A Brief History and Philosophy of Mechanics

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1. Introduction

Mechanics is a branch of physics that deals with the interaction of forces on a physical body and its environment. Many scholars consider the field to be a precursor to modern physics. The laws of mechanics apply to many different microscopic and macroscopic objects—ranging from the motion of electrons to the orbital patterns of galaxies. [1]

Attempting to understand the underlying principles of the universe is certainly a daunting task. It is therefore no surprise that the development of 'idea and thought' took many centuries, and bordered many different fields—atomism, metaphysics, religion, mathematics, and mechanics. The history of mechanics can be divided into three main periods: antiquity, classical, and quantum.

2. Period of Antiquity (800 BC – 500 AD)

Although the idea at the time was not popular, and would later be forgotten for nearly two millennia, atomism would build the foundation for modern physics and mechanics. In the fifth century BC, "Democritus and Leucippus taught that the hidden substance in all physical objects consists of different arrangements of atoms and void." [2] According to Democritus, the workings of the universe could be explained by mechanical means, driven by vibrations among atoms. [2]

The idea that matter was created by indivisible particles was rejected by Plato, who was a student of Socrates. Plato believed that the beauty of the world could not be created by simply the interaction of indivisible particles. He felt that the four elements—fire, earth, air, and water—did not consist of atoms, but were geometric solids. [3] Being a student of Plato, Aristotle was also critical of atomism, and felt that the existence of a void violated physical principles. [2] Although Plato and Aristotle rejected an idea that would later help form the principles of modern applied science, they did contribute significantly to the history of mechanics, and science in general, by the creation and development of the Academy in Athens. [4] Many great scholars and philosophers were educated at the Academy.

During this period, several clever inventions were created. Some of these were Archimedes screw, Hero of Alexandria's aeolipile (steam engine), the catapult and trebuchet, the crossbow, pulley systems, odometer, clockwork, and a rolling-element bearing (used in Roman ships). [5] Although mechanical inventions were being made at an accelerated rate, it wasn't until after the Middle Ages when classical mechanics developed.

3. Classical Period (1500 – 1900 AD)

Classical mechanics had many contributors, although the most notable ones were Galileo, Huygens, Kepler, Descartes and Newton. "They showed that objects move according to certain rules, and these rules were stated in the forms of laws of motion." [1]

The most famous of these laws were Newton's Laws of Motion, which accurately describe the relationships between force, velocity, and acceleration on a body. His three laws are usually referred to as the law of inertia, law of acceleration, and law of reciprocal actions. In 1687, Newton's laws were published in his most famous work entitled *Philosophiae Naturalis Principia Mathematica*. He was able to publish this work with support of knowledge acquired by his scientific predecessors.

Unbeknownst to Copernicus, he helped start classical mechanics when he moved away from the widely-held geocentric theory (based on the works of Aristotle and Plato). Copernicus revitalized the heliocentric model, which stated that the Sun was at the centre of the solar system. His work—*De Revolutionibus*—was published in 1543, a year after his death. [6] Although the religious figures at the time strongly opposed this idea, it would eventually be well defended by observations and theoretical views held by Kepler and Galileo. [6] In fact, Galileo would later face an inquisition by the Roman Catholic Church, where he was required to recant his position on a heliocentric universe.

The controversy between the Church and Galileo would later be remembered by historians as a time when science finally broke free from the Church. This would be the start of a new period of learning—the basics for modern science.

Galileo, Kepler, and Descartes all contributed significantly to building a foundation for Newton, who would ultimately lead the way to forming classical mechanics. Near the end of the 19th century, experiments were beginning to reach the atomic level. At this point, classical mechanics failed to explain newly acquired, fundamental ideas—such as the size of atoms and their corresponding energy levels. [8] Failure to explain physics at this level would mark the beginning of the quantum period.

4. Quantum Period (1900 AD – Present)

Quantum mechanics replaces classical mechanics at the atomic and subatomic levels. It successfully describes four ideas that classical mechanics cannot: particle-wave duality, quantization of certain physical quantities, Heisenberg's uncertainty principle, and quantum entanglement. [9]

The early history of quantum mechanics was filled with scientific heroes such as Max Planck, Albert Einstein, Louis de Broglie, Werner Heisenberg, Max Born, Erwin Schrödinger, Paul Dirac, and Richard Feynman.

In 1900, while studying black body radiation, Max Planck proposed that energy could be quantized. Einstein later built on this idea when he described the photoelectric effect, and introduced the idea of the photon. In 1925, Heisenberg and Born developed matrix mechanics, which defined quantum mechanics, its laws, and properties. [9] Matrices were used to help describe the behaviour of subatomic particles. [9] It was later shown to be equivalent to Schrödinger's wave formulation.

Two years later, Heisenberg created his uncertainty principle, which states that it is impossible to know both the momentum and position of a particle at the same time. If one were to know the momentum of a particle with increasing accuracy, the position of that particle would be known with decreasing accuracy. In other words, the two are inversely related. Fundamentally, this principle states that it is impossible to know the complete state of a system.

This principle was derived mainly to determine if it was possible to measure the location of an electron around a nucleus. [9] It offered insight into the nature of atoms and their orbitals; the principal also revealed how complex physics and mechanics become when observed at the quantum level.

Modern quantum mechanics has created a strange universe—from dark matter and energy, to quarks and gluons, and vibrating strings. This world is much different from Plato's geometric solids.

5. Conclusions

The history of mechanics spans many generations, and is connected with many well-known scientific as well as historical figures. History shows that politics and religion play an important role in developing science. It took nearly two millennia to prove atomism as a sound theory for the make-up of all that encompasses the matter we are familiar with—including us.

The future of mechanics looks promising with new quantum theories that are being developed to describe the 'nature of everything.' These new theories will drastically change the way humans live and perceive the universe. It is important to look back and be thankful for the work that came before, as today's science and physics would not be possible without the hard work and dedication of scholars over the past few millennia.

References

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