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 could fit onto an A3 sheet of paper, including all the formulae you are expected to know for GCSE. An ✚ points to an illustrative example. The notes refer to the AQA subject content. Pi (π) is a math letter in the same family as p and q, but we use it to stand for 3.14159... don't take it into the examination!

BIDMAS

...or BODMAS. For the correct order of operations, take care when using a calculator.

1. Brackets
2. Indices (or Powers)
3. Division and Multiplication
4. 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 (add successive multiples)

✚ 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

✚ $126 = 2 \times 3^2 \times 7$

Powers and roots

Special indices for any value of x

$$x^0 = 1$$

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

✚ $$x^{-2} = \frac{1}{x^2} = \frac{1}{x \times x}$$

Calculating with fractions

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

✚ $$\frac{1}{3} + \frac{1}{5} = \frac{5}{15} + \frac{3}{15} = \frac{8}{15}$$

Multiplying fractions: multiply numerators and denominators...

✚ $$\frac{1}{3} \times \frac{1}{5} = \frac{1}{15}$$

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

✚ $$\frac{1}{3} \div \frac{1}{5} = \frac{1}{3} \times \frac{5}{1} = \frac{5}{3}$$

Fractions, decimals, percentages

Fraction to decimal: numerator ÷ denominator

✚ $\frac{1}{8} = 1 \div 8 = 0.125$

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:

$\frac{1}{2}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{5}$	$\frac{1}{8}$
0.5	0.333...	0.666...	0.25	0.75	0.2	0.125

Units

Look for the biggest square number factor of the number:

✚ $\sqrt{200} = \sqrt{100} \times \sqrt{2} = 10\sqrt{2}$

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

Accuracy

Truncate: the number, then use a "decider digit" to round up or down.

Decimal places: use the decimal point

✚ 562.5683 to 1dp.
562.5 (< 6) = 562.57 to 2dp.

Significant figures: use the first non-zero digit.

✚ 562.5683 to 2sf.
5 (≥ 5) 683 = 560 to 2sf.
✚ 0.007735 to 3sf.
0.00773 (< 8) = 0.00773 to 3sf.

Error intervals

Find the range of numbers that will round to a given value:

✚ $x = 5.83$ (2 decimal places)
$5.825 \le x < 5.835$

✚ $y = 60$ (2 significant figures)
$55 \le y < 65$

Note use of ≤ and <, and that the last significant figure of each is 5

Algebraic notation

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

Expressions and formulae

An equation is true for some particular value of x

✚ $2x + 1 = 7$ is true only if $x = 3$

...but an identity is true for every value of x

✚ $(x + a)^2 = x^2 + 2ax + a^2$
(note the use of the symbol ≡)

Laws of indices

For any value n

$$a^n \times a^m = a^{n+m}$$
$$\frac{a^n}{a^m} = a^{n-m}$$
$$(a^n)^m = a^{nm}$$

✚ $$\frac{(3x)^2}{(2y)^3} = \frac{3x \times 3x}{2y \times 2y \times 2y} = \frac{3^2}{2^3} x^2 y^{-3}$$

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 its gradient:

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

...and its y intercept...

Points 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

$$a(b + c) = ab + ac$$

✚ $5(2x - 3y) = 5x - 15y$

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

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 $x - 3 = 0$ so $x = 3$, or $x - 5 = 0$ so $x = 5$.

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 x terms or y or y

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

Add or subtract to cancel...

$$10x - 9x = 65 - 21$$

Finally, substitute and solve...

$$2 \times 8 - 3x = 13, \text{ so } x = 3$$

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...

$$2x + 3y - 3y = z - 3y$$

...then divide both sides by 2

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

Right angled triangles

Pythagoras' Theorem.
Links all three sides.
No 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

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

Use "2nd$F$" or "SHIFT" key to find a missing angle

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

$x°$	$\sin x°$	$\cos x°$	$\tan x°$
0	0	1	0
30	$\frac{1}{2}$	$\frac{\sqrt{3}}{2}$	$\frac{1}{\sqrt{3}}$
45	$\frac{1}{\sqrt{2}}$	$\frac{1}{\sqrt{2}}$	1
60	$\frac{\sqrt{3}}{2}$	$\frac{1}{2}$	$\sqrt{3}$
90	1	0	

Areas and volumes

Area of triangle $= \frac{1}{2} \times$ base $\times$ height

Volume of cuboid = length × width × height

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

Circumference of circle $= \pi \times D$
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 × length

Transformations

Reflection
- Line of reflection

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

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

Translation
- Vector

Angle facts

Equal angles at parallel lines always use corresponding...

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)

Exterior angles always total 360°

Averages

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

Frequency tables

Height (h cm)	Frequency
$150 < h \le 160$	12
$160 < h \le 170$	15
$170 < h \le 180$	8

Modal class: $150 < h \le 160$

Estimate mean: add a row for midpoint, and a row for midpoint × frequency

Height (h cm)	Frequency	Midpoint	Midpoint × Frequency
$150 < h \le 160$	12	155	1860
$160 < h \le 170$	15	165	2475
$170 < h \le 180$	8	175	1400
	35		5735

Estimate mean $= \frac{5735}{35} = 163.9$ cm

Inequalities

Triangular numbers

1st	2nd	3rd	4th	5th
1	3	6	10	15

Square numbers (n^2 = n × n)

1st	2nd	3rd	4th	5th
1	4	9	16	25

Cube numbers (n^3 = n × n × n)

1st	2nd	3rd	4th	5th
1	8	27	64	125

nth term of an arithmetic (linear) sequence is $an + d$

✚ sequence 5, 8, 11, 14, ... is
$3n + 2$ (always increase 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, ...

Inequalities

p = [illegible]

$p = 0$	impossible
$0 < p < 0.5$	unlikely
$p = 0.5$	evens
$0.5 < p < 1$	likely
$p = 1$	certain

Probability basics

Multiply for independent events

✚ P(3 on first and 5 on second)

$$\frac{1}{6} \times \frac{1}{6} = \frac{1}{36}$$

Add for mutually exclusive events

✚ P(3 or 4 on die)

$$\frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3}$$

Apply these rules to tree diagrams.

Parts of a circle

Direct proportion

Use a ratio for unequal sharing

✚ Divide £400 in the ratio 1 : 3 : 4
1 + 3 + 4 = 8, then £400 ÷ 8 = £50
1 × £50 = £200, 3 × £50 = £150
4 × £50 = £200 (check: £200 + £150 + £50 = £400 ✓)

Ratio and fractions

Link between ratios and fractions

✚ Share in girls to boys ratio 2 : 3

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

Percentages

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

✚ Increase £50 by 20%.

$$\frac{120}{100} \times 50 = 1.20 \times 50 = £60.00$$

$£100 \times £0.80 = £73.60$

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

✚ The population of a town increases from 15000 to 16250. Find the percentage increase.

$$\frac{\text{increase}}{\text{original}} \times 100\% = \frac{1250}{15000} \times 100\% = 8.3\%$$

Reverse Percentages: $\frac{\text{new}}{\text{original}}$

Learn the most frequently used ones:

1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{8}$	$\frac{1}{10}$
100%	50%	25%	20%	12.5%	10%

Speed, distance, time

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

✚ A car travels 90 miles in 2 hours, 30 minutes. Find its average speed.
90 miles ÷ 2.5 hours = 36 mph

Correlation

Positive correlation

Negative correlation

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Judd E. Hollander

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