PHYSICAL QUANTITIES and the UNITS of the INTERNATIONAL SYSTEM (SI)

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CHAPTER
ONE

PHYSICAL QUANTITIES, UNITS, NUMERICAL VALUES AND QUANTITY EQUATIONS

1.1 SENSORS AND NATURAL PHENOMENA

The most versatile "instruments" of measurement are those of the human body. Of these, our eyes receive greatest amount of information concerning the world at large. Almost equally important are our ears, which register sounds. Also important is our sense of touch; the extraordinary sensitivity of our fingertips informs us about qualities of the touched surface — its warmth or coolness, while the muscles that fiex or loose enable us to compare weights and the hardness of materials. Smell and taste, which are related more closely to chemistry than to physics, are also instruments for recognizing the world around us. These aids, which continuously feed us information, are commonly known as *senses*. However, our senses can deceive our reason particularly since they are frequently unreliable and prone to mistakes. Optical illusions, for example, which to us present a falseness that appears real.

One particular disadvantage of reliance on the senses is subjectivity. Certain phenomena will always be repeated in exactly the same way if they are produced by identical stimuli under identical conditions. However, each of us experiences phenomena around us in a different way. The individuals experience is determined by the mood of a particular moment and by the conditions under which a phenomenon occurs. For this reason people react in different ways to identical stimuli, and even one and the same person does not experience repetitions of a phenomenon in the same way each time. Thus, one observes, senses and experiences all phenomena subjectively. *Subjective personal feelings, however, cannot form the basis of science which requires accuracy. Science is based on objective facts and on objectively-gained experience; and these can be gained only through measurement by instruments other than the senses.*

Let us consider some of the fundamental physical concepts, for instance *time* and *space*, as well as their combinations, which include matter and movement. Our first impressions concerning these concepts were, without doubt, the result of our sensory perception.

Time stretches back far into the past, before our birth, and will continue even after our death; it is forever eluding us and cannot be halted, as if it has a way of its own. The question of the genesis of time is a very difficult one, and one which we will not even attempt to answer.

When we are resting, running or driving through the countryside we are conscious (if we are conscious of anything) of the passage of time. Our heartbeats measure time, at the rate of approximately one heartbeat per second all life long. Natural phenomena also help us measure time. Each 24-hour period is marked by the appearance and disappearance of the sun. The cycle of the four seasons, which we all hope to see and experience many more times, marks each year. But our senses have trouble measuring intervals of time that are much greater than the period between one heartbeat and the next, or the time taken up by a blink of an eye. (Nevertheless, it is worth noting that we can forecast eclipses of the sun thousands of years into the future, and we can also calculate that at a certain date in the past, at a certain spot on earth, an eclipse of the sun can be seen).

Space and the distances that divide it describe in a particular way, like time, the nature of the world. When we say that the sun is "near" in relation to any other star, or that Beijing is "far" in relation to any town in our country, we have in fact begun to measure distance, i.e. space. Segments of space, i.e., distances, can be measured by counting the number of spans of a palm, or the number of ruler-sized intervals or steps required to pass the distance between two points. The distance of one kilometer can be measured by steps without much effort. Smaller distances can be measured with the aid of fingers. But how are we to measure distances so great that they cannot be measured in steps, or those so tiny that they cannot be perceived? The measurement of exceptionally great and exceptionally small distances particularly helps us understand the way nature works. To better approach this understanding, physicists have found methods for measuring distances to the planets and the stars, as well as ways of measuring even the "diameter" of atoms.

One of the great achievements of our time in physics is knowledge concerning the inner structure of matter. We have discovered that various materials (skin, bone, wood, rock, nylon, air, even the sun) are made up of equal, basic components — atoms. Combinations of these basic units are responsible for the "shaping" of everything in our complex world we live in, even our bodies. We have not discovered these atoms directly, with the aid of our senses. They are too small for to be perceived by our everyday experience. We have learned of their existence by extending the potentials of our senses through the theories and methods of physics and chemistry.

1.2 PHYSICAL QUANTITIES

In the previous section we touched upon only a few natural, i.e., physical, quantities and concepts like time, space and distances dividing space, as well as the way in which these quantities can be measured. Apart from time and space, many other natural phenomena, processes and states of which is based exclusively on their measurement. Natural phenomena, processes, and states neither appear (come into being or arrive) nor are considered alone and in isolation; they are always linked to tangible bodies, or

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