



i

2

=

?

1

$$i^2 = -1$$

; every complex number can be expressed in the form

a

+

b

i

$$a + bi$$

, where a and b are real numbers. Because no real number satisfies the above equation, i was called an imaginary number by René Descartes. For the complex number

a

+

b

i

$$a + bi$$

, a is called the real part, and b is called the imaginary part. The set of complex numbers is denoted by either of the symbols

C

$$\mathbb{C}$$

or  $\mathbb{C}$ . Despite the historical nomenclature, "imaginary" complex numbers have a mathematical existence as firm as that of the real numbers, and they are fundamental tools in the scientific description of the natural world.

Complex numbers allow solutions to all polynomial equations, even those that have no solutions in real numbers. More precisely, the fundamental theorem of algebra asserts that every non-constant polynomial equation with real or complex coefficients has a solution which is a complex number. For example, the equation

(

x

+

1

)

2

=

?

9

$$\{\displaystyle (x+1)^{2}=-9\}$$

has no real solution, because the square of a real number cannot be negative, but has the two nonreal complex solutions

?

1

+

3

i

$$\{\displaystyle -1+3i\}$$

and

?

1

?

3

i

$$\{\displaystyle -1-3i\}$$

.

Addition, subtraction and multiplication of complex numbers can be naturally defined by using the rule

i

2

=

?

1

$${\displaystyle i^{\{2\}}=-1}$$

along with the associative, commutative, and distributive laws. Every nonzero complex number has a multiplicative inverse. This makes the complex numbers a field with the real numbers as a subfield. Because of these properties, ?

a

+

b

i

=

a

+

i

b

$${\displaystyle a+bi=a+ib}$$

?, and which form is written depends upon convention and style considerations.

The complex numbers also form a real vector space of dimension two, with

{

1

,

i

}

$${\displaystyle \{1,i\}}$$

as a standard basis. This standard basis makes the complex numbers a Cartesian plane, called the complex plane. This allows a geometric interpretation of the complex numbers and their operations, and conversely some geometric objects and operations can be expressed in terms of complex numbers. For example, the real numbers form the real line, which is pictured as the horizontal axis of the complex plane, while real multiples of

i

$${\displaystyle i}$$

are the vertical axis. A complex number can also be defined by its geometric polar coordinates: the radius is called the absolute value of the complex number, while the angle from the positive real axis is called the

argument of the complex number. The complex numbers of absolute value one form the unit circle. Adding a fixed complex number to all complex numbers defines a translation in the complex plane, and multiplying by a fixed complex number is a similarity centered at the origin (dilating by the absolute value, and rotating by the argument). The operation of complex conjugation is the reflection symmetry with respect to the real axis.

The complex numbers form a rich structure that is simultaneously an algebraically closed field, a commutative algebra over the reals, and a Euclidean vector space of dimension two.

Cardinality of the continuum

$\aleph_0 = \frac{c}{n}$  where  $n$  is any finite cardinal  $\neq 0$  and  $c = 2^c \times 0 = 2^c$

In set theory, the cardinality of the continuum is the cardinality or "size" of the set of real numbers

$\mathbb{R}$

$\mathbb{R}$

, sometimes called the continuum. It is an infinite cardinal number and is denoted by

$c$

$\mathbf{\frac{c}{}}$

(lowercase Fraktur "c") or

|

$\mathbb{R}$

|

.

$\mathbf{\{|\}}\mathbf{\{\mathbb{R}\}}\mathbf{\{|\}}.$

The real numbers

$\mathbb{R}$

$\mathbb{R}$

are more numerous than the natural numbers

$\mathbb{N}$

$\mathbb{N}$

. Moreover,

$\mathbb{R}$

$\mathbb{R}$

has the same number of elements as the power set of

N

$\{\displaystyle \mathbb{N}\}$

. Symbolically, if the cardinality of

N

$\{\displaystyle \mathbb{N}\}$

is denoted as

?

0

$\{\displaystyle \aleph _{0}\}$

, the cardinality of the continuum is

This was proven by Georg Cantor in his uncountability proof of 1874, part of his groundbreaking study of different infinities. The inequality was later stated more simply in his diagonal argument in 1891. Cantor defined cardinality in terms of bijective functions: two sets have the same cardinality if, and only if, there exists a bijective function between them.

Between any two real numbers  $a < b$ , no matter how close they are to each other, there are always infinitely many other real numbers, and Cantor showed that they are as many as those contained in the whole set of real numbers. In other words, the open interval  $(a,b)$  is equinumerous with

R

$\{\displaystyle \mathbb{R}\}$

, as well as with several other infinite sets, such as any n-dimensional Euclidean space

R

n

$\{\displaystyle \mathbb{R} ^{n}\}$

(see space filling curve). That is,

The smallest infinite cardinal number is

?

0

$\{\displaystyle \aleph _{0}\}$

(aleph-null). The second smallest is

?

1

$\aleph_1$

(aleph-one). The continuum hypothesis, which asserts that there are no sets whose cardinality is strictly between

?

0

$\aleph_0$

and

c

$\frac{c}{}$

, means that

c

=

?

1

$\frac{c}{}=\aleph_1$

. The truth or falsity of this hypothesis is undecidable and cannot be proven within the widely used Zermelo–Fraenkel set theory with axiom of choice (ZFC).

Unicode subscripts and superscripts

*The Phonetic Extensions Supplement block has several more: Latin/IPA , Greek*

Unicode has subscripted and superscripted versions of a number of characters including a full set of Arabic numerals. These characters allow any polynomial, chemical and certain other equations to be represented in plain text without using any form of markup like HTML or TeX.

The World Wide Web Consortium and the Unicode Consortium have made recommendations on the choice between using markup and using superscript and subscript characters:

When used in mathematical context (MathML) it is recommended to consistently use style markup for superscripts and subscripts [...] However, when super and sub-scripts are to reflect semantic distinctions, it is easier to work with these meanings encoded in text rather than markup, for example, in phonetic or phonemic transcription.

Fraktur

[z], for unvoiced [s], ch? [ž] / ch? [š], d?ch? [dž] / t?ch? [ʧ]), while accents (à?, â?, ê?, î?, ô?, û?) together with digraphs (ah?

Fraktur (German: [fʔakʔtuʔʔʔ] ) is a calligraphic hand of the Latin alphabet and any of several blackletter typefaces derived from this hand. It is designed such that the beginnings and ends of the individual strokes



Unicode expressly recommends that these characters not be used in general text as a substitute for presentational markup; the letters are specifically designed to be semantically different from each other. Unicode does not include a set of normal serif letters in the set. Still they have found some usage on social media, for example by people who want a stylized user name, and in email spam, in an attempt to bypass filters.

All these letter shapes may be manipulated with MathML's attribute `mathvariant`.

The introduction date of some of the more commonly used symbols can be found in the Table of mathematical symbols by introduction date.

## Enclosed Alphanumeric Supplement

*Supplement[1][2] Official Unicode Consortium code chart (PDF)* 0 1 2 3 4 5 6 7 8 9 A B C D E F  
U+1F10x ? ? ? ? ? ? ? ? ? ? ? ? ? ? U+1F11x ? ?

Enclosed Alphanumeric Supplement is a Unicode block consisting of Latin alphabet characters and Arabic numerals enclosed in circles, ovals or boxes, used for a variety of purposes. It is encoded in the range U+1F100–U+1F1FF in the Supplementary Multilingual Plane.

The block is mostly an extension of the Enclosed Alphanumerics block, containing further enclosed alphanumeric characters which are not included in that block or Enclosed CJK Letters and Months. Most of the characters are single alphanumerics in boxes or circles, or with trailing commas. Two of the symbols are identified as dingbats. A number of multiple-letter enclosed abbreviations are also included, mostly to provide compatibility with Broadcast Markup Language standards (see ARIB STD B24 character set) and Japanese telecommunications networks' emoji sets. The block also includes the regional indicator symbols to be used for emoji country flag support.

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