UNIT 09

Nature of Science

Q1. Describe scope of physics. 09109001

Ans: Scope of physics:

Physics is the fundamental science that deals with the constituents of the universe, that is, matter, energy, space, time and their mutual relationships and interaction. It strives to understand how the universe works, from the smallest subatomic particles to the largest star and galaxies. You have studied some of the basic properties of matter, energy and their mutual inter-relationship in the earlier chapters of this book. We will discuss with some details the concept of space and time in the higher classes. Briefly, 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 determine frequency of oscillations. Another example is the time dilation which is a phenomenon discussed by ultra-high speed compared to one relatively at rest. Physics explores how these fundamental aspects 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 mechanics, explains the behavior of particles at the atomic and subatomic levels. It is how the physics has applied its principles to wide variety of phenomena, from everyday occurrence such as related to motion and heat to the extreme conditions found in the universe.

Q2. What are main branches of Physics? State briefly. 09109002

Ans: <u>Branches of Physics:</u>

Due to expanding scope of research in Physics, it is usually divided into following branches.

i. Mechanics:

It is study of motion and the physical effects which influence motion. It is based on Newton's laws of motion and gravitation and is often called classical mechanics.

ii. Heat and Thermodynamics:

It deals with the thermal energy possessed by the materials and its used when it flows from one body to another. It may be called as thermal physics.

iii. Acoustics:

It deals with the nature and physical aspects of audible sound energy. The wide range of applications of sound properties are studied in the field of acoustics.

iv. Optics:

It deals with the physical aspects of visible light.

v. Electromagnetism:

It is the study of electromagnetic phenomenon and mutual relationship between electric current and magnetic field.

vi. Quantum Mechanics:

It explains the behavior of particles at the atomic and subatomic level.

vii. Relativistic Mechanics:

It explains how space and time are not absolute quantities but related to observer. It describes the relationship between them and how they are influenced by gravity and speed.

viii. Nuclear Physics:

It is the study of the properties of nuclei of the atoms and particles within the nuclei.

ix. Particle Physics:

It is the study of subatomic particles and elementary particles which are basic building blocks of matter.

x. Astronomy:

It is study of distribution of celestial bodies like planets, stars and galaxies.

xi. Cosmology:

It explores the large structure and evolution of the universe.

xii. Solid State Physics:

It is the study of some specific properties of matter in solid form.

Q3. What is meant by Interdisciplinary field of Physics? Give Examples. 09109003

Ans: Interdisciplinary Nature of Physics:

It refers to integration and interaction of Physics with various other fields of study. Physics, being fundamental science, provides essential principles, techniques and methods that are applicable across a wide range of disciplines.

i. Bio Physics:

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

ii. 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.

iii. 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.

iv. Geophysics:

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

v. Climate Physics:

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

vi. Computation Physics:

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

Q4. Explain interdisciplinary Research in Science. 09109004

Ans: Interdisciplinary Research:

Collaboration and interdisciplinary nature of science is essential for addressing the complex issues and challenges of today and fostering innovation. By working together and sharing knowledge, scientist can achieve more significant breakthrough and contribute to a deeper understanding of the natural and physical world around us. It allows us to contribute to advance in technology, healthcare, environmental issues and many other areas. We need collaborated effects because:

i. Solution of complex issues require multifaceted expertise.

Many challenging issues, such as climate change, disease prevention and treatment, sustainable energy solution are of diverse nature. It is difficult for one climate change requires knowledge for meteorology, oceanography physics, chemistry, biological and environmental sciences. Similarly, the health care issues such as recent Covid epidemic involved combined efforts of expertise from biology, chemistry, physics, medical technologies and data science to combat this challenge.

ii. Interdisciplinary approaches foster innovation:

Combined different perspectives and methodologies evolve innovation or out of box solutions. This approach can lead to novel insight and breakthroughs that might not emerge working in isolation. For example, Nano-technology is a blend of physics, chemistry, material science and engineering to create materials and devices at the Nano-scale with unique applications in development involves computer science, mathematical logic, neuroscience etc. The collaboration across these fields enhanced the development of intelligence systems and their application.

iii. Rapid sharing of knowledge and information across the globe:

Sharing and collaboration of knowledge across the globe brings rapids advances in science. The online internet information exchanges, conferences and workshops provide platforms bringing together researchers from different fields to share their fresh finding, discussion and brainstorming new approaches. Collaborated research projects and research journals are also means of collaborate research.

Interdisciplinary research and collaboration leads to a more holistic understanding of challenging issues by interacting with different perspectives such as that of environment and space exploration.

Q5. What is scientific method? Describes its main stages with examples. 09109005

Ans: Scientific Method:

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.

i. Identify or recognize an issue or a problem.
ii. Gather information through observation of its various aspects.
iii. Propose and explanation or a guess work known as hypotheses.
iv. Perform experiment or collect evidences to test the hypothesis.
v. Record, organize and analyze gathered data, plotting and interpreting graphs to reach at a conclusion which is called a theory.
vi. Repeated tests of the theory to wide range of similar issues then lead toward the formulation of a law.

Some key steps are elaborated here.

i. 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 (Fig. 9.1).

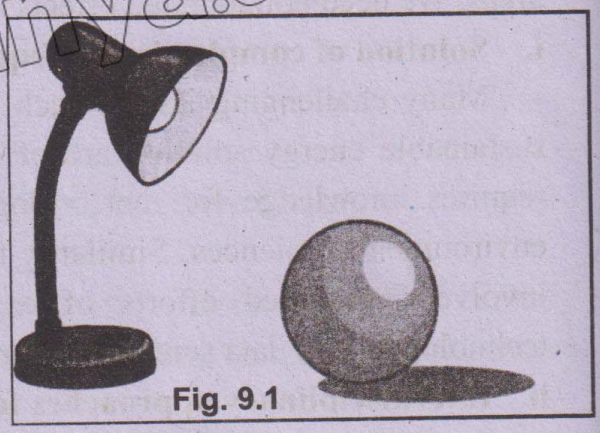

Fig. 9.1

ii. Hypothesis:

On the basis of the data collected through observations or 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 shadows of opaque objects are formed when they come in the path of light because light travels in a straight line.

iii. 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 card boards, each with a hole, are placed in a straight line, such that the hole in 1st card is in front of a torch. When we see through the hole in cards, we can see the light of the troch (Fig. 9.2-a). If any of these cards is displaced, we cannot see light passing through (Fig. 9.2-b). Thus this experiments proves that light travels in a straight line.

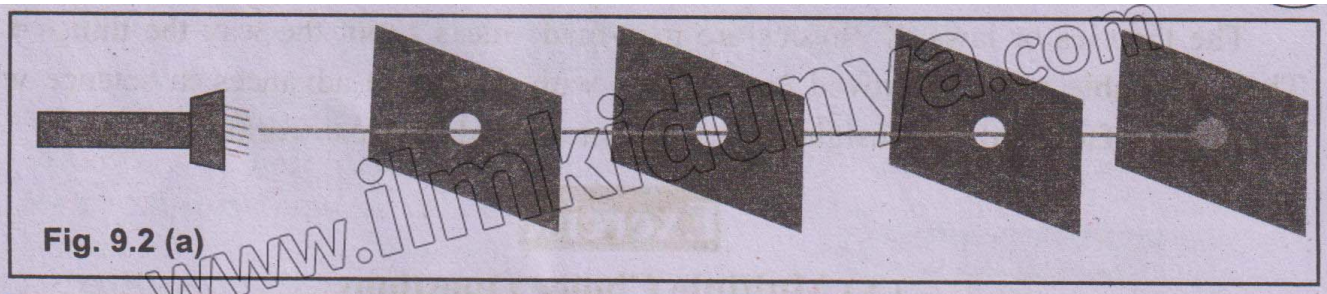

Fig. 9.2 (a)

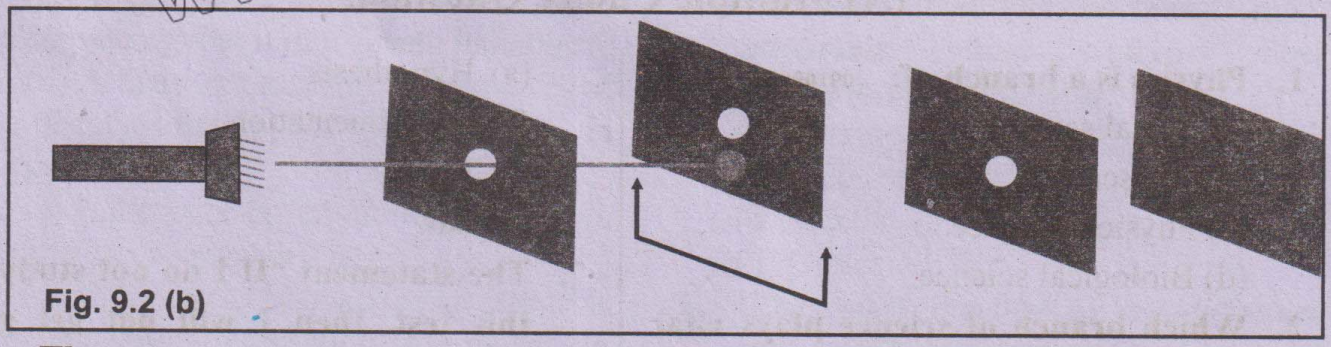

Fig. 9.2 (b)

iv. Theory:

After the successful verification of an assumption and with the help of careful experimentations, it becomes a theory and is applicable to similar phenomena. With the help of the above experiments, 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.

v. Prediction:

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

vi. Falsifiability:

It is a concept introduced that suggests theory to be considered scientific if it also make 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.

vii. 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 behavior 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 situation, 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 insights about the natural and physical world.

Exercise

(A) Multiple Choice Questions

1. **Physics is a branch of:** 09109006
   (a) Social science
   (b)Life science
   (c) Physical science
   (d) Biological science
2. **Which branch of science plays vital role in technology and engineering:** 09109007
   (a) Biology (b) Chemistry
   (c) Geology (d) Physics
3. **Automobile technology is based on:** 09109008
   (a) Acoustics
   (b) Electromagnetism
   (c) Optics
   (d) Thermodynamics
4. **A user friendly software application of smart phone use:** 09109009
   (a) Laser technology
   (b) Information technology
   (c) Medical technology
   (d) Electronic technology
5. **The working of refrigeration and air conditioning involves:** 09109010
   (a) Electromagnetism
   (b) Mechanics
   (c) Climate science
   (d) Thermodynamics
6. **What is the ultimate truth of a scientific method?** 09109011
   (a) Hypothesis
   (b) Experimentation
   (c) Theory
   (d) Law
7. **The statement "If I do not study for this test, then I will not get good grade" is an example of:** 09109012
   (a) Theory (b) observation
   (c) Prediction (d) Law
8. **Which of the following are methods of investigation?** 09109013
   (a) Observation (b) Experimentation
   (c) Research (d) All of these
9. **A hypothesis:** 09109014
   (a) May or may not be testable
   (b) is supported by evidence
   (c)is a possible answer to a question
   (d) all of these
10. **A graph of an organized data is an example:** 09109015
    (a) Collecting data
    (b) Forming a hypothesis
    (c) Asking question
    (d) Analyzing data
11. **The colour of a door is brown, is an example of:** 09109016
    (a) Observation (b) Hypothesis
    (c) Prediction (d) Law

Answer Key

1.	(c)	2.	(d)	3.	(d)	4.	(b)	5.	(d)	6.	(d)
7.	(c)	8.	(d)	9.	(d)	10.	(d)	11.	(a)		

SLO based Additional MCQs

Theory

1. **What is the best definition of the term "theory," as it us used in science?** 09109017
(a) A theory is a guess or hunch about something that has occurred in nature
(b) A theory is a comprehensive set of ideas explaining a phenomenon in nature
(c) A theory is based on verifiable laws and can be proven true
(d) A theory is a hypothesis that uses laws and observation to make an assumption

Laws and Theories

2. **Which Statement below correctly identifies the difference between laws and theories?** 09109018
(a) Laws describe phenomena, while theories explain why phenomena exist
(b) Laws are a statement of fact, while theories are statement of opinion
(c) Laws explain why phenomena exist, while theories explain how
(d) Laws are a prediction of phenomena, while theories are an explanation

Hypothesis

3. **Why do scientists develop a hypothesis before conducting research?** 09109019
(a) It give them direction on how to interpret the results of their research
(b) It helps to predict outcomes and define the parameters of the research
(c) Hypotheses give the researcher an outcome to shape their work around
(d) Hypotheses help a researcher decide which observations to record and which to ignore

Thermodynamics

4. **The Branch of Physics that is most important when studying how glasses help people see:** 09109020
(a) Thermodynamics
(b) Electromagnetism
(c) Mechanics
(d) Optics

5. **When studying how air conditioners cool your house, then it is:** 09109021
(a) Thermodynamic
(b) Electromagnetism
(c) Nuclear Physics
(d) Optics

Nuclear Physics

6. **The branch of Physics that deals with the particles such as neutrons and protons:** 09109022
(a) Solid State Physics
(b) Plasma Physics
(c) Electricity
(d) Nuclear Physics

Branches of Science

7. **Which branch of science plays an important role in engineering?** 09109023
(a) biology
(b) Chemistry
(c) Physics
(d) Life science

8. **Physics is one of the branches of:** 09109024
(a) Physical sciences
(b) Biological sciences
(c) Social science
(d) Life science

Answer Key

1.	(b)	2.	(a)	3.	(b)	4.	(d)	5.	(a)
6.	(d)	7.	(c)	8.	(a)				

(B) Short Answer Questions

9.1 State in your own words, what is science? Write its two main groups. 09109025

Ans: Science is a collective knowledge about the natural phenomena, processes and events occurring around us.

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

Physics is important and basic part of physical sciences beside other discipline such as chemistry and geology.

9.2 What is physics all about? Name some of its branches. 09109026

Ans: Physics is the fundamental science that deals with the constituents of the universe, that is, matter, energy, space, time and their mutual relationships and interaction.

i. Mechanics
ii. Heat and Thermodynamics
iii. Acoustics
iv. Optics
v. Electromagnetism
vi. Quantum Mechanics
vii. Relativistic Mechanics
viii. Nuclear Physics
ix. Particle Physics
x. Astronomy
xi. Cosmology
xii. Solid State Physics

9.3 What is meant by interdisciplinary fields? Give a few examples. 09109027

Ans: It refers to integration and interaction of Physics with various other fields of study. Physics, being fundamental science, provides essential principles, techniques and methods that are applicable across a wide range of disciplines.

i. Bio Physics
ii. Medical Physics
iii. Astrophysics
iv. Climate Physics
v. Computation Physics
vi. Geophysics

9.4 List the main steps of scientific method. 09109028

Ans: Main steps of scientific method are:

i. Observation
ii. Hypothesis
iii. Experiment
iv. Theory
v. Prediction
vi. Falsifiability
vii. Law

9.5 What is a hypothesis? Give one example. 09109029

Ans: On the basis of the data collected through observations or 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 shadows of opaque objects are formed when they come in the path of light because light travels in a straight line.

9.6 Distinguish between a theory and a law of physics. 09109030

Ans. Theory:

After the successful verification of an assumption and with the help of careful experimentations, it becomes a theory.

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 behavior of nature which explains the observations and experiments of the past and can predict about other aspects of nature.

9.7 Differentiate the terms, science, technology and engineering with examples. 09109031

Ans: Science: Understanding the natural world through research and experimentation. Science is a collective knowledge about the natural phenomena, processes and events occurring around us.

Example: Studying the properties of electricity (Physics) → Discovering the laws of electromagnetic induction.

Technology: Applying scientific knowledge for practical purposes.

Example: Using the laws of electromagnetic induction to develop generators, motors, and transformers (Electrical Technology).

Engineering: Using scientific and mathematical principles to design, build, and maintain structures, machines, and systems.

Example: Designing and building a hydroelectric power plant using generators, turbines, and transformers (Civil Engineering and Electrical Engineering).

9.8 What is the basis of laser technology? 09109032

Ans: 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. It is also used extensively for military purpose.

9.9 What is falsifiability concept? How is it important? 09109033

Ans: It is a concept introduced that suggests theory to be considered scientific if it also make 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.

9.10 What is scope of physics in everyday life? 09109034

Ans: Physics plays a vital role in our everyday life. It is the foundation of many technologies that we use daily. From electrical appliances like refrigerators and air conditioners to transportation systems like cars, airplanes, and trains, physics is behind their working. Medical equipment like MRI machines, ultrasound machines, and radiation therapy also rely on physics principles. Even communication systems like phones and the internet are based on physics. Additionally, physics is used in energy generation, building design, weather forecasting, sports equipment, and computer technology. In short, physics is an integral part of our daily lives, and its applications continue to grow and expand into new areas.

SLO Based Additional Short Questions

Branches of Physics

9.1 What is different between geophysics and climate physics? 09109035

Ans. Geophysics:

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

Climate Physics:

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

Uses of Physics

9.2 State some uses of physics in daily life. 09109036

Ans. Physics in daily life:

(i) Transportation (brakes, air travel)
(ii) Technology (smartphones, computers)
(iii) Medicine (MRI, radiation therapy)
(iv) Energy (solar panels, wind turbines)
(v) Sports (golf, skateboarding)

(C) Constructed Response Questions

9.1 Is the theory of science an ultimate truth? 09109037

Ans: Scientific theories are not considered ultimate truths. They are provisional and subject to change as new evidence emerges. Theories are also approximations of complex phenomena and are context-dependent, meaning they may not be universally applicable. As a result, scientific truths are probabilistic and empirical, refined over time through ongoing research and experimentation.

9.2 Do you think that the existing laws of nature may need a change in future? Describe briefly. 09109038

Ans: Yes, it's possible that our current understanding of the laws of nature may need to be refined or even revised in the future. As new discoveries are made and new technologies emerge, our understanding of the universe and its underlying laws may evolve.

9.3 Describe three jobs that use science. 09109039

Ans: Here are three jobs that use science:

1. Medical Research Scientist:

Conducts experiments and gathers data to understand diseases and develop new treatments. They use biology, chemistry, and physics to analyze data and draw conclusions.

2. Environmental Engineer:

Designs solutions to environmental problems, such as air and water pollution. They use chemistry, biology, and physics to develop sustainable systems and technologies.

3. Data Analyst (Astrophysics):

Analyzes large datasets from astronomical observations to understand celestial phenomena. They use mathematical and computational techniques, along with knowledge of astrophysics, to identify patterns and trends.

9.4 When a theory is rejected or need tis modification? 09109040

Ans: A scientific theory is rejected or modified when new evidence contradicts it, predictions fail, inconsistencies arise, or alternative explanations emerge.

9.5 Comment on the statement. "A theory is capable of being proved right but not being proved wrong is not a scientific theory". 09109041

Ans: A scientific theory must be falsifiable, meaning it can be proven wrong through experimentation or observation. If a theory cannot be proven wrong, it is not considered a scientific theory.

9.6 What has been the general reaction to new ideas about established truths? 09109042

Ans: New ideas that challenge established truths are often met with skepticism and resistance. This is because people tend to be invested in their existing understanding of the world and can be hesitant to accept change. As a result, innovative ideas and discoveries are frequently rejected or ridiculed at first, only to be widely accepted later on.

9.7 If a hypothesis is not testable, is the hypothesis wrong? Explain. 09109043

Ans: No, if a hypothesis is not testable, it doesn't necessarily mean it's wrong. It just means that it can't be proven or disproven through experimentation or observation.

9.8 Explain how a small amount of data cannot prove that a prediction is always correct but can prove it is not always correct. 09109044

Ans: A small amount of data can't confirm a universal truth, but it can disprove one. In other words, a single counterexample can falsify a claim, but no amount of supporting data can prove it with absolute certainty it will remain uncertain.

9.9 What is the relationship between an experiment and a hypothesis? 09109045

Ans: An experiment is designed to test a hypothesis. The hypothesis is a predicted outcome, and the experiment is conducted to determine whether the hypothesis is correct or not.

9.10 Explain why the solution of complex problems need interdisciplinary research and collaboration. 09109046

Ans: Complex problems often require interdisciplinary research and collaboration because they involve multiple factors and perspectives that cannot be addressed by a single discipline or field of expertise.

(D) Comprehensive Questions

9.1 Describe the scope of physics. What are the main branches of physics? State briefly. 09109047

Ans: See Q No.1 and 2 of theory part.

9.2 What is meant by interdisciplinary fields of physics? Give three examples. 09109048

Ans: See Q No.3.

9.3 What is scientific method? Describe its main stages with examples. 09109049

Ans: See Q No.5.