Historical Development of Science of Motion

1. 1st Century BC: Philolaus’s Astronomical System: All nearby Celestial bodies go around a central fire in perfect circles! Earth a perfect sphere rotating on its axis. This was a heliocentric theory!

2. 2nd Century AD: Alexandrian School of Astronomy: Ptolemy: Geocentric theory. Earth at the center of the universe with fixed stars. Sun and other planets move around the earth. Orbits were made up of perfectly circular motion. He needed cycles and epicycles of perfect circles to describe the motion of planets to account for observed motion. He succeeded only approximately.

3. 1570 to 1720: First Scientific Revolution. Players in the revolution are a Pole - Nicolaus Copernicus, a Dane - Tycho Brahe, a German - Johannes Kepler, an Italian - Galileo Galilei and and Englishman - Isaac Newton.

(a) 1530-33: Copernicus proposed a Helio-
centric theory. There was no new astronomical data. He also needed cycles around the sun, epicycles around the cycles to approximately predict the motion of planets in the heavens. His predictions were not much better than those of Ptolemy.

(b) 1576: Tycho Brahe did not believe in Copernicus’s theory but strongly believed in the power of reliable observations. He carefully measured and documented motions of planets, sun and moon over many years. He had the first astronomical observatory before the advent of telescopes. He also observed non constant stars, the supernova of 1572. The Chinese had seen a supernova in 1054 but this information had not travelled to Europe.

(c) 1609-1619: Kepler, Tycho Brahe’s assistant was an accomplished mathematician of the times. He was entrusted with the carefully recorded data of Brahe. He was able to formulate his famous
three laws of planetary motion: (1) Planets executed elliptical orbits with sun at one of its foci, (2) Law stating that the radius vector of planets swept out equal areas in equal times and (3) the relationship of the period of the orbit of planet to the size of the orbit. A fully heliocentric theory!

(d) 1564-1642: Age of Galileo and science of kinematics. Galileo developed instruments to measure time (water clocks and pendulums), devices to slow down the acceleration due to gravity (inclined planes) and good enough telescopes to discover the moons of Jupiter and study their motion. He developed the scientific method to understand motion and in particular motion under the influence of gravity. He was well supported in his research because of the usefulness of his quantitative analysis of motion to the motion of projectiles and his fabrication of telescopes which could be used in campaigns. He conceptually abstracted
what would happen to an object not subject to any forces - law of inertia. He developed the concepts of relative motion - Galilean relativity, and he discovered the principle of independence of motion along two mutually perpendicular directions - superposition principle of vertical and horizontal motion of projectiles.

(e) 1642-1727: Isaac Newton. He was the giant of classical mechanics. Newton discovered the three laws of motion, defined inertial mass of a body, the quantity of motion or momentum and the relation of force to change in the state of motion or acceleration. He developed new mathematics - infinitesimal Calculus - to solve the problem of planetary motion. He discovered the law of Universal Gravitation which applies over all scales, at least as far as we have tested it upto today! With the laws of motion and universal gravitation he was able to quantitatively explain the mo-
tion of celestial bodies and explained the three laws of Kepler as a natural consequence. The limitation of his dynamics was only discovered when one observed motion in which velocities approached the speed of light, or when one studied extreme gravity environments - such as the black hole, and when one studied the interaction of microscopic objects such as atoms, protons, neutrons and electrons. These limitations were discovered only towards the end of the 19th century and in the 20th century when Newtonian mechanics was superceded by that of relativity and quantum mechanics.

(f) Newton also realized that a new force or forces must exist to explain the cohesion of matter and further deduced that these forces of cohesion of matter must be much stronger than gravitation. He did not surmise that they must be electrical.

(g) Newton also studied the phenomenon of
light and its propagation, discovered refraction of light and its dependence on color of light - the rainbow. He considered light to consist of particles!

(h) Newtonian mechanics was deterministic, that is, if the location and momenta of all bodies in a system of mutually interacting bodies was known at a particular instant of time then his laws of motion could predict all subsequent motion of these bodies.