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What is Physics?

Key words

Physics

laws

matter

particles

1609 was a crucial year in the development of science. That was the year that Galileo first turned a telescope on the heavens. Without a telescope, what do you see if you look out at the night sky? There are specks of light – the stars – which cross the sky in the course of a night. There's also the occasional planet, looking little different from a star, and the Moon.

Before Galileo, people imagined that the heavens were somehow 'perfect'. The stars were the same from one night to the next, unchanging during a person's lifetime. Down here on Earth, things were different. Things changed; plants, animals and people grew and died. The orbit of the Moon represented the boundary between our world and the perfection beyond.

In Barcelona, a 'live statue' of Galileo invites a young observer to look through his telescope.

Galileo's telescope allowed him to be the first person to overturn these ideas. In particular, he saw that Jupiter had four moons whose positions changed with time – they were orbiting the planet. He began to develop the idea that the universe beyond the Moon was not so different from our own world. Today, we have detailed images of the planets and their moons. Although they are very varied in appearance, we have no doubt that they are all made of the same elements that we know of here on Earth, and that they move according to the same laws of motion as we experience.

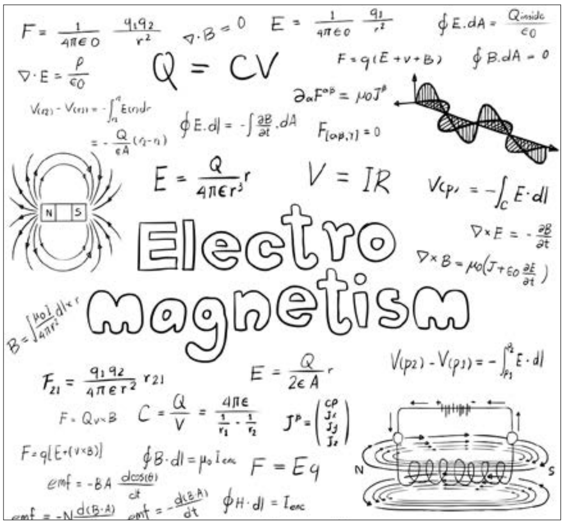
Universality: This is one thing that Physics tries to do. It tries to devise rules or laws that apply everywhere. As far as we know, the same laws apply in the most distant galaxies as apply here on Earth. They also applied in the distant past and will continue to apply in the future.

These are big claims. Periodically, physicists have suggested that things might have been different in the past – gravity might have been weaker, for example. If this could be proved true, we would of course have to accept it. But so far, the laws of Physics seem to be universal.

Self-consistency: This is a related idea. All of the laws of Physics must fit together. We can't have one set of laws that apply to atoms and a different, contradictory set that apply to planets.

One of the most beautiful aspects of Physics is the link between the very small and the very large. Particle physicists have built up a theory of the tiny particles that make up matter and the forces between them – the 'Standard Model' – which cosmologists have been able to use to explain the history of the universe, starting with the Big Bang.

Reductionism and unification: Who would want a book filled with hundreds of laws to describe the natural world? Physicists try to solve problems using a limited number of basic ideas (concepts and laws) which have been developed gradually over the last four centuries. They try to bring these laws together in order to show the underlying unity of nature. For example, in 1820, Hans Christian Oersted discovered the magnetic effect of an electric current. This led to the unifying of two separate fields of Physics in the laws of electromagnetism.



The theory of electromagnetism unifies ideas about electricity, magnetism, light waves and more.

A red laser cutting machine

Mathematics: Physicists make measurements. The things they are interested in are mostly quantities, and by measuring them they hope to find the laws that relate them. These laws take the form of mathematical equations or models which can then be used to describe what we observe and also to predict what will happen. Think of the mathematical models which are used by climate scientists to predict the weather and the future of Earth's climate.

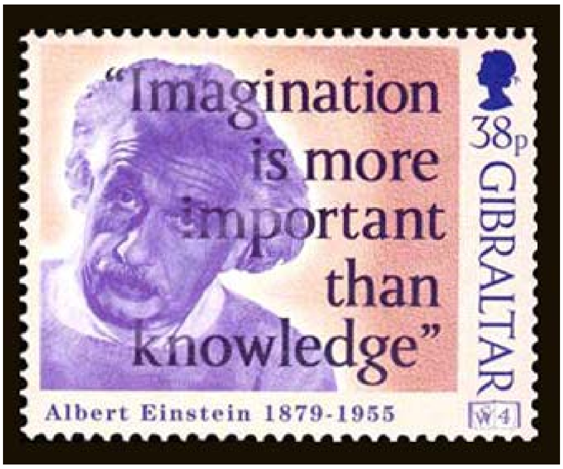
Indeed, there is a symbiotic relationship between Maths and Physics. Many important ideas in Maths have been developed because they were useful in Physics – for example, calculus was developed by Newton and by Leibnitz in order to solve problems in mechanics.

A statue of Isaac Newton, by the Scottish Sculptor Eduardo Paolozzi, outside the British Library in London. It highlights the role of measurement in Physics.

Technology: Physics is useful! Our developing understanding of Physics has allowed many useful inventions. And it can work the other way round: new inventions have allowed us to do new types of experiment. The laser is an interesting example. Physicists understood the principle of the laser and built the first one in 1960; it found many lab applications but it was decades before it became the basis of many everyday consumer products.

Is Physics complete?

Of course not. You can think of it like this: Picture Galileo at the centre of a vast, dark chamber. He shines his torch and illuminates an area around his feet – this represents his understanding of motion and the Solar System. The area of illumination was expanded by Newton, particularly in the fields of motion, astronomy and optics. In the nineteenth century, Physics expanded into electromagnetism. The twentieth century brought atomic and nuclear Physics, cosmology and so on. As the area of illumination expands, there is a longer boundary between the light and the dark. That's where physicists are working today.



Physics is one of the greatest constructions of the human imagination. There's lots more imagining to be done.

There are still many questions to be resolved. One example is how to unify Quantum Physics (the theory which explains how matter behaves at the level of atoms and nuclei) with the laws which govern the behaviour of matter on a larger scale. It's unacceptable to have two sets of laws which operate at different scales, but how to connect them up?

David Sang is Physics editor of Catalyst. Note: other sciences are available.