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FROM CLASSICAL MECHANICS TO MODERN INTERPRETATIONS

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ABSTRACT

Motion is simply the manner in which objects transform their location with time. In this paper I have provided a brief overview of the theories explaining motion, its history starting with the ancient conceptions of Galileo and Newton and all the way up to the relativity theory of Einstein and the modern quantum mechanics. Considering the approach of kinematics, dynamics, and the more recent theories, I would like to show how our understanding of motion has evolved to become so simple and super complex so as to enable us know the large as well as the tiny particles in the universe. Once we have discussed the classical era we move on to the major paradigm shifts of the 20th century which actually broke the biscuit of the Newtonian worldview. Starting with Einstein Special and General Relativity, which disturbed the concept of absolute simultaneity. Relativity is a vivid picture of a dynamic and interwoven space in which the speed of light remains the same to all people, and gravity ceases to be a force but rather a curvature of space.

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INTRODUCTION

When dealing with motion in physics, we mention displacement, distance, velocity, acceleration, speed and time. Motion as a whole is in reality the oldest and most fundamental of physics. Before the scientific revolution, Aristotelian physics postulated that things moved as per their natural condition. However, this was challenged by the experiments of falling body and inertia by Galileo Galilei which led to the formalist of the laws that govern the macroscopic world by Sir Isaac Newton.

The most ordinary, and the most obvious thing, in physics, is, indeed, honest, purely, motion, which is nothing but a constant change of the locus of something in reference to a selected standard position, with respect to time. Because all of the massive growth of galactic superclusters down to the minute thermal wiggle of atoms are always in motion, the study of motion has been the most ancient and a most primordial branch of physics. Simply put, to understand motion, is to understand the mechanics, which control the entire universe.

We have changed our thinking in relation to motion so many times in the past. Almost two millennia of the Western perception of kinematics had been essentially Aristotelian physics. Aristotle divided motion into two categories: natural motion (similar to), things moving to their natural place in the universe (such as a stone falling to Earth or smoke rising to the heavens), and violent motion (that continues moving only when you apply force in some direction or the other). That model just has rest as the default of stuff, and the mathematical part of explaining motion was, in all essentials, non-existent.

The breakdown of the Aristotelian worldview in the course of the Scientific Revolution essentially marked the birth of modern physics. Galileo Galilei changed the situation by introducing empirical observation and strict experimentation. In

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his theory on the inclined planes and falling bodies, he derived the principle of inertia- basically, that a body which is moving in a straight line will continue doing so unless something such as friction halts it. It was such a tremendous leap of concept that we now begin treating uniform motion as natural as rest.

Continuing on the empiric research of Galileo, and the planetary laws we learned with Kepler, I may say that Sir Isaac Newton codified the macroscopic laws of the universe in his classic Principia which was published in the year 1687. To address the instant rates of change in moving bodies in a proper way, Newton (with Gottfried Wilhelm Leibniz) introduced infinitesimal calculus the first effort to define velocity (first time derivative of position) and acceleration (second time derivative of position). Newton put his laws in the context of the absolute space and the absolute time- a fixed background, unchangeable in any way, on which the events in the universe occurred.

While this deterministic Newtonian framework dominated scientific thought for centuries and remains highly accurate for low-speed, macroscopic phenomena, the late 19th and early 20th centuries revealed its limitations. As observational technologies improved, physicists discovered that at velocities approaching the speed of light, and at the microscopic scale of atoms, classical mechanics catastrophically failed.

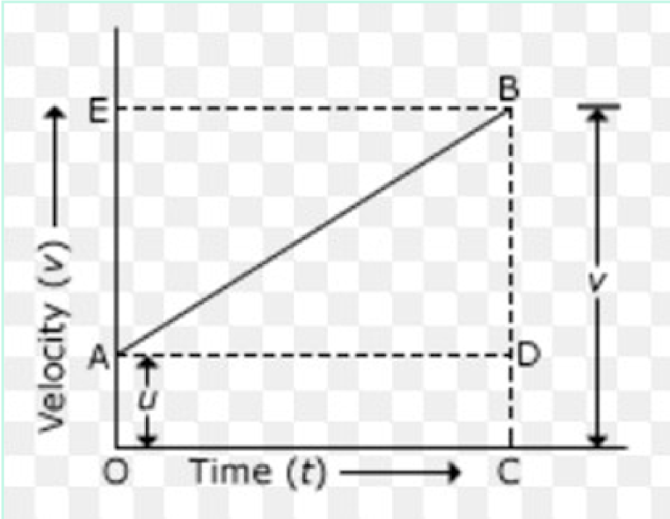
This review paper traces the theoretical evolution of motion. It begins by outlining the classical mechanics of Newton, extends into the analytical formulations of Lagrange and Hamilton, and subsequently examines the 20th century paradigm shifts. Albert Einstein's theories of relativity, which intertwined space and time into a dynamic fabric, and the advent of quantum mechanics, which replaced the deterministic trajectories of classical particles with wave functions and probabilities. Finally, the paper discusses the ongoing challenge of reconciling these divergent frameworks into a unified theory of motion.

CLASSICAL MECHANICS

Classical mechanics describes the motion of macroscopic objects, from projectiles to machinery, as well as astronomical objects. It is divided into two primary sub-disciplines: kinematics and dynamics.

1. Kinematics: The Description of Motion

Kinematics focuses on describing motion without considering the forces that cause it. It relies on a set of mathematical equations that relate displacement (s), initial velocity (u), final velocity (v), acceleration (a), and time (t). For an object under constant acceleration, the fundamental equations of motion are:



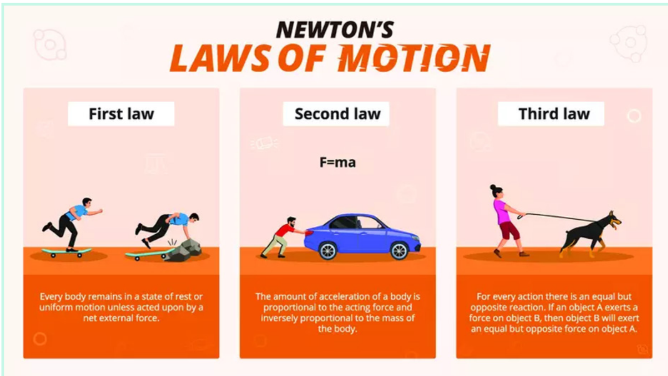
I. Velocity-time Relation:- $v - u = at$

II. Displacement-time Relation:- $S = ut + \frac{1}{2}at^2$

III. Velocity - Displacement Relation:- $2as = v^2 - u^2$

2. Dynamics: The Causes of Motion

Dynamics explains why objects move by introducing the concept of force. This field is governed by Newton's Three Laws of Motion:-



- First Law (Inertia): An object remains at rest or in uniform motion in a straight line unless acted upon by an external force.
- Second Law (Force and Acceleration): The rate of change of momentum of a body is directly

proportional to the applied force. This is famously expressed as: F = ma

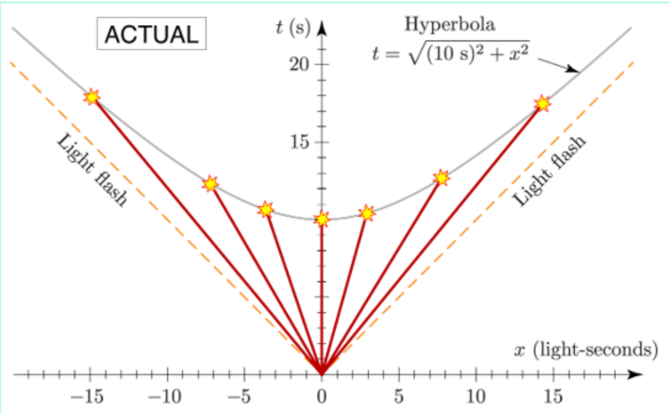
- Third Law (Action and Reaction): For every action, there is an equal and opposite reaction.

3. The Paradigm Shifts: Modern Physics

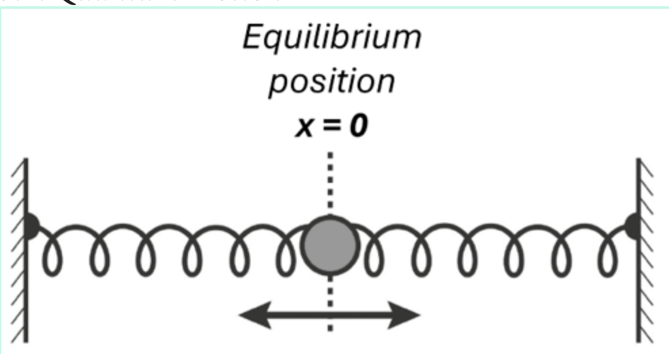
While classical mechanics is highly accurate for everyday objects moving at standard speeds, it breaks down at extreme scales—both in the realm of the very fast and the very small.

3.1. Relativistic Motion

In 1905, Albert Einstein introduced the Special Theory of Relativity, radically altering the concept of motion at speeds approaching the speed of light (c). Classical mechanics assumed that time and space were absolute. Einstein demonstrated that time dilates and length contracts depending on the relative motion of the observer. Consequently, the velocities of objects do not simply add together linearly at relativistic speeds.



3.2. Quantum Motion



At the atomic and subatomic levels, classical descriptions of motion fail entirely. Quantum mechanics, developed in the 1920s, shows that particles like electrons do not have precise trajectories or positions. Instead, their "motion" is described by probability clouds and wave functions (such as the Schrödinger equation). Heisenberg's Uncertainty Principle dictates that the exact position and momentum of a particle cannot be simultaneously known:

$$\Delta x\, \Delta p \geq \frac{h}{2}$$

CONCLUSION

The study of motion is the backbone of physical science. Classical mechanics provides a robust and practical framework for engineering and everyday physics through kinematics and dynamics. However, the pursuit of understanding motion at extreme velocities and microscopic scales led to relativity and quantum mechanics, fundamentally reshaping our view of reality. Future research in quantum gravity and string theory continues to seek a unified framework for motion that bridges the macroscopic and microscopic worlds.

The study of motion has consistently forced humanity to re-evaluate the fundamental nature of reality. For centuries, the Newtonian paradigm provided a deterministic universe operating within the rigid, absolute stages of space and time. However, the progression into modern physics revealed a far more complex universe. Einstein's relativity demonstrated that motion intrinsically weaves space and time into a single, flexible fabric, while quantum mechanics shattered determinism, replacing the predictable paths of particles with inherent probabilities. Thus, motion is more than just the displacement of mass; it is the key conceptual probe that physicists use to uncover the underlying rules of the universe.

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