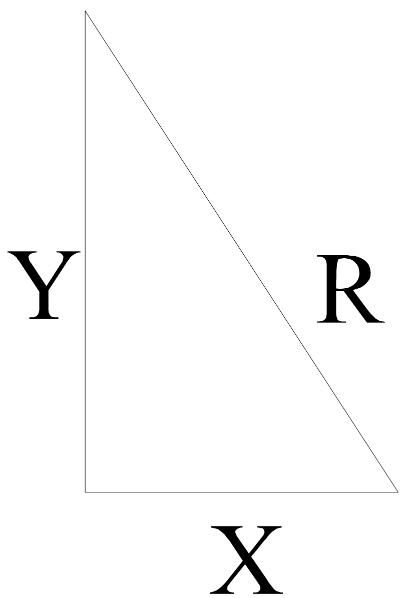
Natural Philosophy Physics with a Personal Computer



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Natural Philosophy: Physics with a Personal Computer

From Galileo to gluons

by

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Foreword

The Study of Nature

The word "physics", from Greek, means nature. Once physics embraced all practical knowledge - medicine, biology, chemistry, engineering. Mathematics took physics from a descriptive science to be the engine of man's betterment. The fundamental principle of physics is: *nature is the final arbiter of any theory, regardless of the author*. Even the mighty Aristotle fell before the experiments of Galileo. Prior to the 19th century, "natural philosophy" was the name for physics and is chosen as the title for the book because of its appropriateness. Physics has been pursued from various perspectives: religion, nature-worship, atheism or agnosticism. Many physicists look for "the hand of the creator", in the underlying elegance. Others seek the "big bang" of creation. Mostly physics is valued for its ability to sufficiently explain and predict natural phenomena.

About this Book

Physics is taught disjointly by the major subjects with a book for each. General physics texts cover many of the subjects but restricted by the assumed mathematical background of the reader however many authors mix the subjects out of historical order. For example, most readers do not realize that the well developed mathematics of fluids and heat transfer were incorporated into electricity and magnetism after Faraday postulated EM's fluid-like character. Similarly Hamilton's principle, developed for kinetics is fundamental for Schrödinger's wave equation. I have attempted to organize the material as chronologically as possible but this cannot be done exactly because some things are developing in parallel.

In historical perspective, it is interesting to note how physics is a part of and moves with society. Statics developed to support architectural design, kinetics to aim cannons, thermodynamics powered the industrial revolution, electricity and magnetism created the information revolution of the 21st century. Many biographical sketches of the important contributors are presented to show common characteristics and failings of the individuals. Newton spent only a small part of his life creating physics was secretive, a poor teacher and made 2 errors: ignoring Newton's rings because they did not fit his corpuscular theory of light and not using the adiabatic gas law for calculating the speed of sound. Einstein won his Noble prize for applying Planck's energy quantization to the photoelectric effect but was not a major contributor to the development of quantum mechanics. He did not like it and challenged its creators as described in Section 12.12: The Quantum Paradox. While Einstein is primarily remembered for his work in Special Relativity, the basic results were discovered by Lorentz. In interviews, Einstein failed to acknowledge knowing about the work that preceded him. His contribution was to explain the Fitzgerald-Lorentz contraction - which was major; his masterpiece was General Relativity.

The original concept for this book was to cover physics from statics to nuclear and particle physics. The first 12 chapters and the beginning of chapter 13 were written at home while I was working at Brookhaven National Laboratory. I intended to finish the book in retirement, but have not made much progress and have decided to publish the work as it currently is. In its present form it has 497 figures, 65 tables, 81 computer programs in 28 pages of front material and 764 of text including back material. In preparing the book, I have drawn on class notes, many text books and my own professional experience. It includes mathematical "tricks," that I have not seen in print such as Prof. Luttinger's technique for an integral divided by its normalization as a logarithmic derivative. I often develop a subject in Cartesian coordinates, express this using a Laplacian and then convert to the geometry suitable for the problem. One technique I discovered in writing this book is the use of magnetic monopoles. This grew out of restoring Coulomb's work on magnetism (which has disappeared from modern texts). When writing the parts on electromagnetism, I discovered that I could relate the magnetic field from electric current to a certain strength magnetic monopole - although permanent magnetic monopoles do not exist in nature.

The notation in the text is like that used for computer programing. That is, "*" is used if the intent is multiplication. Two terms that are adjacent to each other signify that the first term is an operator on the second term. The operation might be multiplication but not necessarily. The symbol "/" is for division. In the denominator, terms included within "( )" are included in the denominator. Exponentiation is signified as: 1.234Ex, where x is power of 10; if a minus sign preceded the x, it is a negative power of 10. The argument of square root √( ) is enclosed by parenthesis to indicate the extent of the square root. Similarly functions including trigonometric functions, have their argument enclosed in parenthesis.

The book differs from other texts by introducing the reader to variational methods: Hamilton's and Lagrange's methods in chapter 3 so these will not seem strange in later chapters. The hydrodynamic equations, so essential to nuclear bomb design, are introduced in chapter 4 because they are unfamiliar to most physicists. How Fermi calculated a critical assembly is presented in chapter 11. An overview of General Relativity is presented in chapter 10. Similarly, sound is treated as an eigenvalue problem in chapter 7 for later use in quantum mechanics. Vector analysis is introduced in the earliest chapters as are matrix methods. Both are used throughout.

As for units, the book starts using British units mainly for reader familiarity but fairly soon switches to SI units that are used throughout including quantum mechanics so that energy levels are calculated in volts - a familiar unit from flashlight batteries.

Use of the Personal Computer

Another discovery made in the course of writing this book was the utility of the personal computer. A camera-ready copy of this book was provide to the publisher by preparing it in Word Perfect which includes the text, table and the figures. The figures, with a few exceptions, were drawn by the Qbasic computer program or by hand using graphics software.

The surprising aspect of the computer was that numerical calculation of a problem was like doing a laboratory experiment. Solving the problem and displaying results gives insight into the problem not gained by analytical solutions. The computer was used to calculate fluid flow around a corner, to do numerical fitting to data, to solve multi-dimensional partial differential equations, to generate Bessel functions (for solving the drum problem), Legendre polynomials for electrical problems and Laguerre polynomials for the quantum mechanical solution of the hydrogen atom.

The distribution disk (see Appendix A) contains81+ computer programs all but 1 written in the Qbasic language. In the text these are explained by presenting the numbered lines of code in the left column and the explanation of the purpose of each line in the right column. These are provided as source code, not executable files so that the reader can run the programs in their own computer using Qbasic which is free with Windows (see Appendix A). Thus the reader can not only run the programs, they can modify the programs. Also included on the distribution disk are two .exe codes: CHARNUC that presents the chart of the nuclides (see Appendix A and Chapter 13) and UCONCON which is a units conversion program and relativity calculator.

Prerequisites

Mathematical proficiency at the algebraic level is assumed. Chapter 1 concludes with a review of algebra, trigonometry, analytical geometry, and calculus. More advanced mathematics is introduced when it is needed.

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