

Chapter 1

The Realm of Physics

The First Steps' Learning

- What is Science?
- What is Physics ?
- Why to Study Physics and How to Study Physics?
- Limitations & Assumptions?
- What to Study in Physics?
- Physics & Mathematics

2 | The First Steps Physics

As you begin your journey of revealing the concepts and laws of physics you should know exactly what lies ahead of you. Physics, the most fundamental of all the physical sciences, is concerned with the basic principles behind all physical phenomena in our universe. From chemists to micro-biologists, scientists of all disciplines make use of the ideas of physics. It is the foundational structure on which engineering, technology and the other sciences—astronomy, chemistry, geology, biology etc are placed. The beauty of physics lies in the simplicity of its basic concepts, fundamental theories and their vast and varied applications.

The blue sky, motion of planets around the sun, appearance of rainbow, pleasant waterfalls, disastrous earth-quakes, the beautiful night sky with bright celestial objects are few of the manifestations of the endless lists of natural phenomena. Directly or indirectly the explanation of these facts (natural happenings) belongs to the Realm of Physics. These are far reaching facts and questions, and in this Physics book we are to only make a modest beginning of answering/ understanding them. In fact, our goal is to give you a background of the fundamentals of physics, so that your study of physics later will be more effective, and you would be able to understand all these facts and laws by yourself. In this chapter, we shall delve into certain ideas about the science, the physics, and the 'realm' of physics.

What is Science ?

The word science originates from the latin word “*Scientia*” which means “*to know*”. Now, the question that may arise to your mind is —“To know”, but about what? In somewhat more informative manner, science means “To know—to understand a natural phenomenon”. But now the question arises, how to understand the various natural phenomena? Are there some laws which describe these natural phenomena? Are these laws (if any) stated somewhere? Who derived these laws? Answers to all these questions lies in the basis of science, which is—“*The test of all knowledge is experiment*”. Experiment is the sole judge of any scientific truth. And the more interesting thing is that, an experiment itself is the source of knowledge, and from the results of an experiment, some conclusions have been drawn. These conclusion help us in producing the laws. Then again experiments are done to test the laws so stated, to have an idea about their applicability in different situations.

Broadly speaking, science is a systematic attempt to understand all natural phenomena by performing experiments, observation of results thus found and then by using the knowledge so gained, logical thinking and

imagination, scientists try to explain the related natural phenomena. The conclusions made by the scientists may be in the form of statements, laws, limitation on applicability etc and we, the curious few are going to learn the works done by these scientists.

'Values' of Science

To pursue an effective study of science you need to cultivate the following sets of values, earnestly:

- Being curious about things and events around you.
- To have the courage to ask the question against established beliefs and practices.
- Always asking 'What', 'Why' and 'How', and try to find the exact answers by critical observation, experimentation, consultation, discussion and reason.
- To record honestly your observations and experimental results in your laboratory or outside it.
- To repeat experiments carefully and systematically if required but without manipulating your results under any circumstances.
- Being only guided by facts, reasons and logic. Not to be biased in one way or other.
- To aspire to make new discoveries and inventions by sustained and dedicated work.

What is Physics ?

Physics is the branch of science, which deals with the basic laws of nature related to energy and matter, and their applicability to different physical and natural phenomena. Physics is an experimental science, physicists observe the phenomena of nature and try to deduce certain theories and principles which explain these phenomena. The theory and principles developed by physicists, when well established and of universal acceptance are termed as physical laws or principles of physics. If one wants to be a physicist, he/she has to first go through the works of great physicists like Galileo, Newton, Maxwell, Faraday, Einstein as well as others in depth and then look for some happening in nature which is still unexplored or needs refinement of the existing laws and/or theories to explain it fully. But for you people—the students, the first step is to understand the existing theories first at very conceptual level and then try different varieties of questions to grasp the subject fully, and only after that you could try to discover the things.

In words of Great physicist and Nobel laureate, **Richard P. Feynman**, “the world”—is something like a great chess game, being played by the gods, and we are observers of the game. Let us discuss this analogy of the great physicists in detail.

Take a game of chess, which you don't know how to play, neither you are allowed to play, the only thing is that you are allowed to watch the game being played by other players. Just imagine this situation and think what happens. It is quite obvious, that after watching the game for a long time, you would be able to understand a few rules of the game, however, they may be incorrect or incomplete in same or other way. For example, you are watching the movement of elephant continuously and you deduce “that it would be always moving straight and can cross any number of squares but always remain on the corner column”, all of a sudden

the player changes the course of motion of elephant along the row and then you have to make your rule more complete by adding “that elephant always moves along a straight line either along a row or column and can cross any number of squares”. Now, let us consider that after watching the game for a long time, you are able to deduce many of the rules or almost all, *ie*, you become aware of all the rules of game. Can you play the game effectively after knowing all the rules ? The answer is no because you may know all the rules, but still you don't have that much expertise which let you understand all the moves and that's why you may not be able to make the best move in the given situation. *And, exactly in the same way the physics works!*

Now make any analogy between chess game and physics.

Analogy between the Game of Chess and the subject matter of Physics

Play Field	Chess Board	Nature/Universe
Master	The Player	The God (If you are not an atheist!)
Centre Person	You	The Physicist
Happenings	Moves	Natural phenomena
Ways	Rules	Laws, principles and concepts of physics
Further Ways	Extension or Modification of Rules	Change or modification in existing laws and theories so that a new situation is explained fully, and to get the limitations of existing theories and principles
Third Party	Neutral spectators of the game	The common man

4 | The First Steps Physics

In short we can say that physics involves keen observation of natural and physical phenomena. With the help of the knowledge, logical thinking and imagination, we know the answer of (why? and how?) related to a concerned phenomenon. Once the natural phenomenon has been understood, some

fundamental theory would be developed and then forever, we make use of this theory in various applications. Experiments would be carried out to check the validity of this theory in different domains or to find some degree of incorrectness or incompleteness, in the existing theory.

Why to Study Physics and How to Study Physics ?

You might ask, why to study physics ? What is the need of physics in our daily life ? There are numerous reasons, one can count in support of studying physics. Here we will find a few.

First one, we can't imagine our life without physics. Look around you—the book in your hand, you are able to read (see) only because of physics. The notebook in which you are making notes, is useful only because of physics, if there would not be any friction between paper and pen tip, then you would not be able to write. If you are able to grasp the contents of a lecture or are discussing a question with your friend then you are able to hear your friend because of sound waves. From a few of the applications of physics in our daily life mentioned above, can you imagine life without physics!

The second one, almost all technical and engineering disciplines are based upon physics, whether it is mechanical, electrical, electronics or telecommunication.

The third one, physics is an adventure. When you study physics, you will find it challenging and interesting, sometimes frustrating and painful, but immensely rewarding and satisfying.

And for you—the students, the most important reason to study physics is—that in almost of all of the basic courses in science, physics is compulsory. Moreover, any discipline of life includes physics directly or indirectly. So, without having basic understanding of physics and its laws it is difficult to get success in any field.

Now, you can ask, if physics is so important for me, then how should I study physics ? As such we hope that you understood how the discipline of physics has developed and your aim is to understand and learn the concepts, physical laws and fundamental theory of physics developed by our eminent physicists. So, what is best way to learn physics ? Simply, first learn all the physical laws and then see how they fit (work) in different physical situations. But we cannot do it in this way for two reasons, first we do not yet know all the basic laws, the search is still going on and it will continue for forever to find the unknown ones. And second, the correct statements of the laws of physics involve some very unfamiliar ideas which require advance mathematics for their description *ie*, one should require considerable amount of fundamental knowledge even to understand what the various terms mean in physical laws. Hence, the best way to start physics is to do it bit by bit. What we mean by a bit is that first we consider a simplified model of the actual situation and when we have learnt the simplified model and other requirements to understand the exact situation then we will go for the learning of the actual and exact situation. For example, if one has to analyse the motion of a ball under gravity, then it is advantageous to first analyse the motion of the ball neglecting air friction etc because under this assumption we can treat the ball as a point mass and can neglect the rotational and spinning aspects of motion, and when we have become well acquainted with rotational motion, we can look for the exact picture. The same methodology we are going to

adopt in this book, we will start from very beginning at very basic levels and slowly will go ahead to mix the concepts to understand exact situation or the more approximate situation.

As such, we can say that each bit, or part of the whole of nature is always an approximation to the complete truth or the complete truth as we know it. In fact, every

thing that we know is an approximation of some kind because we do not know all the laws yet.

Limitations and Assumptions

As we are going to explore the concepts of physics, it is very important to understand the meaning behind the word “assumption”, which we use very frequently.

What to Study in Physics ?

Initially, the physics were roughly divided into mechanics, heat, gravitation, electricity, magnetism, quantum mechanics, optics etc. However, the aim of physicists is always to see the nature as a whole *ie*, to interlink various branches of physics. This is another major challenge for physicists to combine various branches, in addition to find the laws behind experiments. The process of amalgamation (interlinking) of various process is continuous one because as the time passes newer things are being found.

Broadly speaking, physics can be divided into two : *classical physics* and *relativistic physics*. The relativistic physics (Major contributor of the relativistic physics is Einstein) is the correct one or complete, in the sense what we know till now. While classical physics (Mainly given by Galileo, Newton and others) fits only in some situations.

Relativistic physics is more correct, interesting and contains unfamiliar ideas and is

difficult to understand, while classical physics is approximate and doesn't include difficult ideas but still the interesting one. Now, the question arises what should we study first—Relativistic physics which is more accurate or the classical physics which is only an approximate one. The first you are going to learn the classical physics because knowledge of classical physics is the first step to learn the relativistic physics.

In this book of physics we will mainly emphasize on classical physics and won't talk about relativistic physics. We will study in the sequence as

1. Mechanics
2. Heat and Thermodynamics
3. Properties of Matter
4. Wave Motion
5. Optics
6. Electromagnetism
7. Modern Physics

Physics and Mathematics

Physics involves the laws related to nature, which has been developed after a series of experiments have been conducted. These laws can be expressed in statement (words), but physics always involves some physical quantities. So, it is always advisable and

beneficial to express physical laws in a mathematical form. Can you imagine your life without words, language, expressions etc, something like same would happen in physics if mathematics won't be there. In short, we can say mathematics is the language of physics.