^2 - 25 = (2x)^2 - 5^2 = (2x + 5)(2x - 5)$$

Also notice that: $2x^2 - 8 = 2(x^2 - 4) = 2(x + 4)(x - 4)$

and $3x^3 - 48xy^2 = 3x(x^2 - 16y^2) = 3x(x + 4y)(x - 4y)$

Factorising by pairing

We can factorise expressions like $2x^2 + xy - 2x - y$ using the method of factorising by pairing:

$$\begin{aligned} 2x^2 + xy - 2x - y &= x(2x + y) - 1(2x + y) && \text{(factorise front and back pairs, ensuring both} \\ & && \text{brackets are identical)} \\ &= (2x + y)(x - 1) \end{aligned}$$

Exercise B

Factorise

1) $x^2 - x - 6$

2) $x^2 + 6x - 16$

3) $2x^2 + 5x + 2$

4) $2x^2 - 3x$ (factorise by taking out a common factor)

5) $3x^2 + 5x - 2$

6) $2y^2 + 17y + 21$

7) $7y^2 - 10y + 3$

8) $10x^2 + 5x - 30$

9) $4x^2 - 25$

10) $x^2 - 3x - xy + 3y^2$

11) $4x^2 - 12x + 8$

12) $16m^2 - 81n^2$

13) $4y^3 - 9a^2y$

14) $8(x+1)^2 - 2(x+1) - 10$

Chapter 5: CHANGING THE SUBJECT OF A FORMULA

We can use algebra to change the subject of a formula. Rearranging a formula is similar to solving an equation – we must do the same to both sides in order to keep the equation balanced.

Example 1: Make x the subject of the formula $y = 4x + 3$.

Solution:

$$y = 4x + 3$$

Subtract 3 from both sides:

$$y - 3 = 4x$$

Divide both sides by 4;

$$\frac{y - 3}{4} = x$$

So $x = \frac{y - 3}{4}$ is the same equation but with x the subject.

Example 2: Make x the subject of $y = 2 - 5x$

Solution: Notice that in this formula the x term is negative.

$$y = 2 - 5x$$

Add $5x$ to both sides

$$y + 5x = 2 \quad (\text{the } x \text{ term is now positive})$$

Subtract y from both sides

$$5x = 2 - y$$

Divide both sides by 5

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

Example 3: The formula $C = \frac{5(F - 32)}{9}$ is used to convert between ° Fahrenheit and ° Celsius.

We can rearrange to make F the subject.

$$C = \frac{5(F - 32)}{9}$$

Multiply by 9

$$9C = 5(F - 32) \quad (\text{this removes the fraction})$$

Expand the brackets

$$9C = 5F - 160$$

Add 160 to both sides

$$9C + 160 = 5F$$

Divide both sides by 5

$$\frac{9C + 160}{5} = F$$

Therefore the required rearrangement is $F = \frac{9C + 160}{5}$.

Exercise A

Make x the subject of each of these formulae:

1) $y = 7x - 1$

2) $y = \frac{x + 5}{4}$

3) $4y = \frac{x}{3} - 2$

4) $y = \frac{4(3x - 5)}{9}$

Rearranging equations involving squares and square roots

Example 4: Make x the subject of $x^2 + y^2 = w^2$

Solution:

$$x^2 + y^2 = w^2$$

Subtract y^2 from both sides:

$$x^2 = w^2 - y^2 \quad (\text{this isolates the term involving } x)$$

Square root both sides:

$$x = \pm\sqrt{w^2 - y^2}$$

Remember that you can have a positive or a negative square root. We cannot simplify the answer any more.

Example 5: Make a the subject of the formula $t = \frac{1}{4}\sqrt{\frac{5a}{h}}$

Solution:

$$t = \frac{1}{4}\sqrt{\frac{5a}{h}}$$

Multiply by 4

$$4t = \sqrt{\frac{5a}{h}}$$

Square both sides

$$16t^2 = \frac{5a}{h}$$

Multiply by h :

$$16t^2h = 5a$$

Divide by 5:

$$\frac{16t^2h}{5} = a$$

Exercise B:

Make t the subject of each of the following

1) $P = \frac{wt}{32r}$

2) $P = \frac{wt^2}{32r}$

3) $V = \frac{1}{3}\pi t^2 h$

4) $P = \sqrt{\frac{2t}{g}}$

5) $Pa = \frac{w(v-t)}{g}$

6) $r = a + bt^2$

More difficult examples

Sometimes the variable that we wish to make the subject occurs in more than one place in the formula. In these questions, we collect the terms involving this variable on one side of the equation, and we put the other terms on the opposite side.

Example 6: Make t the subject of the formula $a - xt = b + yt$

Solution:

$$a - xt = b + yt$$

Start by collecting all the t terms on the right hand side:

Add xt to both sides:
$$a = b + yt + xt$$

Now put the terms without a t on the left hand side:

Subtract b from both sides:
$$a - b = yt + xt$$

Factorise the RHS:
$$a - b = t(y + x)$$

Divide by $(y + x)$:
$$\frac{a - b}{y + x} = t$$

So the required equation is
$$t = \frac{a - b}{y + x}$$

Example 7: Make W the subject of the formula $T - W = \frac{Wa}{2b}$

Solution: This formula is complicated by the fractional term. We begin by removing the fraction:

Multiply by $2b$:
$$2bT - 2bW = Wa$$

Add $2bW$ to both sides:
$$2bT = Wa + 2bW \quad (\text{this collects the } W\text{'s together})$$

Factorise the RHS:
$$2bT = W(a + 2b)$$

Divide both sides by $a + 2b$:
$$W = \frac{2bT}{a + 2b}$$

Exercise C

Make x the subject of these formulae:

1) $ax + 3 = bx + c$

2) $3(x + a) = k(x - 2)$

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

4) $\frac{x}{a} = 1 + \frac{x}{b}$

Chapter 6: SOLVING QUADRATIC EQUATIONS

A quadratic equation has the form $ax^2 + bx + c = 0$.

There are two methods that are commonly used for solving quadratic equations:

- * factorising
- * the quadratic formula

Note that not all quadratic equations can be solved by factorising. The quadratic formula can always be used however.

Method 1: Factorising

Make sure that the equation is rearranged so that the right hand side is 0. It usually makes it easier if the coefficient of x^2 is positive.

Example 1 : Solve $x^2 - 3x + 2 = 0$

Factorise $(x-1)(x-2) = 0$

Either $(x-1) = 0$ or $(x-2) = 0$

So the solutions are $x = 1$ or $x = 2$

Note: The individual values $x = 1$ and $x = 2$ are called the **roots** of the equation.

Example 2: Solve $x^2 - 2x = 0$

Factorise: $x(x-2) = 0$

Either $x = 0$ or $(x-2) = 0$

So $x = 0$ or $x = 2$

Method 2: Using the formula

Recall that the roots of the quadratic equation $ax^2 + bx + c = 0$ are given by the formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Example 3: Solve the equation $2x^2 - 5 = 7 - 3x$

Solution: First we rearrange so that the right hand side is 0. We get $2x^2 + 3x - 12 = 0$

We can then tell that $a = 2$, $b = 3$ and $c = -12$.

Substituting these into the quadratic formula gives:

$$x = \frac{-3 \pm \sqrt{3^2 - 4 \times 2 \times (-12)}}{2 \times 2} = \frac{-3 \pm \sqrt{105}}{4} \quad (\text{this is the } \textit{surd form} \text{ for the solutions})$$

If we have a calculator, we can evaluate these roots to get: $x = 1.81$ or $x = -3.31$

EXERCISE

1) Use factorisation to solve the following equations:

a) $x^2 + 3x + 2 = 0$

b) $x^2 - 3x - 4 = 0$

c) $x^2 = 15 - 2x$

2) Find the roots of the following equations:

a) $x^2 + 3x = 0$

b) $x^2 - 4x = 0$

c) $4 - x^2 = 0$

3) Solve the following equations either by factorising or by using the formula:

a) $6x^2 - 5x - 4 = 0$

b) $8x^2 - 24x + 10 = 0$

4) Use the formula to solve the following equations to 3 significant figures. Some of the equations can't be solved.

a) $x^2 + 7x + 9 = 0$

b) $6 + 3x = 8x^2$

c) $4x^2 - x - 7 = 0$

d) $x^2 - 3x + 18 = 0$

e) $3x^2 + 4x + 4 = 0$

f) $3x^2 = 13x - 16$

Chapter 7: INDICES

Basic rules of indices

y^4 means $y \times y \times y \times y$.

4 is called the **index** (plural: indices), **power** or **exponent** of y .

There are 3 basic rules of indices:

- 1) $a^m \times a^n = a^{m+n}$ e.g. $3^4 \times 3^5 = 3^9$
- 2) $a^m \div a^n = a^{m-n}$ e.g. $3^8 \div 3^6 = 3^2$
- 3) $(a^m)^n = a^{mn}$ e.g. $(3^2)^5 = 3^{10}$

Further examples

$$y^4 \times 5y^3 = 5y^7$$

$$4a^3 \times 6a^2 = 24a^5$$

$$2c^2 \times (-3c^6) = -6c^8$$

$$24d^7 \div 3d^2 = \frac{24d^7}{3d^2} = 8d^5$$

(multiply the numbers and multiply the a 's)

(multiply the numbers and multiply the c 's)

(divide the numbers and divide the d terms i.e. by subtracting the powers)

Exercise A

Simplify the following:

1) $b \times 5b^5 =$

(Remember that $b = b^1$)

2) $3c^2 \times 2c^5 =$

3) $b^2c \times bc^3 =$

4) $2n^6 \times (-6n^2) =$

5) $8n^8 \div 2n^3 =$

6) $d^{11} \div d^9 =$

7) $(a^3)^2 =$

8) $(-d^4)^3 =$

More complex powers

Zero index:

Recall from GCSE that

$$a^0 = 1.$$

This result is true for any non-zero number a .

Therefore $5^0 = 1$ $\left(\frac{3}{4}\right)^0 = 1$ $(-5.2304)^0 = 1$

Negative powers

A power of -1 corresponds to the reciprocal of a number, i.e. $a^{-1} = \frac{1}{a}$

Therefore $5^{-1} = \frac{1}{5}$

$$0.25^{-1} = \frac{1}{0.25} = 4$$

$$\left(\frac{4}{5}\right)^{-1} = \frac{5}{4}$$

(you find the reciprocal of a fraction by swapping the top and bottom over)

This result can be extended to more general negative powers: $a^{-n} = \frac{1}{a^n}$.

This means:

$$3^{-2} = \frac{1}{3^2} = \frac{1}{9}$$

$$2^{-4} = \frac{1}{2^4} = \frac{1}{16}$$

$$\left(\frac{1}{4}\right)^{-2} = \left(\left(\frac{1}{4}\right)^{-1}\right)^2 = \left(\frac{4}{1}\right)^2 = 16$$

Fractional powers:

Fractional powers correspond to roots:

$$a^{1/2} = \sqrt{a}$$

$$a^{1/3} = \sqrt[3]{a}$$

$$a^{1/4} = \sqrt[4]{a}$$

In general:

$$a^{1/n} = \sqrt[n]{a}$$

Therefore:

$$8^{1/3} = \sqrt[3]{8} = 2$$

$$25^{1/2} = \sqrt{25} = 5$$

$$10000^{1/4} = \sqrt[4]{10000} = 10$$

A more general fractional power can be dealt with in the following way: $a^{m/n} = (a^{1/n})^m$

So $4^{3/2} = (\sqrt{4})^3 = 2^3 = 8$

$$\left(\frac{8}{27}\right)^{2/3} = \left(\left(\frac{8}{27}\right)^{1/3}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

$$\left(\frac{25}{36}\right)^{-3/2} = \left(\frac{36}{25}\right)^{3/2} = \left(\sqrt{\frac{36}{25}}\right)^3 = \left(\frac{6}{5}\right)^3 = \frac{216}{125}$$

Exercise B:

Find the value of:

1) $4^{1/2}$

2) $27^{1/3}$

3) $\left(\frac{1}{9}\right)^{1/2}$

4) 5^{-2}

5) 18^0

6) 7^{-1}

7) $27^{2/3}$

8) $\left(\frac{2}{3}\right)^{-2}$

9) $8^{-2/3}$

10) $(0.04)^{1/2}$

11) $\left(\frac{8}{27}\right)^{2/3}$

12) $\left(\frac{1}{16}\right)^{-3/2}$

Simplify each of the following:

13) $2a^{1/2} \times 3a^{5/2}$

14) $x^3 \times x^{-2}$

15) $(x^2 y^4)^{1/2}$

Chapter 8: Surds

Surds is the name given to the mathematics of square roots.

A1. Simplifying Surds

The *TRICK* here is to write the number under the square root as a square number multiplied by another number. (Square numbers are 1, 4, 9, 16, 25, 36, 49 etc.)

Examples:	1. $\sqrt{75} = \sqrt{25 \times 3} = 5\sqrt{3}$	2. $\sqrt{32} = \sqrt{16 \times 2} = 4\sqrt{2}$
-----------	---	---

Simplify These	(a) $\sqrt{12}$	(b) $\sqrt{72}$	(c) $\sqrt{500}$
----------------	-----------------	-----------------	------------------

A2. Harder Simplifications

Examples:	1. $\begin{aligned} &\sqrt{75} + \sqrt{12} \\ &= \sqrt{25 \times 3} + \sqrt{4 \times 3} \\ &= 5\sqrt{3} + 2\sqrt{3} \\ &= 7\sqrt{3} \end{aligned}$	2. $\begin{aligned} &\sqrt{32} + \sqrt{18} \\ &= \sqrt{16 \times 2} + \sqrt{9 \times 2} \\ &= 4\sqrt{2} + 3\sqrt{2} \\ &= 7\sqrt{2} \end{aligned}$
-----------	--	--

Simplify These	(a) $\sqrt{27} + \sqrt{12}$	(b) $\sqrt{125} + \sqrt{45}$
----------------	-----------------------------	------------------------------

B. Multiplying Surds

B1. Surds by Surds

Examples:	1. $\begin{aligned} &\sqrt{3} \times \sqrt{5} \\ &= \sqrt{3 \times 5} \\ &= \sqrt{15} \end{aligned}$	2. $\begin{aligned} &\sqrt{2} \times \sqrt{18} \\ &= \sqrt{2 \times 18} \\ &= \sqrt{36} \\ &= 6 \end{aligned}$	3. $\begin{aligned} &\sqrt{7} \times \sqrt{7} \\ &= \sqrt{7 \times 7} \\ &= \sqrt{49} \\ &= 7 \end{aligned}$
-----------	--	--	--

Simplify These	(a) $\sqrt{3} \times \sqrt{11}$	(b) $\sqrt{2} \times \sqrt{8}$	(c) $\sqrt{6} \times \sqrt{6}$
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B2. Harder Multiplications.

Examples:	1. $\begin{aligned} &5(6 + \sqrt{5}) \\ &= 30 + 5\sqrt{5} \end{aligned}$	2. $\begin{aligned} &\sqrt{3}(4 - 2\sqrt{3}) \\ &= 4\sqrt{3} - 2 \times 3 \\ &= 4\sqrt{3} - 6 \end{aligned}$
-----------	--	--

Multiply These	(a) $3(\sqrt{5} + 2)$	(b) $\sqrt{2}(\sqrt{2} + 3)$	(c) $\sqrt{7}(3 - 2\sqrt{7})$
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B3. Hardest GCSE Multiplications!

<p>Examples:</p> <p>1. $(1 + \sqrt{2})(2 + \sqrt{2})$</p> <p>You have multiply everything in one bracket by everything in the other. A good way to do this is using the box method.</p> <p>Write the surds along the sides:</p> <table border="1" style="margin-left: 40px;"> <tr> <td></td> <td>2</td> <td>$\sqrt{2}$</td> </tr> <tr> <td>1</td> <td></td> <td></td> </tr> <tr> <td>$\sqrt{2}$</td> <td></td> <td></td> </tr> </table> <p>Multiply to fill each box:</p> <table border="1" style="margin-left: 40px;"> <tr> <td></td> <td>2</td> <td>$\sqrt{2}$</td> </tr> <tr> <td>1</td> <td>2</td> <td>$\sqrt{2}$</td> </tr> <tr> <td>$\sqrt{2}$</td> <td>2</td> <td>2</td> </tr> </table> <p>Add up and simplify the 4 terms in the box:</p> $2 + 2 + \sqrt{2} + 2\sqrt{2} = 4 + 3\sqrt{2}$		2	$\sqrt{2}$	1			$\sqrt{2}$				2	$\sqrt{2}$	1	2	$\sqrt{2}$	$\sqrt{2}$	2	2	<p>2. $(2 + \sqrt{3})(5 + 2\sqrt{3})$</p> <table border="1" style="margin-left: 40px;"> <tr> <td></td> <td>5</td> <td>$2\sqrt{3}$</td> </tr> <tr> <td>2</td> <td></td> <td></td> </tr> <tr> <td>$\sqrt{3}$</td> <td></td> <td></td> </tr> </table> <table border="1" style="margin-left: 40px;"> <tr> <td></td> <td>5</td> <td>$2\sqrt{3}$</td> </tr> <tr> <td>2</td> <td>10</td> <td>$4\sqrt{3}$</td> </tr> <tr> <td>$\sqrt{3}$</td> <td>$5\sqrt{3}$</td> <td>6</td> </tr> </table> $10 + 6 + 4\sqrt{3} + 5\sqrt{3} = 16 + 9\sqrt{3}$		5	$2\sqrt{3}$	2			$\sqrt{3}$				5	$2\sqrt{3}$	2	10	$4\sqrt{3}$	$\sqrt{3}$	$5\sqrt{3}$	6
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	5	$2\sqrt{3}$																																			
2	10	$4\sqrt{3}$																																			
$\sqrt{3}$	$5\sqrt{3}$	6																																			

Multiply These	(a) $(2 + \sqrt{5})(7 + \sqrt{5})$	(b) $(\sqrt{2} - 5)(\sqrt{2} + 3)$	(c) $(5 - \sqrt{7})(3 - 2\sqrt{7})$
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C. Rationalising the Denominator

C1 Basic Examples.

Examples:	1. $\frac{5}{\sqrt{3}} = \frac{5}{\sqrt{3}} \times \frac{\sqrt{3}}{\sqrt{3}} = \frac{5\sqrt{3}}{3}$	2. $\frac{3}{\sqrt{2}} = \frac{3}{\sqrt{2}} \times \frac{\sqrt{2}}{\sqrt{2}} = \frac{3\sqrt{2}}{2}$
-----------	---	---

Rationalise the denominator	(a) $\frac{2}{\sqrt{5}}$	(b) $\frac{7}{\sqrt{11}}$	(c) $\frac{\sqrt{2}}{\sqrt{8}}$
-----------------------------	--------------------------	---------------------------	---------------------------------

C2 Hard Examples.

Example	$\frac{4}{\sqrt{3}+1} = \frac{4}{\sqrt{3}+1} \times \frac{\sqrt{3}-1}{\sqrt{3}-1} = \frac{4\sqrt{3}-4}{2}$
---------	--

Rationalise the denominator	(a) $\frac{2}{\sqrt{5}+1}$	(b) $\frac{7}{5-\sqrt{2}}$
-----------------------------	----------------------------	----------------------------

Completing the square

A LEVEL LINKS

Scheme of work: 1b. Quadratic functions – factorising, solving, graphs and the discriminants

Key points

- Completing the square for a quadratic rearranges $ax^2 + bx + c$ into the form $p(x + q)^2 + r$
- If $a \neq 1$, then factorise using a as a common factor.

Examples

Example 1 Complete the square for the quadratic expression $x^2 + 6x - 2$

$x^2 + 6x - 2$ $= (x + 3)^2 - 9 - 2$ $= (x + 3)^2 - 11$	<ol style="list-style-type: none">1 Write $x^2 + bx + c$ in the form $\left(x + \frac{b}{2}\right)^2 - \left(\frac{b}{2}\right)^2 + c$2 Simplify
---	---

Example 2 Write $2x^2 - 5x + 1$ in the form $p(x + q)^2 + r$

$2x^2 - 5x + 1$ $= 2\left(x^2 - \frac{5}{2}x\right) + 1$ $= 2\left[\left(x - \frac{5}{4}\right)^2 - \left(\frac{5}{4}\right)^2\right] + 1$ $= 2\left(x - \frac{5}{4}\right)^2 - \frac{25}{8} + 1$	<ol style="list-style-type: none">1 Before completing the square write $ax^2 + bx + c$ in the form $a\left(x^2 + \frac{b}{a}x\right) + c$2 Now complete the square by writing $x^2 - \frac{5}{2}x$ in the form $\left(x + \frac{b}{2}\right)^2 - \left(\frac{b}{2}\right)^2$3 Expand the square brackets – don't forget to multiply $\left(\frac{5}{4}\right)^2$ by the factor of 24 Simplify
---	---

$$= 2\left(x - \frac{5}{4}\right)^2 - \frac{17}{8}$$

Practice

- 1 Write the following quadratic expressions in the form $(x + p)^2 + q$
- | | |
|-------------------------|--------------------------|
| a $x^2 + 4x + 3$ | b $x^2 - 10x - 3$ |
| c $x^2 - 8x$ | d $x^2 + 6x$ |
| e $x^2 - 2x + 7$ | f $x^2 + 3x - 2$ |
- 2 Write the following quadratic expressions in the form $p(x + q)^2 + r$
- | | |
|---------------------------|---------------------------|
| a $2x^2 - 8x - 16$ | b $4x^2 - 8x - 16$ |
| c $3x^2 + 12x - 9$ | d $2x^2 + 6x - 8$ |
- 3 Complete the square.
- | | |
|--------------------------|--------------------------|
| a $2x^2 + 3x + 6$ | b $3x^2 - 2x$ |
| c $5x^2 + 3x$ | d $3x^2 + 5x + 3$ |

Extend

- 4 Write $(25x^2 + 30x + 12)$ in the form $(ax + b)^2 + c$.

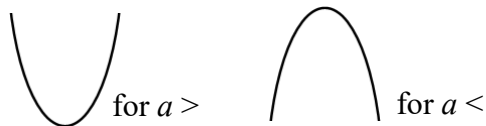
Sketching quadratic graphs

A LEVEL LINKS

Scheme of work: 1b. Quadratic functions – factorising, solving, graphs and the discriminants

Key points

- The graph of the quadratic function $y = ax^2 + bx + c$, where $a \neq 0$, is a curve called a parabola.
- Parabolas have a line of symmetry and a shape as shown.
- To sketch the graph of a function, find the points where the graph intersects the axes.
- To find where the curve intersects the y -axis substitute $x = 0$ into the function.
- To find where the curve intersects the x -axis substitute $y = 0$ into the function.
- At the turning points of a graph the gradient of the curve is 0 and any tangents to the curve at these points are horizontal.
- To find the coordinates of the maximum or minimum point (turning points) of a quadratic curve (parabola) you can use the completed square form of the function.



Examples

Example 1 Sketch the graph of $y = x^2$.

	<p>The graph of $y = x^2$ is a parabola.</p> <p>When $x = 0, y = 0$.</p> <p>$a = 1$ which is greater than zero, so the graph has the shape:</p>
--	--

Example 2 Sketch the graph of $y = x^2 - x - 6$.

<p>When $x = 0, y = 0^2 - 0 - 6 = -6$ So the graph intersects the y-axis at $(0, -6)$</p> <p>When $y = 0, x^2 - x - 6 = 0$</p> <p>$(x + 2)(x - 3) = 0$</p> <p>$x = -2$ or $x = 3$</p>	<ol style="list-style-type: none"> Find where the graph intersects the y-axis by substituting $x = 0$. Find where the graph intersects the x-axis by substituting $y = 0$. Solve the equation by factorising. Solve $(x + 2) = 0$ and $(x - 3) = 0$. $a = 1$ which is greater than zero, so the graph has the shape:
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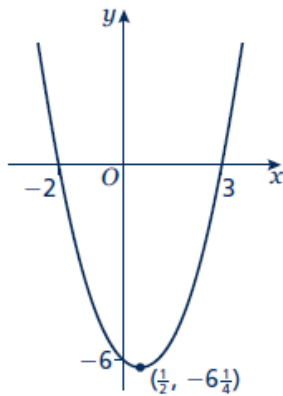
So,

the graph intersects the x -axis at $(-2, 0)$ and $(3, 0)$

$$\begin{aligned}x^2 - x - 6 &= \left(x - \frac{1}{2}\right)^2 - \frac{1}{4} - 6 \\ &= \left(x - \frac{1}{2}\right)^2 - \frac{25}{4}\end{aligned}$$

When $\left(x - \frac{1}{2}\right)^2 = 0$, $x = \frac{1}{2}$ and

$y = -\frac{25}{4}$, so the turning point is at the point $\left(\frac{1}{2}, -\frac{25}{4}\right)$



(continued on next page)

6 To find the turning point, complete the square.

7 The turning point is the minimum value for this expression and occurs when the term in the bracket is equal to zero.

Practice

- Sketch the graph of $y = -x^2$.
- Sketch each graph, labelling where the curve crosses the axes.
a $y = (x + 2)(x - 1)$ **b** $y = x(x - 3)$ **c** $y = (x + 1)(x + 5)$
- Sketch each graph, labelling where the curve crosses the axes.
a $y = x^2 - x - 6$ **b** $y = x^2 - 5x + 4$ **c** $y = x^2 - 4$
d $y = x^2 + 4x$ **e** $y = 9 - x^2$ **f** $y = x^2 + 2x - 3$
- Sketch the graph of $y = 2x^2 + 5x - 3$, labelling where the curve crosses the axes.

Extend

- 5 Sketch each graph. Label where the curve crosses the axes and write down the coordinates of the turning point.
- a** $y = x^2 - 5x + 6$ **b** $y = -x^2 + 7x - 12$ **c** $y = -x^2 + 4x$
- 6 Sketch the graph of $y = x^2 + 2x + 1$. Label where the curve crosses the axes and write down the equation of the line of symmetry.

Solving linear and quadratic simultaneous equations

A LEVEL LINKS

Scheme of work: 1c. Equations – quadratic/linear simultaneous

Key points

- Make one of the unknowns the subject of the linear equation (rearranging where necessary).
- Use the linear equation to substitute into the quadratic equation.
- There are usually two pairs of solutions.

Examples

Example 1 Solve the simultaneous equations $y = x + 1$ and $x^2 + y^2 = 13$

$x^2 + (x + 1)^2 = 13$	1 Substitute $x + 1$ for y into the second equation.
$x^2 + x^2 + x + x + 1 = 13$	2 Expand the brackets and simplify.
$2x^2 + 2x + 1 = 13$	
$2x^2 + 2x - 12 = 0$	3 Factorise the quadratic equation.
$(2x - 4)(x + 3) = 0$	4 Work out the values of x .
So $x = 2$ or $x = -3$	5 To find the value of y , substitute both values of x into one of the original equations.
Using $y = x + 1$	
When $x = 2$, $y = 2 + 1 = 3$	
When $x = -3$, $y = -3 + 1 = -2$	
So the solutions are	6 Substitute both pairs of values of x and y into both equations to check your answers.
$x = 2, y = 3$ and $x = -3, y = -2$	
Check:	
equation 1: $3 = 2 + 1$ YES	
and $-2 = -3 + 1$ YES	
equation 2: $2^2 + 3^2 = 13$ YES	
and $(-3)^2 + (-2)^2 = 13$ YES	

Example 2 Solve $2x + 3y = 5$ and $2y^2 + xy = 12$ simultaneously.

$x = \frac{5-3y}{2}$ $2y^2 + \left(\frac{5-3y}{2}\right)y = 12$ $2y^2 + \frac{5y-3y^2}{2} = 12$ $4y^2 + 5y - 3y^2 = 24$ $y^2 + 5y - 24 = 0$ $(y + 8)(y - 3) = 0$ <p>So $y = -8$ or $y = 3$</p> <p>Using $2x + 3y = 5$</p> <p>When $y = -8$, $2x + 3 \times (-8) = 5$, $x = 14.5$</p> <p>When $y = 3$, $2x + 3 \times 3 = 5$, $x = -2$</p> <p>So the solutions are</p> $x = 14.5, y = -8 \text{ and } x = -2, y = 3$ <p>Check:</p> <p>equation 1: $2 \times 14.5 + 3 \times (-8) = 5$ YES and $2 \times (-2) + 3 \times 3 = 5$ YES</p> <p>equation 2: $2 \times (-8)^2 + 14.5 \times (-8) = 12$ YES and $2 \times (3)^2 + (-2) \times 3 = 12$ YES</p>	<ol style="list-style-type: none"> 1 Rearrange the first equation. 2 Substitute $\frac{5-3y}{2}$ for x into the second equation. Notice how it is easier to substitute for x than for y. 3 Expand the brackets and simplify. 4 Factorise the quadratic equation. 5 Work out the values of y. 6 To find the value of x, substitute both values of y into one of the original equations. 7 Substitute both pairs of values of x and y into both equations to check your answers.
---	--

Practice

Solve these simultaneous equations.

1 $y = 2x + 1$
 $x^2 + y^2 = 10$

2 $y = 6 - x$
 $x^2 + y^2 = 20$

3 $y = x - 3$
 $x^2 + y^2 = 5$

4 $y = 9 - 2x$
 $x^2 + y^2 = 17$

5 $y = 3x - 5$
 $y = x^2 - 2x + 1$

6 $y = x - 5$
 $y = x^2 - 5x - 12$

7 $y = x + 5$

8 $y = 2x - 1$

$$x^2 + y^2 = 25$$

$$x^2 + xy = 24$$

9 $y = 2x$
 $y^2 - xy = 8$

10 $2x + y = 11$
 $xy = 15$

Extend

11 $x - y = 1$
 $x^2 + y^2 = 3$

12 $y - x = 2$
 $x^2 + xy = 3$

Quadratic inequalities

A LEVEL LINKS

Scheme of work: 1d. Inequalities – linear and quadratic (including graphical solutions)

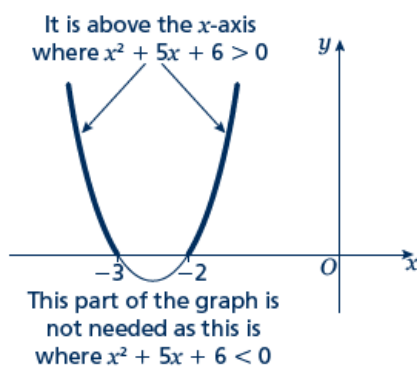
Key points

- First replace the inequality sign by = and solve the quadratic equation.
- Sketch the graph of the quadratic function.
- Use the graph to find the values which satisfy the quadratic inequality.

Examples

Example 1 Find the set of values of x which satisfy $x^2 + 5x + 6 > 0$

$$\begin{aligned}x^2 + 5x + 6 &= 0 \\(x + 3)(x + 2) &= 0 \\x &= -3 \text{ or } x = -2\end{aligned}$$



$$x < -3 \text{ or } x > -2$$

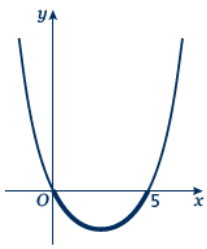
1 Solve the quadratic equation by factorising.

2 Sketch the graph of $y = (x + 3)(x + 2)$

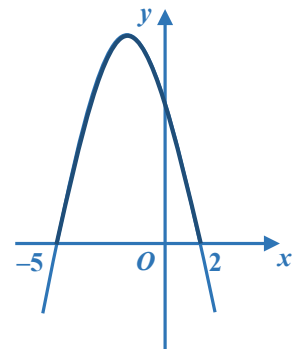
3 Identify on the graph where $x^2 + 5x + 6 > 0$, i.e. where $y > 0$

4 Write down the values which satisfy the inequality $x^2 + 5x + 6 > 0$

Example 2 Find the set of values of x which satisfy $x^2 - 5x \leq 0$

$x^2 - 5x = 0$ $x(x - 5) = 0$ $x = 0 \text{ or } x = 5$  $0 \leq x \leq 5$	<ol style="list-style-type: none"> 1 Solve the quadratic equation by factorising. 2 Sketch the graph of $y = x(x - 5)$ 3 Identify on the graph where $x^2 - 5x \leq 0$, i.e. where $y \leq 0$ 4 Write down the values which satisfy the inequality $x^2 - 5x \leq 0$
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Example 3 Find the set of values of x which satisfy $-x^2 - 3x + 10 \geq 0$

$-x^2 - 3x + 10 = 0$ $(-x + 2)(x + 5) = 0$ $x = 2 \text{ or } x = -5$  $-5 \leq x \leq 2$	<ol style="list-style-type: none"> 1 Solve the quadratic equation by factorising. 2 Sketch the graph of $y = (-x + 2)(x + 5) = 0$ 3 Identify on the graph where $-x^2 - 3x + 10 \geq 0$, i.e. where $y \geq 0$ 3 Write down the values which satisfy the inequality $-x^2 - 3x + 10 \geq 0$
---	---

Practice

- 1 Find the set of values of x for which $(x + 7)(x - 4) \leq 0$
- 2 Find the set of values of x for which $x^2 - 4x - 12 \geq 0$
- 3 Find the set of values of x for which $2x^2 - 7x + 3 < 0$
- 4 Find the set of values of x for which $4x^2 + 4x - 3 > 0$
- 5 Find the set of values of x for which $12 + x - x^2 \geq 0$

Extend

Find the set of values which satisfy the following inequalities.

6 $x^2 + x \leq 6$

7 $x(2x - 9) < -10$

8 $6x^2 \geq 15 + x$

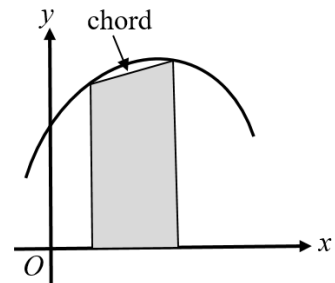
Area under a graph

A LEVEL LINKS

Scheme of work: 7b. Definite integrals and areas under curves

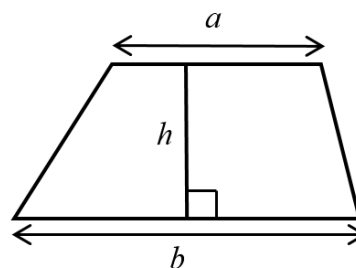
Key points

- To estimate the area under a curve, draw a chord between two points you are finding the area between and straight down to the horizontal axis to create a trapezium. The area of the trapezium is an approximation for the area under the curve.



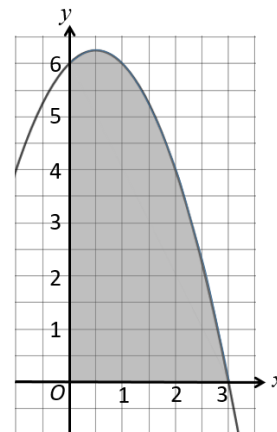
the
lines
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a

- The area of a trapezium = $\frac{1}{2}h(a+b)$



Examples

- Example 1** Estimate the area of the region between the curve $y = (3-x)(2+x)$ and the x -axis from $x = 0$ to $x = 3$. Use three strips of width 1 unit.



x	0	1	2	3
$y = (3-x)(2+x)$	6	6	4	0

Trapezium 1:

$$a_1 = 6 - 0 = 6, b_1 = 6 - 0 = 6$$

Trapezium 2:

$$a_2 = 6 - 0 = 6, b_2 = 4 - 0 = 4$$

Trapezium 3:

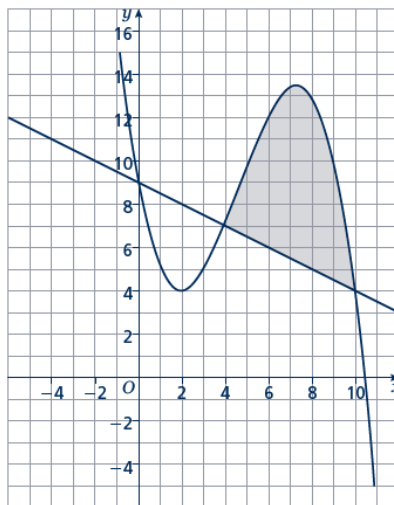
$$a_3 = 4 - 0 = 4, b_3 = 0 - 0 = 0$$

- Use a table to record the value of y on the curve for each value of x .
- Work out the dimensions of each trapezium. The distances between the y -values on the curve and the x -axis give the values for a .

(continued on next page)

$\frac{1}{2}h(a_1 + b_1) = \frac{1}{2} \times 1(6 + 6) = 6$ $\frac{1}{2}h(a_2 + b_2) = \frac{1}{2} \times 1(6 + 4) = 5$ $\frac{1}{2}h(a_3 + b_3) = \frac{1}{2} \times 1(4 + 0) = 2$ <p>Area = 6 + 5 + 2 = 13 units²</p>	<p>3 Work out the area of each trapezium. $h = 1$ since the width of each trapezium is 1 unit.</p> <p>4 Work out the total area. Remember to give units with your answer.</p>
--	--

Example 2 Estimate the shaded area.
Use three strips of width 2 units.



<table border="1" style="width: 100%; text-align: center;"> <tr><td>x</td><td>4</td><td>6</td><td>8</td><td>10</td></tr> <tr><td>y</td><td>7</td><td>12</td><td>13</td><td>4</td></tr> </table> <table border="1" style="width: 100%; text-align: center;"> <tr><td>x</td><td>4</td><td>6</td><td>8</td><td>10</td></tr> <tr><td>y</td><td>7</td><td>6</td><td>5</td><td>4</td></tr> </table> <p>Trapezium 1: $a_1 = 7 - 7 = 0$, $b_1 = 12 - 6 = 6$</p> <p>Trapezium 2: $a_2 = 12 - 6 = 6$, $b_2 = 13 - 5 = 8$</p> <p>Trapezium 3: $a_3 = 13 - 5 = 8$, $a_3 = 4 - 4 = 0$</p>	x	4	6	8	10	y	7	12	13	4	x	4	6	8	10	y	7	6	5	4	<p>1 Use a table to record y on the curve for each value of x.</p> <p>2 Use a table to record y on the straight line for each value of x.</p> <p>3 Work out the dimensions of each trapezium. The distances between the y-values on the curve and the y-values on the straight line give the values for a.</p> <p>4 Work out the area of each trapezium. $h = 2$ since the width of each trapezium is 2 units.</p> <p>5 Work out the total area. Remember to give units with your answer.</p>
x	4	6	8	10																	
y	7	12	13	4																	
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$\frac{1}{2}h(a_1 + b_1) = \frac{1}{2} \times 2(0 + 6) = 6$ $\frac{1}{2}h(a_2 + b_2) = \frac{1}{2} \times 2(6 + 8) = 14$ $\frac{1}{2}h(a_3 + b_3) = \frac{1}{2} \times 2(8 + 0) = 8$ <p>Area = 6 + 14 + 8 = 28 units²</p>	
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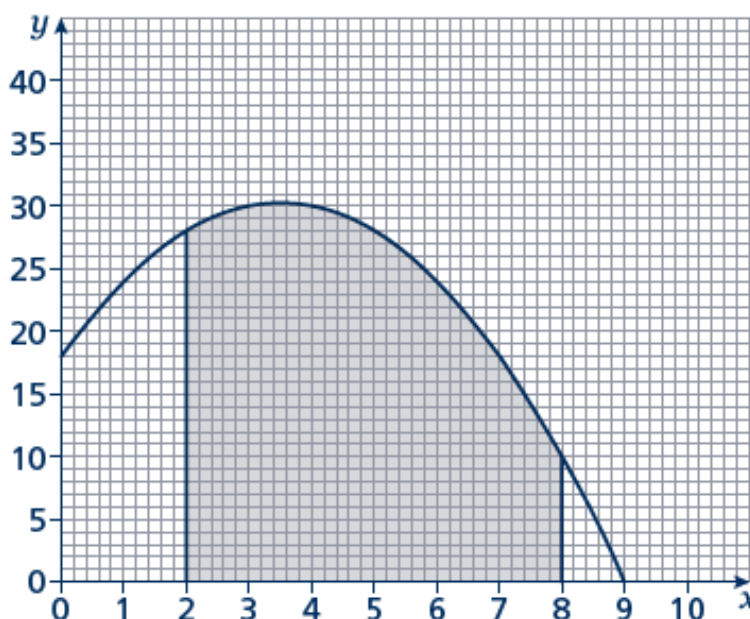
Practice

Hint:
For a full answer, remember to include 'units²'

the

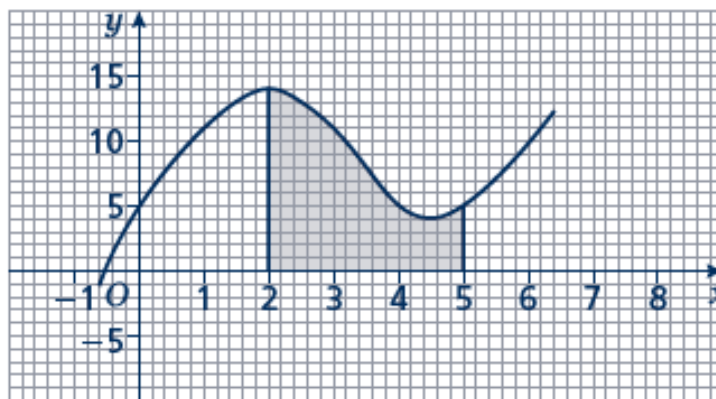
- 1** Estimate the area of the region between the curve $y = (5 - x)(x + 2)$ and x -axis from $x = 1$ to $x = 5$.
Use four strips of width 1 unit.

- 2** Estimate the shaded area shown on the axes.
Use six strips of width 1 unit.



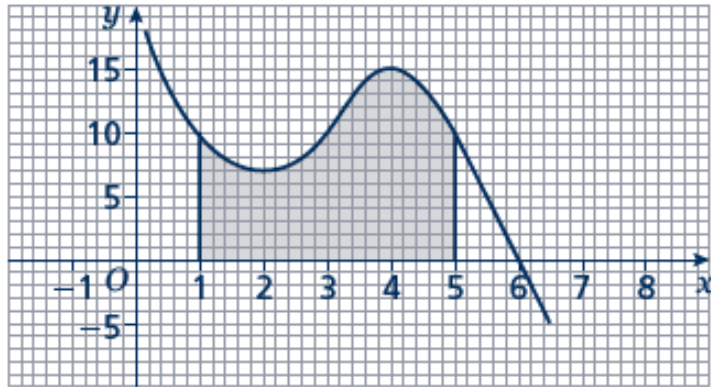
- 3** Estimate the area of the region between the curve $y = x^2 - 8x + 18$ and the x -axis from $x = 2$ to $x = 6$.
Use four strips of width 1 unit.

- 4 Estimate the shaded area.
Use six strips of width $\frac{1}{2}$ unit.



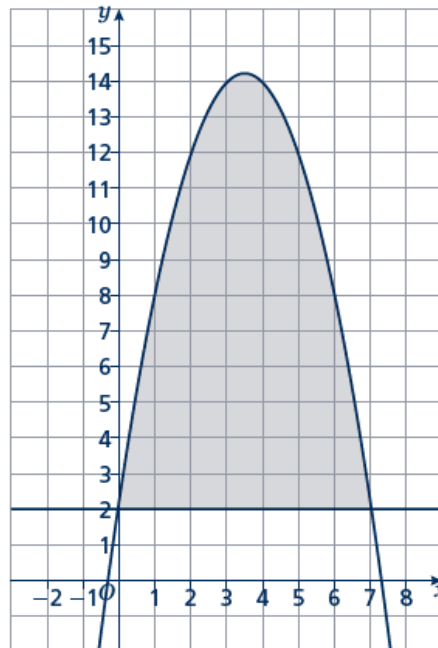
- 5 Estimate the area of the region between the curve $y = -x^2 - 4x + 5$ and the x -axis from $x = -5$ to $x = 1$.
Use six strips of width 1 unit.

- 6 Estimate the shaded area.
Use four strips of equal width.



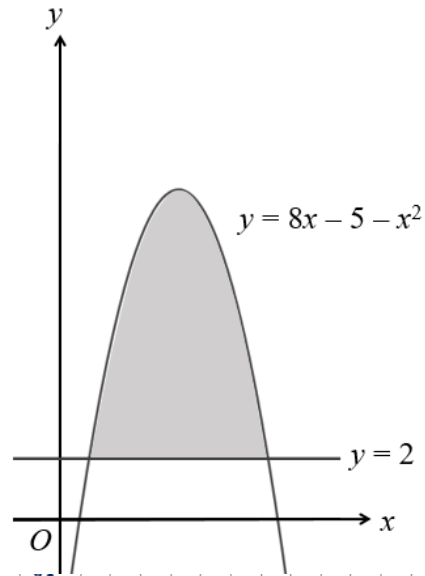
- 7 Estimate the area of the region between the curve $y = -x^2 + 2x + 15$ and the x -axis from $x = 2$ to $x = 5$.
Use six strips of equal width.

- 8 Estimate the shaded area.
Use seven strips of equal width.



Extend

- 9 The curve $y = 8x - 5 - x^2$ and the line $y = 2$ are shown in the sketch. Estimate the shaded area using six strips of equal width.



- 10 Estimate the shaded area using five strips of equal width.

