GCSE Mathematics Higher Tier

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

Here is pretty much all the Higher Tier content you need to cram on A1 sheet of paper, including all the formulae you are supposed to know for GCSE. An ✚ points to an illustrative example. The codes refer to the AQA subject content. Put this in a safe place so you don't lose it, carry it in your bag, make notes on it (sorry), don't take it into the examination...

Laws of indices A4

For any value a

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

✚ $\left(\frac{2x^3}{y^2}\right)^3 = \frac{2x^3}{y^2} \times \frac{2x^3}{y^2} \times \frac{2x^3}{y^2} = \frac{8x^9}{y^6}$

Difference of two squares A4

$$a^2 - b^2 = (a + b)(a - b)$$
✚ $x^2 - 25 = (x + 5)(x - 5)$

Rearrange a formula A7

The subject of a formula is the term on its own. Rearrange to ...

✚ Make x the subject of

$$2x = ay - y = by$$
$$2x + by = ay + xy$$
$$x(2 + b) = y - ay$$
$$x = \frac{y - ay}{2 + b}$$
$$x = \frac{y(1 - a)}{2 + b}$$

Functions A7

Combining functions:

$$fg(x) = f(g(x))$$

✚ if $f(x) = x - 3$ and $g(x) = x^2$

$$fg(x) = x^2 - 3$$
$$gf(x) = (x - 3)^2$$

The inverse of f is f^{-1}

✚ if $f(x) = 2x + 3$ then

$$x = f^{-1}(x) = \frac{x - 3}{2}$$

y = mx + c A8

Equation of straight line $y = mx + c$, m is the gradient, c is the y-intercept.

✚ Find the equation of the line that passes through $(3, -1)$ and $(2, 1)$.

Find its gradient:

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

...and its y-intercept...

If passes through $(3, -1)$, so $c = 5$

Equation is $y = -2x + 5$

Parallel lines: gradients are equal; perpendicular lines: gradients are "negative reciprocals".

✚ $y = 2x + 3$ and $y = 2x - 5$ are parallel to each other; $y = 2x + 3$ and $y = -\frac{1}{2}x + 3$ are perpendicular.

Transformations of curves A11

Starting with the curve $y = f(x)$

Translation $\begin{pmatrix} 0 \\ a \end{pmatrix}$ for $y = f(x) + a$

Translation $\begin{pmatrix} a \\ 0 \end{pmatrix}$ for $y = f(x + a)$

Reflect in x-axis for $y = -f(x)$

Reflect in y-axis for $y = f(-x)$

Speed, distance and time A13

Gradient = acceleration / (you may need to draw a tangent to the curve at a point to find the gradient)

Area under curve = distance travelled.

Standard graphs A13

Quadratics A17, A19

If a quadratic equation cannot be factorised, use the formula

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

✚ Solve $3x^2 + 5x - 7 = 0$

$$x = \frac{-5 \pm \sqrt{109}}{6}$$
$$x = -2.73 \text{ or } x = \frac{-5 - \sqrt{109}}{6} = 0.73$$

Completing the square to find the turning point of a quadratic graph.

✚ $y = x^2 - 4x - 2$

$y = (x - 2)^2 - 4 - 2$

$y = (x - 2)^2 - 7$

Turning point is at $(2, -7)$

Equation of a circle A19

$x^2 + y^2 = r^2$ is a circle with centre $(0, 0)$ and radius r.

✚ $x^2 + y^2 = 25$ has centre $(0, 0)$ and radius 5

Simultaneous equations A20

One linear, one quadratic:

✚ Solve $\begin{cases} x^2 + 2y = 10 \\ x^2 - y^2 = 20 \end{cases}$

Rearrange the linear and substitute into the quadratic:

$$x = 10 - 2y$$
$$so\ (10 - 2y)^2 - y^2 = 20$$

Expand and solve the quadratic:

$$100 - 40y + 4y^2 - y^2 = 20$$
$$3y^2 - 40y + 80 = 0$$
$$y = 2.84 \text{ or } 9$$

Finally, substitute into the linear and solve, pairing values...

$x = 5 \times 0 = 10$ so $(x, y) = (10, 0)$

$x = 5 \times 4 = 10$ so $(x, y) = (-2, 4)$

Sequences A24, A25

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

✚ nth term of 5, 8, 11, 14, ... is $3n + 2$. (always increases by 3 from term to term: $3 \times 1 + 2 = 5$).

nth term of a quadratic sequence is $an^2 + bn + c$

✚ First three terms of $n^2 - 3n - 1$ are $-3, 1, 7, \ldots$

Geometric sequence: multiply each term by a common ratio

✚ 2, 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, ...

Right angled triangles G20

Pythagoras Theorem.
Links all three sides.
No angles.

$$a^2 + b^2 = c^2$$

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

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

Advanced trigonometry G21, G22

A is opposite a
B is opposite b
C is opposite c

Sine Rule
Use if you are given an angle-side pair.

Missing side: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Missing angle: $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

Cosine Rule
Use if you can't use the sine rule.

Missing side: $a^2 = b^2 + c^2 - 2bc\cos A$

Missing angle: $\cos A = \frac{b^2 + c^2 - a^2}{2bc}$

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

$x°$	$\sin^2 x$	$\cos^2 x$	$\tan^2 x$
0	0	1	0
30	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{1}{3}$
45	$\frac{1}{2}$	$\frac{1}{2}$	1
60	$\frac{3}{4}$	$\frac{1}{4}$	3
90	1	0	

Circle theorems G16

Angle in a semicircle is 90°

Angle at the centre is double the angle at the circumference

Angles in the same segment are equal

Opposite angles in a cyclic quadrilateral total 180°

Alternate segment theorem

Tangent and radius are perpendicular

Areas and volumes G16, G17, G18, G21

Circumference of circle $= \pi \times D$

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

Area of triangle $= \frac{1}{2}ab\sin C$

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

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

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

Volume of prism = area of cross section × length

Volume of cone $= \frac{1}{3}\pi r^2 h$

Volume of frustum is difference between the volumes of two cones

Transformations G1, G4

Reflection	Rotation	Enlargement
• Line of reflection	• Centre of rotation	• Centre of enlargement
Translation	• Angle of rotation	• Scale factor (> 1 = bit > 0 but < 1 = smaller)
• Vector	• Clockwise or anticlockwise	the shape will get smaller).

Loci and sets G19

Rules to sketch regions and solids:

	Line	Region
• Length/perimeter	1	2
• Area	1^2	2^2
• Volume	1^3	2^3

Converting recurring decimals A2

Write a recurring decimal x fractions

✚ $x = 0.\dot{3}\dot{5}$

(two digits are in the recurring pattern, so multiply by 100)

$100x = 35.\dot{3}\dot{5}$

(this is the same as $35 + 0.\dot{3}\dot{5}$)

$99x = 35$ (i.e. $0.\dot{3}\dot{5} = 0.353535... = 35 \times$ ...)

$x = \frac{35}{99}$ so $0.\dot{3}\dot{5} = \frac{35}{99}$

Upper and lower bounds A3

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

✚ $x = 5.91$ (2 decimal places)

$5.905 \le x < 5.915$

✚ $y = 66$ (2 significant figures)

$65.5 \le y < 66.5$

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

Inequalities and inequalities A3

An equation is true for some particular value of x

✚ $2x + 1 = 7$ is true 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 ≡)

Percentages, multipliers R5, R6

Percentage increase or decrease, use a multiplier (powers for repetition).

✚ Isabella buys euro (€) and sells Kids in a bike. The number decreases by 15% each year. Estimate the number of Kids after 6 years.

$20\,000 \times 0.85^6 = 75\,646$ (2dp)

Formula for compound interest

$$\text{Total accrued} = P\left(1 + \frac{r}{100}\right)^n$$

✚ I invest £4000 at 3% compound interest. What is my account worth after 5 years?

$£4000 \times \left(1 + \frac{3}{100}\right)^5 = £4640.54$

Direct & inverse proportion R10

y is directly proportional to x:

$y = kx$ for a constant k

✚ A is directly proportional to r^2

$A = k \times r^2$ ... $A = 6$ and $r = 10$ for k

$6 = k \times 10^2$ so $k = 3$, $3 \times 6 = 2.5x^2$

$A = 2.5 \times 8^2 = 160$

y is inversely proportional to x

$y = k$ or $y = \frac{k}{x}$ for a constant k

Probability scale P1, P2

Multiply for independent events

✚ P(6) on dice and H on coin)

$$\frac{1}{6} \times \frac{1}{2} = \frac{1}{12}$$

Add for mutually exclusive events

✚ P(3) or H on dice)

$$\frac{1}{6} + \frac{1}{2} = \frac{4}{6}$$

Apply these rules to tree diagrams.

Venn diagrams P3

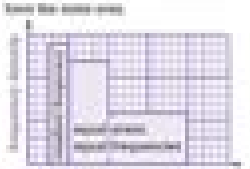
In general...

$P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$

$P(A \text{ and } B) = P(A \text{ given } B) \times P(B)$

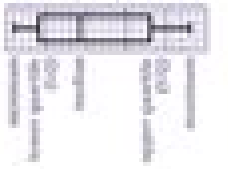
Histograms S3

Frequency = frequency density multiplied by class width. This means that bars with the same frequency have the same area.



Box plots S4

Interquartile range (IQR) = UQ − LQ



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