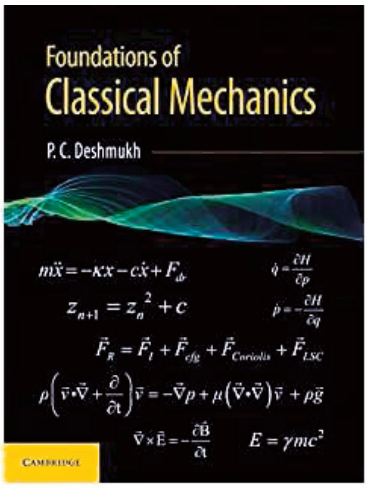
# A New Look at Classical Mechanics*

*Dipanjan Chakraborty*




***Foundations of Classical Mechanics***
**Author**: P C Deshmukh
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Classical Mechanics is one of the fundamental pillars of Physics, which every student of Science must master to begin his or her journey. It describes our natural world to a very large extent. Despite the fact that every curriculum in Physics is designed with Classical Mechanics as its first basic course, there remains a severe lack of suitable textbooks for such an important subject. Having taught the subject twice in the undergraduate curriculum of IISER Mohali, this author's experience/interactions have strongly reinforced this opinion. In the last ten years, the higher education system in India has gone through a silent revolution. With the establishment of the IISERs, there is a profound change in the methodology of science education although this remains somewhat exclusive. In the University curriculum, the usual text books on the subject are scant in the sense that they do not provoke any further scientific curiosity in the reader's mind. Rather they treat the topic as an exercise in solving differential equations. Perhaps this remains a limitation of the authors. In contrast, the modern curriculum encourages a more critical thinking and *Foundations of Classical Mechanics* seems to do just that.

The first eight chapters of the book deal with the dynamics of particles. The ninth chapter introduces a very important topic to the readers – chaos in dynamical systems. Beyond these, the chapters 10–12 introduce the classical treatment of fields with specific examples of fluid mechanics and electrodynamics. Finally, chapters 13–14 provide a detailed discussion on special and general theory of relativity. Despite the fact that the book covers such a wide range of topics in classical physics, the chapters are well written and there is a unique balance between a qualitative and a quantitative description of the topics.

The first chapter starts with the Newton's laws

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sical mechanics. But the author goes beyond this and introduces the concept of symmetry and its connection with the underlying conservation principles. The connection is repeatedly emphasized throughout the book.

The second chapter of the book introduces the essential mathematical preliminaries that are basic requisites in dealing with the different topics. It is worth noting that the author assumes that the readers have been exposed to some basic mathematical concepts such as calculus, matrix algebra and vectors. Nevertheless, the introductory section of this chapter revisits these concepts and also introduces the readers to the idea of a directional derivative (the beginning of multivariate calculus). Coordinate transformations such as rotation and reflection are also illustrated in this chapter with suitable figures and schematics, after which a rigorous mathematical description is presented. The concept of pseudo-vectors is explained with illustrative examples.

The mathematical preliminaries also introduce the curvilinear coordinate systems with specific examples of the spherical polar and the cylindrical coordinate system. For the more advanced readers, particularly for students with Physics majors curriculum, the author discusses the concept of covariant and the contravariant tensors, which are later used in electrodynamics and the special theory of relativity.

With the mathematical preliminaries in hand, the book goes on to discuss one of the rather difficult topics in Newtonian mechanics—motion in a non-inertial frame and the concept of the pseudo-forces. A qualitative/intuitive understanding of pseudo-forces is provided before a more rigorous discussion on their origin and applications. While the case of linearly accelerated frame is straight forward, the chapter also discusses the more complex scenario of a rotating frame of reference. The quantitative discussion is very nicely presented with the help of schematics and illustrations. In this regard, I particularly find the section "Real effects that seek pseudo forces" to be very interesting. The section illustrates our daily encounter with pseudo forces that arises from the Earth's rotation.

Chapters 4 and 5 of the book deal with small oscillations of a single particle. As with other chapters, the author provides an insightful description of the origin of oscillatory behaviour in a system and its connection to the potential minimum. The standard treatment of oscillations of a single particle is illustrated with different examples. The collective oscillatory motion of a system of particles in the form of waves is also included in the chapter. Additionally, for the more advanced readers, Fourier series and Fourier transformation are also introduced. Perhaps, what is missing in this chapter is the discussion on normal modes of a system of particles.

Beyond chapter 5, the discussions are targeted towards the more advanced readers, who are pursuing a Physics major. The variational principle, Euler–Lagrange equations and Hamilton's equation are covered in chapter 6 with ample illustrative examples. The

subsequent chapters 7 and 8 discuss rigid body motion and central forces. A special mention must be made of the chapter on chaos in dynamical systems. This insightful chapter introduces fractals and dynamical systems to the young minds. The inclusion of this chapter is unique in a textbook on classical mechanics and is welcome. Most of the textbooks on classical physics have ignored dynamical systems, although the topic is a natural extension of classical mechanics.

The classical treatment of fields is introduced in chapters 10–12, with emphasis on electrodynamics and fluid mechanics. Additional mathematical concepts such as gradient, divergence and curl are also developed. The special theory of relativity discusses the standard Lorentz transformations in the four-vector formalism. Simultaneity, time dilation and length contraction are discussed with very nice illustrative examples. Finally, the book concludes with a brief yet detailed overview of general theory of relativity.

The general structure of the book is highly appealing and there appears a nice "fluidity" in the presentation. The structure of the presentation is also extremely useful. A careful reading of the book reveals that the book is targeted both at the advanced readers as well as the beginners – students who have not been exposed to basics of Physics in their high school curriculum. The first five chapters are designed in this format. The required mathematical preliminaries are introduced keeping in mind the requirements for the first five chapters. At a later stage, more advanced topics such as vector operators are introduced for the subsequent chapters.

What is fascinating about the book is that the author has managed to find an equilibrium between the qualitative and the quantitative description of the underlying Physics. At no point, the reader is overburdened with mathematical details. There are plenty of illustrative examples that go a long way to excite the inquisitive mind. If you have not got a copy of this book yet, then I urge you to get one for yourself.

***Dipanjan Chakraborty***
Assistant Professor
Department of Physics
IISER Mohali
Knowledge city, Sector 81, SAS Nagar
Manauli PO 140 306, Punjab, India.
Email: chakraborty@iisermohali.ac.in