Introducing:
Newtonian Physics

1-a Why "Newtonian"?

This book is based, mainly, on Newton's principles of physics. It is intended to be a first book for students, at the introductory level. The book uses algebra, geometry and trigonometry but leaves calculus out. It may not be exactly suitable for those who wish to become physicists, but the material presented will certainly make them feel ready for physics at any level. The book is developed essentially for students of biological and health sciences (hence no calculus). As an introductory level course, it will be found to be good for all science (and mathematics) students.

The book looks at physics from a macroscopic point of view. We will not go into microscopic details. Phenomena involving extremely small and extremely large magnitudes of time, will, in general, not be attended to. To be more specific, study of Relativity(i), Atomic and Nuclear Physics(2) and the like, will be left out. Thus unveiling the myths of Avatars' Pandora, and exploring the secrets of *how I wonder what you are*, will not be undertaken either.

The book does not go as deep in physics as we know it today. But whatever is presented, is good enough for most of what we do around here, in our everyday life, including trips to Moon and Mars. We shall be presenting to you a simpler, gentler, everyday version of physics that should abundantly support you to get a degree in everything but physics. If you change your mind and proceed toward a degree in physics, future courses in physics will bring you up-to-date and you will never feel that you wasted your time. In fact you will find yourselves better equipped compared to most other students. This is because the fundamentals never change. Good to now that Newton's laws have not been found wrong or defective since the year 1687 (when they were published) to-date; some 325 years ago!

So, it is the everyday physics that we shall be presenting in this textbook. Because of our limited scope, please do not ask questions such as: why is the universe expanding, or what is the purpose of the multi-billion dollar *Large Hadron Collider*, or why are they planning to build a 22-mile long *linear particle accelerator*(3). At this stage, it may not be a bad idea to (i) learn the maximum of physics with minimum of indulgence, (ii) graduate and get a decent job in your field of interest, and (iii) live happily ever after.

1-b The Plan

We shall first build an infra-structure. This structure will be strong enough to support not only our *humble* physics, but all the *heavy-weight* physics as well (with some adjustments, maybe) that you may learn later. This approach is fundamentally different from the ones followed by other textbooks. You only have to read the first three chapters called *Basic Principles* to understand what we mean.

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(1) To learn more about Relativity, please refer to: $E = mc^2$ by "Synthetik FM" (2007) or, more recently, by "Mariah Carey" (2008).

(2) To learn more about Nuclear Physics, please follow the sequence "Big Bang Theory" presented weekly by the well-known nuclear physicist Dr. Sheldon Cooper and his team, on CBS.

(3) This is indeed an unnecessary (and hence inconsequential) question

The book tends to introduce physics and its laws from an observational and logical perspective to produce coherence and philosophical satisfaction in our minds. Thus it will not appear to you to be a disorganized jumble of topics dumped on to one another. Physics begins with observations that are processed by logic to predict new aspects that must be verified by experiments. Experiments bring *new* theoretical aspects into our field of vision which must be verified by *new* experiments, giving rise to even more *new* theoretical aspects. The process results in a diverging infinite series of expansion and propagation of knowledge.

1-c Role of Mathematics

Even though physics is glued to mathematics (though not *vice versa*), we (the physicists) shall still maintain our identity. This is because physics is different from mathematics, even though it will probably not be possible to do any physics without using mathematics. However, the final outcome of our investigations will always be in the language of physics. It will be correct to say that mathematics is a tool box for physics. These tools help us to shape and reshape our observations in the physical world to produce a logically and philosophically acceptable theory. To this end, we shall be using suitable branches of mathematics, generously and extensively. It should be noted that as a tool box, mathematics is also extensively used by workers in other scientific and non-scientific fields of learning.

How Different?

In physics, we **always** have an object, identified as the *target* object. A target object is caused to perform some activity by other objects (or their agents), to be identified as *incident* objects (or *agencies)*. In mathematics there are no target or incident objects and none is caused to perform any activity. What they have, is an infinite number of massless geometrical points, each of zero dimensions (no length, no breadth and no thickness). These points do not perform any activity. See the difference? There is no object, and there is no activity!

As an example, consider a *circle.* In physics, a circle is the trajectory of a target object that moves obeying a certain protocol, impressed upon it by incident objects or their agencies. In mathematics, a circle is the locus of all points (an infinite number of them, sitting pretty in their seats) that just *happen* to be satisfying the same protocol. Here there is no object and no motion. As another example, consider the Pythagorean Theorem: $a^2 + b^2 = c^2$. Here a and b are the two sides of a right-angled triangle and c is the hypotenuse. In physics, the theorem offers us a way of combining two completely independent (incident) entities or agencies (a and b) of the same genre, acting upon a target object. The entity c will then represent the combined effect of those agencies on the target object. A good example is that of a *coil* made of some conducting material. In an AC circuit, the coil has two completely independent properties: *resistance* R and *reactance* χ, both expressed in units of *ohm* (thus being of the same genre). The combined effect on the coil, called *impedance* Z, is given by $Z^2 = R^2 + \chi^2$.

Again, being at *right angle* in mathematics, translates to being *absolutely and totally independent* in physics. In physics, we promote the concept of independence (total and absolute) in place of being perpendicular or being at right angles to one another or being orthogonal, etc, etc.

What Suitable Branches?

The different branches of mathematics that are used for physics at the introductory level for non-physics-major students (broadly speaking) are (i) arithmetic, (ii) algebra (pre-calculus), (iii) geometry, (iv) trigonometry, and (v) graphs. Pre-calculus algebra contains, among other things, logarithms, exponents, expansion theorems, complex numbers and their algebra and so on.

In this textbook we shall place extra emphasis on graphs, geometry and trigonometry. Graphs have a of distinct advantage when it comes to deriving some equations. Graphs are a visual technique and as such should be preferred over algebra wherever and whenever possible. Algebra is abstract. We see nothing. In graphs, the visuality of the situation is an added (welcome) advantage. Additionally, we are able to explain some perplexing features easily. For example, many entities in physics are *halves* of one thing or another. Displacements of objects with non-jerk motion come with a factor of *one-half*. Most energies are also *halves* of something. It may be perplexing with the use of algebra but if you use graphical methods, you probably not even ask the question.

Some geometrical methods help us to bypass tedious algebra. If the number of incident objects (acting on a target objet), remains limited to two or three, we may construct triangles (single or paired) and then use geometrical methods, instead of algebraic methods. This approach seems to work very well in several sections of the textbook.

1-d Extent of Indulgence: "Less is More"

A significant number of authors, have a tendency of reducing the number of topics covered in their textbooks. Each new edition comes with a reduced number of topics in the text. The quality of the end-of-the-chapter problems, also keeps deteriorating. Many challenging and good quality problems are consistently being taken out. The cause of this shrinkage is a cancer-inducing policy known as "Less is More". It advocates teaching of fewer topics in physics but at greater depth. The result invariably always is that the surface area decreases but the depth remains unchanged. The net of knowledge imparted to the students shrinks.

The policy: *less is more,* is best suited to publications like the *Playboy magazine,* but is totally detrimental for the academic health of our students. In the first place it gives them the impression that the students of the years past were more intelligent. (And I never shied-away from bringing this point home to my students.) It tells us that the student community is getting dumber by the day? It also means that the ability of our student to creatively think and solve challenging problems is shrinking or melting away.

One does need to find a cut-off point for the amount of material, to be included in a course. This is because of the.limited time available for teaching. But this should be the prerogative of the teacher, and not of the book. The book should provide the teacher with all the relevant material (plus some mere) and leave the implementation to the teacher. But the teacher should never feel that he (or she) has been short-changed. This textbook vehemently opposes the *less is more* philosophy. We must provide the community with maximum of knowledge and let the students absorb to their capacity. The policy *less is more* is a cancer-inducing virus, a cancer that is bound to cause irreparable damage to our academic health.

1-e Extent of Indulgence: "Mindless Memorization"

A significant number of educators, have a tendency of requiring our students not to memorize mindlessly but derive all equations (or other relevant material), from basic principles. In essence, it boils down to asking the students to *not* memorize anything but be able to evolve them from concepts

Working out equations from basic principles requires time which may not always be available. In an examination, we ask students to solve up to 5 problems in an hour. Only the few gifted students will be able to do so but if you knew the equations by heart, you can easily solve all 5 problems.

Memorization is the 50th basic human right of mankind (49th basic human right is to eat an ice-cream a day). We have a mind with a healthy brain. Why not use it? The brain does not deteriorate by use. It grows and its quality improves. No one ever digests all information immediately. But if you remember the material, you will be able to understand it tomorrow, or day-after, or next week. But if you do not remember, there will be nothing to understand or improve your personality.

Chemistry students memorize (quite obviously). Biology students memorize. Anatomy is total memorization. Physiology and Geology are no different. English majors memorize and so do economists and philosophers. Why not physics students?

The advice to *avoid mindless memorization*, is another cancer-inducing virus, with a high potency to corrupt our efficiency of learning physics, beyond repair. We should encourage our students to memorize and memorize until they have a mind-full of memorized goods from all branches of physics.

1-f Extent of Indulgence: "Significant Figures"

A significant number of educators follow a policy of *significant figures* in all calculations and in the final results. Such a policy leads to unduly approximated answers. Often times the whole purpose of the exercise is lost. For example, if you want to prove to your students that the potential difference between two points A and B is independent of the path, and you have been following the *significant figures* policy, you would be sadly dismayed.

When we use mathematics, we are in the kingdom of mathematics and we must obey the rules of the land. There is no concept of *significant figures* in the math-land. We are supposed to calculate up to a very large number of decimal places. It is believed that Newton performed his calculations to 36 decimal places (no calculators!).

We do not want to be that rigorous because we are doing introductory level physics only and certainly not doing research. A thoughtful consideration of all factors, has led us to recommend strongly that we perform all calculations to five decimal places and do not take an approximate value at any stage. Once the final result has been arrived and we are back in the physics territory, then we can round up the number to a degree we deem suitable. Suppose the answer to a calculation is: 12345.67891 miles. After having mentioned this number as the final outcome of the calculations, we may now make an approximation. This approximation will vary from person to person. Some may like to approximate to 12346 miles, others may approximate to 12350 miles, some may say *a little over 12000 miles*, and so on. All of the above approximations will be gladly accepted and respected. However, if this answer is to be used in a subsequent calculation, we shall go back to the original answer: 12345.67891 miles.

1-f Solving Problems

Proficiency in solving problems is a measure of understanding the principles. A problem may be solved in more than ways but the one who really understands physics, will be able to solve the problem by using most efficient method. Such a method will use minimum of algebra and minimum number of steps of calculation. One of my favorite authors, had introduced the *Kiss* principle: *keep it short and simple.* I am introducing the *Miss* principle*: make it short and simple.* Avoid solving in two stages, if it is possible to solve it in one.

The book intends to provide good quality problems, at the end of each chapter. There will be a good number of solved problems also. We intend to provide answers of all problems (and not just the answers of odd-numbered problems). After solving a problem, you must be told if the answers, you arrived at, are correct. If in-correct, you could go back and embark upon a fault-finding mission. But if you are not told, you will sit with the impression that all is well and the case will remain closed until it hurts you in an examination (or something).

We also intend to provide students with some helpful formats for solving problems. These are based on the theory and simplify the process of solving a problem. One such format, named the *deviate* format has been very popular with students. Similar problem-solving formats are available in many parts of the book. Some aspects of the theory may not be too obvious to be picked up by students on their own. For example the role of the discriminant of a quadratic equation in finding the magnitude of the impact velocity of a projectile, or the maximum acceleration of a bungee jumper. We always encourage students to make use of such techniques.

1-g And More

A clear distinction must be made between *materials and substances* and *objects and devices*. The physical properties of these two groups are distinctly different. Thus it will be wrong to say that a capacitor has permittivity or that a gold necklace has density. Permittivity is a property of materials and substances. A capacitor being an object or device cannot have permittivity. Similarly density is a property of the material/substance and not of objects/devices made from them. Thus a gold necklace cannot have density.