

Elements Of Newtonian Mechanics Including Nonlinear Dynamics

Following the Boltzmann-Gibbs approach to statistical mechanics, this new edition of Dr ter Haar's important textbook, *Elements of Statistical Mechanics*, provides undergraduates and more senior academics with a thorough introduction to the subject. Each chapter is followed by a problem section and detailed bibliography. The first six chapters of the book provide a thorough introduction to the basic methods of statistical mechanics and indeed the first four may be used as an introductory course in themselves. The last three chapters offer more detail on the equation of state, with special emphasis on the van der Waals gas; the second-quantisation approach to many-body systems, with an examination of two-time temperature-dependent Green functions; phase transitions, including various approximation methods for treating the Ising model, a brief discussion of the exact solution of the two-dimensional square Ising model, and short introductions to renormalisation group methods and the Yang and Lee theory of phase transitions. In the problem section which follows each chapter the reader is asked to complete proofs of basic theory and to apply that theory to various physical

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situations. Each chapter bibliography includes papers which are of historical interest. A further help to the reader are the solutions to selected problems which appear at the end of the book.

It is a feature of the history of the subject that the study of atomic physics was accompanied by a partial neglect of that of classical mechanics. This led to the unsatisfactory situation in which the physicist was expected to assimilate the elements of quantum and statistical mechanics without understanding the classical foundations on which these subjects were built. The situation has improved in recent years through the general lengthening of degree courses, and it is now usual to study the analytical formulation at the late undergraduate stage. A number of excellent treatises are available, and there are also many elementary accounts to be found in general works on physical principles. However, there has been available so far no self-contained introduction to the subject which provides the beginner with a broad general review without involving him in too much detail. It is hoped that this book may bridge the gap by providing the experimental physicist with a sufficient background for his theoretical understanding and the theorist with some stimulus to study the masterpieces of the subject. The mathematical equipment required is no more than in the normal honours physics course. For the purposes of Chapters IX XI it includes an

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elementary knowledge of cartesian tensors. A familiarity with Newtonian mechanics and some acquaintance with special relativity theory are presumed, though summarizing accounts are also given.

This book presents the basic elements of theoretical physics in a highly accessible, captivating way for university students in the third year of a degree in physics. It covers analytical mechanics, thermodynamics and statistical physics, special and general relativity and non-relativistic quantum theory, fully developing the necessary mathematical methods beyond standard calculus. The central theme is scientific curiosity and the main focus is on the experimental meaning of all quantities and equations. Several recent verifications of General Relativity are presented, with emphasis on the physical effects – why they were predicted to exist and what signals they were seen to produce.

Similarly, the basic reasons why superconductors have zero resistance and are perfect diamagnets are pinpointed. Quantum Eraser Experiments and Delayed Choice Experiments are described. Many statements of Quantum Theory are a challenge to common sense and some crucial predictions have often been considered hard to believe and have been tested experimentally. The book examines the EPR paradox, Bell states and teleportation. To show the beauty and richness of the subject, various

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topics from different areas of Physics are covered. These include: discrete quantum models and lattices (periodic and not), Casimir effect, Anyons, Fano Resonances, the Hanbury Brown and Twiss effect, the Aharonov-Bohm effect, the Meitner-Auger effect, Squeezed Light, the Rabi model, neutrino oscillations, aspects of Quantum Transport, Quantum Pumping, and Berry phases, black holes and cosmological problems.

This textbook offers a readily comprehensible introduction to classical Newtonian gravitation, which is fundamental for an understanding of classical mechanics and is particularly relevant to Astrophysics. The opening chapter recalls essential elements of vectorial calculus, especially to provide the formalism used in subsequent chapters. In chapter two Classical Newtonian gravity theory for one point mass and for a generic number N of point masses is then presented and discussed. The theory for point masses is naturally extended to the continuous case. The third chapter addresses the paradigmatic case of spherical symmetry in the mass density distribution (central force), with introduction of the useful tool of qualitative treatment of motion. Subsequent chapters discuss the general case of non-symmetric mass density distribution and develop classical potential theory, with elements of harmonic theory, which is essential to understand the potential development in series of the

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gravitational potential, the subject of the fourth chapter. Finally, in the last chapter the specific case of motion of a satellite around the earth is considered. Examples and exercises are presented throughout the book to clarify aspects of the theory. The book is aimed at those who wish to progress further beyond an initial bachelor degree, onward to a master degree, and a PhD. It is also a valuable resource for postgraduates and active researchers in the field.

In the third edition a number of minor misprints that appeared in the second edition have have been corrected. Furthermore, 17 new problems have been added, at the end of chapters 6, 8, 9, 11, 12, 13, and 14. The answers to these 17 problems have not been listed in the 'Answers' section at the end of the book. This will permit the problems to be used as hand-in problems or perhaps in mid-term exams.

JMK €9 PGH Copenhagen May 2000 Preface to the Second Edition In the second edition, a number of misprints that appeared in the first edition have been corrected. In addition to this, we have made improvements based on the experience gathered in the use of the first English edition of the book in the introductory course in physics at the University of Copenhagen. A chapter introducing nonlinear dynamics has been added. The purpose of this chapter is to provide supplementary reading for the students who are interested in this area of active

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research, where Newtonian mechanics plays an essential role. The students who wish to dig deeper, should consult texts dedicated to the study of nonlinear dynamical systems and chaos. The literature list at the end of this book contains several references for the topic.

(revised) This is a textbook on classical mechanics at the intermediate level, but its main purpose is to serve as an introduction to a new mathematical language for physics called geometric algebra. Mechanics is most commonly formulated today in terms of the vector algebra developed by the American physicist J. Willard Gibbs, but for some applications of mechanics the algebra of complex numbers is more efficient than vector algebra, while in other applications matrix algebra works better. Geometric algebra integrates all these algebraic systems into a coherent mathematical language which not only retains the advantages of each special algebra but possesses powerful new capabilities. This book covers the fairly standard material for a course on the mechanics of particles and rigid bodies. However, it will be seen that geometric algebra brings new insights into the treatment of nearly every topic and produces simplifications that move the subject quickly to advanced levels. That has made it possible in this book to carry the treatment of two major topics in mechanics well beyond the level of other textbooks.

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A few words are in order about the unique treatment of these two topics, namely, rotational dynamics and celestial mechanics.

Quantum field theory is hardly comprehensible without path integrals: the goal of this book is to introduce students to this topic within the context of ordinary quantum mechanics and non-relativistic many-body theory, before facing the problems associated with the more involved quantum field theory formalism.

Purpose and Emphasis. Mechanics not only is the oldest branch of physics but was and still is the basis for all of theoretical physics. Quantum mechanics can hardly be understood, perhaps cannot even be formulated, without a good knowledge of general mechanics. Field theories such as electrodynamics borrow their formal framework and many of their building principles from mechanics. In short, throughout the many modern developments of physics where one frequently turns back to the principles of classical mechanics its model character is felt. For this reason it is not surprising that the presentation of mechanics reflects to some extent the development of modern physics and that today this classical branch of theoretical physics is taught rather differently than at the time of Arnold Sommerfeld, in the 1920s, or even in the 1950s, when more emphasis was put on the theory and the applications of partial-differential equations. Today, symmetries and invariance principles, the structure of the space–time continuum, and the geometrical structure of mechanics play an important role. The

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beginner should realize that mechanics is not primarily the art of describing block-and-tackles, collisions of billiard balls, constrained motions of the cylinder in a washing machine, or - cycle riding.

This is the definitive treatise on the fundamentals of statistical mechanics. A concise exposition of classical statistical mechanics is followed by a thorough elucidation of quantum statistical mechanics: postulates, theorems, statistical ensembles, changes in quantum mechanical systems with time, and more. The final two chapters discuss applications of statistical mechanics to thermodynamic behavior. 1930 edition.

You universe is about you and the way things really are--how to improve your chances of a much longer and more satisfying life. It could be called an extension of an old and honorable tradition, that of enlightened self-interest. Traditional ideologies teach sacrifice for something "greater" than yourself, but in the era of cryonics and anti-senescence research, with a little brains and a little luck, you can do much better.

This book is based on the author's lecture notes for his Introductory Newtonian Mechanics course at the Hellenic Naval Academy. In order to familiarize students with the use of several basic mathematical tools, such as vectors, differential operators and differential equations, it first presents the elements of vector analysis that are needed in the subsequent chapters. Further, the Mathematical Supplement at the end of the book offers a brief introduction to the concepts of differential calculus mentioned. The main text is divided into three parts, the first of which presents the mechanics of a single particle

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from both the kinetic and the dynamical perspectives.

The second part then focuses on the mechanics of more complex structures, such as systems of particles, rigid bodies and ideal fluids, while the third part consists of 60 fully solved problems. Though chiefly intended as a primary text for freshman-level physics courses, the book can also be used as a supplemental (tutorial) resource for introductory courses on classical mechanics for physicists and engineers

Analytical Elements of Mechanics, Volume 2: Dynamics focuses on the processes, methodologies, approaches, and technologies involved in classical mechanics. The book first offers information on the differentiation of vectors, including vector functions of a scalar variable; derivatives of sums and products; vector tangents of a space curve; vector binormals of a space curve; and Taylor's theorem for vector functions. The manuscript then ponders on kinematics, as well as angular velocity and acceleration, absolute and relative velocity and acceleration, and rates of change of orientation of a rigid body. The text examines second moments and laws of motion. Discussions focus on second moments of sets of particles and continuous bodies, second moments of a point, motions of rigid bodies, and linear and angular momentum. The publication is a dependable reference for readers interested in the dynamics of the analytical elements of mechanics.

This book presents the basic elements of Analytical Mechanics, starting from the physical motivations that favor it with respect to the Newtonian Mechanics in Cartesian coordinates. Rather than presenting Analytical

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Mechanics mainly as a formal development of Newtonian Mechanics, it highlights its effectiveness due to the following five important achievements: 1) the most economical description of time evolution in terms of the minimal set of coordinates, so that there are no constraint forces in their evolution equations; 2) the form invariance of the evolution equations, which automatically solves the problem of fictitious forces; 3) only one scalar function encodes the formulation of the dynamics, rather than the full set of vectors which describe the forces in Cartesian Newtonian Mechanics; 4) in the Hamiltonian formulation, the corresponding evolution equations are of first order in time and are fully governed by the Hamiltonian function (usually corresponding to the energy); 5) the emergence of the Hamiltonian canonical algebra and its effectiveness in simplifying the control of the dynamical problem (e.g. the constant of motions identified by the Poisson brackets with the Hamiltonian, the relation between symmetries and conservations laws, the use of canonical transformations to reduce the Hamiltonian to a simpler form etc.). The book also addresses a number of points usually not included in textbook presentations of Analytical Mechanics, such as 1) the characterization of the cases in which the Hamiltonian differs from the energy, 2) the characterization of the non-uniqueness of the Lagrangian and of the Hamiltonian and its relation to a “gauge” transformation, 3) the Hamiltonian formulation of the Noether theorem, with the possibility that the constant of motion corresponding to a continuous symmetry of the dynamics is not the canonical generator

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of the symmetry transformation but also involves the generator of a gauge transformation. In turn, the book's closing chapter is devoted to explaining the extraordinary analogy between the canonical structure of Classical and Quantum Mechanics. By correcting the Dirac proposal for such an explanation, it demonstrates that there is a common Poisson algebra shared by Classical and Quantum Mechanics, the differences between the two theories being reducible to the value of the central variable of that algebra.

Many problems in classical mechanics can now be readily solved using computers. This text integrates Maple, a general-purpose symbolic computation program, into the traditional sophomore- or junior-level mechanics course. Intended primarily as a supplement to a standard text, it discusses all the topics usually covered in the course and shows how to solve problems using Maple and how to display solutions graphically to gain further insight. The text is self-contained and can also be used for self-study or as the primary text in a mechanics course.

This textbook provides an introduction to classical mechanics at a level intermediate between the typical undergraduate and advanced graduate level. This text describes the background and tools for use in the fields of modern physics, such as quantum mechanics, astrophysics, particle physics, and relativity. Students who have had basic undergraduate classical mechanics or who have a good understanding of the mathematical methods of physics will benefit from this book. Classical Mechanics presents an updated treatment of the dynamics of particles and particle systems suitable for students preparing for advanced study of physics and closely

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related fields, such as astronomy and the applied engineering sciences. Compared to older books on this subject, the mathematical treatment has been updated for the study of more advanced topics in quantum mechanics, statistical mechanics, and nonlinear and orbital mechanics. The text begins with a review of the principles of classical Newtonian dynamics of particles and particle systems and proceeds to show how these principles are modified and extended by developments in the field. The text ends with the unification of space and time given by the Special Theory of Relativity. In addition, Hamiltonian dynamics and the concept of phase space are introduced early on. This allows integration of the concepts of chaos and other nonlinear effects into the main flow of the text. The role of symmetries and the underlying geometric structure of space-time is a key theme. In the latter chapters, the connection between classical and quantum mechanics is examined in some detail.

Classical Mechanics with MATLAB Applications is an essential resource for the advanced undergraduate taking introduction to classical mechanics. Filled with comprehensive examples and thorough descriptions, this text guides students through the complex topics of rigid body motion, moving coordinate systems, Lagrange's equations, small vibrations, and the special theory of relativity. Step-by-step illustrations and examples and computational physics tools further enhance learning and understanding by demonstrating accessible ways of obtaining mathematical solutions. In addition to the numerous examples throughout, each chapter contains a section of MATLAB code to introduce the topic of programming scripts and their modification for the reproduction of graphs and simulations. This book constructs the mathematical apparatus of classical mechanics from the beginning, examining basic problems in dynamics like the theory of oscillations and the Hamiltonian

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formalism. The author emphasizes geometrical considerations and includes phase spaces and flows, vector fields, and Lie groups. Discussion includes qualitative methods of the theory of dynamical systems and of asymptotic methods like averaging and adiabatic invariance. In the second edition, a number of misprints that appeared in the first edition have been corrected. In addition to this, we have made improvements based on the experience gathered in the use of the first English edition of the book in the introductory course in physics at the University of Copenhagen. A chapter introducing nonlinear dynamics has been added. The purpose of this chapter is to provide supplementary reading for the students who are interested in this area of active research, where Newtonian mechanics plays an essential role. The students who wish to dig deeper, should consult texts dedicated to the study of nonlinear dynamical systems and chaos. The literature list at the end of this book contains several references for the topic. The book still contains a one-semester (15 weeks) first university course on Newtonian mechanics. This necessarily introduces some constraints on the choice of topics and the level of mathematical sophistication expected from the reader. If one looks for discussions of technical issues, such as the physics behind various manifestations of friction, or the tensorial nature of the rotation vector, one will look in vain. The book contains what we feel are the essential aspects of Newtonian Mechanics. It is a pleasure again to thank Springer-Verlag and in particular Dr. H. J. KOisch and the staff at the Heidelberg office for helpfulness and professional collaboration.

Separation of the elements of classical mechanics into kinematics and dynamics is an uncommon tutorial approach, but the author uses it to advantage in this two-volume set. Students gain a mastery of kinematics first – a solid

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foundation for the later study of the free-body formulation of the dynamics problem. A key objective of these volumes, which present a vector treatment of the principles of mechanics, is to help the student gain confidence in transforming problems into appropriate mathematical language that may be manipulated to give useful physical conclusions or specific numerical results. In the first volume, the elements of vector calculus and the matrix algebra are reviewed in appendices. Unusual mathematical topics, such as singularity functions and some elements of tensor analysis, are introduced within the text. A logical and systematic building of well-known kinematic concepts, theorems, and formulas, illustrated by examples and problems, is presented offering insights into both fundamentals and applications. Problems amplify the material and pave the way for advanced study of topics in mechanical design analysis, advanced kinematics of mechanisms and analytical dynamics, mechanical vibrations and controls, and continuum mechanics of solids and fluids. Volume I of Principles of Engineering Mechanics provides the basis for a stimulating and rewarding one-term course for advanced undergraduate and first-year graduate students specializing in mechanics, engineering science, engineering physics, applied mathematics, materials science, and mechanical, aerospace, and civil engineering. Professionals working in related fields of applied mathematics will find it a practical review and a quick reference for questions involving basic kinematics.

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This upper-level undergraduate and beginning graduate textbook primarily covers the theory and application of Newtonian and Lagrangian, but also of Hamiltonian mechanics. In addition, included are elements of continuum mechanics and the accompanying classical field theory,

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wherein four-vector notation is introduced without explicit reference to special relativity. The author's writing style attempts to ease students through the primary and secondary results, thus building a solid foundation for understanding applications. Numerous examples illustrate the material and often present alternative approaches to the final results.

In this book we describe the evolution of Classical Mechanics from Newton's laws via Lagrange's and Hamilton's theories with strong emphasis on integrability versus chaotic behavior. In the second edition of the book we have added historical remarks and references to historical sources important in the evolution of classical mechanics.

This book guides undergraduate students in the use of Maxima—a computer algebra system—in solving problems in classical mechanics. It functions well as a supplement to a typical classical mechanics textbook. When it comes to problems that are too difficult to solve by hand, computer algebra systems that can perform symbolic mathematical manipulations are a valuable tool. Maxima is particularly attractive in that it is open-source, multiple-platform software that students can download and install free of charge.

Lessons learned and capabilities developed using Maxima are easily transferred to other, proprietary software.

This textbook teaches classical mechanics as one of the foundations of physics. It describes the mechanical stability and motion in physical systems ranging from the molecular to the galactic scale. Aside from the standard topics of mechanics in the physics curriculum, this book includes an introduction to the theory of elasticity and its use in selected modern engineering applications, e.g. dynamic mechanical analysis of viscoelastic materials. The text also covers many aspects of numerical mechanics, ranging from the solution of ordinary differential equations, including molecular dynamics simulation of many particle systems, to the finite element

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method. Attendant Mathematica programs or parts thereof are provided in conjunction with selected examples. Numerous links allow the reader to connect to related subjects and research topics. Among others this includes statistical mechanics (separate chapter), quantum mechanics, space flight, galactic dynamics, friction, and vibration spectroscopy. An introductory chapter compiles all essential mathematical tools, ranging from coordinates to complex numbers. Completely solved problems and examples facilitate a thorough understanding of the material.

The first volume in a three-part series, Elements of Mechanics provides a rigorous calculus-based introduction to classical physics. It considers diverse phenomena in a systematic manner and emphasises the development of consistent and coherent models guided by symmetry considerations and the application of general principles. Modern developments c

Classic undergraduate text explores wave functions for the hydrogen atom, perturbation theory, the Pauli exclusion principle, and the structure of simple and complex molecules. Numerous tables and figures.

This book is intended as a textbook for an entry-level university course in Newtonian mechanics for students of physics, astronomy, and the engineering sciences. The material has been used as a first-semester text for first-year undergraduates at the Niels Bohr Institute, which is part of the University of Copenhagen. Our way of presenting Newtonian mechanics is influenced by the writings of the late Max Born. Also, the Feynman Lectures on Physics have been an important source of inspiration. In fact, the idea for the book came when we read Section 16.1 of Volume 1 of the Feynman Lectures. Ideas from the well-known Berkeley Physics Course may also be traced in the text. All of the books quoted in the literature list have, in one way or another,

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served as a source for our lectures for undergraduates. It is assumed that the students already have a rudimentary knowledge of Newtonian mechanics, say at the high-school level. Some background in vectors and elementary calculus is also required, i.e., the students should know how to add vectors as well as how to differentiate and integrate elementary functions. The Appendix contains the required background for the use of vectors in Newtonian mechanics. The second volume in the author's three-part series, *Properties of Materials* uses the principles of classical mechanics to qualitatively and quantitatively model specific features of matter. The text develops linear models of elasticity to correlate and quantify the changes in an object's shape induced by the application of a constant force. It describes quiescent and flowing liquids and gases and examines the behavior of oscillating systems subjected to time-dependent external applied forces. The author employs linear superposition to analyze the combined effects of two or more waves simultaneously present in a medium, such as standing waves, beating, interference, and diffraction. The book considers acoustics, including the production, propagation, and perception of sound, as well as optics, including the laws of reflection and refraction. It also treats temperature, heat, and thermometry before applying the laws of thermodynamics to ideal gas systems. Throughout the investigations of particular phenomena, the author emphasizes the modeling of composite systems assembled from simple constituents. This text extends the rigorous calculus-based introduction to classical physics begun in his *Elements of Mechanics*. With more than 300 problems, it can serve as a primary textbook in an introductory physics course, as a student supplement, or as an exam review for graduate or professional studies. Solutions manual available upon qualifying course adoption [View the author's related](#)

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textbooks Elements of Mechanics and Electricity and Magnetism. Read reviews of Elements of Mechanics. This book provides an introduction to geometric algebra as a unified language for physics and mathematics. It contains extensive applications to classical mechanics in a textbook format suitable for courses at an intermediate level. The text is supported by more than 200 diagrams to help develop geometrical and physical intuition. Besides covering the standard material for a course on the mechanics of particles and rigid bodies, the book introduces new, coordinate-free methods for rotational dynamics and orbital mechanics, developing these subjects to a level well beyond that of other textbooks. These methods have been widely applied in recent years to biomechanics and robotics, to computer vision and geometric design, to orbital mechanics in government and industrial space programs, as well as to other branches of physics. The book applies them to the major perturbations in the solar system, including the planetary perturbations of Mercury's perihelion. Geometric algebra integrates conventional vector algebra (along with its established notations) into a system with all the advantages of quaternions and spinors. Thus, it increases the power of the mathematical language of classical mechanics while bringing it closer to the language of quantum mechanics. This book systematically develops purely mathematical applications of geometric algebra useful in physics, including extensive applications to linear algebra and transformation groups. It contains sufficient material for a course on mathematical topics alone. The second edition has been expanded by nearly a hundred pages on relativistic mechanics. The treatment is unique in its exclusive use of geometric algebra and in its detailed treatment of spacetime maps, collisions, motion in uniform fields and relativistic precession. It conforms with Einstein's view that the Special Theory of

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Relativity is the culmination of developments in classical mechanics.

This textbook takes a broad yet thorough approach to mechanics, aimed at bridging the gap between classical analytic and modern differential geometric approaches to the subject. Developed by the authors from over 30 years of teaching experience, the presentation is designed to give students an overview of the many different models used through the history of the field—from Newton to Hamilton—while also painting a clear picture of the most modern developments. The text is organized into two parts. The first focuses on developing the mathematical framework of linear algebra and differential geometry necessary for the remainder of the book. Topics covered include tensor algebra, Euclidean and symplectic vector spaces, differential manifolds, and absolute differential calculus. The second part of the book applies these topics to kinematics, rigid body dynamics, Lagrangian and Hamiltonian dynamics, Hamilton–Jacobi theory, completely integrable systems, statistical mechanics of equilibrium, and impulsive dynamics, among others. This new edition has been completely revised and updated and now includes almost 200 exercises, as well as new chapters on celestial mechanics, one-dimensional continuous systems, and variational calculus with applications. Several Mathematica® notebooks are available to download that will further aid students in their understanding of some of the more difficult material. Unique in its scope of coverage and method of approach, Classical Mechanics with Mathematica® will be useful resource for graduate students and advanced undergraduates in applied mathematics and physics who hope to gain a deeper understanding of mechanics.

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