

## 1.3 Mach's Critique of Newtonian Thought

In order to write down his laws of motion Newton made several assumptions of fundamental nature without satisfactory explanations. In 1883 the German physicist Ernst Mach examined these assumptions critically in his book, "*The Science of Mechanics*." He was careful in making distinctions between assumptions, definitions, and derived results. His examination of Newtonian mechanics led him to enunciate his principle of inertia and question the validity of the assumptions of absolute time and absolute space.

For instance, the origin of the property of inertia, first brought into physics by Galileo, is not explained in Newton's formulation of mechanics. Newton just states that every material body possesses an innate property called inertia due to which a force is needed to change the momentum of the body. Mach proposed that inertia is not an intrinsic property of matter but the inertia of a body depends on the presence of all matter in the universe. This principle is called **Mach's principle**.

Mach also insisted that rather than relying on absolute time one must develop mechanics that uses time based on the mechanical workings of some physical system. Actually, this was an original goal of Newton himself as he was loath to making hypothesis and declared that he will base his thinking only on observable facts. However, Newton himself violated his desired goals and introduced the hypotheses of absolute time in physics. to quote from Newton's *Principia*,

"Absolute, true and mathematical time, of itself, and from its own nature flows equably without regard to anything external, and by another name is called duration: relative, apparent and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time ..."

Mach noted that repetitive motion of some physical system, such as a pendulum, a clock, or revolution of Earth, is necessary to measure the passage of time. Therefore, he insisted that time, rather than being absolute, must be connected to the mechanical laws that govern the motion of physical systems. Mach made a similar argument concerning space: since distances in space are measured with meter sticks, therefore, the space must be connected to the laws that govern the lengths of meter sticks.

Mach's ideas had a profound influence on Albert Einstein when he was a student. They shaped his thinking about space and time and helped usher in a new era of physics.