

## Glossary of command terms

### Command terms with definitions

Students should be familiar with the following key terms and phrases used in examination questions, which are to be understood as described below. Although these terms will be used in examination questions, other terms may be used to direct students to present an argument in a specific way.

<b>Calculate</b>	Obtain a numerical answer showing the relevant stages in the working.
<b>Comment</b>	Give a judgment based on a given statement or result of a calculation.
<b>Compare</b>	Give an account of the similarities between two (or more) items or situations, referring to both (all) of them throughout.
<b>Compare and contrast</b>	Give an account of the similarities and differences between two (or more) items or situations, referring to both (all) of them throughout.
<b>Construct</b>	Display information in a diagrammatic or logical form.
<b>Contrast</b>	Give an account of the differences between two (or more) items or situations, referring to both (all) of them throughout.
<b>Deduce</b>	Reach a conclusion from the information given.
<b>Demonstrate</b>	Make clear by reasoning or evidence, illustrating with examples or practical application.
<b>Describe</b>	Give a detailed account.
<b>Determine</b>	Obtain the only possible answer.
<b>Differentiate</b>	Obtain the derivative of a function.
<b>Distinguish</b>	Make clear the differences between two or more concepts or items.
<b>Draw</b>	Represent by means of a labelled, accurate diagram or graph, using a pencil. A ruler (straight edge) should be used for straight lines. Diagrams should be drawn to scale. Graphs should have points correctly plotted (if appropriate) and joined in a straight line or smooth curve.
<b>Estimate</b>	Obtain an approximate value.
<b>Explain</b>	Give a detailed account, including reasons or causes.
<b>Find</b>	Obtain an answer, showing relevant stages in the working.
<b>Hence</b>	Use the preceding work to obtain the required result.
<b>Hence or otherwise</b>	It is suggested that the preceding work is used, but other methods could also receive credit.
<b>Identify</b>	Provide an answer from a number of possibilities.

<b>Integrate</b>	Obtain the integral of a function.
<b>Interpret</b>	Use knowledge and understanding to recognize trends and draw conclusions from given information.
<b>Investigate</b>	Observe, study, or make a detailed and systematic examination, in order to establish facts and reach new conclusions.
<b>Justify</b>	Give valid reasons or evidence to support an answer or conclusion.
<b>Label</b>	Add labels to a diagram.
<b>List</b>	Give a sequence of brief answers with no explanation.
<b>Plot</b>	Mark the position of points on a diagram.
<b>Predict</b>	Give an expected result.
<b>Prove</b>	Use a sequence of logical steps to obtain the required result in a formal way.
<b>Show</b>	Give the steps in a calculation or derivation.
<b>Show that</b>	Obtain the required result (possibly using information given) without the formality of proof. “Show that” questions do not generally require the use of a calculator.
<b>Sketch</b>	Represent by means of a diagram or graph (labelled as appropriate). The sketch should give a general idea of the required shape or relationship, and should include relevant features.
<b>Solve</b>	Obtain the answer(s) using algebraic and/or numerical and/or graphical methods.
<b>State</b>	Give a specific name, value or other brief answer without explanation or calculation.
<b>Suggest</b>	Propose a solution, hypothesis or other possible answer.
<b>Verify</b>	Provide evidence that validates the result.
<b>Write down</b>	Obtain the answer(s), usually by extracting information. Little or no calculation is required. Working does not need to be shown.

# Notation list

Of the various notations in use, the IB has chosen to adopt a system of notation based on the recommendations of the International Organization for Standardization (ISO). This notation is used in the examination papers for this course without explanation. If forms of notation other than those listed in this guide are used on a particular examination paper, they are defined within the question in which they appear.

Because students are required to recognize, though not necessarily use, IB notation in examinations, it is recommended that teachers introduce students to this notation at the earliest opportunity. Students are **not** allowed access to information about this notation in the examinations.

Students must always use correct mathematical notation, not calculator notation.

$\mathbb{N}$	the set of positive integers and zero, $\{0, 1, 2, 3, \dots\}$
$\mathbb{Z}$	the set of integers, $\{0, \pm 1, \pm 2, \pm 3, \dots\}$
$\mathbb{Z}^+$	the set of positive integers, $\{1, 2, 3, \dots\}$
$\mathbb{Q}$	the set of rational numbers
$\mathbb{Q}^+$	the set of positive rational numbers, $\{x \mid x \in \mathbb{Q}, x > 0\}$
$\mathbb{R}$	the set of real numbers
$\mathbb{R}^+$	the set of positive real numbers, $\{x \mid x \in \mathbb{R}, x > 0\}$
$\mathbb{C}$	the set of complex numbers, $\{a + ib \mid a, b \in \mathbb{R}\}$
$i$	$\sqrt{-1}$
$z$	a complex number
$z^*$	the complex conjugate of $z$
$ z $	the modulus of $z$
$\arg z$	the argument of $z$
$\operatorname{Re} z$	the real part of $z$
$\operatorname{Im} z$	the imaginary part of $z$
$\operatorname{cis} \theta$	$\cos \theta + i \sin \theta$
$\{x_1, x_2, \dots\}$	the set with elements $x_1, x_2, \dots$
$n(A)$	the number of elements in the finite set $A$
$\{x \mid \}$	the set of all $x$ such that
$\in$	is an element of
$\notin$	is not an element of
$\emptyset$	the empty (null) set
$U$	the universal set
$\cup$	union

$\cap$	intersection
$\subset$	is a proper subset of
$\subseteq$	is a subset of
$A'$	the complement of the set $A$
$A \times B$	the Cartesian product of sets $A$ and $B$ (that is, $A \times B = \{(a, b) \mid a \in A, b \in B\}$ )
$a \mid b$	$a$ divides $b$
$a^{1/n}, \sqrt[n]{a}$	$a$ to the power of $\frac{1}{n}$ , $n^{\text{th}}$ root of $a$ (if $a \geq 0$ then $\sqrt[n]{a} \geq 0$ )
$ x $	the modulus or absolute value of $x$ , that is $\begin{cases} x & \text{for } x \geq 0, x \in \mathbb{R} \\ -x & \text{for } x < 0, x \in \mathbb{R} \end{cases}$
$\equiv$	identity
$\approx$	is approximately equal to
$>$	is greater than
$\geq$	is greater than or equal to
$<$	is less than
$\leq$	is less than or equal to
$\nlessgtr$	is not greater than
$\nlessgtr$	is not less than
$\Rightarrow$	implies
$\Leftarrow$	is implied by
$\Leftrightarrow$	implies and is implied by
$[a, b]$	the closed interval $a \leq x \leq b$
$]a, b[$	the open interval $a < x < b$
$u_n$	the $n^{\text{th}}$ term of a sequence or series
$d$	the common difference of an arithmetic sequence
$r$	the common ratio of a geometric sequence
$S_n$	the sum of the first $n$ terms of a sequence, $u_1 + u_2 + \dots + u_n$
$S_\infty$	the sum to infinity of a sequence, $u_1 + u_2 + \dots$
$\sum_{i=1}^n u_i$	$u_1 + u_2 + \dots + u_n$
$\prod_{i=1}^n u_i$	$u_1 \times u_2 \times \dots \times u_n$

$\binom{n}{r}$	$\frac{n!}{r!(n-r)!}$
$f: A \rightarrow B$	$f$ is a function under which each element of set $A$ has an image in set $B$
$f: x \mapsto y$	$f$ is a function under which $x$ is mapped to $y$
$f(x)$	the image of $x$ under the function $f$
$f^{-1}$	the inverse function of the function $f$
$f \circ g$	the composite function of $f$ and $g$
$\lim_{x \rightarrow a} f(x)$	the limit of $f(x)$ as $x$ tends to $a$
$\frac{dy}{dx}$	the derivative of $y$ with respect to $x$
$f'(x)$	the derivative of $f(x)$ with respect to $x$
$\frac{d^2y}{dx^2}$	the second derivative of $y$ with respect to $x$
$f''(x)$	the second derivative of $f(x)$ with respect to $x$
$\frac{d^n y}{dx^n}$	the $n^{\text{th}}$ derivative of $y$ with respect to $x$
$f^{(n)}(x)$	the $n^{\text{th}}$ derivative of $f(x)$ with respect to $x$
$\int y \, dx$	the indefinite integral of $y$ with respect to $x$
$\int_a^b y \, dx$	the definite integral of $y$ with respect to $x$ between the limits $x = a$ and $x = b$
$e^x$	the exponential function of $x$
$\log_a x$	the logarithm to the base $a$ of $x$
$\ln x$	the natural logarithm of $x$ , $\log_e x$
$\sin, \cos, \tan$	the circular functions
$\left. \begin{array}{l} \arcsin, \arccos, \\ \arctan \end{array} \right\}$	the inverse circular functions
$\csc, \sec, \cot$	the reciprocal circular functions
$A(x, y)$	the point $A$ in the plane with Cartesian coordinates $x$ and $y$
$[AB]$	the line segment with end points $A$ and $B$

$AB$	the length of $[AB]$
$(AB)$	the line containing points A and B
$\hat{A}$	the angle at A
$\hat{CAB}$	the angle between $[CA]$ and $[AB]$
$\triangle ABC$	the triangle whose vertices are A, B and C
$\mathbf{v}$	the vector $\mathbf{v}$
$\overrightarrow{AB}$	the vector represented in magnitude and direction by the directed line segment from A to B
$\mathbf{a}$	the position vector $\overrightarrow{OA}$
$\mathbf{i}, \mathbf{j}, \mathbf{k}$	unit vectors in the directions of the Cartesian coordinate axes
$ \mathbf{a} $	the magnitude of $\mathbf{a}$
$ \overrightarrow{AB} $	the magnitude of $\overrightarrow{AB}$
$\mathbf{v} \cdot \mathbf{w}$	the scalar product of $\mathbf{v}$ and $\mathbf{w}$
$\mathbf{v} \times \mathbf{w}$	the vector product of $\mathbf{v}$ and $\mathbf{w}$
$\mathbf{I}$	the identity matrix
$P(A)$	the probability of event $A$
$P(A')$	the probability of the event “not $A$ ”
$P(A B)$	the probability of the event $A$ given $B$
$x_1, x_2, \dots$	observations
$f_1, f_2, \dots$	frequencies with which the observations $x_1, x_2, \dots$ occur
$P_x$	the probability distribution function $P(X=x)$ of the discrete random variable $X$
$f(x)$	the probability density function of the continuous random variable $X$
$F(x)$	the cumulative distribution function of the continuous random variable $X$
$E(X)$	the expected value of the random variable $X$
$\text{Var}(X)$	the variance of the random variable $X$
$\mu$	population mean
$\sigma^2$	population variance, $\sigma^2 = \frac{\sum_{i=1}^k f_i(x_i - \mu)^2}{n}$ , where $n = \sum_{i=1}^k f_i$
$\sigma$	population standard deviation

$\bar{x}$	sample mean
$s_n^2$	sample variance, $s_n^2 = \frac{\sum_{i=1}^k f_i(x_i - \bar{x})^2}{n}$ , where $n = \sum_{i=1}^k f_i$
$s_n$	standard deviation of the sample
$s_{n-1}^2$	unbiased estimate of the population variance, $s_{n-1}^2 = \frac{n}{n-1} s_n^2 = \frac{\sum_{i=1}^k f_i(x_i - \bar{x})^2}{n-1}$ , where $n = \sum_{i=1}^k f_i$
$B(n, p)$	binomial distribution with parameters $n$ and $p$
$Po(m)$	Poisson distribution with mean $m$
$N(\mu, \sigma^2)$	normal distribution with mean $\mu$ and variance $\sigma^2$
$X \sim B(n, p)$	the random variable $X$ has a binomial distribution with parameters $n$ and $p$
$X \sim Po(m)$	the random variable $X$ has a Poisson distribution with mean $m$
$X \sim N(\mu, \sigma^2)$	the random variable $X$ has a normal distribution with mean $\mu$ and variance $\sigma^2$
$\Phi$	cumulative distribution function of the standardized normal variable with distribution $N(0, 1)$
$\nu$	number of degrees of freedom
$A \setminus B$	the difference of the sets $A$ and $B$ (that is, $A \setminus B = A \cap B' = \{x \mid x \in A \text{ and } x \notin B\}$ )
$A \Delta B$	the symmetric difference of the sets $A$ and $B$ (that is, $A \Delta B = (A \setminus B) \cup (B \setminus A)$ )
$K_n$	a complete graph with $n$ vertices
$K_{n,m}$	a complete bipartite graph with one set of $n$ vertices and another set of $m$ vertices
$\mathbb{Z}_p$	the set of equivalence classes $\{0, 1, 2, \dots, p-1\}$ of integers modulo $p$
$\gcd(a, b)$	the greatest common divisor of integers $a$ and $b$
$\text{lcm}(a, b)$	the least common multiple of integers $a$ and $b$
$A_G$	the adjacency matrix of graph $G$
$C_G$	the cost adjacency matrix of graph $G$