# QUADRATIC EQUATIONS OR TRIGONOMETRY IN MATHEMATICS

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Where $x$ represents an unknown value, and $a$, $b$, and $c$ represent known numbers. One supposes generally that $a \neq 0$; those equations with $a = 0$ are considered degenerate because the equation then becomes linear or even simpler. The numbers $a$, $b$, and $c$ are the *coefficients* of the equation and may be distinguished by calling them, respectively, the *quadratic coefficient*, the *linear coefficient* and the *constant* or *free term*.

The values of $x$ that satisfy the equation are called *solutions* of the equation, and *roots* or *zeros* of the expression on its left-hand side. A quadratic equation has at most two solutions. If there is only one solution, one says that it is a double root. If all the coefficients are real numbers, there are either two real solutions, or a single real double root, or two complex solutions that are complex conjugates of each other. A quadratic equation always has two roots, if complex roots are included; and a double root is counted for two. A quadratic equation can be factored into an equivalent equation.

Solutions to problems that can be expressed in terms of quadratic equations were known as early as 2000 BC.

Because the quadratic equation involves only one unknown, it is called "univariate". The quadratic equation contains only powers of $x$ that are non-negative integers, and therefore it is a polynomial equation. In particular, it is a second-degree polynomial equation, since the greatest power is two.

It may be possible to express a quadratic equation $ax^2 + bx + c = 0$ as a product $(px + q)(rx + s) = 0$. In some cases, it is possible, by simple inspection, to determine values of $p$, $q$, $r$, and $s$ that make the two forms equivalent to one another. If the quadratic equation is written in the second form, then the "Zero Factor Property" states that the quadratic equation is satisfied if $px + q = 0$ or $rx + s = 0$. Solving these two linear equations provides the roots of the quadratic.

For most students, factoring by inspection is the first method of solving quadratic equations to which they are exposed.

If one is given a quadratic equation in the form $x^2 + bx + c = 0$, the sought factorization has the form $(x + q)(x + s)$, and one has to find two numbers $q$ and $s$ that add up to $b$ and whose product is $c$ (this is sometimes called "Vieta's rule" and is related to Vieta's formulas).

As an example, $x^2 + 5x + 6$ factors as $(x + 3)(x + 2)$. The more general case where $a$ does not equal 1 can require a considerable effort in trial and error guess-and-check, assuming that it can be factored at all by inspection.

Except for special cases such as where $b = 0$ or $c = 0$, factoring by inspection only works for quadratic equations that have rational roots. This means that the great majority of quadratic equations that arise in practical applications cannot be solved by factoring by inspection.

The process of completing the square makes use of the algebraic identity

which represents a well-defined algorithm that can be used to solve any quadratic equation.

Starting with a quadratic equation in standard form, $ax^2 + bx + c = 0$

1. Divide each side by $a$, the coefficient of the squared term.
2. Subtract the constant term $c/a$ from both sides.
3. Add the square of one-half of $b/a$, the coefficient of $x$, to both sides. This "completes the square", converting the left side into a perfect square.
4. Write the left side as a square and simplify the right side if necessary.
5. Produce two linear equations by equating the square root of the left side with the positive and negative square roots of the right side.
6. Solve each of the two linear equations.

We illustrate use of this algorithm by solving $2x^2 + 4x - 4 = 0$

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