# GCSE Mathematics Foundation Tier

Number · Algebra · Ratio, proportion and rate of change · Geometry & measures · Probability · Statistics

Here is pretty much all the Foundation Tier content you need to know on 10 sheet of paper, including all the formulas you are required to know for GCSE. Its ✚ packed in as illustrative example. The notes refer to the DfE subject content. The idea is a well, keep it in your desk, carry it in your bag, write notes on it (sorry, don't take it into the examination)...

## BIDMAS

...or BODMAS. Use the correct order of operations; take care when using a calculator.

- Brackets
- Indices (or Orders)
- Division and Multiplication
- Addition and Subtraction

## Types of Number

Integer: a "whole" number
Factors: the divisors of an integer
✚ Factors of 12 are: 1, 2, 3, 4, 6, 12
Multiples: a "times table" for an integer (will continue indefinitely)
✚ Multiples of 12 are: 12, 24, 36, ...
Prime number: an integer which has exactly two factors (1 and the number itself). Note: 1 is not a prime number.

## HCF / LCM

Highest Common Factor (HCF)
✚ Factors of 6 are: 1, 2, 3, 6
Factors of 9 are: 1, 3, 9
HCF of 6 and 9 is 3
Lowest Common Multiple (LCM)
✚ Multiples of 6 are: 6, 12, 18, 24, ...
Multiples of 9 are: 9, 18, 27, 36, ...
LCM of 6 and 9 is 18

## Prime Factors

Write a number as a product of its prime factors, and indices for repeated factors.
✚ $120 = 5 \times 3^1 \times 2^3$

## Powers and roots

Special indices: for any value $a$

$$a^0 = 1$$

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

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

## Calculating with fractions

Adding or subtracting fractions: use a common denominator...

✚ $$\frac{1}{4} + \frac{1}{3} = \frac{3}{12} + \frac{4}{12} = \frac{7}{12}$$

Multiplying fractions: multiply numerators and denominators...

✚ $$\frac{1}{4} \times \frac{1}{3} = \frac{1}{12}$$

Dividing fractions: "flip" the second fraction, then multiply...

✚ $$\frac{1}{4} \div \frac{1}{3} = \frac{1}{4} \times \frac{3}{1} = \frac{3}{4}$$

## Fractions, decimals

Fraction to numerator ÷ denominator

✚ $$\frac{1}{4} = 1 \div 4 = 0.25$$

Use place values to change decimals to fractions. Simplify where possible.

✚ $$0.45 = \frac{45}{100} = \frac{9}{20}$$

Learn the most frequently used ones:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1/2 | 1/3 | 2/3 | 1/4 | 3/4 | 1/5 | 2/5 | 3/5 |
| 4/5 | 1/6 | 5/6 | 1/8 | 3/8 | 5/8 | 7/8 | 1/10 |

## Circle

Look for the biggest square number factor of the number:
✚ $\sqrt{80} = \sqrt{16 \times 5} = 4\sqrt{5}$

## Standard form

Standard form numbers are of the form: $a \times 10^n$ where $1 \le a < 10$ and $n$ is an integer.

## Standard units

1 tonne = 1000 kilograms
1 kilogram = 1000 grams

1 kilometre = 1000 metres
1 metre = 100 centimetres
= 1000 millimetres
1 centimetre = 10 millimetres

1 day = 24 hours
1 hour = 60 minutes = 3600 seconds
1 minute = 60 seconds

## Rounding

Truncate the number: then use a "smaller digit" to round up or down.
Decimal places: use the decimal point
✚ 162.5483 to 1dp.
162.5 (1 dp) < 162.57 to 2dp
Significant figures: use the first non-zero digit.
✚ 162.5483 to 2sf.
16 | 2.5483 = 160 to 2sf
✚ 0.007 | 11, 0 = 0.0077 to 2sf
0.007 < 11, 0 = 0.0077 to 2sf

## Error intervals

Find the range of numbers that will round to a given value:
✚ $x = 5.03$ (2 decimal places)
$5.025 \le x < 5.035$
✚ $y = 60$ (2 significant figures)
$55 \le y < 65$

Note: one of $\le$ and $<$, and that the last significant figure of each is 5.

## Algebraic notation

$$ab = a \times b$$
$$3x = x + x + x$$
$$a^2 = a \times a$$
$$a^3 = a \times a \times a$$
$$a^2b = a \times a \times b$$
$$\frac{a}{b} = a \div b$$

## Expansion and simplification

An equation is true for some particular value of $x$
✚ $2x + 3 = 7$ is true at $x = 2$
...but an identity is true for every value of $x$
✚ $(x + a)^2 = x^2 + 2ax + a^2$
(note the use of the symbol $\equiv$)

## Laws of indices

For any value $a$

$$a^m \times a^n = a^{m+n}$$
$$a^m \div a^n = a^{m-n}$$
$$(a^m)^n = a^{mn}$$

✚ $$\left(\frac{3x^2}{2y^3}\right)^4 = \frac{3^4x^8}{2^4y^{12}} = \frac{81x^8}{16y^{12}}$$

## Number grids

## $y = mx + c$

Equation of straight line $y = mx + c$: $m$ is the gradient, $c$ is the $y$ intercept.
✚ Find the equation of the line that joins (0, 3) to (2, 11)
Find the gradient:

$$\frac{11 - 3}{2 - 0} = \frac{8}{2} = 4$$

...and the $y$ intercept...
Point through (0, 3), so $c = 3$
Equation is $y = 4x + 3$

Parallel lines: gradients are equal.
✚ $y = 2x + 3$ and $y = 2x - 1$ both have gradient 2 so are parallel.

## Expanding brackets

$$p(q + r) = pq + pr$$

✚ $5(x - 2y) = 5x - 10y$
$(x + a)(x + b) = x^2 + ax + bx + ab$
✚ $(2x - 3)(x + 5)$
$= 2x^2 - 3(x + 5)$
$= 2x^2 - 6x - 15$
$= 2x^2 + 7x - 15$

Reverse of expanding is factorising: putting an expression into brackets.

## Quadratics

Solve a quadratic by factorising
✚ Solve $x^2 - 8x + 15 = 0$
Put into brackets (taking care with any negative numbers)...
$(x - 3)(x - 5) = 0$
...then either $x - 3 = 0$ or $x - 5 = 0$
so that $x = 3$ or $x = 5$.

## Difference of two squares

$$a^2 - b^2 = (a + b)(a - b)$$

✚ $x^2 - 25 = (x + 5)(x - 5)$

## Simultaneous equations

✚ Solve $\begin{cases} 2x + 3y = 13 \\ 5x - 3y = 7 \end{cases}$

Multiply to match a term in $x$ or $y$

$$\begin{cases} 10x + 15y = 65 \\ 9x - 15y = 21 \end{cases}$$

Add or subtract to cancel...
$19x = 76$, so $x = 4$
Finally, substitute and solve...
$2 \times 4 + 3y = 13$, so $y = 1$

## Rearrange a formula

The subject of a formula is the term on its own. The rules that "balance" the formula to change its subject.
✚ Make $x$ the subject of
$2x + 3y = z$
Move subtract $3y$ from both sides...
$2x = z - 3y$
...then divide both sides by 2

$$x = \frac{z - 3y}{2}$$

## Right angled triangles

Pythagoras Theorem.
Links all three sides.
By angles.
$a^2 + b^2 = c^2$

The longest side of any right angled triangle is the hypotenuse; check that your answer is consistent with this.

Trigonometry.
Links two sides and one angle.
SOH | CAH | TOA

$$\sin\theta = \frac{opp}{hyp} \quad \cos\theta = \frac{adj}{hyp} \quad \tan\theta = \frac{opp}{adj}$$

Use "SHIFT" or "SHIFT" key to find a missing angle.

Special values of sin, cos, tan
Learn (or be able to find without a calculator)...

| $\theta^\circ$ | $\sin\theta^\circ$ | $\cos\theta^\circ$ | $\tan\theta^\circ$ |
|---|---|---|---|
| 0 | 0 | 1 | 0 |
| 30 | $\frac{1}{2}$ | $\frac{\sqrt{3}}{2}$ | $\frac{1}{\sqrt{3}}$ |
| 45 | $\frac{\sqrt{2}}{2}$ | $\frac{\sqrt{2}}{2}$ | 1 |
| 60 | $\frac{\sqrt{3}}{2}$ | $\frac{1}{2}$ | $\sqrt{3}$ |
| 90 | 1 | 0 | |

## Area and volume

Area of triangle = $\frac{1}{2} \times$ base $\times$ height  Volume of cuboid = length $\times$ width $\times$ height

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

Circumference of circle = $2 \times \pi \times r$
Area of circle = $\pi \times r^2$

Arc length = $\frac{\theta}{360} \times \pi \times D$

Area of sector = $\frac{\theta}{360} \times \pi \times r^2$

Volume of cylinder = $\pi r^2 \times$ height

Volume of prism = area of cross section $\times$ length

## Transformations

Reflection
- Line of reflection

Rotation
- Centre of rotation
- Angle of rotation
- Clockwise or anticlockwise

Enlargement
- Centre of enlargement
- Scale factor (SF)
- SF > 1 the shape will get smaller).

Translation
- Vector

## Angle facts

Equal angles in parallel lines always are correct homologs...

Alternate angles  Corresponding angles

Angles on a straight line total 180°

Angles in a full turn total 360°

Interior angles in a triangle total 180°

Use this for the interior angles of any polygon...

...or 180° × (n − 2)

Interior angles always total 360°

## Sequences

Triangular numbers:

| | | | | |
|---|---|---|---|---|
| 1 | 3 | 6 | 10 | 15 |

Square numbers ($n^2 = n \times n$):

| | | | | |
|---|---|---|---|---|
| 1 | 4 | 9 | 16 | 25 |

Cube numbers ($n^3 = n \times n \times n$):

| | | | | |
|---|---|---|---|---|
| 1 | 8 | 27 | 64 | 125 |

Nth term of an arithmetic (linear) sequence is $an + d$
✚ sub terms of 5, 8, 11, 14, ... is
Result (always increases by 3
First term is $3 \times 1 + 2 = 5$)
Geometric sequence: multiply each term by a common ratio
✚ 3, 6, 12, 24, ... (ratio is 2)
Fibonacci sequence: make the next term by adding the previous two...
✚ 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, ...

## Probability

$p$ = (number ways to succeed) ÷ (number ways to succeed + number ways to fail)

| | |
|---|---|
| $p = 0$ | impossible |
| $0 < p < 0.5$ | unlikely |
| $p = 0.5$ | even |
| $0.5 < p < 1$ | likely |
| $p = 1$ | certain |

## Expected Value

Multiply for independent events
✚ P(H on fair coin) & P(H on coin)

$$\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$$

Add for mutually exclusive events
✚ P(T on a fair die)

$$\frac{1}{6} + \frac{1}{6} = \frac{2}{6}$$

Apply these rules to tree diagrams.

## Pie charts of a circle

## Ratio

Use a ratio for unequal sharing
✚ Divide £400 in the ratio 1 : 3
1 + 3 = 4; then £400 ÷ 4 = £100
1 × £100 = £100, 3 × £100 = £300
(check: £100 + £300 = £400 ✓)

## Ratio and fractions

Link between ratios and fractions
✚ Ratio for girls to ratio 2 : 3

$$\frac{2}{5} \text{ are boys}, \frac{3}{5} \text{ are girls}$$

## Percentages

$$x \text{ percent of } y = \frac{x}{100} \times y$$

✚ Increase £150 by 20%

$$\frac{20}{100} = 150 \times 1.15 = 172.50$$

$$£150 + £15.00 = £172.50$$

$$y \text{ is a percentage of } x = \frac{y}{x} \times 100\%$$

✚ The population of a town increases from 75000 to 84750. Find the percentage increase.

$$\frac{84750}{75000} = 100\% + 13\%$$

$$\text{Percentage change} = \frac{\text{increase}}{\text{original}} \times 100\%$$

Learn the most frequently used ones:

| | | | | |
|---|---|---|---|---|
| 1 | 1/2 | 1/3 | 1/4 | 1/5 |
| 100% | 50% | 33% | 25% | 20% |

## Speed / distance / time

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

✚ A car travels 90 miles in 1 hour, 30 minutes. Find its average speed.
90 miles ÷ 1.5 hours = 60 mph

## Averages

Mode: most frequently occurring.
Median: put the data in numerical order, then choose the middle one.
Mean = $\frac{\text{total of items of data}}{\text{number of items of data}}$

## Correlation

Positive correlation  Negative correlation

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