# Physical World

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**Etymological Meaning of Science**

Comes from the Latin verb *Scientia*, which means 'to know'

**Origin**

Science is as old as the human species. From the 16$^{th}$ century onwards, great strides were made in science in Europe.

**Definition**

Science is a systematic way of acquiring knowledge about the surroundings by careful observations and experimentations over a period of time.

**Steps Involved in a Standard Scientific Method**

- Systematic observation
- Controlled experiments
- Qualitative reasoning
- Quantitative reasoning
- Mathematical modelling
- Prediction
- Verification or falsification of theories

**Nature of Science**

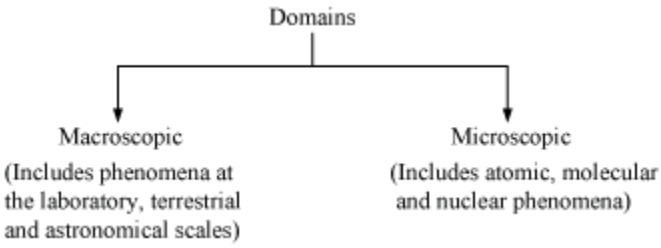
- Science is ever dynamic.
- There is no 'final theory' in science.
- Modifications can be made in the established scientific laws.

**Understanding Physics and Physical World**

**Physics**

- It is a branch of science.
- Etymological meaning: Comes from a Greek word meaning ‘nature’
- Definition: Study of nature and natural phenomena, put in an organised way in various subtopics

**Scope of Physics**




**Branches of Physics**

- **Mechanics**

  Concerned with the motion of particles, rigid and deformable bodies, and general systems of particles.

- **Electrodynamics**

  Deals with electric and magnetic phenomena associated with charged and magnetic particles.

- **Optics**

  Deals with the phenomena involving light

- **Thermodynamics**

  Deals with systems in macroscopic equilibrium, and is concerned with changes in internal energy, temperature, entropy, etc., of the system through external work and transfer of heat

**Scope**

- Explains every phenomena occurring in nature on the basis of established rules

- Involves the study of phenomena at the very small scales of subatomic level as well as the phenomena involving very large measurements

**Applications in Society**

- Physics and technology are related to each other. Both have a direct impact on society.
- Technology is the application of the principles of physics for practical purposes.
- Physics acts on behalf of and, hopefully, to the benefit of mankind.
- The modern developments in physics have catered to fulfil the needs of society and make their life styles more comfortable.
- The developments of radio, television, satellites and means of transport have helped the society.

**Fundamental Forces in Nature**

- Physics has revealed that all the forces occurring in different contexts arise from a few fundamental forces in nature. These fundamental forces are as follows:
- Gravitational forces
- Weak nuclear forces
- Electromagnetic forces
- Strong nuclear forces

**Gravitational Forces**

- Proposed by Newton
- This is the force of mutual attraction which is directly proportional to the product of the masses, and inversely proportional to the square of the separation between them.
- Weakest forces in nature

**Weak Nuclear Forces**

- Discovered during the study of the phenomenon of β-decay in radioactivity
- These are the forces of interaction between elementary particles of short life times.
- About $10^{25}$ times stronger than gravitational forces

**Electromagnetic Forces**

- Forces between charged particles
- The moving charges produce magnetic effects.
- Electric and magnetic effects are inseparable; hence, the term electromagnetic.
- These forces may be attractive or repulsive.
- Electrostatic forces are $10^{36}$ times stronger than gravitational forces.
- Operate over small distances.

**Strong Nuclear Forces**

- These forces bind the neutrons and protons together in different nuclei.
- Short range forces (operate within the distances of the order of $10^{-14}$ m)
- Strongest forces in nature; $10^{38}$ times stronger than gravitational forces
- Attractive in nature

**Unification of Forces**

| **S. No** | **Name of Physicist** | **Achievement in Unification** |
|---|---|---|
| **1.** | Isaac Newton | Unified terrestrial and celestial mechanics |
| **2.** | Hans Christian Oersted | Electric and magnetic phenomena – electromagnetism |

| | | |
|---|---|---|
| **3.** | James Clerk Maxwell | Unified electricity, magnetism and optics; showed that light is an electromagnetic wave |
| **4.** | Sheldon Glashow, Abdus Salam, Steven Weinberg. | Weak nuclear force and the electromagnetic force can be viewed as different aspects of electro-weak force |
| **5.** | Carlo Rubia, Simon Van der Meer | Verified experimentally the predictions of the theory of electro-weak force. |

**Nature of Physical Laws**

- **Conserved Quantities**

  These are some special physical quantities that remain constant with time.

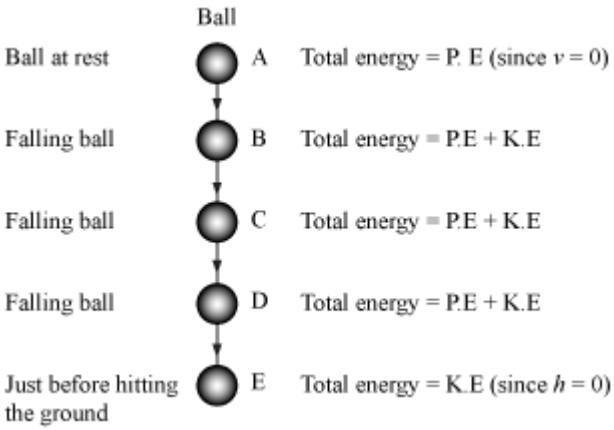
  Example – Energy, linear momentum, angular momentum, charge, parity, etc.

- **Law of Conservation of Energy**

  For motion under an external conservative force, the total mechanical energy (that is the sum of kinetic and potential energy of a body) remains constant.

  Example – Free fall of an object under gravity

  The sum of potential energy and kinetic energy of the ball remains the same at every point during its fall.



The law of conservation of energy is valid for any kind of transformation between different forms of energy or across all domains of nature from the microscopic to the macroscopic.

- **Law of Conservation of Linear Momentum**

  In the absence of an external force, the linear momentum of a system remains unchanged.

- **Law of Conservation of Angular Momentum**

  If the total external torque acting on a system is zero, then angular momentum of the system remains constant.

- **Law of Conservation of Charge**

  Charges are neither created nor destroyed, but are simply transferred from one body to another.

  In many cases, conservation laws simplify the problems.

  Using conservation laws of energy and momentum for beta decay, Pauli predicted the existence of a new particle called neutrino emitted along with electron in β-decay.

  **Note**

- Conservation laws have a deep connection with symmetries of nature. For example, laws of nature do not change with time.

- Laws of nature are the same everywhere in the universe.