# Maths - Foundation

## Basic percentages

### Key vocabulary

**Fraction** – A quantity which is not a whole number.

**Decimal** – A decimal number is often used to mean a number that uses a decimal point followed by digits that show a value smaller than one.

**Percentage** – Amount out of one hundred.

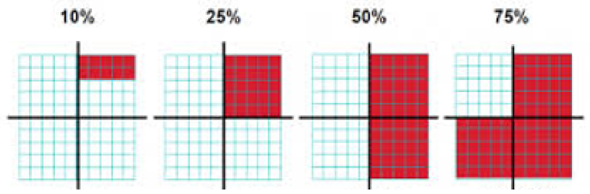
**Increase** – To make bigger.

**Decrease** – To make smaller.

**Depreciate** – Decrease in value over time.

**Multipliers** – a quantity by which a given number is to be multiplied.

## Picture perfect




Reverse percentages

John pays £60 for a bag after getting 20% discount. How much did it originally cost ?

*Remember: Original price is always equal to 100%*

Sale price = 100% - 20% = 80%

| | | | | |
|---|---|---|---|---|
| ÷ 80 | 80% | = | £60 | ÷ 80 |
| | 1% | = | 0.75 | |
| × 100 | 100% | = | £75 | × 100 |

## Assessment style question

A primary school has 212 students.
50% of the students are boys.
How many of the students are boys?

A fish tank, that is full of water, has sprung a leak.
12% of the water is lost every hour.
What percentage of the water is lost after three hours?

A cereal bar weighs 24g.
The cereal bar contains 3.8g of protein.
Work out what percentage of the cereal bar is protein.

When a tennis ball is dropped, it bounces and then rises.
The ball rises to 80% of the height from which it is dropped.
The ball is dropped from a height of 4 metres.

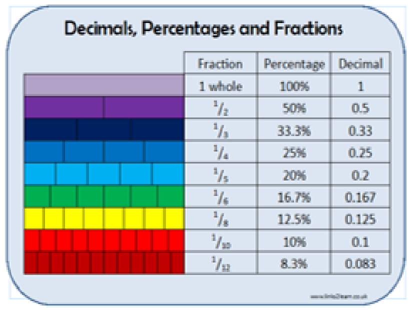
(a) Calculate the height of the rise after the first bounce.
(b) Calculate the height of the rise after the second bounce.

The ball carries on bouncing, each time rising to 80% of the last rise.

(c) For how many bounces does the ball rise to a height greater than 10cm?

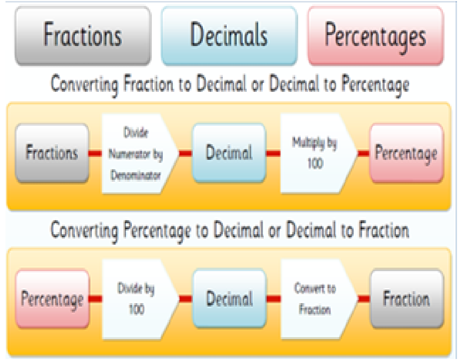
Dorothy organises a charity raffle.
She sells 800 tickets for £2 each.
4% of the tickets win a prize that costs £20.
65% of the profit goes to Charity A and the rest goes to Charity B.
How much money does Dorothy raise for Charity B?

## Always remember



Decimals, Percentages and Fractions

| Fraction | Percentage | Decimal |
|---|---|---|
| 1 whole | 100% | 1 |
| 1/2 | 50% | 0.5 |
| 1/3 | 33.3% | 0.33 |
| 1/4 | 25% | 0.25 |
| 1/5 | 20% | 0.2 |
| 1/6 | 16.7% | 0.167 |
| 1/8 | 12.5% | 0.125 |
| 1/10 | 10% | 0.1 |
| 1/12 | 8.3% | 0.083 |




**Percentages**

%

### on a calculator

39% of 82

0.39 x 82

Change to a decimal and multiply

### increasing

Increase £60 by 12%

12% of 60 = 0.12 x 60 = £7.20

New amount = £60 + £7.20
= £67.20

**ADD**

### fraction to %

$\frac{15}{20} = \frac{75}{100} = 75\%$ (x5)

OR

15 ÷ 20 x 100 = 75%

### decreasing

decrease £60 by 12%

12% of 60 = 0.12 x 60 = £7.20

New amount = £60 - £7.20
= £52.80

**SUBTRACT**

### without a calculator

50% - half
25% - half and half
75% - 50% + 25%
10% - divide by 10
5% - half 10%
20% - double 10%

Simple interest = amount x multiplier x time

Compound interest = amount x multipier$^{time}$

# Maths - Foundation

## Circumference and area

### Key vocabulary

**Circumference**
The perimeter **around** the circle

**Diameter**
The distance **across the centre** of the circle

**Radius**
The distance from the **centre to the edge** of the circle

**Sector**
**Part of the area** of a circle, enclosed by two radii

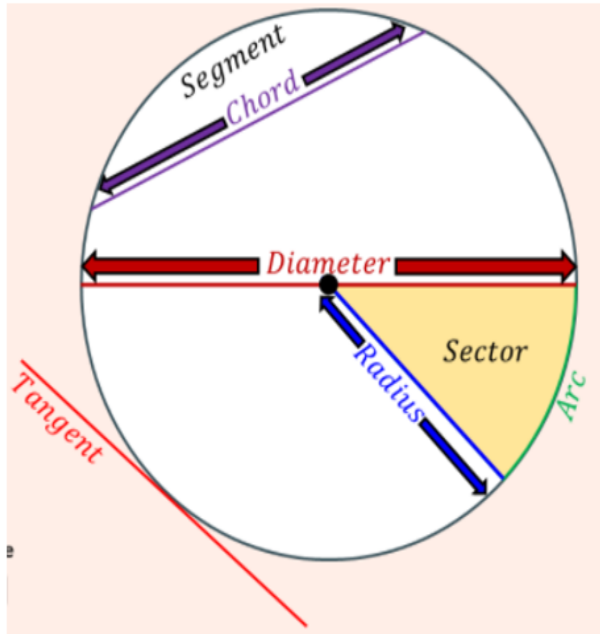
**Arc**
**Part of the circumference** of a circle

**Tangent**
A straight line that touches the curve of the circle at a point

**Chord**
A straight line segment between two points on the circle edge

**Segment**
The area created by the chord

### Picture perfect




### Always remember

**Area**

$A = \pi r^2$ ⇨ Pi times the radius squared


Diameter is double the radius

$A = \pi \times 6.5^2$

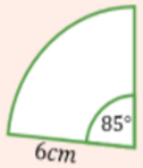
$A = \pi \times 42.25$

$A = 132.73m^2$

**Sector**

$A = \frac{n^\circ}{360}\pi r^2$

Calculate the **proportion** of the circle required then use area formula




$\frac{85^\circ}{360^\circ}(\pi \times 6^2)$

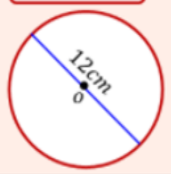
$26.7cm^2$

**Circumference**

$C = \pi d$

$C = 2\pi r$

The circumference is always about three time the length of the diameter



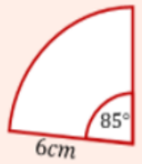

$C = \pi \times 12cm$

$C = 37.7cm$

**Arc length**

$L = \frac{n^\circ}{360}\pi d$

Calculate the **proportion** of the circle required then use circumference formula

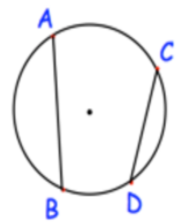



$\frac{85^\circ}{360^\circ}(\pi \times 12)$

$8.90cm$

### Assessment style question

Nicole is a wedding organiser.
The guests are to sit at circular tables with a diameter of 180cm.
Each guest needs 70cm around the circumference of the table.
There are 18 tables at the venue.
A total of 145 guests are attending the wedding
Are there enough tables?




(a) Draw a circle with two chords, AB and CD.
(b) Construct the perpendicular bisector of AB.
(c) Construct the perpendicular bisector of CD.
(d) What do you notice about where the two perpendicular bisectors meet?

# Maths - Foundation

## Solving equations

### Key vocabulary

Equation

Expression

Identity

Formulae

Inequality

Solve

Simplify

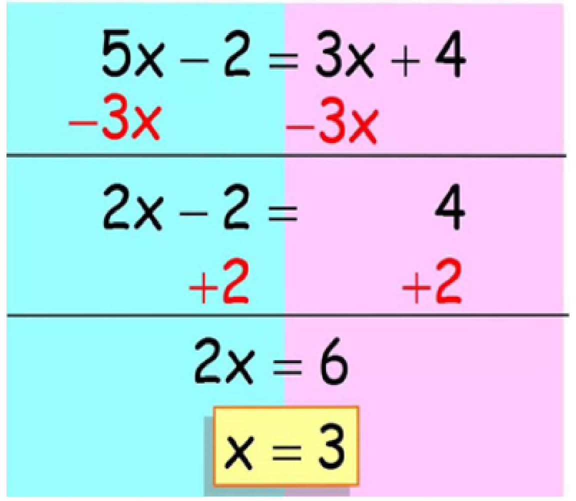
Like terms

Co-efficient

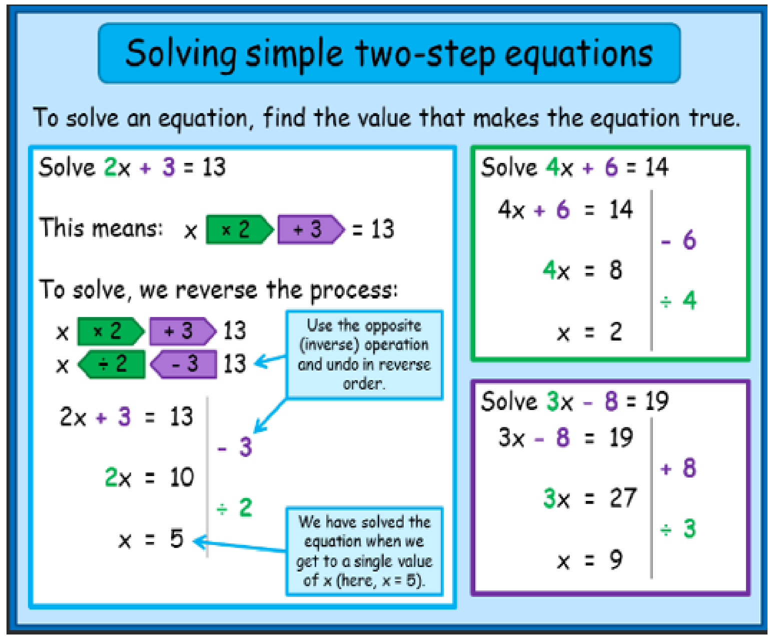
Expand

Factorise

### Picture perfect




### Always remember



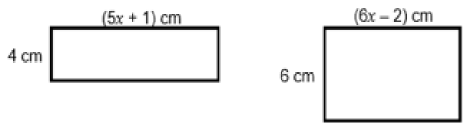

| Inequality Symbols | |
|---|---|
| ≠ | not equal |
| < | less than |
| ≤ | less than or equal to |
| > | greater than |
| ≥ | greater than or equal to |

### Assessment style question

(a) Solve $4x + 1 = 9$

(b) Solve $2x - 5 = 4$

These two rectangles have the same area.




Write down an equation to show this.

**[1 mark]**

# Maths - Foundation

## Indices

### Key vocabulary

**Square**: A square number is the result of multiplying a number by itself.
**Cube**: A cube number is the result of multiplying a number by itself twice.
**Root**: A root is the reverse of a power.
**Indices**: These are the squares, cubes and powers.
**Operation**: In maths these are the functions ⍰ ⍰ + -.

### Picture perfect

**indices**

$a^0 = 1$ $\quad a^{m/n} = (\sqrt[n]{a})^m$

$a^{-n} = \frac{1}{a^n}$ $\quad a^{-1} = \frac{1}{a}$

$a^{1/n} = \sqrt[n]{a}$ $\quad a^{1/2} = \sqrt{a}$

### Always remember

**Basic Laws of Indices**

Special indices to consider

| | |
|---|---|
| $x^1 = x$ | Anything to the power 1 = itself |
| $x^0 = 1$ | Anything to the power 0 = 1 |
| $1^x = 1$ | 1 to the power of anything = 1 |

These laws can be applied if the bases are the same

| | |
|---|---|
| $x^a \times x^b = x^{a+b}$<br>$z^3 \times z^7 = z^{10}$ | When multiplying powers with the same base – Add the powers |
| $x^a \div x^b = x^{a-b}$<br>$s^2 \div s^5 = s^{-3}$ | When dividing powers with the same base – Subtract the powers |
| $(x^a)^b = x^{a \times b}$<br>$(e^4)^3 = e^{12}$ | When raising the power (brackets) – Multiply the powers |

**Advanced Laws of Indices**

Negative Indices

$x^{-n} \Rightarrow 1/x^n$

Find Reciprocal
Apply Positive Power
Apply top and bottom

$z^{-3} = \left(\frac{1}{z}\right)^3 = \frac{1}{z^3}$ $\quad 6^{-2} = \left(\frac{1}{6}\right)^2 = \frac{1}{36}$

Fractional Indices

$x^{\frac{m}{n}} = (\sqrt[n]{x})^m$

Root by denominator first
Then power of numerator

$x^{\frac{1}{2}} = \sqrt{x}$ $\quad x^{\frac{1}{3}} = \sqrt[3]{x}$ $\quad x^{\frac{1}{4}} = \sqrt[4]{x}$ $\quad x^{\frac{2}{3}} = (\sqrt[3]{x})^2$

$64^{\frac{2}{3}} = (\sqrt[3]{64})^2 = (4)^2 = 16$

Negative Fractional Indices

$x^{-\frac{a}{b}} = \frac{1}{(\sqrt[b]{x})^a}$

Negative Fractional Powers: Apply reciprocal first!

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

### Assessment style question

Question 1: Can you spot any mistakes?

$6^2 = 12$ $\quad 1^7 = 7$

$10^4 = 40$ $\quad 2^6 = 32$

Question 1: Can you spot any mistakes?

$2^6 \times 2^3 = 4^9$

$7^{15} \div 7^5 = 7^3$

$6^3 \times 6^4 = 6^{12}$

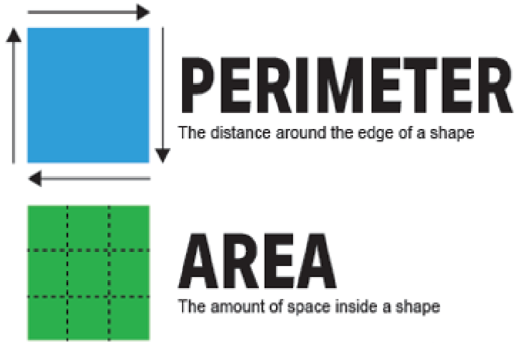
# Maths - Foundation

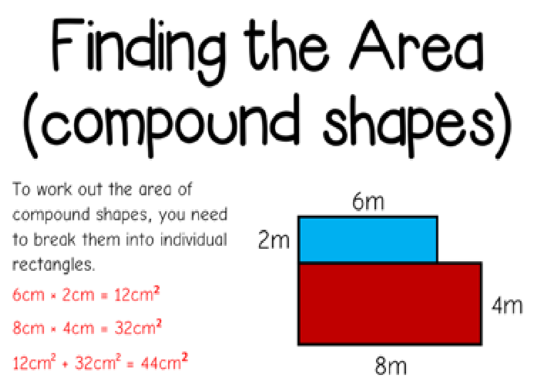
## Perimeter & Area

### Key vocabulary

Perimeter
Area
Length
Width
Height
Circumference
Radius
Diameter
Pi (π)
Units$^2$
Compound area

### Picture perfect

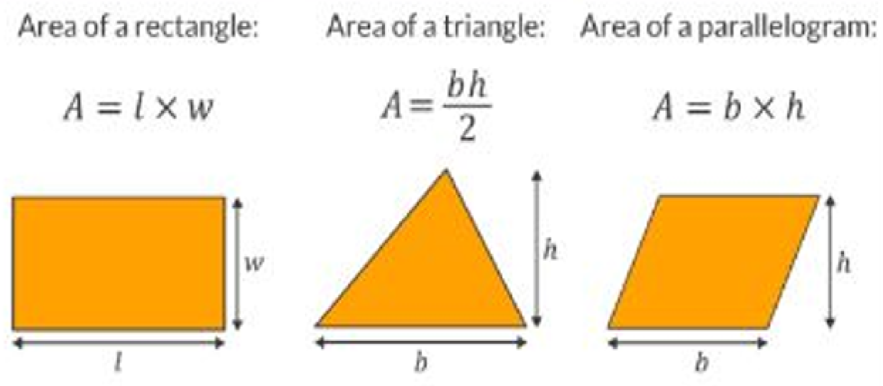


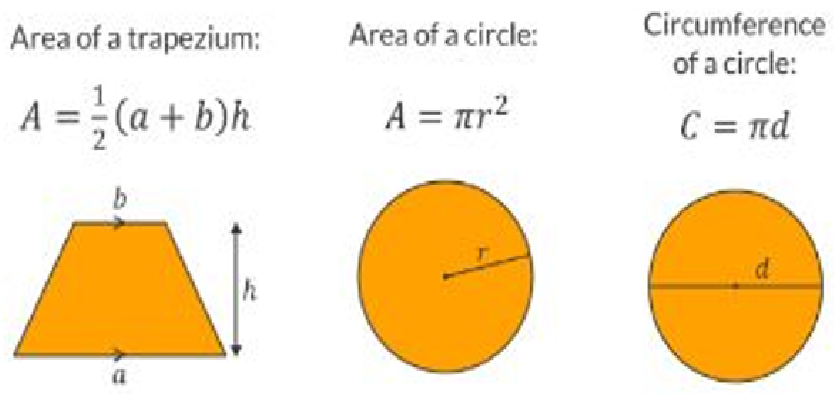




### Always remember

Perimeter units include mm, cm, m, km etc.

Area units include mm$^2$, cm$^2$, m$^2$ etc.

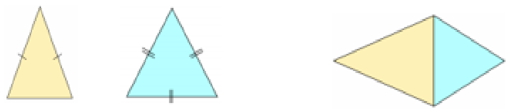



### Assessment style question

A rectangle has a perimeter of 18cm.
Write down a possible pair of values for its length and width

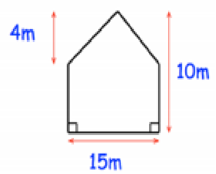
An isosceles triangle has a perimeter of 73cm
An equilateral triangle has a perimeter of 51cm
The triangles are put together to make a kite.



Work out the perimeter of the kite.

Find the area of the triangle with a base of 12cm and perpendicular height of 9cm.

William is painting the side of his house.
He has 8 litres of paint and each litre of paint covers 16m$^2$
Does William have enough paint?



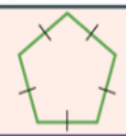

# Maths - Foundation

## Properties of polygons

### Key vocabulary

### Picture perfect

| Regular | Irregular |
|---|---|
| Side lengths are the same | Side lengths are not **ALL** the same |
| Interior and exterior angles the same | Interior and exterior angles the not **ALL** the same |



Equal sides are marked with a dash through the line

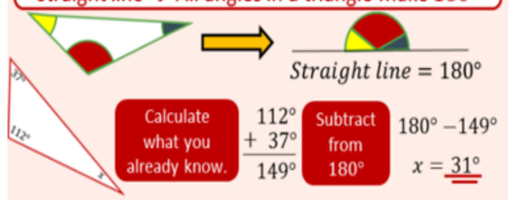
| Convex | Concave |
|---|---|
| The shape is 'bulging' outwards | The shape has 'caved' inwards |
| All angles less than 180° | One or more angles is greater than 180° |

### Assessment style question

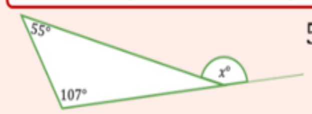
### Always remember

**Triangles**

All three angles can be orientated to fit on a straight line → All angles in a triangle make 180°




Exterior angle = Sum of two angles on opposite side.



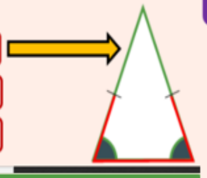

$55° + 107° = x°$

$162° = x°$

**Isosceles triangle**

It has two equal lengths

It has two equal angles



They are classified by the number of sides they have

| Number of sides | Name of shape |
|---|---|
| 3 | Triangle |
| 4 | Quadrilateral |
| 5 | Pentagon |
| 6 | Hexagon |
| 7 | Heptagon |
| 8 | Octagon |
| 9 | Nonagon |
| 10 | Decagon |

**Polygons**

Knowledge of triangles is important

| Number of sides | Number of Δ | Sum of interior angles | Regular interior angle | Regular exterior angle |
|---|---|---|---|---|
| 3 | 1 | 180° | 60° | 120° |
| 4 | 2 | 360° | 90° | 90° |
| 5 | 3 | 540° | 108° | 72° |
| 6 | 4 | 720° | 120° | 60° |
| 7 | 5 | 900° | 129° | 51° |
| 8 | 6 | 1080° | 135° | 45° |
| $n$ | $(n-2)$ | $(n-2) \times 180°$ | $\frac{(n-2) \times 180°}{n}$ | $360° \div n$ |

The number of triangles in a shape will always be **TWO** less than the number of sides

# Maths - Foundation

## Ratio

### Key vocabulary

**Ratio** -Ratio compares the size of **one part** to **another part**.

**Proportion** -Proportion compares the size of **one part** to the size of the **whole** .

**Proportional** - a change in one is always accompanied by a change in the other.

**Simplifying** - Divide each part of the ratio by a common factor

**Equivalent**- Ratios are equivalent if they have the same simplest form.

## Picture perfect

Share £20 in the ratio 2:5:3

1) Find the total number of parts

2 + 5 + 3 = 10

2) Divide the amount by the total number of parts

£20 ÷ 10 = £2 = 1 part

3) Multiply each number in the ratio by the value of 1 part

2 : 5 : 3

x £2 x £2 x £2

£4 : £10 : £6

### Find Two Equivalent Ratios

5:20

**Multiply**

$5{:}20 \rightarrow \frac{5}{20}$

$\frac{5}{20} \cdot \frac{2}{2} = \frac{5 \cdot 2}{20 \cdot 2} = \frac{10}{40}$

$\frac{10}{40} \rightarrow$ 10:40

**Divide**

$5{:}20 \rightarrow \frac{5}{20}$

$\frac{5}{20} \div \frac{5}{5} = \frac{5 \div 5}{20 \div 5} = \frac{1}{4}$

$\frac{1}{4} \rightarrow$ 1:4

## Always remember

# Ratios

A ratio is a way of comparing two or more quantities.

Purple paint is made by mixing blue and red paint in the ratio of 2 to 3.

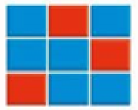
To make mortar, sand and cement are mixed together in the ratio of 5 to 2.

Lilly, Jack and Jo have shared the money in the ratio of 2 to 6 to 3.

2:3 5:2 2:6:3

A ratio must be written in the correct order, with **the quantity mentioned first written first.**

Ratios are easier to work out when they are in their simplest form. To simplify ratios, both numbers must be **divided by their highest common factor.**



The ratio of blue to red tiles is 6 to 3 but this can be simplified.

6:3 (÷3 ÷3) 2:1

3 is the highest common factor of 6 and 3, so divide both numbers by 3.

### Dividing in a Ratio

Sometimes an amount needs to be divided according to a particular ratio. Ava, Isla and Freya made £315 selling balloons at a fayre. They agreed to split the money in the ratio of 3:2:4. How much money does each person get?

1. Add the numbers in the ratio to calculate the total number of parts. — 3 + 2 + 4 = 9
2. Find the value of 1 part by dividing the total amount by the total number of parts, 9. — 315 ÷ 9 = 35; 1 part = 35
3. Multiply the value of 1 part, 35, by the numbers in the ratio to calculate how much money each person gets. — 3 x 35 = 105; 2 x 35 = 70; 4 x 35 = 140
4. 315 divided in the ratio of 3:2:4 is 105:70:140. Check your answer by adding together the values. — Ava £105, Isla £70, Freya £140; 105 + 70 + 140 = 315

## Assessment style question

Shannon is revising for her summer exams.
The table below shows the number of minutes Shannon spends revising on each of 5 evenings.
It also shows the number of minutes Shannon spends relaxing on the 5 evenings.

| | Monday | Tuesday | Wednesday | Thursday | Friday |
|---|---|---|---|---|---|
| Number of minutes revising | 88 | 198 | 150 | 133 | 160 |
| Number of minutes relaxing | 20 | 40 | 28 | 25 | 34 |

Sophie is making 400 scones.
She uses butter, sugar and flour in the ratio 2:1:9
Here are the costs of those ingredients.

| | |
|---|---|
| Butter | £2.20 per 500g |
| Sugar | £1.60 per kilogram |
| Flour | 60p per 1.5kg |

The total mass of the butter, sugar and flour in each scone is 30g

Work out the total cost of these ingredients for the 400 scones.

Mrs Chambers is organising a school trip to a museum for year 7 and year 8.
She needs to work out the total cost of the museum tickets and bus hire.
The table below shows the museum ticket prices.

| Visitor Age | Price |
|---|---|
| 0 - 3 | free |
| 4 - 12 | £4.50 |
| 13 - 17 | £6.50 |
| 18+ | £11.50 |

Each bus has 51 seats and costs £125

Altogether 300 students want to go on the trip.
The ratio of the number of students to the number of teachers is 25:1
The ratio of the number of students in year 7 to the number of students in year 8 is 8:7

At the time of the trip, all of the students in year 7 are 11 or 12 years old.
Of year 8 students, the ratio of number of 12 year olds to 13 year olds is 2:3.
Work out the total price of the school trip.

# Maths - Foundation

# Real life Graphs

## Key vocabulary

**Coordinates** - a set of value that show an exact position on a coordinate grid

**Linear equation** - an equation, when plotted, makes a straight line

**Gradient** - the steepness of the line of a linear equation

**y-intercept** - where the linear equation cuts the y-axis

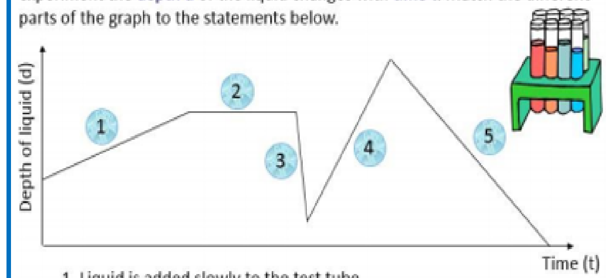
**Substitution** - when you replace an unknown for a given value

## Picture perfect

Graphs can be used to represent a number of real life situations. It is important to read the labels on both axes to determine the meaning of the graph.

Example:

A test tube containing a chemical liquid is used in an experiment. During the experiment the depth d of the liquid changes with time t. Match the different parts of the graph to the statements below.

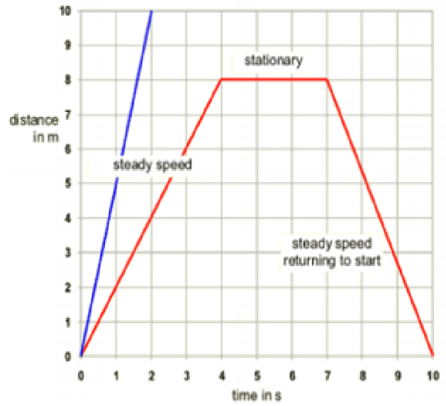



1. Liquid is added slowly to the test tube.
2. The level of the liquid remains constant.
3. Some liquid is poured out quickly.
4. Some liquid is poured in quite quickly
5. The test tube is emptied.

## Always remember

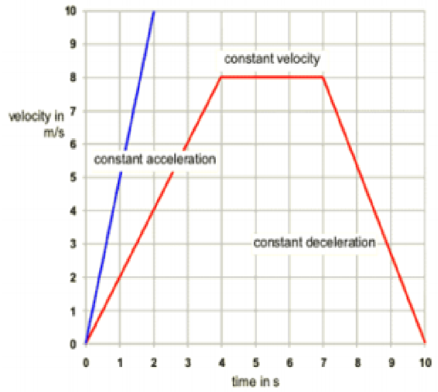
**Distance-time graphs**

Distance time graphs show distance away from a point. When an object is stationary, the line on the graph is horizontal. When an object is moving at a steady speed, the line on the graph is straight, but sloped. The **steeper** the line, the greater the **speed** of the object.




**Speed-time graphs**

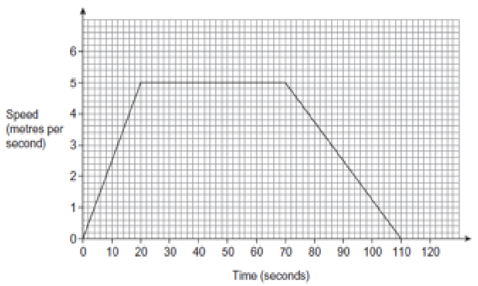
A speed-time graph tells us **changes** over **time**. When the object is travelling at a constant speed, the line on the graph is horizontal. When an object is accelerating or decelerating, the line on the graph is sloped. The **steeper** the gradient of the line, the greater the **acceleration** (a bigger change in speed in the same time).




## Assessment style question

The distance around a cycle track is 400 metres.

Robin cycles on the track.
Here is his speed-time graph.

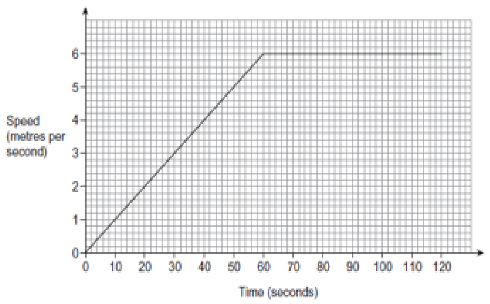



(a) Show that Robin cycles **exactly** once around the track in 110 seconds.

(2)

(b) Sanjay cycles on the same track.

Here is his speed-time graph.




Does Sanjay cycle the first 400 metres in a quicker time than Robin?
You **must** show your working.

(3)

# Maths - Foundation

## Standard Form

### Key vocabulary

- Standard form
- Ordinary number
- Power
- Index Laws
- Convert
- Ordinary number
- Adding,subtracting
- Multiplying, dividing

### Picture perfect

**Basic Structure**

$1 \leq a < 10 \longleftarrow a \times 10^{b} \longrightarrow$ *Whole number*

$$2.83 \times 10^{6} = 2830000$$

Positive power of 10 = Large number

$$3.14 \times 10^{-4} = 0.000314$$

Negative power of 10 = Small decimal number

**Standard Form**

Positive Power = Large Number

$4.3 \times 10^{6} = 4\ 300\ 000$

Negative Power = Small Number

$2.1 \times 10^{-3} = 0.021$

Standard Form Examples www.cazoommaths.com

| Ordinary Number | Standard Form |
|---|---|
| 29 | $2.9 \times 10^{1}$ |
| 350 | $3.50 \times 10^{2}$ |
| 4716 | $4.716 \times 10^{3}$ |
| 600000000 | $6 \times 10^{8}$ |
| 0.3 | $3 \times 10^{-1}$ |
| 0.09 | $9 \times 10^{-2}$ |
| 0.0071 | $7.1 \times 10^{-3}$ |
| 0.000502 | $5.02 \times 10^{-4}$ |

### Always remember

A number is converted into **standard form** when the number is very large or very small, this mainly used in science and astronomy.

- The format of a number in standard form consists of a number between 1 and 10 **but cannot be 10**, multiplied by a power of 10.

$$(1 \leq x < 10) \times 10^{n}$$

- Converting a **very small number into standard form**: Size of a bacteria is 0.00000037 0.00000037 = $3.7 \times 10^{-7}$
- Converting a **very large number into standard form**: Distance from Earth to the sun is 147100 million metres 147 100 000 000 = $1.471 \times 10^{11}$
- Converting into a **small ordinary number** $2.4 \times 10^{-6}$ = 0.0000024
- Converting into a **large ordinary number** $5.67 \times 10^{9}$ = 5 670 000 000

**Common mistakes:**

- When not in standard form but in the same format as the number is not between $1 \leq x < 10$

(too big) $76.18 \times 10^{6} = 7.618 \times 10^{7}$ and (too small) $0.12 \times 10^{-6} = 1.2 \times 10^{-7}$

When the **number is getting smaller the power gets bigger**, and when the **number gets bigger the power gets smaller**

**Add/Subtract Standard form**

Take numbers out of Standard form.
Add/Subtract values.
Convert answer back to Standard form.

$$(3.23 \times 10^{4}) + (8.2 \times 10^{3})$$
$$= 32300 + 8200$$
$$= 40500$$
$$= 4.05 \times 10^{4}$$

**Multiply/Divide Standard form**

Separate the numbers and powers of 10.
Multiply/Divide numbers,
Apply laws of indices to power of 10s
Give answer in Standard form

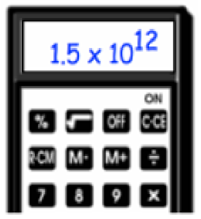
$$(4.6 \times 10^{4}) \times (3 \times 10^{3})$$
$$4.6 \times 3 \times 10^{4} \times 10^{3}$$
$$13.8 \times 10^{7}$$ ✗
$$1.38 \times 10^{8}$$ ✓

$$(1.56 \times 10^{-4}) \div (7.5 \times 10^{-7})$$
$$1.56 \div 7.5 \times 10^{-4} \div 10^{-7}$$
$$0.208 \times 10^{3}$$ ✗
$$2.08 \times 10^{2}$$ ✓

### Assessment style question

Peter has multiplied two numbers using his calculator.
The calculator shows the answer.
He can remember that one number was 5000.
What was the other number used in the multiplication?

The mass of Earth is $5.97 \times 10^{24}$
The mass of Jupiter is $1.898 \times 10^{27}$
Using a calculator, work out how many times heavier Jupiter is than Earth.
Give your answer to one decimal place.



# Maths - Higher

## Circumference and area

### Key vocabulary

**Circumference**
The perimeter **around** the circle

**Diameter**
The distance **across the centre** of the circle

**Radius**
The distance from the **centre to the edge** of the circle

**Sector**
**Part of the area** of a circle, enclosed by two radii

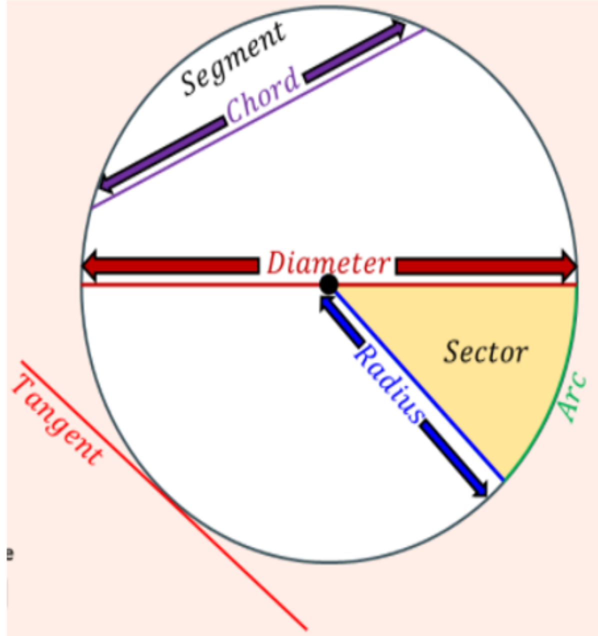
**Arc**
**Part of the circumference** of a circle

**Tangent**
A straight line that touches the curve of the circle at a point

**Chord**
A straight line segment between two points on the circle edge

**Segment**
The area created by the chord

### Picture perfect




### Always remember

**Area**

$A = \pi r^2$ ➡ Pi times the radius squared


Diameter is double the radius

$A = \pi \times 6.5^2$

$A = \pi \times 42.25$

$A = 132.73m^2$

**Sector**

$A = \frac{n^\circ}{360}\pi r^2$

Calculate the proportion of the circle required then use area formula


$\frac{85^\circ}{360^\circ}(\pi \times 6^2)$

$26.7cm^2$

**Circumference**

$C = \pi d$

$C = 2\pi r$

The circumference is always about three time the length of the diameter

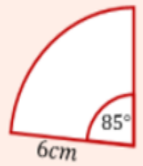

$C = \pi \times 12cm$

$C = 37.7cm$

**Arc length**

$L = \frac{n^\circ}{360}\pi d$

Calculate the proportion of the circle required then use circumference formula

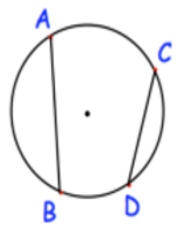



$\frac{85^\circ}{360^\circ}(\pi \times 12)$

$8.90cm$

### Assessment style question

Nicole is a wedding organiser.
The guests are to sit at circular tables with a diameter of 180cm.
Each guest needs 70cm around the circumference of the table.
There are 18 tables at the venue.
A total of 145 guests are attending the wedding
Are there enough tables?




(a) Draw a circle with two chords, AB and CD.
(b) Construct the perpendicular bisector of AB.
(c) Construct the perpendicular bisector of CD.
(d) What do you notice about where the two perpendicular bisectors meet?

# Maths - Higher

## Equations

### Key vocabulary

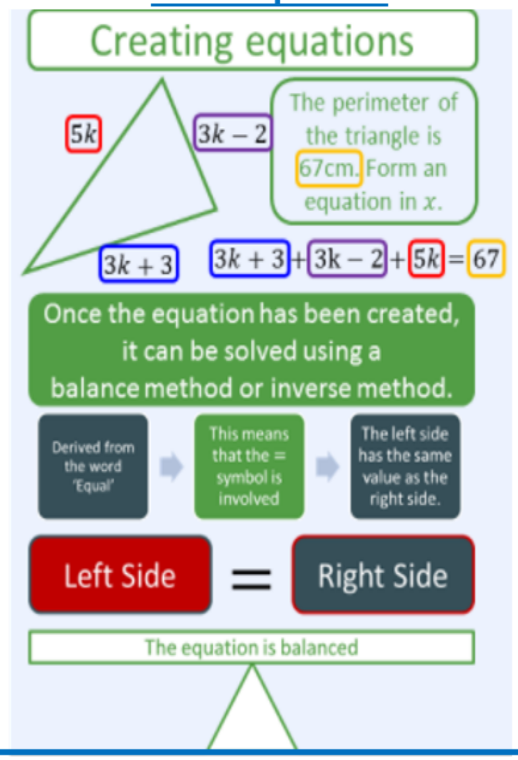
**Inverse**: This is another word for opposite. We complete the opposite operation to the one shown in the question.

**Integer**: A whole number.

**Equation**: A mathematical statement that shows that two expressions are equal.

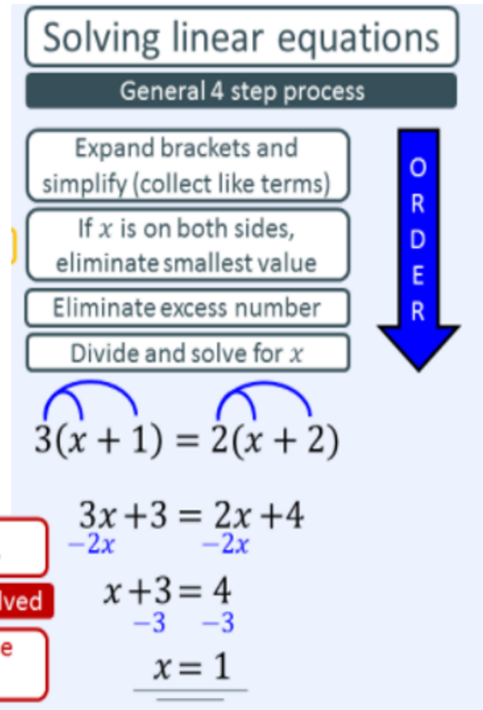
**Solve**: To get the solution or answer to a question.

### Picture perfect




### Always remember

As with all mathematical calculations, please remember to use **BIDMAS**: **Brackets** then **Indices** then **Division & Multiplication** then **Addition & Subtraction**




### Advanced equations

Equations where fractions are involved

Fractions are divisions and can be eliminated by multiplying

$\frac{x}{2} = 5$ ×2 ×2 $x = 10$

Remove variable from denominator

$\frac{2y}{(3-y)} = 4$ ×(3 − y) ×(3 − y) ⇒ $2y = 4(3-y)$

Cross-multiplying allows us to move terms in a fraction from one side of an equation to the other

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

An equation with TWO UNKNOWNS

−3x −1 −3x −1

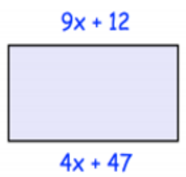
5x + 1 = 3x + 17

÷2 2x = 16 ÷2

x = 8

### Assessment style question

Shown is a rectangle




(a) Explain why 9x + 12 = 4x + 47

(b) Find x

Explain why 8x + 3 = 2(4x + 1) has no solution.

Spot the mistake:

Solve 7x − 5 = 5x + 23

−5x −5x

2x − 5 = 23

−5 −5

2x = 18

÷2 ÷2

x = 9

# Maths - Higher

## Indices

### Key vocabulary

**Square**: A square number is the result of multiplying a number by itself.
**Cube**: A cube number is the result of multiplying a number by itself twice.
**Root**: A root is the reverse of a power.
**Indices**: These are the squares, cubes and powers.
**Operation**: In maths these are the functions ⍰ ⍰ + -.

### Picture perfect

**indices**

$a^0 = 1$ $\qquad$ $a^{m/n} = (\sqrt[n]{a})^m$

$a^{-n} = \frac{1}{a^n}$ $\qquad$ $a^{-1} = \frac{1}{a}$

$a^{1/n} = \sqrt[n]{a}$ $\qquad$ $a^{1/2} = \sqrt{a}$

### Assessment style question

Question 1: Can you spot any mistakes?

$6^2 = 12$ $\qquad$ $1^7 = 7$

$10^4 = 40$ $\qquad$ $2^6 = 32$

Question 1: Can you spot any mistakes?

$2^6 \times 2^3 = 4^9$

$7^{15} \div 7^5 = 7^3$

$6^3 \times 6^4 = 6^{12}$

### Always remember

**Basic Laws of Indices**

Special indices to consider

| | |
|---|---|
| $x^1 = x$ | Anything to the power 1 = itself |
| $x^0 = 1$ | Anything to the power 0 = 1 |
| $1^x = 1$ | 1 to the power of anything = 1 |

These laws can be applied if the bases are the same

| | |
|---|---|
| $x^a \times x^b = x^{a+b}$<br>$z^3 \times z^7 = z^{10}$ | When multiplying powers with the same base – Add the powers |
| $x^a \div x^b = x^{a-b}$<br>$s^2 \div s^5 = s^{-3}$ | When dividing powers with the same base – Subtract the powers |
| $(x^a)^b = x^{a \times b}$<br>$(e^4)^3 = e^{12}$ | When raising the power (brackets) – Multiply the powers |

**Advanced Laws of Indices**

**Negative Indices**

$x^{-n} \Rightarrow 1/x^n$

Find Reciprocal
Apply Positive Power
Apply top and bottom

$z^{-3} = \left(\frac{1}{z}\right)^3 = \frac{1}{z^3}$ $\qquad$ $6^{-2} = \left(\frac{1}{6}\right)^2 = \frac{1}{36}$

**Fractional Indices**

$x^{\frac{m}{n}} = (\sqrt[n]{x})^m$

Root by denominator first
Then power of numerator

$x^{\frac{1}{2}} = \sqrt{x}$ $\quad$ $x^{\frac{1}{3}} = \sqrt[3]{x}$ $\quad$ $x^{\frac{1}{4}} = \sqrt[4]{x}$ $\quad$ $x^{\frac{2}{3}} = (\sqrt[3]{x})^2$

$64^{\frac{2}{3}} = (\sqrt[3]{64})^2 = (4)^2 = 16$

**Negative Fractional Indices**

$x^{-\frac{a}{b}} = \frac{1}{(\sqrt[b]{x})^a}$

Negative Fractional Powers: Apply reciprocal first!

$9^{-\frac{3}{2}} = \frac{1}{9^{\frac{3}{2}}} = \frac{1}{(\sqrt[2]{9})^3} = \frac{1}{(3)^3}$

# Maths - Higher

## Measures

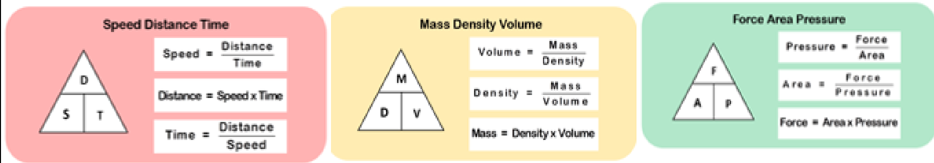
### Key vocabulary

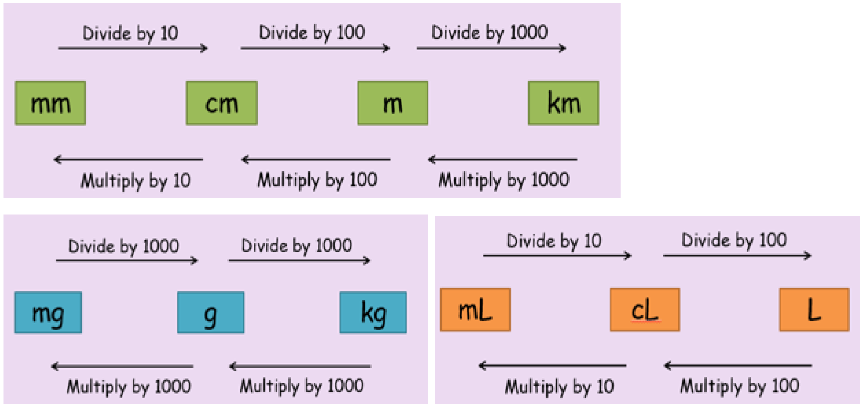
Metric, imperial, speed, density, conversion, length, capacity, mass, upper and lower bounds, limits of accuracy, error interval

### Next Steps

- Area and volume conversions

### Picture perfect




### Always remember

| Length | Mass | Capacity |
|---|---|---|
| 1 cm = 10 mm | 1 g = 1000 mg | 1 cl = 10 ml |
| 1 m = 100 cm | 1 kg = 1000 g | 1 $cm^3$ = 1 ml |
| 1 km = 1000 m | 1 tonne = 1000 kg | 1 litre = 1000 ml |
| | | 1 litre = 1000 $cm^3$ |

### Upper and Lower Bounds

Any recorded measurement has almost certainly been rounded. The true value will be somewhere between the lower and upper bound.

Lower bound = smallest possible number that rounds up to the given number.

Upper bound = largest possible number that rounds down to the given number.

The lower and upper bounds are sometimes known as limits of accuracy and the range between them is the error interval.

### Assessment style question:

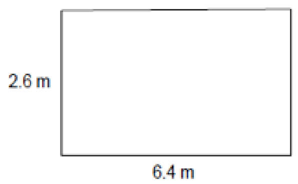
Tom's car travels 40 miles per gallon.

One litre of petrol costs £1.19

1 gallon = 4.5 litres

Work out the cost of petrol when Tom drives 200 miles.

The dimensions of a rectangular floor are to the nearest 0.1 metres.




A force of 345 Newtons is applied to the floor.
The force is to the nearest 5 Newtons.

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

Work out the upper bound of the pressure.
Give your answer to 4 significant figures.
You **must** show your working.

# Maths - Higher

## Perimeter and Area

**Key vocabulary**

Perimeter- The length around a shape

Area- The size within a shape

Surface Area- The total areas of each face of a 3D shape

Regular- All the sides and angles of a shape are equal

Perpendicular height- The height that forms a right angle with the base length.

Face- The flat surface of a 3D shape

Edge- The line where two faces meet

Vertex- Corner of a shape

Prism- A 3D shape that has the same face when you cut it along its length. Eg: a cuboid, a loaf of bread.

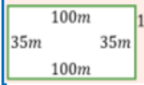
Cross section- The constant face of a prism. Eg: for a cylinder its cross section is a circle.

## Picture perfect

Perimeter

The total distance **AROUND** a 2D shape

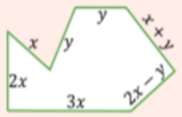
Adding all the side lengths together




$100 + 100 + 35 + 35$

$270m$

The process does not change if we have algebraic terms



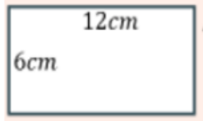

$= 9x + 2y$

Rectangular areas

The total **space** taken up by a 2D shape

Multiplying two side lengths together

Area of rectangle $= l \times w$




Area $= 6cm \times 12cm$

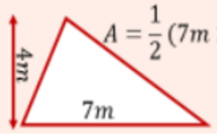
$72cm^2$

## Always remember

Triangular areas

The area of a triangle takes up **half** the space of the rectangle that is formed around it

Area of triangle $= \frac{1}{2}(b \times h)$




$A = \frac{1}{2}(7m \times 4m) = \frac{1}{2}(28m^2)$

$14m^2$

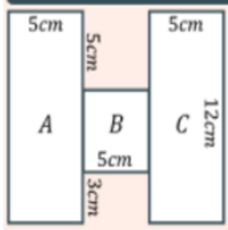
Be sure to use perpendicular heights

Calculate base × height first

Remember to **halve** your answer!

Rectangular areas

With compound shapes, break it down.

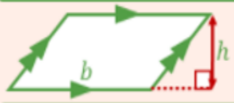



$A = 60cm^2$
$B = 20cm^2$
$C = 60cm^2$

$140cm^2$

Parallelogram

Imagine a tilted rectangle



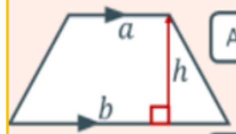

$= b \times h$

Be sure to use **perpendicular heights**

Trapezium

A more complex formula to know

$= \frac{1}{2}(a + b) \times h$




Add the parallel sides

Halve it

Multiply by height

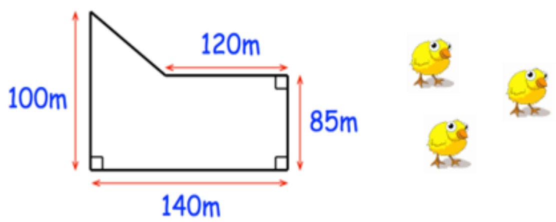
## Assessment style question

A cube has a volume of 27cı and a surface area 36cm2 . How long is each side?

A cube has a volume of 8cm What is the surface area?

A cube has a surface area of 6cm2 . What is its area?

Question 2: Farmer Martin keeps chickens in the field below. Each chicken needs $3m^2$. What is the maximum number of chickens that he can keep?



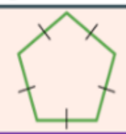
# Maths - Higher

## Properties of polygons

## Key vocabulary

## Picture perfect

| Regular | Irregular |
|---|---|
| Side lengths are the same | Side lengths are not **ALL** the same |
| Interior and exterior angles the same | Interior and exterior angles the not **ALL** the same |



Equal sides are marked with a dash through the line

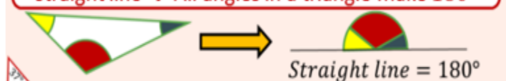
| Convex | Concave |
|---|---|
| The shape is 'bulging' outwards | The shape has 'caved' inwards |
| All angles less than 180° | One or more angles is greater than 180° |

## Assessment style question

## Always remember

### Triangles

All three angles can be orientated to fit on a straight line → All angles in a triangle make 180°





Calculate what you already know. $112° + 37° = 149°$

Subtract from 180°: $180° - 149°$, $x = 31°$

Exterior angle = Sum of two angles on opposite side.

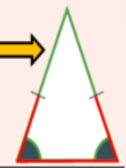

$55° + 107° = x°$

$162° = x°$

### Isosceles triangle

It has two equal lengths

It has two equal angles



They are classified by the number of sides they have

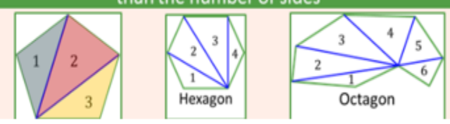
| Number of sides | Name of shape |
|---|---|
| 3 | Triangle |
| 4 | Quadrilateral |
| 5 | Pentagon |
| 6 | Hexagon |
| 7 | Heptagon |
| 8 | Octagon |
| 9 | Nonagon |
| 10 | Decagon |

### Polygons

Knowledge of triangles is important

| Number of sides | Number of △ | Sum of interior angles | Regular interior angle | Regular exterior angle |
|---|---|---|---|---|
| 3 | 1 | 180° | 60° | 120° |
| 4 | 2 | 360° | 90° | 90° |
| 5 | 3 | 540° | 108° | 72° |
| 6 | 4 | 720° | 120° | 60° |
| 7 | 5 | 900° | 129° | 51° |
| 8 | 6 | 1080° | 135° | 45° |
| $n$ | $(n-2)$ | $(n-2) \times 180°$ | $\frac{(n-2) \times 180°}{n}$ | $360° \div n$ |

The number of triangles in a shape will always be <u>TWO</u> less than the number of sides



# Maths - Higher

## Ratio and Proportion

### Key vocabulary

**Ratio:** Relationship between two or more numbers.
**Part:** This is the numeric value '1' of, would be equivalent to.
**Simplify:** Divide all parts of a ratio by the same number.
**Equivalent:** Equal in value.
**Convert:** Change from one form to another.
**Scale:** The ratio of the length in a drawing to the length of the real thing.
**Proportion:** A name we give to a statement that two ratios are equal.
**Exchange rate:** The value of one currency for the purpose of conversion to another.

### Picture perfect

**Ratio**: The is the relationship between two or more numbers and each number is separate by a colon.

The ratio of footballs to rugby balls: 1:4

The ratio of rugby balls to footballs: 4:1

Football is mentioned first so that is why the 1 comes before 4.

Rugby is mentioned first so that is why the 4 comes before 1.

### Assessment style question

Sophie is making 400 scones.
She uses butter, sugar and flour in the ratio 2:1:9
Here are the costs of those ingredients.

| | |
|---|---|
| Butter | £2.20 per 500g |
| Sugar | £1.60 per kilogram |
| Flour | 60p per 1.5kg |

The total mass of the butter, sugar and flour in each scone is 30g

Work out the total cost of these ingredients for the 400 scones.

James is making concrete using cement, sand and gravel in the ratio 1 : 2 : 3
James has:
63kg cement
112kg sand
210kg gravel

What is the maximum amount of concrete that James can make?

### Always remember

Is the relationship between two or more quantities

It is written in the form $a : b$

Compares one part to another part

The ratio of red to blue is 4 : 5

The ratio of blue to red is 5 : 4

Sentence structure is important!

**Simplifying Ratios**

$12 : 8 \xrightarrow{\div 2} 6 : 4 \xrightarrow{\div 2} \underline{3 : 2}$

Divide all numbers by the same value

The ratio of boys to girls in a Geography class is 15 : 5
What fraction of the class is girls?

$\frac{5\ girls}{20\ total\ parts} \Rightarrow \frac{1}{4}$

**Direct Proportion**

As one value increases, the other increases at the same rate

Three Coffees cost £7.50,
How much would five Coffees cost?

Find the value of one coffee then multiply by quantity needed

$£7.50 \div 3 = £2.50\ per\ coffee$

$£2.50 \times 5 = \underline{£12.50}$

**Inverse Proportion**

As one value increases, the other decreases at the same rate

It takes 3 men 4 days to build a wall.
How long would it take 2 men?

Find the time taken by one man then divide by quantity stated

$3men \times 4\ days = 12\ days$

$12\ days \div 2\ men = \underline{6\ days}$

### Sharing in a given ratio

Find total number of parts → Find value of one part → Multiply by original ratio

Share \$40 in the ratio 3 : 5

**Find total number of parts** — Add the ratio parts together

$3 + 5 = 8$

**Find value of one part** — Divide amount by number of parts

$\$40 \div 8 = \$5$

Each part of the ratio is worth \$5

**Multiply by original ratio**

$3 : 5 \xrightarrow{\times \$5} \underline{\$15 : \$25}$

Mark and John have sweets in the ratio 3 : 4, If Mark has 27 sweets.
How many does John have?

$27 \div 3 = 9\ sweets\ per\ part$

$4 \times 9 = 36\ (John's\ sweets)$

### Map scale factors

It is the ratio of a distance on the map/model to the corresponding size in real life.

Written in the form $1 : n$

Map or Model → $\times\ scale\ factor$ → Real life

Real life → $\div\ scale\ factor$ → Map or Model

Know your conversions

$10mm = 1cm$

$100cm = 1m$

$1000m = 1km$

A map has a scale of 1:25000.
Michael is 6cm from his home.
How far from home is he?
Give your answer in $km$

$6cm \times 25000 = 150000cm$

$150000cm \xrightarrow{\div 100} 1500m \xrightarrow{\div 1000} \underline{1.5km}$

# Maths - Higher

## Real Life Graphs

### Key vocabulary

Graph
Real life
Distance
Time
Depth/water level
Money
Interpret
Draw
Describe

### Picture perfect

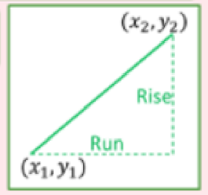
**Rate of Change**

A rate that describes how one quantity changes in relation to another quantity

It is represented by the Gradient of a line

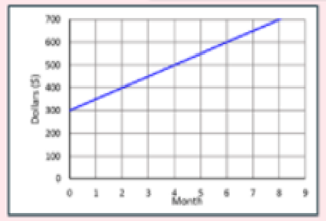
$\text{Gradient} = \frac{y_2 - y_1}{x_2 - x_1}$

$\text{Gradient} = \frac{Rise}{Run}$




**Interpreting Rates of Change**

Gradient ➡ Amount of $(y)$ per Amount of $(x)$

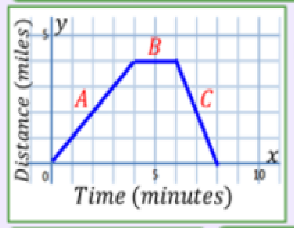



Rate of change = $50 per month

### Always remember

**Distance – Time graphs**

Distance - Time graphs record the journey of an object as it begins to move away from and return to a point.



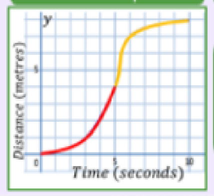

A Moving away
B Stationary
C Returning

Gradient = Speed

$Gradient = \frac{rise}{run}$

Not all objects travel at a constant speed

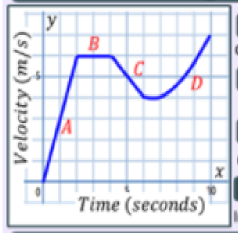
$Speed = \frac{Distance}{Time}$




Calculate speed at a specific point by creating a tangent.

**Velocity – Time graphs**

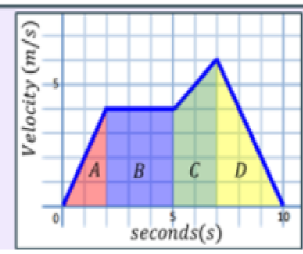
Velocity - Time graphs record the velocity of a particle moving along a straight line




Stage A
Constant rate of acceleration
Stage B
Steady 'constant' speed
Stage C
Constant rate of deceleration
Stage D
Increasing rate of acceleration

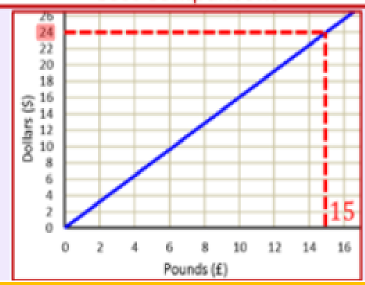
The gradient of the line is the acceleration.

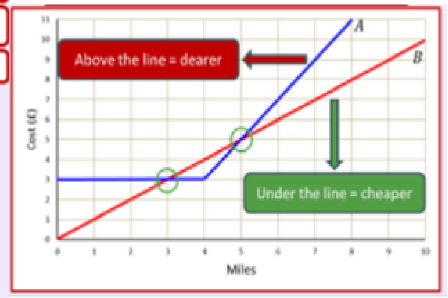
Area under graph = Distance travelled




**Financial graphs**

Currency Conversions
Predict future costs
Cost Comparisons



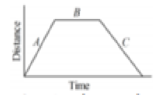

### Assessment style question

A conversion graph to convert between Euros and US Dollars.

Horizontal axis: Euros from 0 to €100
Vertical axis: US Dollar (decide scale yourself)

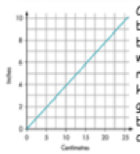
| | |
|---|---|
| US Dollars | $ 77 |
| Euros | € 70 |

Example 2: Using the graph below, identify what A, B and C mean in terms of travel.




A = steady speed,
B = no movement,
C = steady speed back to start

Using a conversion graph



Conversion graphs can be used to convert between any 2 units which have a linear relationship.
Here, you can use the graph to convert between inches and centimetres

# Maths - Higher

## Standard Form

### Key vocabulary

- Indices
- Power
- Power of ten
- Standard form
- Ordinary number
- Convert

### Picture perfect

**Basic Structure**

$1 \le a < 10 \longleftarrow a \times 10^{b} \longrightarrow$ *Whole number*

$2.83 \times 10^6 = 2830000$

Positive power of 10 = Large number

$3.14 \times 10^{-4} = 0.000314$

Negative power of 10 = Small decimal number

Powers of 10:

- $10^6 = 1000000$
- $10^3 = 1000$
- $10^2 = 100$
- $10^1 = 10$
- $10^0 = 1$
- $10^{-1} = 0.1$
- $10^{-2} = 0.01$
- $10^{-3} = 0.001$
- $10^{-6} = 0.000001$

**Standard Form**

Positive Power = Large Number

$4.3 \times 10^6 = 4\ 300\ 000$

Negative Power = Small Number

$2.1 \times 10^{-3} = 0.021$

### Always remember

**Add/Subtract Standard form**

Take numbers out of Standard form.
Add/Subtract values.
Convert answer back to Standard form.

$(3.23 \times 10^4) + (8.2 \times 10^3)$

$= 32300 + 8200$

$= 40500$

$= 4.05 \times 10^4$

**Multiply/Divide Standard form**

Separate the numbers and powers of 10.
Multiply/Divide numbers,
Apply laws of indices to power of 10s
Give answer in Standard form

$(4.6 \times 10^4) \times (3 \times 10^3)$

$4.6 \times 3 \times 10^4 \times 10^3$

$13.8 \times 10^7$ ✗

$1.38 \times 10^8$ ✓

$(1.56 \times 10^{-4}) \div (7.5 \times 10^{-7})$

$1.56 \div 7.5 \times 10^{-4} \div 10^{-7}$

$0.208 \times 10^3$ ✗

$2.08 \times 10^2$ ✓

### Assessment style question

Here are five numbers.

47 000 $\quad 4.5 \times 10^4 \quad 5 \times 10^3 \quad 2.8 \times 10^5$ $\quad$ 125 000

Work out the difference between the largest and smallest numbers.
Give your answer in standard form.

Solve $\dfrac{x}{0.02} = 3.1 \times 10^{-4}$

Give your answer in standard form.

# Maths - Higher

## Surds

### Key vocabulary

**Indices**: The number of times a number is multiplied by itself.

**Roots**: - Square Root - Cube Root

**Surds**: Surds are numbers left in 'square root form' (or 'cube root form' etc). They are therefore irrational numbers. The reason we leave them as surds is because in decimal form they would go on forever.

**Rationalise**: The process by which a fraction is rewritten so that the denominator contains only rational numbers, i.e. no roots.

### Picture perfect

**Law of Surds**

1. $\sqrt{a} \times \sqrt{b} = \sqrt{ab}$
2. $\sqrt{a} \times \sqrt{a} = \sqrt{a^2} = a$
3. $a\sqrt{b} \times c\sqrt{d} = ac\sqrt{bd}$
4. $\dfrac{\sqrt{a}}{\sqrt{b}} = \sqrt{\dfrac{a}{b}}$
5. $\dfrac{\sqrt{a}}{\sqrt{b}} = \dfrac{\sqrt{a}}{\sqrt{b}} \cdot \dfrac{\sqrt{b}}{\sqrt{b}} = \dfrac{\sqrt{ab}}{b}$
6. $\dfrac{a}{\sqrt{b}} = \dfrac{a}{\sqrt{b}} \cdot \dfrac{\sqrt{b}}{\sqrt{b}} = \dfrac{a\sqrt{b}}{b}$

### Always remember

Surds are expressions which contain an irrational square root

$\sqrt{a} \times \sqrt{b} = \sqrt{a \times b}$ $\quad \sqrt{3} \times \sqrt{7} = \sqrt{3 \times 7} = \sqrt{21}$

$\dfrac{\sqrt{a}}{\sqrt{b}} = \sqrt{\dfrac{a}{b}}$ $\quad \dfrac{\sqrt{6}}{\sqrt{10}} = \sqrt{\dfrac{6^{3}}{10_{5}}} = \sqrt{\dfrac{3}{5}}$

$\sqrt{a} + \sqrt{b} \neq \sqrt{a+b}$ $\quad \sqrt{5} + \sqrt{20} = \sqrt{25}$ ✗

**Writing in the form $a\sqrt{b}$**

Think square numbers

$\sqrt{200}$ $\quad Square\ Factors = 4, 25, 100$

Choose the largest square factor

$\sqrt{100} \times \sqrt{2} = 10\sqrt{2}$

### Rationalising the denominator

Rationalising the denominator involves removing all of the roots from the bottom of a fraction.

$\dfrac{6}{\sqrt{3}} \Rightarrow \dfrac{6}{\sqrt{3}} \times \dfrac{\sqrt{3}}{\sqrt{3}}$ (Multiply top and bottom by irrational root) $\Rightarrow \dfrac{6\sqrt{3}}{\sqrt{9}} \Rightarrow \dfrac{6\sqrt{3}}{3}$

**A more complex denominator**

$\dfrac{5}{3+\sqrt{2}} \Rightarrow \dfrac{5}{3+\sqrt{2}} \times \dfrac{3-\sqrt{2}}{3-\sqrt{2}}$ (Multiply top and bottom by Conjugate (opposite root))

$= \dfrac{5(3-\sqrt{2})}{(3+\sqrt{2})(3-\sqrt{2})}$ (Expand and simplify)

$= \dfrac{15-5\sqrt{2}}{9-3\sqrt{2}+3\sqrt{2}-2} = \dfrac{15-5\sqrt{2}}{7}$

### Assessment style question

Mrs Jenkins is making decorations for a wedding.
She needs $18\sqrt{5}$ metres of ribbon in total.
Mrs Jenkins has 40 metres of ribbon.
Does she have enough ribbon?

Question 1: Find the area of each of these rectangles

(a) $\sqrt{10}$ cm by $\sqrt{5}$ cm
(b) $\sqrt{12}$ cm by $\sqrt{3}$ cm
(c) $9\sqrt{2}$ cm by $2\sqrt{2}$ cm

Question 2: Find the perimeter of each of these rectangles

(a) $10\sqrt{3}$ cm by $5\sqrt{3}$ cm
(b) $\sqrt{10} + \sqrt{2}$ cm by $\sqrt{10} - \sqrt{2}$ cm
(c) $\sqrt{72}$cm by $\sqrt{18}$ cm

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