Mathematics (0580)

IGCSE • Core • CAIE

Compact Cheat Sheet

The Practice Book
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1 Algebra and graphs

KEY FORMULAS

Laws of Indices: Division

$$a^m \div a^n = a^{m-n}$$

Use when dividing two powers with the same base. Subtract the index in the denominator from the index in the numerator.

Laws of Indices: Multiplication

$$a^m \times a^n = a^{m+n}$$

Use when multiplying two powers with the same base. Add the indices and keep the base unchanged.

nth Term of a Linear Sequence

$$T_n = dn + c$$

Use to find any term of a linear (arithmetic) sequence directly, without listing every term. d is the common difference between consecutive terms; c is the "zeroth term" found from $c = T_1 - d$.

Rearranging a Formula

$$v = u + at \implies t = \frac{v-u}{a}$$

Use to make a different letter the subject of a formula. Treat the target letter as the unknown of an equation and apply the same inverse-operation steps used to solve an equation.

KEY CONCEPTS

- **Collecting Like Terms**: *Like terms* have identical letter parts, letters raised to the same powers. Add or subtract only the numerical coefficients of like terms and leave the letter part unchanged. $5x$ and $-2x$ collect to $3x$; $5x$ and $5x^2$ do not collect, since x and x^2 are different letter parts.
- **Distance-Time Graphs**: On a distance-time graph the *gradient* gives the speed, a steeper line means a faster speed. A horizontal segment means the object is stationary, since distance is not changing while time passes. A negative gradient means motion back towards the starting point.
- **Finding the Common Difference**: The common difference d of a linear sequence is found by subtracting a term from the next term, $d = T_{n+1} - T_n$. A positive d means the sequence increases; a negative d means it decreases.
- **Reading and Plotting Coordinates**: A coordinate (x, y) gives the horizontal position x and the vertical position y relative to the origin $(0, 0)$. Always read or plot the x-coordinate first, then the y-coordinate.
- **Solving a Linear Equation by the Balance Method**: An equation stays true if the same operation is applied to both sides. Undo operations in reverse order: expand any brackets first, then move terms so the unknown is on one side, then use the inverse operation (subtraction undoes addition, division undoes multiplication) to leave the unknown alone.
- **Solving a Linear Inequality**: An inequality compares two expressions with $<$, $>$, $\leq$ or $\geq$. Solve it with the same steps used for an equation, isolating the unknown on one side.
- **Speed-Time Graphs**: On a speed-time graph a horizontal line means *constant speed* (not stationary, stationary would be a speed of zero). An upward slope means acceleration and a downward slope means deceleration. The *area* under the graph gives the distance travelled.

EXAM TIPS

TIP A complete sketch of a straight line or a quadratic must show every axis intercept with its coordinates labelled, plus the vertex for a quadratic. Markschemes award separate marks for each labelled feature, so an unlabelled sketch loses marks even if the shape is correct.

TIP Multiplying or dividing both sides of an inequality by a *negative* number reverses the direction of the inequality symbol. $-2x < 10$ becomes $x > -5$ after dividing by -2. This is the single most common source of error in Core inequality questions.

TIP When a bracket is multiplied by a negative number, every term inside flips sign. $-3(2x-5)$ expands to $-6x+15$, not $-6x-15$. Underline the outside multiplier before expanding so the sign is not forgotten.

2 Coordinate geometry

KEY FORMULAS

Equation of a Straight Line

$$y = mx + c$$

Represents any straight line, where m is the gradient and c is the value where the line crosses the y-axis (the y-intercept).

Gradient of a Line Through Two Points

$$m = \frac{y_2 - y_1}{x_2 - x_1}$$

Use to find the gradient m of the straight line through two known points (x_1, y_1) and (x_2, y_2). It measures the rise (change in y) divided by the run (change in x).

KEY CONCEPTS

- **Finding the Equation from a Gradient and One Point**: When the gradient m and one point on the line are known, substitute the point's coordinates into $y = mx + c$ and solve for c. Writing the full equation then only needs the known m and this value of c.
- **Parallel Lines Share the Same Gradient**: Two lines are *parallel* if and only if they have equal gradients m. Their y-intercepts c must differ, otherwise they would be the same line. To read whether two lines are parallel, compare the value of m in each $y = mx + c$ equation.
- **Reading the Sign of the Gradient**: A *positive* gradient rises from left to right; a *negative* gradient falls from left to right. A horizontal line has gradient 0 because there is no rise. A vertical line has an *undefined* gradient, since the run is 0 and division by zero is not allowed.

EXAM TIPS

TIP In the gradient formula, subtract the two y-values and the two x-values in the *same order*. Using $y_2 - y_1$ on top but $x_1 - x_2$ on the bottom flips the sign of the gradient. This is the most common source of a wrong sign in Core coordinate questions.

3 Geometry

KEY FORMULAS

Exterior Angle of a Regular Polygon

$$\text{exterior angle} = \frac{360^\circ}{n}$$

Use for a *regular* polygon with n equal sides. The exterior angles of any polygon always sum to 360°, so each one is 360° divided by the number of sides.

Scale Factor for Similar Figures

$$k = \frac{\text{length on enlarged figure}}{\text{corresponding length on original figure}}$$

Use once two figures are known to be similar. Find k from one matching pair of sides, then multiply any length on the original by k to get the matching length on the enlargement.

Sum of Interior Angles of a Polygon

$$S = (n - 2) \times 180^\circ$$

Use to find the total of all interior angles of any polygon with n sides, whether regular or irregular.

KEY CONCEPTS

- **Angle in a Semicircle**: An angle drawn at the circumference using a diameter as one side is always 90°. So if a triangle inside a circle has the diameter as one of its sides, the angle opposite that diameter is a right angle.
- **Angles in Parallel Lines**: When a transversal crosses two parallel lines, *corresponding* angles (in an F shape) are equal, *alternate* angles (in a Z shape) are equal, and *co-interior* angles (in a C shape) sum to 180°.
- **Basic Angle Facts**: Angles on a straight line sum to 180°. Angles at a point sum to 360°. Vertically opposite angles, formed where two straight lines cross, are equal. The interior angles of a triangle sum to 180°.
- **Constructing a Perpendicular Bisector**: To bisect segment AB, open the compasses to more than half of AB. With centre A draw arcs above and below the line, then with the same setting and centre B draw arcs crossing them. The straight line through the two crossing points passes through the midpoint of AB and meets it at 90°.
- **Parts of a Circle**: The *radius* joins the centre to the circumference; the *diameter* passes through the centre and equals $2r$. A *chord* joins two points on the circle. A *tangent* touches the circle at exactly one point and is perpendicular to the radius there. An *arc* is part of the circumference; a *sector* is bounded by two radii and an arc; a *segment* is bounded by a chord and an arc.
- **Properties of Special Quadrilaterals**: A *square* has four equal sides and four right angles. A *rectangle* has opposite sides equal and four right angles. A *rhombus* has four equal sides with diagonals that bisect each other at right angles. A *parallelogram* has opposite sides parallel and equal and opposite angles equal. A *trapezium* has exactly one pair of parallel sides. A *kite* has two pairs of adjacent equal sides.
- **Tangent Perpendicular to Radius**: A tangent to a circle meets the radius drawn to the point of contact at exactly 90°. This right angle creates a right-angled triangle, so lengths involving a tangent and a radius can be found with Pythagoras' theorem.
- **Three-Figure Bearings**: A bearing is an angle measured *clockwise from north*, always written with three figures. North is 000°, east is 090°, south is 180° and west is 270°. Angles below 100° keep a leading zero, so a bearing of forty degrees is written 040°.

EXAM TIPS

TIP Core papers award a mark for the reason as well as the value, so quote the rule you used, for example "alternate angles" or "angles in a triangle sum to 180°". A correct number with no reason often scores only part of the marks.

TIP In a "construct" question the compass arcs are the evidence of method, so never rub them out. A correct final line with no arcs showing loses the construction marks even when the answer looks right.

4 Mensuration

KEY FORMULAS

Area of a Circle

$$A = \pi r^2$$

Use to find the area enclosed by a circle of radius r.

Area of a Parallelogram

$$A = bh$$

Use for the area of a parallelogram; b is a side and h is the perpendicular height to that side, not a slanted edge.

Area of a Rectangle

$$A = lw$$

Use for the area of any rectangle; multiply the length l by the width w.

Area of a Triangle

$$A = \frac{1}{2}bh$$

Use for the area of any triangle; b is the base and h is the perpendicular height to that base.

Circumference of a Circle

$$C = \pi d = 2\pi r$$

Use to find the distance around a circle from its diameter d or radius r.

Converting Between Area Units

$$1\text{m}^2 = 10{,}000\text{cm}^2$$

Use when converting an area between metric units. Because area has two length dimensions, the conversion factor is the *square* of the linear factor, for example $100^2 = 10{,}000$ between m^2 and cm^2.

Surface Area of a Cylinder

$$S = 2\pi r^2 + 2\pi rh$$

Use for the total surface area of a closed cylinder; two circular ends of area πr^2 each, plus the curved surface, which unrolls to a rectangle of width $2\pi r$ and height h.

Surface Area of a Sphere

$$S = 4\pi r^2$$

Use for the total surface area of a sphere of radius r.

Volume of a Cuboid

$V = lwh$

Use for the volume of any cuboid; the product of its length, width and height.

Volume of a Cylinder

$V = \pi r^2 h$

Use for the volume of any cylinder; the circular cross-section area πr^2 multiplied by the height h.

Volume of a Sphere

$V = \frac{4}{3}\pi r^3$

Use for the volume of a sphere of radius r.

KEY CONCEPTS

- **Building Compound Solids from Simple Parts**: A compound solid, such as a cone on a cylinder or a hemisphere on a cylinder, is analysed one solid at a time. Add the volumes of the parts for a total volume, and add the *external* surfaces only, not any internal joining face, for a total surface area.
- **Capacity and Volume Are the Same Measurement**: "Capacity" means the same as "volume" at this level, but is usually quoted in litres or millilitres rather than m^3 or cm^3. 1 litre $= 1000$ ml $= 1000$ cm^3.
- **Perpendicular Height**: The height h used in an area formula is always the *perpendicular* distance from the base to the opposite vertex or side, measured at a right angle. A slanted side is not the height unless it happens to meet the base at 90°.
- **Slant Height of a Cone**: A cone's slant height l is the distance from the apex to the edge of the base, measured along the sloped surface. It is found from the radius r and the perpendicular (vertical) height h by Pythagoras: $l = \sqrt{r^2 + h^2}$.
- **Splitting or Subtracting for Compound Shapes**: A compound (composite) shape is made of two or more standard shapes joined together, or a standard shape with a piece removed. Either split the shape into simpler rectangles, triangles or sectors and add their areas, or find the area of a surrounding standard shape and subtract the area of the missing piece.
- **The Length Conversion Ladder**: Each step between adjacent metric length units is a fixed multiplying factor: $\times 10$ between mm and cm, $\times 100$ between cm and m, and $\times 1000$ between m and km. Divide by the same factor to convert in the opposite direction.

EXAM TIPS

TIP If a question says "in terms of π", keep π as a symbol in the final answer, for example 16π cm. If it says "to 3 s.f." (or gives no instruction), substitute $\pi \approx 3.142$ and round the decimal answer.

TIP The cone surface area formula $S = \pi r^2 + \pi r l$ uses the *slant* height l, never the vertical height h. If a question gives h, compute $l = \sqrt{r^2 + h^2}$ first. The cone volume formula $V = \frac{1}{3}\pi r^2 h$ uses the *vertical* height h instead; mixing the two up is the most common mensuration error at this level.

TIP The perimeter of a compound shape is not simply the sum of the original shapes' perimeters. Walk around the actual outer boundary of the final figure, working out any side lengths that are not given directly; they are usually found by adding or subtracting the labelled sides.

5 Number

KEY FORMULAS

Average Speed

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

Used to calculate the average speed when distance and time are known. Rearrange to find distance ($\text{Distance} = \text{Speed} \times \text{Time}$) or time ($\text{Time} = \frac{\text{Distance}}{\text{Speed}}$).

Bounds from a Rounded Value

$$\text{Lower Bound} = x - \frac{d}{2}, \quad \text{Upper Bound} = x + \frac{d}{2}$$

Use when a value x has been rounded to a given degree of accuracy d (e.g. the nearest whole unit, or 1 decimal place). Halve the degree of accuracy and subtract for the lower bound, add for the upper bound.

Fraction of an Amount

$$\frac{a}{b} \text{ of } C = \frac{a}{b} \times C$$

Used to find a fraction of a given quantity. The word "of" means multiply.

Laws of Indices: Division

$$x^a \div x^b = x^{a-b}$$

Use when dividing two powers with the same base x. Subtract the index in the denominator from the index in the numerator.

Laws of Indices: Multiplication

$$x^a \times x^b = x^{a+b}$$

Use when multiplying two powers with the same base x. Add the indices and keep the base unchanged.

Percentage Change

$$\text{Percentage Change} = \frac{\text{New Value} - \text{Original Value}}{\text{Original Value}} \times 100$$

Used to calculate the percentage increase or decrease from an original value to a new value. A negative result means a decrease.

KEY CONCEPTS

- **Converting Between Fractions, Decimals, and Percentages**: To convert a fraction to a decimal, divide the numerator by the denominator. To convert a decimal to a percentage, multiply by 100. To convert a percentage to a fraction, write it over 100 and simplify.
- **Number Types**: Key number types are *integers* (positive or negative whole numbers), *primes* (divisible only by 1 and themselves), *square numbers* ($n \times n$), *cube numbers* ($n \times n \times n$), *factors*

(numbers that divide exactly into a given number), and *multiples* (numbers in a given number's times table).

- **Order of Operations**: Calculations follow a strict order: *Brackets*, *Indices*, *Division and Multiplication* (left to right), then *Addition and Subtraction* (left to right). Work through an expression in this order every time, never left to right alone.
- **Ratio and Proportion**: A *ratio* compares part to part (e.g. $2:3$), while a *proportion* compares a part to the whole. In *direct* proportion, as one quantity increases, the other increases at the same rate; in *inverse* proportion, as one increases, the other decreases.
- **Set Notation**: Key symbols: $\mathcal{E}$ is the universal set, $\cup$ means *union* ("or"), $\cap$ means *intersection* ("and"), A' is the *complement* of A ("not in A"), and $n(A)$ is the number of elements in set A.
- **Standard Form**: A way of writing very large or very small numbers as $A \times 10^n$, where $1 \leq A < 10$ and n is an integer. A positive n gives a large number; a negative n gives a small decimal.
- **The 24-Hour Clock**: The 24-hour clock runs from $00{:}00$ (midnight) to $23{:}59$, avoiding the need for am/pm. To convert a 12-hour pm time to 24-hour, add 12 to the hour (e.g. $2{:}45$ pm becomes $14{:}45$). Journey durations are found by counting on from the departure time to the arrival time.
- **The Four Operations with Fractions**: To add or subtract fractions, first write them over a common denominator, then add or subtract the numerators. To multiply fractions, multiply the numerators and multiply the denominators. To divide by a fraction, multiply by its reciprocal (flip the second fraction).
- **Zero, Negative, and Fractional Indices**: Any nonzero base raised to the power 0 equals 1, so $x^0 = 1$. A negative index gives a reciprocal: $x^{-a} = \frac{1}{x^a}$. A fractional index gives a root: $x^{\frac{1}{n}} = \sqrt[n]{x}$.

EXAM TIPS

TIP To share an amount in a ratio (e.g. 72 in the ratio $4:5$): add the parts ($4+5=9$), divide the total amount by the sum of the parts ($72 \div 9 = 8$), then multiply this value by each part of the ratio ($4 \times 8 = 32$ and $5 \times 8 = 40$).

TIP To find a percentage increase or decrease quickly, use a decimal multiplier. For a 20% increase, multiply by 1.20. For a 15% decrease, multiply by $1 - 0.15 = 0.85$.

TIP In a two-circle Venn diagram, the "only A" region excludes the overlap; the "neither" region lies outside both circles but inside $\mathcal{E}$. Always subtract the overlap once when reading a region that is not shared.

TIP Remember there are 60 minutes in an hour, not 100. Use your calculator's degrees/minutes/seconds button, or convert minutes to a fraction or decimal of an hour (e.g. 45 minutes $= 0.75$ hours), before mixing time with ordinary arithmetic.

6 Probability

KEY FORMULAS

Complement Rule

$$P(\text{not } E) = 1 - P(E)$$

Use to find the probability that an event does *not* happen. It is often the quickest route when the event is hard to count directly but its opposite is easy.

Expected Frequency

$$\text{Expected frequency} = n \times P$$

Use to predict how many times an event should occur in n trials, where P is the probability per trial. The result is the average expected count, not a guaranteed value.

Theoretical Probability of an Event

$$P(E) = \frac{\text{number of favourable outcomes}}{\text{total number of outcomes}}$$

Use when every outcome is equally likely. Count the outcomes that match event E over the total number of possible outcomes. Every probability lies between 0 (impossible) and 1 (certain).

KEY CONCEPTS

- **Sample Space Diagrams**: A sample space diagram lists every possible outcome of a combined experiment, such as a grid of the 36 ordered pairs for two dice. The probability of an event is the number of matching cells divided by the total number of cells.
- **The Probability Scale**: Every probability is a number from 0 to 1 inclusive. A value of 0 means the event is impossible, 1 means it is certain, and 0.5 means an even chance. A probability can never be negative or greater than 1, so a value outside $[0, 1]$ signals an arithmetic error.

EXAM TIPS

TIP Give a probability as a fraction, decimal, or percentage, never as a ratio or in words such as *1 in 5*. Leave a fraction in its simplest form unless the question asks for a decimal.

7 Statistics

KEY FORMULAS

Mean from a Frequency Table

$$\bar{x} = \frac{\sum fx}{\sum f}$$

Use when data is given in a frequency table. Multiply each value x by its frequency f and add the results to get $\sum fx$, then divide by $\sum f$, the total frequency.

Mean of a Data List

$$\bar{x} = \frac{\sum x}{n}$$

Use to find the mean (the arithmetic average) of a list of values. Add up all the values to get $\sum x$, then divide by n, the number of values.

Pie Chart Sector Angle

$$\text{angle} = \frac{f}{\text{total}} \times 360^\circ$$

Use to find the angle of a sector in a pie chart. Divide the frequency f of the category by the total frequency, then multiply by 360°. All the sector angles must add up to 360°.

Range of a Data Set

$$\text{Range} = \text{largest value} - \text{smallest value}$$

Use to measure the spread of the data. A large range means the values are widely spread; a small range means they are close together.

KEY CONCEPTS

- **Bar Charts and Pictograms**: A *bar chart* shows the frequency of each category using bars of equal width with gaps between them; the height of each bar gives its frequency. A *pictogram* uses a repeated symbol to represent a fixed number of items and must always include a key stating what one symbol represents.
- **Classifying Data**: Data is either *qualitative* (categories such as colour or nationality) or *quantitative* (numerical). Quantitative data is *discrete* if it can only take separate values, usually whole numbers found by counting (goals scored, number of siblings), or *continuous* if it is measured and can take any value in a range (height, mass, time).
- **Finding the Median**: The *median* is the middle value once the data is written in order from smallest to largest. For n values, when n is odd there is a single middle value; when n is even the median is the mean of the two middle values.
- **Scatter Diagrams and Correlation**: A *scatter diagram* plots paired data as points to show whether two quantities are related. *Positive correlation* means one quantity increases as the other increases; *negative correlation* means one decreases as the other increases; if the points show no pattern there is *no correlation*. The strength is described as strong when the points lie close to a line and weak when they are more scattered.
- **The Three Averages**: An *average* is a single value that represents the centre of a data set. The three averages are the *mean* (the total divided by how many values there are), the *median* (the middle value when the data is ordered), and the *mode* (the value that occurs most often). A data set can have more than one mode, or no mode at all.

EXAM TIPS

TIP Always rewrite the list in ascending order before reading off the median. The most common mistake is to take the middle of the *unordered* list. Ordering also makes the smallest and largest values easy to read for the range.

8 Transformations and vectors

KEY FORMULAS

Enlargement about the origin

$$(x, y) \mapsto (kx, ky)$$

Use to enlarge a point about the origin by scale factor k: multiply both coordinates by k. Every length is multiplied by k while all angles stay the same, so object and image are *similar*.

Reflection in the x-axis or y-axis

$$\text{in } x\text{-axis: } (x, y) \mapsto (x, -y); \quad \text{in } y\text{-axis: } (x, y) \mapsto (-x, y)$$

Use to reflect a point in a coordinate axis. Reflecting in the x-axis negates the y-coordinate; reflecting in the y-axis negates the x-coordinate. The shape keeps its size but its orientation is reversed.

Rotation about the origin

$$90^\circ \text{ clockwise: } (x, y) \mapsto (y, -x); \quad 180^\circ\text{: } (x, y) \mapsto (-x, -y); \quad 90^\circ \text{ anticlockwise: } (x, y) \mapsto (-y, x)$$

Use to rotate a point about the origin through a multiple of 90°. A 90° clockwise turn is the same as a 270° anticlockwise turn. Every length and angle is kept, so object and image are *congruent*.

Translation by a column vector

$$(x, y) \mapsto (x + a,\ y + b)$$

Use to translate a point by the column vector $\begin{pmatrix} a \\ b \end{pmatrix}$: add a to the x-coordinate and b to the y-coordinate. A translation slides every point the same distance in the same direction, so size and orientation are unchanged.

KEY CONCEPTS

- **Reading a column vector**: A *column vector* $\begin{pmatrix} a \\ b \end{pmatrix}$ describes a translation as "a across and b up". A negative top number means move left and a negative bottom number means move down. The top entry is always the horizontal step and the bottom entry the vertical step.
- **What a reflection is**: A *reflection* flips a shape across a mirror line so that the mirror is the *perpendicular bisector* of the segment joining each point to its image. Object and image are *congruent* (same shape and size) but the orientation is reversed, and any point already on the mirror line stays fixed.
- **What a rotation needs**: A *rotation* turns a shape about a fixed point called the *centre of rotation*. To specify one you need three things: the *centre*, the *angle* (usually a multiple of 90°), and the *direction* (clockwise or anticlockwise). The centre is the only point that stays fixed, and the image is congruent to the object.
- **What an enlargement does**: An *enlargement* changes the size of a shape by a *scale factor* k measured from a *centre of enlargement*. Each length is multiplied by k: if $k > 1$ the image is larger and if $0 < k < 1$ it is smaller. Angles are unchanged, so the image is *similar* to the object.

9 Trigonometry

KEY FORMULAS

Cosine Ratio (CAH)

$$\cos\theta = \frac{\text{Adjacent}}{\text{Hypotenuse}}$$

Use to link the angle θ with the side next to it (not the hypotenuse) and the hypotenuse.

Pythagoras' Theorem

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

Use in a right-angled triangle to find a missing side length from the other two; c is the hypotenuse (the longest side, opposite the right angle) and a, b are the two shorter sides.

Sine Ratio (SOH)

$$\sin\theta = \frac{\text{Opposite}}{\text{Hypotenuse}}$$

Use to link the angle θ with the side opposite it and the hypotenuse; find a missing side, or an angle using $\sin^{-1}$.

Tangent Ratio (TOA)

$$\tan\theta = \frac{\text{Opposite}}{\text{Adjacent}}$$

Use to link the angle θ with the opposite and adjacent sides when the hypotenuse is neither known nor wanted.

KEY CONCEPTS

- **Choosing Pythagoras or a Trig Ratio**: Use Pythagoras' theorem when only the three sides are involved and no angle is needed. Use a trig ratio (SOHCAHTOA) whenever an angle is involved, whether it is given or has to be found.
- **Identifying the Hypotenuse**: The hypotenuse is the longest side of a right-angled triangle and always lies opposite the right angle. Label it first, because both Pythagoras' theorem and the trig ratios depend on picking it out correctly.
- **Labelling Opposite, Adjacent and Hypotenuse**: Sides are named relative to the angle in use. The hypotenuse is opposite the right angle, the opposite side is across from the angle θ, and the adjacent side is the remaining side next to θ. Re-label if you switch to a different angle.

EXAM TIPS

TIP Set the calculator to degree (DEG) mode before any trigonometry. In radian or gradian mode every ratio and angle comes out wrong, and the error is easy to miss.

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Generated 2026/07/02