

# Chapter 1

## Physical World

### Science and its origin

Science is a **systematic understanding of natural phenomena** in detail so that it can be **predicted, controlled and modified**. Science involves exploring, experimenting and speculating phenomena happening around us.

- The word **Science** is derived from a latin verb *Scientia* meaning 'to know'.
- **Scientific method** is a way to gain knowledge in a systematic and in-depth way. It involves:
  - *Systematic observations*
  - *Controlled experiments*
  - *Qualitative and Quantitative reasoning*
  - *Mathematical modeling*
  - *Prediction and verification (or falsification) of theories*
  - *Speculation or Prediction*
- Science does not have any final theory. The improved observations, accurate tools keep improving the knowledge and perspective. Johannes Kepler used Tycho Brahe's research on planetary motion to improve Nicolas Copernicus theory.
- Quantum mechanics was developed to deal with atomic and nuclear phenomena. Work of Ernest Rutherford on nuclear model of atom became basis of quantum theory given by Niels Bohr. Antiparticle theory of Paul Dirac led to the discovery of antielectron (positron) by Carl Anderson.

### Natural Sciences

Natural science is a branch of science concerned with the description, prediction, and understanding of natural phenomena, based on observational and empirical evidence. It consists of following disciplines:

- Physics
- Chemistry
- Biology

### Physics

**Physics** is a study of basic laws of nature and their manifestation in different natural phenomena. Physics is the study of physical world and matter and its motion through space and time, along with related concepts such as energy and force.

- Word Physics is derived from a Greek word *phusiké* meaning nature.
- Two principal types of approaches in Physics are:
  1. **Unification:** This approach considers all of the world's phenomena as a collection of universal laws in different domains and conditions. Example, law of gravitation applies both to a falling apple from a tree as well as motion of planets around the sun. Electromagnetism laws govern all electric and magnetic phenomena.
  2. **Reduction:** This approach is to derive properties of complex systems from the properties and interaction of its constituent parts. Example, temperature studied under thermodynamics is also related to average kinetic energy of molecules in a system (kinetic theory).

### Impact and uses of Physics:

- It can explain a phenomena happening over a large magnitude with a simple theory.
- Experiments and observations are used to develop new theories for unidentified phenomena and improve old theories for existing phenomena.
- Development of devices using laws of physics.

## Scope of Physics

Scope of Physics is vast as it covers quantities with length magnitude as high as  $10^{40}$ m or more (astronomical studies of universe) and as low as  $10^{-14}$ m or less (study of electrons, protons etc). Similarly the range of time scale goes from  $10^{-22}$ s to  $10^{18}$ s and mass from  $10^{-30}$ kg to  $10^{55}$ kg.

Physics is broadly divided into two types based on its scope - **Classical Physics and Modern Physics**. Classical physics deal with the **macroscopic phenomena** while the modern physics deals with the **microscopic phenomena**.

## Macroscopic Domain

Macroscopic domain includes phenomena at large scales like laboratory, terrestrial and astronomical. It includes following subjects:

1. **Mechanics** – It is based on Newton’s laws on motion and the laws of gravitation. It is concerned with motion/equilibrium of particles, rigid and deformable bodies and general system of particles.  
Examples,
  - a. Propulsion of rocket by ejecting gases
  - b. Water/Sound waves
  - c. Equilibrium of bent rod under a load
2. **Electrodynamics** – It deals with electric and magnetic phenomena associated with charged and magnetic bodies. Examples,
  - a. motion of a current-carrying conductor in a magnetic field
  - b. the response of a circuit to an ac voltage (signal)
  - c. the propagation of radio waves in the ionosphere
3. **Optics** – It deals with phenomena involving light. Examples,
  - a. Reflection and refraction of light
  - b. Dispersion of light through a prism
  - c. Colour exhibited by thin films
4. **Thermodynamics** – It deals with systems in macroscopic equilibrium and changes in internal energy, temperature, entropy etc. of systems under application of external force or heat. Examples,
  - a. Efficiency of heat engines
  - b. Direction of physical and chemical process

## Microscopic Domain

Microscopic domain includes phenomena at minuscule scales like atomic, molecular and nuclear. It also deals with interaction of probes like electrons, photons and other elementary particles. Quantum theory has been developed to handle these phenomena.

## Factors responsible for progress of Physics

- Quantitative analysis along with qualitative analysis.
- Application of universal laws in different contexts.
- Approximation approach (complex phenomena broken down into collection of basic laws).
- Extracting and focusing on essential features of a phenomenon.

## Hypothesis, Axiom and Models

- a) **Hypothesis** is a supposition without assuming that it is true. It may not be proved but can be verified through a series of experiments.
- b) **Axiom** is a self-evident truth that it is accepted without controversy or question.
- c) **Model** is a theory proposed to explain observed phenomena.
- d) **Assumption** is the basis of physics, where a number of phenomena can be explained. These assumptions are made from experiments, observation and a lot of statistical data.

## Technological applications of Physics

Several examples where Physics and its concepts have led to discoveries/inventions are listed below.

- Steam engine was developed from the industrial revolution in eighteenth century.
- Wireless communication was developed after discovery of laws of electricity and magnetism.
- Neutron-induced fission of uranium, done by Hahn and Meitner in 1938, led to the formation of nuclear power reactors and nuclear weapons.
- Conversion of solar, wind, geothermal etc. energy into electricity.

## Fundamental Forces in nature

The forces which we see in our day to day life like muscular, friction, forces due to compression and elongation of springs and strings, fluid and gas pressure, electric, magnetic, interatomic and intermolecular forces are **derived forces** as their originations are due to a few fundamental forces in nature.

A few fundamental forces are:

1. **Gravitational Force:** It is the **force of mutual attraction** between any two objects by virtue of their masses. It is a **universal force** as every object experiences this force due to every other object in the universe.



The gravitational force causes the apple to fall as well as planets to revolve around the sun.

2. **Electromagnetic Force:** It is the **force between charged particles**. Charges at rest have electric attraction (between unlike charges) and repulsion (between like charges). Charges in motion produce magnetic force. Together they are called Electromagnetic Force.







