A Study on Mechanics and Several Types of Mechanical Bodies

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ABSTRACT

In this paper, the author has studied about the mechanics and several types of mechanical bodies. Historically, mechanics was among the first of the exact sciences to be developed. Its internal beauty as a mathematical discipline and its early remarkable success in accounting in quantitative detail for the motions of the Moon, Earth, and other planetary bodies had enormous influence on philosophical thought and provided impetus for the systematic development of science.

Keywords: Mechanics, Types, Mechanical Bodies, quantum, classical.

INTRODUCTION

Mechanics (from Ancient Greek: μηχανική, mēkhanikḗ, lit. "of machines") is the area of mathematics and physics concerned with the relationships between force, matter, and motion among physical objects. Forces applied to objects result in displacements, or changes of an object's position relative to its environment. Theoretical expositions of this branch of physics has its origins in Ancient Greece, for instance, in the writings of Aristotle and Archimedes. During the early modern period, scientists such as Galileo, Kepler, Huygens, and Newton laid the foundation for what is now known as classical mechanics.

As a branch of classical physics, mechanics deals with bodies that are either at rest or are moving with velocities significantly less than the speed of light. It can also be defined as the physical science that deals with the motion of and forces on bodies not in the quantum realm. Knowledge of mechanics is essential for studying biomechanics. Mechanics is concerned with the analysis of the action of forces on objects. Objects of interest in sport biomechanics are human body and sport equipment. According to the nature of studied objects mechanics is divided into several branches. In rigid body mechanics we presume that all objects are perfectly rigid. This means they change neither their form nor their volume when forces act on them. It simplifies the following mechanical analysis. Parts of human body are of course not perfectly rigid. Deformations would often make the analysis of motion too complicated. Fluid mechanics is concerned with mechanics of gases and liquids. Relativistic mechanics is related to the Einstein relativity theory and quantum mechanics describes behaviour of objects on atomic and subatomic level. In biomechanics we mostly make use of rigid body mechanics which is best applicable for describing the motion of human body and its parts. Since certain sport events take place in fluid environment, biomechanics also uses knowledge of fluid mechanics.

TYPES OF MECHANICS

There are three types of mechanics:

Classical Mechanics

Classical mechanics is an actual hypothesis portraying the movement of perceptible articles, from machine parts to projectiles, and galactic items. For example, rocket, planets, stars and systems. For objects represented by old-style mechanics, if the current state is known, it is conceivable to foresee how it will move later on (determinism) and how it has moved previously (reversibility). The soonest improvement of classical mechanics is frequently alluded to as Newtonian mechanics. It comprises the actual ideas utilized and the numerical strategies imagined by Isaac Newton, Gottfried Wilhelm Leibniz and others in the seventeenth century to portray the movement of bodies affected by an arrangement of forces. Afterwards, more dynamic strategies were created. Classical mechanics gives incredibly precise outcomes when concentrating huge articles that are not amazingly monstrous and speeds not moving toward the speed of light. For effortlessness, it frequently models actual objects as point particles (objects with insignificant size). The movement of a point molecule is portrayed by a few parameters. Those parameters are its position, mass, and the forces applied to it. Every one of these parameters is examined thusly.

Classical mechanics utilizes general ideas of how matter and forces exist and associate. It accepts that matter and energy have unequivocal, understandable qualities. For example, the area in space and speed. Non-relativistic mechanics additionally expect that forces demonstration promptly.

Quantum Mechanics

Quantum mechanics is a basic hypothesis in material science. It gives a portrayal of the actual properties of nature at the size of atoms and subatomic particles. It is the establishment of all quantum physics including quantum computing, quantum field theory, quantum chemistry and quantum data science.

Quantum mechanics vary from classical mechanics. This is because energy, force, momentum, and different parameters of a bound framework are confined to discrete qualities (quantization). Objects have attributes of both particles and waves (wave-molecule duality). There are barriers to how precisely the estimation of an actual value of a physical quantity can be anticipated before its estimation, given a total arrangement of beginning conditions. Quantum mechanics emerged step by step, from speculations to clarify perceptions which could not be accommodated with classical mechanics. For example, Max Planck's answer in 1900 to the dark body radiation matter. Another example is the correspondence among energy and frequency in Albert Einstein's 1905 paper which clarified the photoelectric effect.

Relativistic Mechanics

Relativistic mechanics alludes to mechanics viable with special relativity and general relativity. It gives a non-quantum mechanical portrayal of an arrangement of particles, or of a liquid. This is provided in situations where the speeds of moving items are equivalent to the speed of light c. Therefore, classical mechanics is stretched out effectively to particles going at high speeds and energies. It furnishes predictable incorporation of electromagnetism with the mechanics of particles.

Special relativity expresses that movement is relative. Also, the laws of physics are the equivalent for all experimenters regardless of their inertial reference outlines. Notwithstanding adjusting ideas of existence, special relativity drives one to rethink the ideas of mass, force, and energy which are all significant notions in Newtonian mechanics. Special relativity shows that these ideas are on the whole various parts of the very actual quantity similarly that it demonstrates existence to be interrelated.

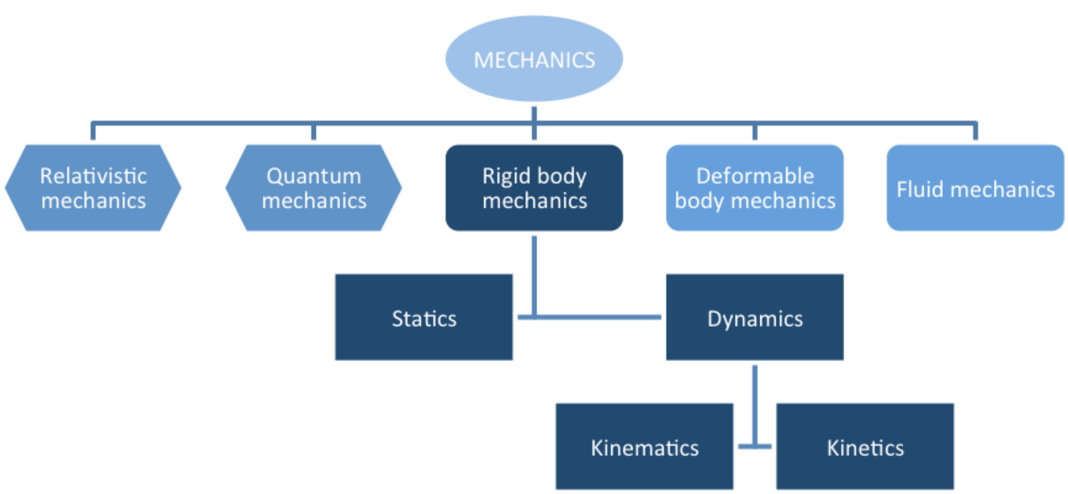

Figure 1: Types of mechanics according to the nature of studied objects and the division of rigid body mechanics

LITERATURE REVIEW

History of classical mechanics and History of quantum mechanics

Aristotelian mechanics

The ancient Greek philosophers were among the first to propose that abstract principles govern nature. The main theory of mechanics in antiquity was Aristotelian mechanics, though an alternative theory is exposed in the pseudo-Aristotelian Mechanical Problems, often attributed to one of his successors.

There is another tradition that goes back to the ancient Greeks where mathematics is used more extensively to analyze bodies statically or dynamically, an approach that may have been stimulated by prior work of the Pythagorean Archytas.[7] Examples of this tradition include pseudo-Euclid (On the Balance), Archimedes (On the Equilibrium of Planes, On Floating Bodies), Hero (Mechanica), and Pappus (Collection, Book VIII).[8][9]

Medieval age

Arabic machine in a manuscript of unknown date.

In the Middle Ages, Aristotle's theories were criticized and modified by a number of figures, beginning with John Philoponus in the 6th century. A central problem was that of projectile motion, which was discussed by Hipparchus and Philoponus.

Persian Islamic polymath Ibn Sīnā published his theory of motion in The Book of Healing (1020). He said that an impetus is imparted to a projectile by the thrower, and viewed it as persistent, requiring external forces such as air resistance to dissipate it. Ibn Sina made distinction between 'force' and 'inclination' (called "mayl"), and argued that an object gained mayl when the object is in opposition to its natural motion. So he concluded that continuation of motion is attributed to the inclination that is transferred to the object, and that object will be in motion until the mayl is spent. He also claimed that a projectile in a vacuum would not stop unless it is acted upon, consistent with Newton's first law of motion.

On the question of a body subject to a constant (uniform) force, the 12th-century Jewish-Arab scholar Hibat Allah Abu'l-Barakat al-Baghdaadi (born Nathanel, Iraqi, of Baghdad) stated that constant force imparts constant acceleration. According to Shlomo Pines, al-Baghdaadi's theory of motion was "the oldest negation of Aristotle's fundamental dynamic law [namely, that a constant force produces a uniform motion], [and is thus an] anticipation in a vague fashion of the fundamental law of classical mechanics [namely, that a force applied continuously produces acceleration]."

Influenced by earlier writers such as Ibn Sina[15] and al-Baghdaadi,[16] the 14th-century French priest Jean Buridan developed the theory of impetus, which later developed into the modern theories of inertia, velocity, acceleration and momentum. This work and others was developed in 14th-century England by the Oxford Calculators such as Thomas Bradwardine, who studied and formulated various laws regarding falling bodies. The concept that the main properties of a body are uniformly accelerated motion (as of falling bodies) was worked out by the 14th-century Oxford Calculators.

Early modern age

Two central figures in the early modern age are Galileo Galilei and Isaac Newton. Galileo's final statement of his mechanics, particularly of falling bodies, is his Two New Sciences (1638). Newton's 1687 Philosophiæ Naturalis Principia Mathematica provided a detailed mathematical account of mechanics, using the newly developed mathematics of calculus and providing the basis of Newtonian mechanics.[9]

There is some dispute over priority of various ideas: Newton's Principia is certainly the seminal work and has been tremendously influential, and many of the mathematics results therein could not have been stated earlier without the development of the calculus. However, many of the ideas, particularly as pertain to inertia and falling bodies, had been developed by prior scholars such as Christiaan Huygens and the less-known medieval predecessors. Precise credit is at times difficult or contentious because scientific language and standards of proof changed, so whether medieval statements are equivalent to modern statements or sufficient proof, or instead similar to modern statements and hypotheses is often debatable.

Modern age

Two main modern developments in mechanics are general relativity of Einstein, and quantum mechanics, both developed in the 20th century based in part on earlier 19th-century ideas. The development in the modern continuum mechanics, particularly in the areas of elasticity, plasticity, fluid dynamics, electrodynamics and thermodynamics of deformable media, started in the second half of the 20th century.

TYPES OF MECHANICAL BODIES

The often-used term body needs to stand for a wide assortment of objects, including particles, projectiles, spacecraft, stars, parts of machinery, parts of solids, parts of fluids (gases and liquids), etc.

Other distinctions between the various sub-disciplines of mechanics, concern the nature of the bodies being described. Particles are bodies with little (known) internal structure, treated as mathematical points in classical mechanics. Rigid bodies have size and shape, but retain a simplicity close to that of the particle, adding just a few so-called degrees of freedom, such as orientation in space.

Otherwise, bodies may be semi-rigid, i.e. elastic, or non-rigid, i.e. fluid. These subjects have both classical and quantum divisions of study.

For instance, the motion of a spacecraft, regarding its orbit and attitude (rotation), is described by the relativistic theory of classical mechanics, while the analogous movements of an atomic nucleus are described by quantum mechanics.

The following are two lists of various subjects that are studied in mechanics.

Note that there is also the "theory of fields" which constitutes a separate discipline in physics, formally treated as distinct from mechanics, whether classical fields or quantum fields. But in actual practice, subjects belonging to mechanics and fields are closely interwoven. Thus, for instance, forces that act on particles are frequently derived from fields (electromagnetic or gravitational), and particles generate fields by acting as sources. In fact, in quantum mechanics, particles themselves are fields, as described theoretically by the wave function.

Classical

Prof. Walter Lewin explains Newton's law of gravitation in MIT course 8.01.

The following are described as forming classical mechanics:

- Newtonian mechanics, the original theory of motion (kinematics) and forces (dynamics).
- Analytical mechanics is a reformulation of Newtonian mechanics with an emphasis on system energy
- Hamiltonian mechanics, a theoretical formalism, based on the principle of conservation of energy.
- Lagrangian mechanics, another theoretical formalism, based on the principle of the least action.
- Classical statistical mechanics generalizes ordinary classical mechanics to consider in an unknown state
- Celestial mechanics, the motion of bodies in space: planets, comets, stars, galaxies, etc.
- Astrodynamics, spacecraft navigation, etc.
- Solid mechanics, elasticity, plasticity, viscoelasticity exhibited by deformable solids.
- Fracture mechanics
- Acoustics, sound (= density variation propagation) in solids, fluids and gases.
- Statics, semi-rigid bodies in mechanical equilibrium
- Fluid mechanics, the motion of fluids
- Soil mechanics, mechanical behavior of soils
- Continuum mechanics, mechanics of continua (both solid and fluid)
- Hydraulics, mechanical properties of liquids
- Fluid statics, liquids in equilibrium
- Applied mechanics, or Engineering mechanics
- Biomechanics, solids, fluids, etc. in biology
- Biophysics, physical processes in living organisms

- Relativistic or Einsteinian mechanics, universal gravitation.

Quantum

The following are categorized as being part of quantum mechanics:

- Schrödinger wave mechanics, used to describe the movements of the wavefunction of a single particle.
- Matrix mechanics is an alternative formulation that allows systems with a finite-dimensional state
- Quantum statistical mechanics generalizes ordinary quantum mechanics to systems in an unknown state;
- Nuclear physics, the motion, structure, and reactions of nuclei
- Condensed matter physics, quantum gases, solids, liquids, etc.

Historically, classical mechanics had been around for nearly a quarter millennium before quantum mechanics developed. Classical mechanics originated with Isaac Newton's laws of motion in Philosophiæ Naturalis Principia Mathematica, developed over the seventeenth century. Quantum mechanics developed later, over the nineteenth century, precipitated by Planck's postulate and Albert Einstein's explanation of the photoelectric effect. Both fields are commonly held to constitute the most certain knowledge that exists about physical nature.

Classical mechanics has especially often been viewed as a model for other so-called exact sciences. Essential in this respect is the extensive use of mathematics in theories, as well as the decisive role played by experiment in generating and testing them.

Quantum mechanics is of a bigger scope, as it encompasses classical mechanics as a sub-discipline which applies under certain restricted circumstances. According to the correspondence principle, there is no contradiction or conflict between the two subjects, each simply pertains to specific situations. The correspondence principle states that the behavior of systems described by quantum theories reproduces classical physics in the limit of large quantum numbers, i.e. if quantum mechanics is applied to large systems (for e.g. a baseball), the result would almost be the same if classical mechanics had been applied. Quantum mechanics has superseded classical mechanics at the foundation level and is indispensable for the explanation and prediction of processes at the molecular, atomic, and sub-atomic level. However, for macroscopic processes classical mechanics is able to solve problems which are unmanageably difficult (mainly due to computational limits) in quantum mechanics and hence remains useful and well used. Modern descriptions of such behavior begin with a careful definition of such quantities as displacement (distance moved), time, velocity, acceleration, mass, and force. Until about 400 years ago, however, motion was explained from a very different point of view. For example, following the ideas of Greek philosopher and scientist Aristotle, scientists reasoned that a cannonball falls down because its natural position is in the Earth; the sun, the moon, and the stars travel in circles around the earth because it is the nature of heavenly objects to travel in perfect circles.

Often cited as father to modern science, Galileo brought together the ideas of other great thinkers of his time and began to calculate motion in terms of distance travelled from some starting position and the time that it took. He showed that the speed of falling objects increases steadily during the time of their fall. This acceleration is the same for heavy objects as for light ones, provided air friction (air resistance) is discounted. The English mathematician and physicist Isaac Newton improved this analysis by defining force and mass and relating these to acceleration. For objects traveling at speeds close to the speed of light, Newton's laws were superseded by Albert Einstein's theory of relativity. [A sentence illustrating the computational complication of Einstein's theory of relativity.] For atomic and subatomic particles, Newton's laws were superseded by quantum theory. For everyday phenomena, however, Newton's three laws of motion remain the cornerstone of dynamics, which is the study of what causes motion.

CONCLUSION

According to our approach to the study of objects motion and their equilibrium, mechanics is divided into statics and dynamics. Statics studies objects that are either at rest, or in constant motion, that is a motion with constant velocity as to its magnitude and direction. Dynamics studies objects with acceleration. Dynamics is divided into kinematics and kinetics. Kinematics describes the motion of objects, while kinetics studies forces that cause changes of motion.

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