

## 10. Nature of Science

### 10.1 Physics And Its Interaction

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#### 10.1.1 Describe Physics As The Study Of Matter, Energy, Space, Time And Their Interactions

Physics is the fundamental science that deals with the constituents of the universe, that is, matter, energy, space, time and their mutual relationships and interactions. It strives to understand how the universe works, from the smallest subatomic particles to the largest star and galaxies.

The space is the three-dimensional extent in which all objects and events occur. It provides framework to define positions and motions of various objects under some force.

The time measures the sequence and durations of events. It is considered fourth dimension. For example, oscillating motion such as that of a swinging pendulum relies on the time interval that determines frequency of oscillations. Another example is the time dilation which is a phenomenon discussed by special theory of relativity where time passes slowly for an observer moving at ultra-high speed compared to one relatively at rest.

Physics explores how these fundamental concepts are inter-connected. For example, the theory of relativity explains how space and time are not absolute quantities but are related to each other. It describes the relationship between space and time and how they are influenced by gravity and speed, for example, the bending of light around massive objects like stars.

Another branch of physics, the quantum mechanic, explains the behaviour of particles at the atomic and subatomic levels. It is how the physics has applied its principles to wide variety of phenomena, from everyday occurrences such as related to motion and heat to the extreme conditions found in the universe.

### 10.2 Sub-Fields of Physics

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#### 10.2.1 Mention Physics As A Subset Of Physical And Natural Science

Science is a collective knowledge about the natural phenomena, processes and events occurring around us. The process starts with asking a question, how and why the things in the world behave as such. We try to look orderliness and regularities among various phenomena apparently of diverse nature. Such study of nature gave birth to a single discipline, known as Natural Philosophy now known as science.

There was a tremendous increase in the volume of scientific knowledge at the beginning of nineteenth century. That made it necessary to classify the study of nature basically into two main disciplines.

1. The biological sciences which deal with the living things.
2. The physical sciences which are about the study of non-living things.

Physics is an important and basic part of physical sciences beside other disciplines such as astrology, chemistry and geology.

## 10.2.2 Relate Different Branches Of Physics With Real-Life Examples

### **Biophysics**

Some biological processes are described using the principles and systems and technique of physics under this field of study. Examples include the mechanics of biological structures, physical properties of cells, tissues and organs.

### **Medical Physics:**

It applies physical principles to develop techniques and technologies for health diagnosis and treatment. The examples include imaging techniques, such as X-rays; ultra sound, MRI and CT scan and also radiation therapy for cancer treatment.

### **Astrophysics:**

It deals with the physical properties and processes of celestial bodies and phenomena. For example, the interaction between the matter and energy in space to understand the universe as a whole.

### **Geophysics:**

It applies physical principles to the study of internal structure of the Earth, its magnetic and gravitational fields, seismic activity (earthquake), volcanoes, etc.

### **Climate Physics:**

It includes the study of physical processes in the environment, including atmospheric dynamics, climate change and weather conditions.

### **Computation Physics:**

It is about computational techniques and methods to solve complex physical problems.

## 10.3 Scientific Approach/ Method

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### 10.3.1 Define Different Scientific Methods For Carrying Out Investigations

Scientific method is a systematic approach used to search for truth of an issue and problem solving regarding natural and physical world. It is based on the following steps:

1. Identify or recognize an issue or a problem.
2. Gather information through observations of its various aspects.
3. Propose an explanation or a guess work known as hypothesis.
4. Perform experiment or collect evidences to test the hypothesis.
5. Theory: record, organize and analyse gathered data, plotting and interpreting graphs.
6. Repeated tests of theory to wide range of similar issues then lead towards the formulation of a law.

### **Observation**

The first step in scientific method is to make observations of natural processes and to collect the data about them. This may be done either by ordinary observations or by obtaining the results from different experiments. For example, it is our common observation that shadow of an opaque object is formed when it is placed in the path of light coming from the Sun or a lamp.

### **Hypothesis**

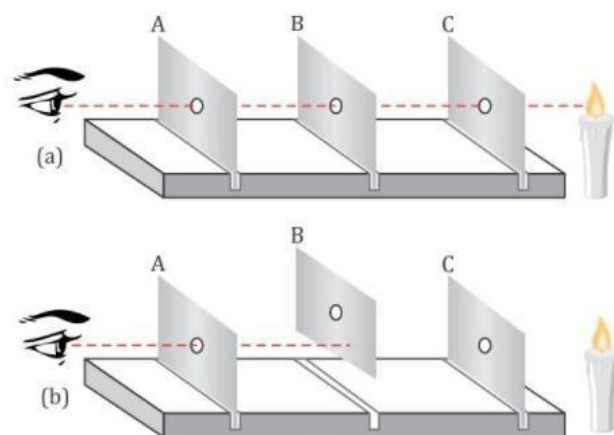
On the basis of the data collected experimentation, we can develop a hypothesis. This is done in order to test its logical results i.e., it is assumed that nature will act in a particular way under certain specific circumstances.

From the above example, we assume that shadows of opaque objects are formed when they come in the path of light because light travels in a straight line.

### Experiment

Experiment is an organized repeatable process which is used to test the truth of a hypothesis.

To verify the assumption made in the above example, four cardboards, each with a hole, are placed in a straight line, such that the hole in 1<sup>st</sup> card is in front of a torch. When we see through the hole in cards, we can see the light of the torch. If any of these cards is displaced, we cannot see light passing through. Thus, this experiment proves that light travels in a straight line.



### Theory

After the successful verification of an assumption and with the help of careful experimentation, it becomes a theory and is applicable to similar phenomena. With the help of the above experiment, the assumption has been proved that light travels in a straight line. So, it then becomes a theory. It is a logical explanation of the causes and effects of an issue or an event that occurs in nature.

### Prediction

After the careful analysis of a theory, we can make predictions about certain unknown aspects of nature. To verify prediction, experiments are designed to test the theory over and over again. If test result do not agree, hypothesis is changed or rejected.

### Falsifiability

It is a concept that suggests a theory to be considered scientific if it also makes predictions that can be tested and potentially proven false. The requirement of falsifiability ensures that theories are not based on vague, non-specific or untestable claims. It distinguishes scientific theories from false or pretended beliefs that cannot be experimentally tested.

### Law

When a theory has been tested many times and generally accepted as true, it is called a law. The law is such a statement regarding the behaviour of nature which explains the observations and experiments of the past and can predict about other aspects of nature. From the fact that light travels in a straight line, we can predict that shadow of an opaque object, similar in shape, is formed whenever it is placed in the path of light. For example, the shadow of a ball will be round whereas the shadow of a rectangular block will be a rectangle. After testing the theory under different situations, this becomes a law of science that light travels in a straight line.

The theories or laws of Physics are man-made ideas about the way the things work. They are liable to be disproved or modified with the future advances in science which brings fresh facts and new the natural and insights about physical world.

## 10.4 Science, Technology and Engineering

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### 10.4.1 Importance Of Physics In Science, Technology And Engineering

Physics plays a vital role being the core of each invention based on physical laws and principles. Technology refers to the methods and techniques developed by using scientific knowledge. It may be a machine technology or a software programme of Information technology. For example,

- Automobile technology is based on the principles of the thermodynamics.
- Radar technology is based on the detection and reflection principles of electromagnetic waves.
- Laser technology is based on the principles of atomic physics. It is widely used in medical diagnosis and treatment, metallurgy, industry, telecommunication and space exploration.

Engineering is the process of applying various technologies and scientific principles to design various instruments, tools and build things that help to meet specific needs in every walk of life. Engineers also consider factors like cost effectiveness and safety measures when designing various products.

- A civil engineer designs a bridge that can withstand strong winds, earthquakes, intense weather conditions and heavy traffic.
- A software engineer designs a user-friendly application of a smartphone.
- An aviation engineer looks for lighter material which can withstand sudden and severe disturbances and extreme weather conditions during the flight of an aeroplane.

Though the science, technology and engineering fields seem distinct but they often work together. Scientific discoveries lead to new technologies and engineers rely on scientific knowledge for our benefits and comforts. They are the potent for change in the outlook of mankind in shaping life style and influencing our way of thinking.