# Equations That Transformed Our Understanding of the World

Throughout history, groundbreaking equations have emerged, revolutionizing our comprehension of the universe and shaping the course of human advancement. These mathematical expressions, composed of symbols and numbers, hold immense power, unlocking the secrets of nature and paving the way for countless discoveries and inventions.

The Pythagorean Theorem: Unveiling the Beauty of Geometry

17 Equations that Changed the World

1. Pythagorean's Theorem — $a^2 + b^2 = c^2$
2. Logarithms — $\log_a b = c \iff a^c = b$
3. Derivatives — $\frac{df}{dt} = \lim_{h \to 0} \frac{f(t+h) - f(t)}{h}$
4. Law of Gravity — $F = G\frac{m_1 m_2}{r^2}$
5. Imaginary Numbers — $i = \sqrt{-1}$
6. Euler's Formula — $V - E + F = 2$
7. Normal Distribution — $f(x) = \frac{1}{\sqrt{2\pi\rho^2}} e^{-\frac{(x-\mu)^2}{2\rho^2}}$
8. Wave Equation — $\frac{\partial^2 u}{\partial t^2} = \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2}$
9. Fourier Transformation — $F(u) = \int_{-\infty}^{\infty} f(x)e^{-2\pi i x u}\, dx$
10. Navier-Stokes Equation — $\frac{\partial v}{\partial t} + v \cdot \nabla v = -\nabla p + \nabla^2 v$
11. Maxwell's Equation
12. 2$^{\text{nd}}$ Law of Thermodynamics — $dS \geq 0$
13. Relativity — $E = mc^2$
14. Schrodinger's Equation — $H\Psi = i\hbar\frac{\partial \Psi}{\partial t}$
15. Information Theory — $H = -\sum p(x)\log p(x)$
16. Chaos Theory — $x_{t+1} = kx_t(1 - x_t)$
17. Black Scholes Equation — $\frac{1}{2}\sigma^2 S^2\frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} + \frac{\partial V}{\partial t} - rV = 0$
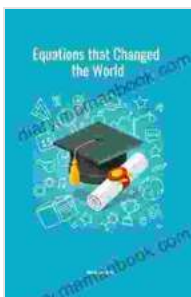
Equations that changed the world by Alberto Carretero

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First formulated by the ancient Greek mathematician Pythagoras, the Pythagorean theorem is a fundamental equation in geometry that describes the relationship between the lengths of the sides of a right triangle. It states that the square of the length of the hypotenuse (the longest side) is equal to the sum of the squares of the lengths of the other two sides: $a^2 + b^2 = c^2$.

This elegant equation has numerous applications in architecture, surveying, navigation, and even astronomy. It is a testament to the power of mathematics to uncover the hidden patterns and symmetries that govern our surroundings.

Newton's Laws of Motion: Unlocking the Secrets of Dynamics
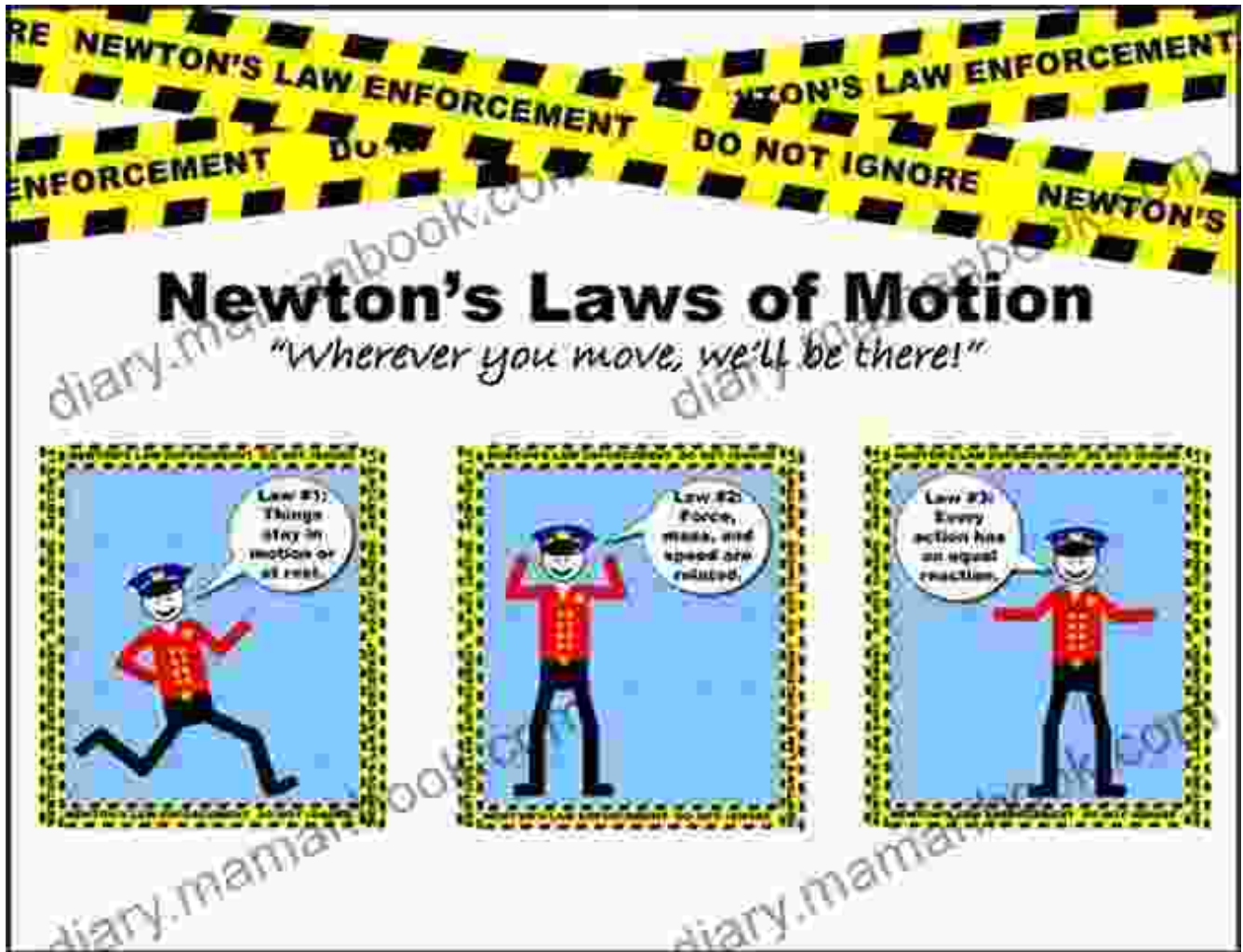
In the 17th century, the English physicist Sir Isaac Newton proposed his three laws of motion. These equations奠定了经典力学的基石, governing the behavior of objects in motion.

First Law: An object at rest will remain at rest unless acted upon by an external force. An object in motion continues to move at constant velocity unless acted upon by an external force.

Second Law: The force acting on an object is equal to the mass of the object multiplied by its acceleration. (F = ma)

Third Law: For every action, there is an equal and opposite reaction.

Newton's laws of motion have had a profound impact on our understanding of the physical world, enabling us to predict and control the behavior of everything from projectiles to spacecraft.

Einstein's Theory of Relativity: Redefining Space and Time
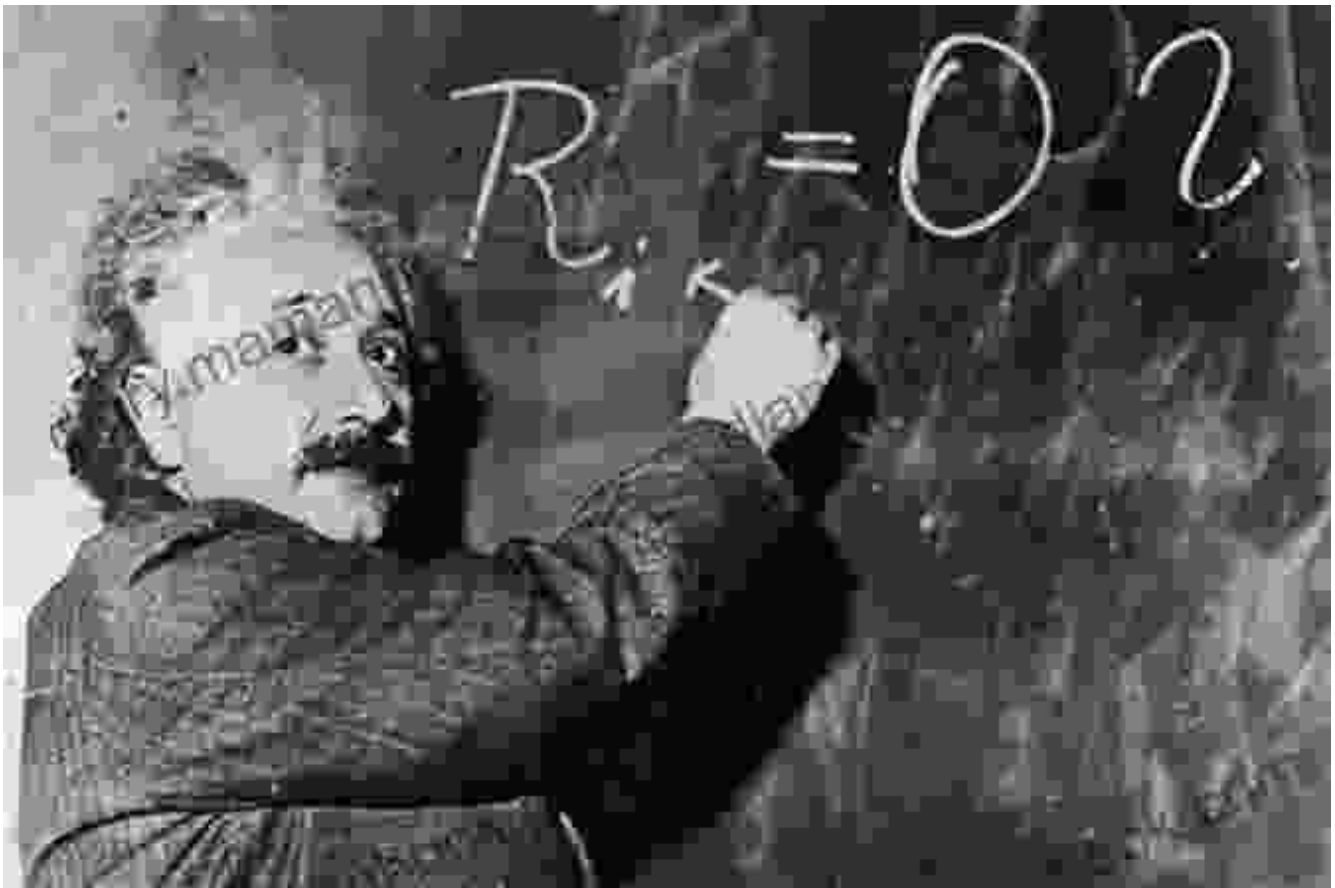
In the early 20th century, Albert Einstein's theory of relativity shattered long-held notions about space, time, and gravity. This groundbreaking theory introduced two groundbreaking equations:

Special Relativity: $E = mc^2$

This equation reveals the equivalence between energy (E) and mass (m). It suggests that even a small amount of mass contains an enormous amount of energy, which can be released in the form of light or heat.

General Relativity: $G_{\mu\nu} = 8\pi T_{\mu\nu}$

This tensor equation describes the curvature of spacetime due to the presence of mass and energy. It explains the bending of light around massive objects and the existence of gravitational waves.

Einstein's theory of relativity has revolutionized our understanding of the universe, providing a new framework for studying phenomena ranging from black holes to the expansion of the cosmos.

The Schrödinger Equation: Unveiling the Mysteries of Quantum Mechanics

Schrödinger Representation – Schrödinger Equation

Time dependent Schrödinger Equation

$$i\hbar \frac{\partial \Phi(x,y,z,t)}{\partial t} = \underline{H}(x,y,z,t)\Phi(x,y,z,t)$$

Developed through analogy to Maxwell's equations and knowledge of the Bohr model of the H atom.

$$H_{classical} = \frac{p^2}{2m} + V$$

Sum of kinetic energy and potential energy.

Hamiltonian   kinetic   potential
energy   energy

Q.M.

$$\underline{H} = \frac{-\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + V(x)$$

one dimension   recall $\underline{p} = -i\hbar\frac{\partial}{\partial x}$

$$\underline{H} = \frac{-\hbar^2}{2m}\nabla^2 + V(x,y,z)$$

three dimensions $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$

The potential, V, makes one problem different form another   H atom, harmonic oscillator.

The Schrödinger equation, formulated by the Austrian physicist Erwin Schrödinger in the 1920s, is a fundamental equation in quantum mechanics. It describes the behavior of quantum systems, such as electrons and atoms.

iħ∂ₜψ = Hψ

In this equation:

- ψ represents the wave function of the quantum system

- ħ is Planck's constant divided by 2π

- *t* is time

- *H* is the Hamiltonian operator, which describes the total energy of the system

The Schrödinger equation provides a powerful tool for understanding the behavior of subatomic particles, leading to groundbreaking advances in fields such as electronics, chemistry, and materials science.

The Maxwell Equations: Unifying Electricity, Magnetism, and Light

17 EQUATIONS THAT CHANGED THE WORLD

#	Name	Equation	Author
1.	Pythagoras's Theorem	$a^2 + b^2 = c^2$	Pythagoras, 530 BC
2.	Logarithms	$\log xy = \log x + \log y$	John Napier, 1610
3.	Calculus	$\frac{df}{dt} = \lim_{h \to 0} \frac{f(t+h) - f(t)}{h}$	Isaac Newton, 1668
4.	Law of Gravity	$F = G \frac{m_1 m_2}{r^2}$	Isaac Newton, 1687
5.	Wave Equation	$\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$	J. d'Alembert, 1746
6.	The square Root of Minus One	$i^2 = -1$	Leonhard Euler, 1750
7.	Euler's Fomula for Polyhedra	$V - E + F = 2$	Leonhard Euler, 1751
8.	Normal Distribution	$\phi(x) = \frac{1}{\sqrt{2\pi\rho}} e^{\frac{(x-\mu)^2}{2\rho^2}}$	C.F. Gauss, 1810
9.	Fourier Transform	$f(\omega) = \int_{-\infty}^{\infty} f(x) e^{-2\pi i x \omega} dx$	Joseph Fourier, 1822
10.	Navier-Stokes Equation	$\rho \left(\frac{\partial v}{\partial t} + v \cdot \nabla v \right) = -\nabla p + \nabla \cdot T + f$	C. Navier, G. Stokes 1845
11.	Maxwell's Equations	$\nabla \cdot E = \frac{\rho}{\varepsilon_0} \quad \nabla \cdot H = 0$ $\nabla \times E = -\frac{1}{c}\frac{\partial H}{\partial t} \quad \nabla \times H = \frac{1}{c}\frac{\partial E}{\partial t}$	J.C. Maxwell, 1865
12.	Second Law of Thermodynamics	$dS \geq 0$	Ludwig Boltzmann, 1874
13.	Relativity	$E = mc^2$	Albert Einstein, 1905
14.	Schrödinger's Equation	$i\hbar \frac{\partial}{\partial t} \psi = H\psi$	Erwin Schrödinger, 1927
15.	Information Theory	$H = -\sum p(x) \log p(x)$	Claude Shannon, 1949
16.	Black-Scholes Equation	$\frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS\frac{\partial V}{\partial S} + \frac{\partial V}{\partial t} - rV = 0$	F. Black, M. Scholes, 1973
17.	Chaos Theory	$X_{t+1} = kx_t(1 - x_t)$	Robert May, 1975

James Clerk Maxwell's equations, developed in the mid-19th century, provide a unified mathematical framework for understanding electricity, magnetism, and light. These four equations describe how electric and magnetic fields interact with each other and with matter.

The Maxwell equations paved the way for the development of numerous technological innovations, including the telephone, radio, and power

transmission systems. They also laid the foundation for Einstein's theory of special relativity.

The Drake Equation: Estimating the Abundance of Extraterrestrial Life

In 1961, astronomer Frank Drake proposed an equation to estimate the number of civilizations in the Milky Way galaxy that are capable of communicating with us:

$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

Where:

- N is the number of civilizations

- R_* is the rate of star formation

- f_p is the fraction of stars with planets

- n_e is the number of planets per star that are suitable for life

- f_l is the fraction of planets that develop life

- f_i is the fraction of life-bearing planets that develop intelligent life

- f_c is the fraction of intelligent civilizations that develop communication technology

- L is the lifetime of a communicating civilization

The Drake equation serves as a thought-provoking framework for stimulating discussion and research on the possibility of extraterrestrial life, sparking the imagination of scientists, philosophers, and science enthusiasts alike.

Throughout history, equations have played a pivotal role in shaping our understanding of the world. From the Pythagorean theorem to the Schrödinger equation, these mathematical expressions have revolutionized science, technology, and our perception of reality. They continue to inspire new discoveries, drive technological advancements, and expand the boundaries of human knowledge. As we delve deeper into the mysteries of

the universe, it is the power of equations that will guide our journey towards a brighter and更加了解的未来。
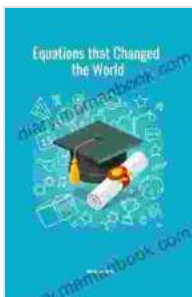
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