UNIVERSITY of CAMBRIDGE
International Examinations

Cambridge
IGCSE

SYLLABUS

Cambridge IGCSE®
Additional Mathematics (US)

0459

For examination in June and November 2014

This syllabus is available only to Centers taking part in the Board Examination Systems (BES) Pilot.

If you have any questions about this syllabus, please contact Cambridge at international@cie.org.uk quoting syllabus code 0459.

Note

Administration materials appear in UK English and are standard for all our international customers. Please read the *Cambridge Glossary* alongside this syllabus. This is available from our website.

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1. Introduction

1.1 Why Choose Cambridge?

University of Cambridge International Examinations is the world's largest provider of international education programs and qualifications for 5 to 19 year olds. We are part of the University of Cambridge, trusted for excellence in education. Our qualifications are recognized by the world's universities and employers.

Recognition

Every year, hundreds of thousands of learners gain the Cambridge qualifications they need to enter the world's universities.

Cambridge IGCSE® (International General Certificate of Secondary Education) is internationally recognized by schools, universities, and employers as equivalent to UK GCSE. Learn more at **www.cie.org.uk/recognition**

Excellence in Education

We understand education. We work with over 9,000 schools in over 160 countries that offer our programs and qualifications. Understanding learners' needs around the world means listening carefully to our community of schools, and we are pleased that 98% of Cambridge schools say they would recommend us to other schools.

Our mission is to provide excellence in education, and our vision is that Cambridge learners become confident, responsible, innovative, and engaged.

Cambridge programs and qualifications help Cambridge learners to become:

- **confident** in working with information and ideas—their own and those of others
- **responsible** for themselves, responsive to and respectful of others
- **innovative** and equipped for new and future challenges
- **engaged** intellectually and socially, ready to make a difference.

Support in the Classroom

We provide a world-class support service for Cambridge teachers and exams officers. We offer a wide range of teacher materials to Cambridge schools, plus teacher training (online and face-to-face), expert advice, and learner support materials. Exams officers can trust in reliable, efficient administration of exams entry and excellent, personal support from our customer services. Learn more at **www.cie.org.uk/teachers**

Nonprofit, Part of the University of Cambridge

We are a part of Cambridge Assessment, a department of the University of Cambridge and a nonprofit organization.

We invest constantly in research and development to improve our programs and qualifications.

1.2 Why Choose Cambridge IGCSE?

Cambridge IGCSE helps your school improve learners' performance. Learners develop not only knowledge and understanding, but also skills in creative thinking, inquiry, and problem solving, helping them perform well and prepare for the next stage of their education.

Cambridge IGCSE is the world's most popular international curriculum for 14 to 16 year olds, leading to globally recognized and valued Cambridge IGCSE qualifications. It is part of the Cambridge Secondary 2 stage.

Schools worldwide have helped develop Cambridge IGCSE, which provides an excellent preparation for Cambridge International AS and A Levels, Cambridge Pre-U, Cambridge AICE (Advanced International Certificate of Education), and other education programs, such as the US Advanced Placement Program and the International Baccalaureate Diploma. Cambridge IGCSE incorporates the best in international education for learners at this level. It develops in line with changing needs, and we update and extend it regularly.

1.3 Why Choose Cambridge IGCSE Additional Mathematics?

Cambridge IGCSE Additional Mathematics is accepted by universities and employers as proof of essential mathematical knowledge and ability.

The Additional Mathematics syllabus builds on the skills and knowledge developed in the Cambridge IGCSE Mathematics (US) (0444) syllabus.

Successful Cambridge IGCSE Additional Mathematics candidates gain lifelong skills, including:

- the further development of mathematical concepts and principles
- the extension of mathematical skills and their use in more advanced techniques
- an ability to solve problems, present solutions logically, and interpret results
- a solid foundation for further study.

1.4 Cambridge International Certificate of Education (ICE)

Cambridge ICE is the group award of Cambridge IGCSE. It gives schools the opportunity to benefit from offering a broad and balanced curriculum by recognizing the achievements of learners who pass examinations in at least seven subjects. Learners take subjects from five subject groups, including two languages, and one subject from each of the other subject groups. The seventh subject can be taken from any of the five subject groups.

Additional Mathematics (0459) falls into Group IV, Mathematics.

Learn more about Cambridge IGCSE and Cambridge ICE at **www.cie.org.uk/cambridgesecondary2**

1.5 How Can I Find Out More?

If You Are Already a Cambridge School

You can make entries for this qualification through your usual channels. If you have any questions, please contact us at **international@cie.org.uk**

If You Are Not Yet a Cambridge School

Learn about the benefits of becoming a Cambridge school at **www.cie.org.uk/startcambridge**.
Email us at **international@cie.org.uk** to find out how your organization can become a Cambridge school.

2. Assessment at a Glance

This qualification is assessed via two components: Paper 1 and Paper 2.

Component	Weighting	Raw score	Nature of assessment
1 Written paper **2 hours** 9–14 questions of various lengths. No choice of question.	50%	80	External
2 Written paper **2 hours** 9–14 questions of various lengths. No choice of question.	50%	80	External

Grades A* to E will be available for candidates who achieve the required standards. Since there is no Core Curriculum for this syllabus, Grades F and G will not be available. Therefore, candidates who do not achieve the minimum mark for Grade E will be unclassified.

Calculators

The syllabus assumes that candidates will be in possession of an electronic calculator with scientific functions for both papers. Algebraic or graphic calculators are **not** permitted.

Non-exact numerical answers will be required to be given correct to three significant figures, or one decimal place in the case of angles in degrees, unless a different level of accuracy is specified in the question.

List of Formulas

The mathematical formulas and tables provided in the List of Formulas and Statistical Tables (MF25) is given in the appendix.

Availability

This syllabus is examined in the May/June examination series and the October/November examination series.

Combining This with Other Syllabi

Candidates can combine this syllabus in an examination series with any other Cambridge syllabus, except:

- syllabi with the same title at the same level
- 4037 Cambridge O Level Additional Mathematics
- 0606 Cambridge IGCSE Additional Mathematics

Candidates who follow the Extended Curriculum of the Cambridge IGCSE Mathematics (US) (0444) and the Cambridge IGCSE Additional Mathematics (US) (0459) syllabus content will cover the Common Core State Standards for Mathematics (CCSSM) for Grades 9–12.

3. Syllabus Goals and Objectives

3.1 Goals

The goals of the syllabus listed below are not in order of priority.

The goals are to enable candidates to:

- consolidate and extend their elementary mathematical skills, and use these in the context of more advanced techniques
- further develop their knowledge of mathematical concepts and principles, and use this knowledge for problem solving
- appreciate the interconnectedness of mathematical knowledge
- acquire a suitable foundation in mathematics for further study in the subject or in mathematics-related subjects
- devise mathematical arguments and use and present them precisely and logically
- integrate information technology (IT) to enhance the mathematical experience
- develop the confidence to apply their mathematical skills and knowledge in appropriate situations
- develop creativity and perseverance in the approach to problem solving
- derive enjoyment and satisfaction from engaging in mathematical pursuits, and gain an appreciation of the beauty, power, and usefulness of mathematics.

3.2 Assessment Objectives

The examination will test the ability of candidates to:

- recall and use manipulative techniques
- interpret and use mathematical data, symbols, and terminology
- comprehend numerical, algebraic, and spatial concepts and relationships
- recognize the appropriate mathematical procedure for a given situation
- formulate problems into mathematical terms and select and apply appropriate techniques of solution.

Any of the above objectives can be assessed in any question in Components 1 and 2.

4. Curriculum Content

Candidates are expected to have followed the Extended Curriculum of the Cambridge IGCSE Mathematics (US) (0444).

Grades A* to E are available.

Proofs of standard results will not be required unless specifically mentioned below.

Candidates will be expected to be familiar with the scientific notation for the expression of compound units, e.g., 5 m s^{-1} for 5 meters per second.

1	Number	Notes/Exemplars
Complex Numbers		
1.1	Understand the idea of a complex number, recall the meaning of the terms real part, imaginary part, modulus, argument, conjugate, and use the fact that two complex numbers are equal if and only if both real and imaginary parts are equal.	Know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + ib$ with a and b real.
1.2	Use the relation $i^2 = -1$ and the commutative, associative, and distributive properties to add, subtract, multiply, and divide two complex numbers expressed in the form $x + iy$.	
1.3	Find the conjugate of a complex number; use conjugates to find moduli and quotients of complex numbers.	
1.4	Represent complex numbers geometrically in the complex plane in rectangular and polar form, and convert between the rectangular and polar forms of a complex number.	
1.5	Understand in simple terms the geometrical effects of conjugating a complex number and of adding, subtracting, and multiplying two complex numbers, and use properties of this representation.	e.g., $(-1 + \sqrt{3}i)^3 = 8$ because $(-1 + \sqrt{3}i)$ has modulus 2 and argument 120°
1.6	Calculate the distance between numbers represented in the complex plane and the midpoint of a line segment.	
1.7	Solve quadratic equations with real coefficients that have complex solutions.	
1.8	Extend polynomial identities to the complex numbers.	e.g., rewrite $x^2 + 4$ as $(x + 2i)(x - 2i)$

Indices and Radicals		
1.9	Perform simple operations with indices and with surds, including rationalizing the denominator.	
Matrices		
1.10	Display information in the form of a matrix of any order and interpret the data in a given matrix.	
1.11	Solve problems involving the calculation of the sum and product (where appropriate) of two matrices and interpret the results.	Understand that, unlike multiplication of numbers, matrix multiplication for square matrices is not a commutative operation, but still satisfies the associative and distributive properties.
1.12	Calculate the product of a scalar quantity and a matrix.	
1.13	Use the algebra of 2×2 matrices (including the zero and identity matrix).	
1.14	Calculate the determinant and inverse of a non-singular 2×2 matrix and solve simultaneous linear equations.	The determinant of a square matrix is non-zero if, and only if, the matrix has a multiplicative inverse.
1.15	Work with 2×2 matrices as transformations of the plane, and interpret the absolute value of the determinant in terms of area.	
2	**Algebra**	**Notes/Exemplars**
Factors, Polynomials, and Rational Expressions		
2.1	Know and use the remainder and factor theorems to find factors of polynomials and solve cubic equations.	
2.2	Identify zeros of polynomials when suitable factorizations are available, use the zeros to construct a rough graph of the function defined by the polynomial, and know the Fundamental Theorem of Algebra.	
2.3	Express simple rational expressions in different forms including writing $\frac{a(x)}{b(x)}$ in the form $q(x) + \frac{r(x)}{b(x)}$, where $a(x)$, $b(x)$, $q(x)$, and $r(x)$ are polynomials with the degree of $r(x)$ less than the degree of $b(x)$, by using inspection or long division and prove polynomial identities.	

2.4	Add, subtract, multiply, and divide polynomial and rational expressions.	Understand that polynomials and rational expressions form a system analogous to the integers, namely, they are closed under the operation of addition, subtraction, and multiplication; add, subtract, and multiply polynomials and rational expressions.
Simultaneous Equations		
2.5	Solve simultaneous equations in two unknowns with at least one linear equation.	e.g., find the points of intersection between the line $y = -3x$ and the circle $x^2 + y^2 = 3$
3	**Functions**	**Notes/Exemplars**
Functions		
3.1	Understand the terms: function, domain, range (image set), one-one function, inverse function and composition of functions.	
3.2	Use the notation $f(x) = \sin x$, $f: x \mapsto \lg x$, $(x > 0)$, $f^{-1}(x)$ and $f^2(x)$ [$= f(f(x))$].	
3.3	Understand the relationship between $y = f(x)$ and $y = \|f(x)\|$, where $f(x)$ may be linear, quadratic, or trigonometric.	
3.4	Explain in words why a given function is a function or why it does not have an inverse and produce an invertible function from a non-invertible function by restricting the domain.	e.g., understand that restricting a trigonometric function to a domain on which it is always increasing or always decreasing allows its inverse to be constructed
3.5	Find the inverse of a one-one function and form composite functions, including verifying by composition that one function is the inverse of another.	
3.6	Use sketch graphs to show the relationship between a function and its inverse.	
3.7	Graph functions and show key features of the graph, including understanding points of intersection.	To include linear, quadratic, square root, cube root, and piecewise-defined functions, including step functions and absolute value functions. Graph polynomial functions, identifying zeros when suitable factorizations are available, and showing end behavior. Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. Graph exponential and logarithmic functions, showing intercepts and end behavior, and trigonometric functions, showing period, midline, and amplitude.

3.8	Recognize even and odd functions from their graphs and algebraic expressions.	
3.9	Construct a function that describes a relationship between two quantities, including determining an explicit expression or a recursive relation, together with constant multiples, sums, and composites of functions.	e.g., • construct a function that models the temperature of a cooling body by adding a constant function to a decaying exponential, and relate these functions to the model • if T(h) is the temperature in the atmosphere as a function of height, and h(t) is the height of a weather balloon as a function of time, then T(h(t)) is the temperature at the location of the weather balloon as a function of time
3.10	Recognize that sequences are functions, which may be defined recursively and whose domain is a subset of the integers.	e.g., the Fibonacci sequence is defined recursively by $f(0) = f(1) = 1$, $f(n + 1) = f(n) + f(n - 1)$ for $n \geqslant 1$
Logarithmic and Exponential Functions		
3.11	Understand and know simple properties and graphs of the logarithmic and exponential functions including $\ln x$ and e^x (series expansions are not required) including interpreting the parameters in a linear or exponential function in terms of a context.	
3.12	Know and use the laws of logarithms (including change of base of logarithms).	Simplify expressions and solve simple equations involving logarithms.
3.13	Solve equations of the form $a^x = b$, including use of logarithms to base 2, 10, or e.	e.g., • solve $5^x = 7$ • solve $2e^{3t} = 12$
3.14	Distinguish between situations that can be modeled with linear functions and with exponential functions.	
4	**Geometry**	**Notes/Exemplars**
4.1	Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if, and only if, corresponding pairs of sides and corresponding pairs of angles are congruent.	
4.2	Explain how the criteria for triangle congruence (ASA, SAS, and SSS) follow from the definition of congruence in terms of rigid motion.	

4.3	Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.	Candidates will be expected to know and use the following theorems in their proofs: Lines and angles: vertical angles are congruent; when a transversal crosses parallel lines, alternate interior angles are congruent and corresponding angles are congruent; points on a perpendicular bisector of a line segment are exactly those equidistant from the segment's endpoints. Triangles: measure of interior angles of a triangle sum to 180°; base angles of isosceles triangles are congruent; the segments joining midpoints of two sides of a triangle is parallel to the third side and half the length; the medians of a triangle meet at a point; a line parallel to one side of a triangle divides the other two proportionally, and conversely; the Pythagorean Theorem proved using triangle similarity. Parallelograms: opposite sides are congruent; opposite angles are congruent; the diagonals of a parallelogram bisect each other and conversely, rectangles are parallelograms with congruent diagonals.
5	**Transformations and Vectors**	**Notes/Exemplars**
5.1	Use vectors in any form, e.g. $\begin{pmatrix} x \\ y \end{pmatrix}$, $\overrightarrow{AB}$, $\mathbf{a}$, $x\mathbf{i} + y\mathbf{j}$.	
5.2	Know and use position vectors and unit vectors.	
5.3	Find the magnitude and direction of a vector, add and subtract vectors and multiply vectors by scalars; determine the magnitude and direction of the sum of two vectors.	
5.4	Compose and resolve velocities.	
5.5	Solve problems involving velocity and other quantities that can be represented by vectors and use relative velocity, including solving problems on interception (but not closest approach).	

6	Coordinate Geometry	Notes/Exemplars
Coordinate Geometry		
6.1	Interpret the equation of a straight line graph in the form $y = mx + c$.	
6.2	Use slope criteria for parallel and perpendicular lines to solve geometric problems with justification.	
6.3	Solve questions involving midpoint and length of a line.	e.g., to find the equation of a circle given the endpoints of the diameter
6.4	Use coordinates to prove simple geometric properties algebraically.	e.g., • determine whether a figure defined by four given points in the coordinate plane is a rectangle • determine whether the point $(1, \sqrt{3})$ lies on the circle which is centered at the origin and passes through the point (0, 2)
6.5	Derive the equation of a circle given center and radius using the Pythagorean Theorem; complete the square to find the center and radius of a circle given by an equation.	
6.6	Derive the equation of a parabola given a focus and directrix.	
6.7	Derive the equations of ellipses and hyperbolas given the foci, using the fact that the sum or difference of distances from the foci is constant.	

7	Trigonometry	Notes/Exemplars
7.1	Solve problems involving the arc length and sector area of a circle, including knowledge and use of radian measure.	Derive, using similarity, the fact that the length of the arc intercepted by an angle is proportional to the radius, and define the radian measure of the angle as the constant of proportionality; derive the formula for the area of a sector.
7.2	Know and use the three trigonometric functions of angles of any magnitude (sine, cosine, tangent).	
7.3	Determine geometrically the values of sine, cosine, tangent for $\frac{\pi}{3}$ and $\frac{\pi}{4}$, and $\frac{\pi}{6}$ express the values of sine, cosine, and tangent for $\pi - x$, $\pi + x$, and $2\pi - x$ in terms of their values for x, where x is any real number.	
7.4	Understand the symmetry (odd and even) and periodicity of trigonometric functions.	

7.5	Understand amplitude and periodicity and the relationship between graphs of, e.g., sin x and sin $2x$.	
7.6	Draw and use the graphs of $y = a \sin bx + c$ $y = a \cos bx + c$ $y = a \tan bx + c$ where a and b are positive integers and c is an integer.	
7.7	Choose trigonometric functions to model periodic phenomena with specified amplitude, frequency, and midline.	
7.8	Prove and use the relationships $\frac{\sin\theta}{\cos\theta} = \tan\theta$ $\sin^2\theta + \cos^2\theta = 1$ and solve simple trigonometric equations involving the three trigonometric functions and the above relationships (not including general solution of trigonometric equations).	Includes the use of inverse trigonometric functions. May use inverse functions to solve trigonometric equations that arise in modeling contexts.
7.9	Prove and use the expansions of sin ($A \pm B$), cos ($A \pm B$), and tan ($A \pm B$) to solve simple trigonometric problems.	
7.10	Prove simple trigonometric identities.	
8	**Probability**	**Notes/Exemplars**
8.1	Understand and use the conditional probability of A given B as $\frac{P(A \text{ and } B)}{P(B)}$ or as the fraction of B's outcomes that also belong to A; interpret independence of A and B in relation to conditional probabilities and the product of probabilities.	e.g., compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer
8.2	Apply $P(A \text{ and } B) = P(A)P(B\|A) = P(B)P(A\|B)$ in simple situations, and interpret the answer in context.	
8.3	Use permutations and combinations to compute probabilities of compound events and solve problems.	
8.4	Define a random variable X by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions; and calculate $E(X)$ and $Var(X)$.	

8.5	Investigate the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values. Find the expected payoff for a game of chance. Evaluate and compare strategies on the basis of expected values.	e.g., • find the expected winnings from a state lottery ticket • compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident
8.6	Analyze decisions and strategies using probability concepts.	e.g., product testing, medical testing, pulling a hockey goalie at the end of a game
9	**Statistics**	**Notes/Exemplars**
9.1	Understand the concept of sampling and recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.	
9.2	Use data from a sample survey to estimate a population mean or proportion; use data to compare two variables.	
9.3	Interpret differences in shape, center, and spread in the context of data sets, accounting for possible effects of outliers.	
9.4	Use standardized values and normal tables for normally distributed continuous data in determining probabilities as areas under the normal curve.	
9.5	Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate.	
9.6	Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.	
9.7	Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities.	

9.8	Represent data on two quantitative variables on a scatter plot, and describe how the variables are related. • Fit a function to the data; use functions (e.g., linear, quadratic, exponential) fitted to data to solve problems in the context of the data • Informally assess the fit of a function by plotting and analyzing residuals • Fit a linear function for a scatter plot that suggests a linear association • Fit a function to the data; use functions fitted to data to solve problems in the context of the data • Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data	
9.9	Interpret the correlation coefficient of a linear fit and distinguish between correlation and causation.	

5. Additional Information

5.1 Guided Learning Hours

Cambridge IGCSE syllabi are designed with the assumption that candidates have about 130 guided learning hours per subject over the duration of the course. ("Guided learning hours" include direct teaching and any other supervised or directed study time. They do not include private study by the candidate.)

However, this figure is for guidance only, and the number of hours required may vary according to local curricular practice and the candidates' prior experience with the subject.

5.2 Recommended Prerequisites

We recommend that candidates who are beginning this course should be currently studying or have previously studied Cambridge IGCSE or Cambridge O Level Mathematics.

5.3 Progression

Cambridge IGCSE Certificates are general qualifications that enable candidates to progress either directly to employment, or to proceed to further qualifications.

Candidates who are awarded grades C to A* in Cambridge IGCSE Additional Mathematics are well prepared to follow courses leading to Cambridge International AS and A Level Mathematics or the equivalent.

5.4 Component Codes

Because of local variations, in some cases component codes will be different in instructions about making entries for examinations and timetables from those printed in this syllabus, but the component names will be unchanged to make identification straightforward.

5.5 Grading and Reporting

Cambridge IGCSE results are shown by one of the grades A*, A, B, C, D, or E, indicating the standard achieved, Grade A* being the highest and Grade E the lowest. "Ungraded" indicates that the candidate's performance fell short of the standard required for Grade E. "Ungraded" will be reported on the statement of results but not on the certificate.

5.6 Access

Reasonable adjustments are made for disabled candidates in order to enable them to access the assessments and to demonstrate what they know and what they can do. For this reason, very few candidates will have a complete barrier to the assessment. Information on reasonable adjustments is found in the *Cambridge Handbook*, which can be downloaded from the website **www.cie.org.uk**

Candidates who are unable to access part of the assessment, even after exploring all possibilities through reasonable adjustments, may still be able to receive an award based on the parts of the assessment they have taken.

5.7 Support and Resources

Copies of syllabi, the most recent question papers, and Principal Examiners' reports for teachers are on the Syllabus and Support Materials CD-ROM, which we send to all Cambridge International Schools. They are also on our public website—go to **www.cie.org.uk/igcse**. Click the **Subjects** tab and choose your subject. For resources, click "Resource List."

You can use the "Filter by" list to show all resources or only resources categorized as "Endorsed by Cambridge." Endorsed resources are written to align closely with the syllabus they support. They have been through a detailed quality-assurance process. As new resources are published, we review them against the syllabus and publish their details on the relevant resource list section of the website.

Additional syllabus-specific support is available from our secure Teacher Support website **http://teachers.cie.org.uk**, which is available to teachers at registered Cambridge schools. It provides past question papers and examiner reports on previous examinations, as well as any extra resources such as schemes of work (unit lesson plans) or examples of candidate responses. You can also find a range of subject communities on the Teacher Support website, where Cambridge teachers can share their own materials and join discussion groups.

6. Appendix

6.1 List of Formulas and Statistical Tables for Components 1 and 2

ALGEBRA

Quadratic Equation

For the equation $ax^2 + bx + c = 0$,

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

TRIGONOMETRY

Identities

$$\sin^2 A + \cos^2 A = 1$$

$$\sin(A \pm B) = \sin A \cos B \pm \cos A \sin B$$

$$\cos(A \pm B) = \cos A \cos B \mp \sin A \sin B$$

$$\tan(A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

Formulas for ΔABC

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

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

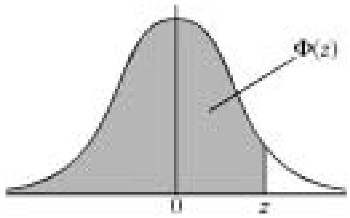
$$\Delta = \frac{1}{2} ab \sin C$$

THE NORMAL DISTRIBUTION FUNCTION

If Z has a normal distribution with mean 0 and variance 1 then, for each value of z, the table gives the value of $\Phi(z)$, where

$$\Phi(z) = \mathrm{P}(Z \le z).$$

For negative values of z use $\Phi(-z) = 1 - \Phi(z)$.



z	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5 ADD	6	7	8	9
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359	4	8	12	16	20	24	28	32	36
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753	4	8	12	16	20	24	28	32	36
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141	4	8	12	15	19	23	27	31	35
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517	4	7	11	15	19	22	26	30	34
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879	4	7	11	14	18	22	25	29	32
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224	3	7	10	14	17	20	24	27	31
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549	3	7	10	13	16	19	23	26	29
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852	3	6	9	12	15	18	21	24	27
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133	3	5	8	11	14	16	19	22	25
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389	3	5	8	10	13	15	18	20	23
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621	2	5	7	9	12	14	16	19	21
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830	2	4	6	8	10	12	14	16	18
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015	2	4	6	7	9	11	13	15	17
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177	2	3	5	6	8	10	11	13	14
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319	1	3	4	6	7	8	10	11	13
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441	1	2	4	5	6	7	8	10	11
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545	1	2	3	4	5	6	7	8	9
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633	1	2	3	4	4	5	6	7	8
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706	1	1	2	3	4	4	5	6	6
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767	1	1	2	2	3	4	4	5	5
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817	0	1	1	2	2	3	3	4	4
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857	0	1	1	2	2	2	3	3	4
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890	0	1	1	1	2	2	2	3	3
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916	0	1	1	1	1	2	2	2	2
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936	0	0	1	1	1	1	1	2	2
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952	0	0	0	1	1	1	1	1	1
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964	0	0	0	0	1	1	1	1	1
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974	0	0	0	0	0	1	1	1	1
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981	0	0	0	0	0	0	0	1	1
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986	0	0	0	0	0	0	0	0	0

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