Understanding Newton

NEWTON'S PRINCIPIA FOR THE COMMON READER

by S. Chandrasekhar
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IN the humanities commentaries are written on classic texts. A few commentaries and the commentators in due course themselves become classic. Thus Mallinatha's commentaries on the texts of Kalidasa are read avidly by scholars who wish to derive the maximum enjoyment and appreciation of the poet's work.

This, however, is rare in science. So when a distinguished scientist with several accolades including the Nobel Prize, writes on *Principia*, a scientific classic written by no less a person than Isaac Newton, and its title states that it is for the "common reader" great expectations are roused. Here we have a distinguished commentator writing on a distinguished book by a distinguished author. So the reader naturally expects a treat. The get-up of the book indeed does justice to the remarkable confluence, combining simple elegance with accuracy of printing.

Professor Chandrasekhar did pathbreaking work in several parts of theoretical astrophysics and general relativity. He would work at a terrific pace in his chosen field regardless of whether it was a popular one amongst his fellow scientists. At the end of a decade's (or so) work he would come out with an authoritative monograph that was treated as the "last word" on the subject. As an author he would make no compromises with rigour and exactness and his works were directed at researchers in the field. It was therefore something of a surprise that this last work was directed at the common reader.

The typical "common reader" will, however, be disappointed with the fare served to him. If after reading (or having on his shelf) *A Brief History of Time* he has persuaded himself that he can undestand science and appreciate Newton's work as described here he will be in for disillusionment. For, to get the maximum benefit out of this book you need to have a knowledge of dynamics, calculus and geometry at the undegraduate level! If you have such accomplishments then by all means take a plunge into the myriad of figures, propositions and prroblems that make up this book.

To get the historical perspective right, Isaac Newton wrote his *magnum opus* entitled *Philosphiae Naturalis Principia Mathematica* (*The Mathematical Principles of Natural Philosophy*) in three parts during 1684-86. In these volumes he described his work on the law of gravitation, dynamics as applied to planetary motion, optics and also many other investigations. He also used calculus, both integral and differential, but in order to make his work more readable (and more credible) to his contemporaries he resorted to the then familiar geometrical proofs in preference to the new methods of calculus that he himself had invented.

Principia as the book is called in short had been the guiding light for mathematicians and physicists for over a century. But for the modern reader the language (even though translated into English from Latin) and style of arguments are archaic. I myself recall opening the book in several places and on several occasions just for selective reading, then putting it down. Yet, as Professor Chandrasekhar says in the opening parts, he undertook the task of explaining and elaborating on Newton's work in the modern framework so that "With the impediments of language and syntax thus eliminated, the physical insight and mathematical craftsmanship that invariably illuminate Newton's proofs come sharply into focus..."

It is certainly a very worthwhile attempt to look at the classic from a modern standpoint, armed with the modern techniques of maths that were unfamiliar to the Newtonians. Professor Chandrasekhar goes through select portions of the *Principia*, describing in places how Newton argued and then explaining it in modern jargon. Thus what to a common reader may appear obscure and antiquated arguments turn out to be examples of ingenious geometrical constructions and brilliant reasoning. The author quotes the Cambridge mathematician Professor Littlewood at one place: "... this construction (by Newton) must have left its readers in helpless wonder".

The author himself admits that when he worked through the various propositions of the *Principia* he did so without looking at Newton's solutions. Only subsequently when he compared his methods with Newton's did he realise how far superior were the latter compared to his own. Coming from one whom modern theoreticians held in awe as an expert in mathematical techniques this is high praise indeed

Without going into technical details the following is the fare served in this feast on (or, more correctly, by) Newton. The author has largely restricted his attention to those parts that deal with the law of gravitation and its dynamical consequences. Thus 24 out of 28 chapters deal with such topics. Starting from basic concepts and axioms on laws of motion, followed by ideas of limit and continuity and notions of calculus, Kepler's laws and their derivation from the law of gravitation follow. There are discussions of celestial mechanics, lunar theory, three-body problem etc, and then what the author calls "superb theorems" on grravitational forces produced by spherical bodies. (The adjective "superb", as the author explains, actually came from J.W.L. Glaisher)

Next come portions of Book III, which deal with wider applications of the law of gravitation, including figures of the Earth and planets, generation of tides, more of lunar theory, the precession of equinoxes and motions of comets. This menu is then supplemented by a few miscellaneous topics like air drag on falling bodies, the solid of least resistance, the velocity of sound and of long waves in canals and the celebrated problem of brachistochrone. The reader may have heard of the brachistochrone episode wherein Newton solved a problem set by Johann Bernoulli as a challenge to mathematicians of Europe and Britain. (There was no EC those days!) It is good to see a detailed and authentic version of the story along with several solutions (including Newton's) of the problem. I strongly recommend the student to read this chapter.

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Having said all this, one cannot help remarking that this last of Professor Chandrasekhar's works does not measure up to the high standard he himself set through his earlier works. Whether it was *An Introduction to the Theory of Stellar Structure*, or his *Mathematical Theory of Black Holes* there was an air of perfection about them. The reader was assured that whatever was worked out was meticulously checked and all conclusions were backed up by fully worked out analytical arrguments. Here in this book there are glaring examples of numerical errors and also some errors of reasoning. An example of the former is the error in calculating the time period of a simple pendulum. Of the latter is a mix-up right at the beginning when calculating the acceleration of the Moon.

On some important aspects of *Principia* the author's commentary would have been welcome, but, alas, they are left out. An example is the Scholium in which Newton discusses the well-known bucket experiment with the introduction of the concept of inertial forces. This is a topic still debated by physicists and philosophers with historical inputs from Bishop Berkeley, Ernst Mach and Albert Einstein. The celebrated Mach's Principle is related to this discussion in Newton's *Principia* but the common reader here does not encounter it at all.



S. Chandrasekhar as a young professor: rigour and exactness

A modern scholar will miss the index at the end and a bibliography. Surely it would have been of great help to be able to locate a topic in the text and to know about works of others in the field.

Professor Chandrasekhar passed away within a few weeks of the publication of this book. Nearing 85 he was more active as a scientist than many half his age. It is a pity that he is not alive to respond to constructive criticism which would surely have made a revised edition far better. Even as it is, the "common reader" interested in knowing how the subject of mechanics developed will find this re-presentation of Newton's outstanding contributions to the subject rewarding to read. ■