Mathematica For Physics

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General Audience

This book is intended for the advanced undergraduate and graduate physics student taking core courses in the physics curriculum.

We expect this text to be a supplement to the standard course text.   The student would use this book to get ideas on how to use Mathematica to solve the problems assigned by the instructor.

Since we cover the canonical problems from the core courses, the student can practice with our solutions, and then modify these solutions to solve the particular problems assigned. The student can focus on the physics, and leave the algebraic complications to Mathematica. This should help the student move up the physics learning curve quickly.

About: Mathematica For Physics

Mathematica is a powerful mathematical software system for students, researchers, and anyone seeking an effective tool for mathematical analysis. Tools such as Mathematica have begun to revolutionize the way science is taught, and research performed.

Now there is a book specifically for students and teachers of physics who wish to use Mathematica to visualize and display physics concepts and to generate numerical and graphical solutions to physics problems. Mathematica for Physics chooses the canonical problems from the physics curriculum, and solves these problems using Mathematica. This book takes the reader beyond the "textbook" solutions by challenging the student to cross check the results using the wide variety of Mathematica's analytical, numerical, and graphical tools.

Throughout the book, the complexity of both the physics and Mathematica is systematically extended to broaden the tools the reader has at his or her disposal, and to broaden the range of problems that can be solved. As such, this text is an appropriate supplement for any of the core advanced undergraduate and graduate physics courses.

Among other assets, the book:

- Provides Mathematica solutions for the canonical problems in the physics curriculum.

- Covers essential problems in: Mechanics, Electrodynamics, Quantum Mechanics, Special and General Relativity, Cosmology, Elementary Circuits, Oscillating Systems.

- Uses the power of Mathematica to go beyond "textbook" solutions and bring the problems alive with animations, and other graphical tools.

- Emphasizes the graphical capability of Mathematica to develop the reader's intuition and visualization in problem solving.

- Introduces the reader to the aspects of Mathematica that are particularly useful for physics.

Electronic Supplement

The Mathematica code for initialization and all user-defined functions is included in the electronic supplement so that you can begin working the examples immediately. We have also included some selected samples from this book.

The electronic supplement is available as item number 0206-862 from MathSource (TM) on WorldWide Web http://mathsource.wri.com/

Best Features Of The Book

With Mathematica, the entire approach to problem solving can be drastically changed. We give some brief examples.

DOUBLE PENDULUM (Page 135):

This is a topic that is generally treated as an "advanced" topic. With Mathematica, the solution is relatively straightforward. Once the solution is obtained, the textbooks try to describe (in words) the general properties of the system, and the normal modes. (In particular, the property that the energy is transferred back and forth between the two segments of the pendulum.) With the animation capability of Mathematica, we do not need to lead the student to these conclusions, but we can point them in the general direction, and let them discover these results on their own by varying the amplitudes of the separate normal modes.

E&M BOUNDARY VALUE PROBLEMS (Page 261):

For the beginning student, it is easy to become overwhelmed by boundary value problems. With the power of Mathematica, it is easy to show how straightforward these solutions are--especially with the help of the different coordinate systems built into Mathematica. When the student finishes the problem with pen and paper, they have only a set of formulas that may mean very little to the student. With Mathematica, we encourage the student to plot the final solution so that they can verify visually if the boundary conditions are satisfied. This technique encourages the student to think about the solution, and not simply grind out the math.


HYDROGEN ATOM (Page 359):

In the standard solution of the hydrogen atom, the student is often lost in the mathematics. Mathematica, however, is able to recognize that the solution of the radial equation is a Laguerre polynomial, assemble the constants to form the principal quantum number, and plot the solutions. The student then has the energy and the curiosity to numerically investigate the behavior of the wavefunctions, and consider the disastrous consequences of choosing a non-integral value for the principal quantum number.

Biographical Statement

Robert Zimmerman is a Professor of Physics and research associate in the Institute of Theoretical Science at the University of Oregon. He has written papers on Mathematical Physics, Elementary Particles, Astrophysics, Cosmology, and General Relativity. He has taught graduate courses in Mathematical Physics, Theoretical Mechanics, Electrodynamics, Quantum Mechanics, General Relativity and Cosmology. He received his Ph.D. from the University of Washington.

Fredrick Olness is an Assistant Professor of Physics at Southern Methodist University in Dallas Texas. His research is in Theoretical High Energy Physics and he studies the Quantum Chromodynamic (QCD) theory of the strong interaction. He received his Ph.D. from the University of Wisconsin, received an SSC Fellowship in 1993, and is a member of the CTEQ collaboration--a novel collaboration of theorists and experimentalists.
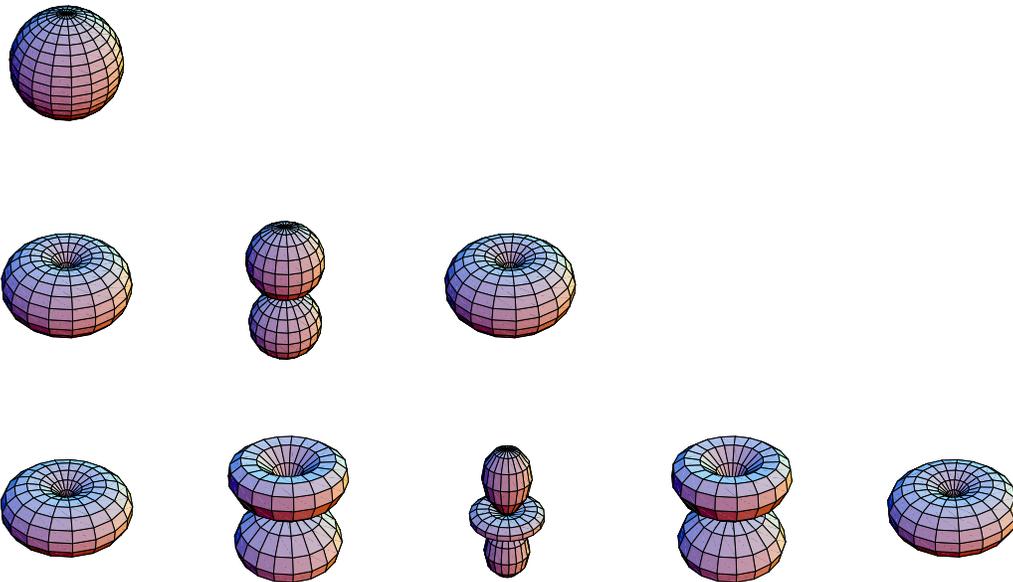
Mathematics for Physics. A guided tour for graduate students. Michael Stone. and. Â For information contact: Michael Stone or Paul Goldbart, Department of Physics, University of Illinois at Urbana-Champaign, 1110 West Green Street, Urbana, Illinois 61801-3080, U.S.A. Dedication. To the memory of Mike's mother, Aileen Stone: 9 × 9 = 81. Obtaining Mathematica: The Department of Physics and Astronomy participates in a licensing arrangement so that students can use the Student Version of Mathematica for free. Information on obtaining and installing Mathematica (Student Version) can be found on the OIT web site. A UCINet login is required. Â Mathematica Crash Course: Students who take lower division math at UCI learn to use Mathematica in the Physics 50 course. The purpose of this crash course is to