Physics with Answers contains 500 problems covering the full range of introductory physics and its applications to many other subjects, along with clear, step-by-step solutions to each problem. No calculus is required. Students often have difficulty in solving practical problems after a subject is introduced in class. This book bridges the gap – it contains every type of problem likely to be encountered at this level, so by attempting these exercises and learning from the solutions, students will gain confidence in solving class problems and improve their grasp of physics.

The book is split into two parts. The first contains the problems, together with useful summaries of the main results needed for solving them. The second part gives full solutions to each problem, often accompanied by thoughtful comments. Subjects covered include statics, Newton's laws, circular motion, gravitation, electricity and magnetism, electric circuits, liquids and gases, heat and thermodynamics, light and waves, atomic physics, and relativity.

The problems are drawn from many fields, including physics, chemistry, biology, engineering, medicine, and architecture. The book will be invaluable to anyone taking an introductory course in physics, whether at college or pre-university level.

PHYSICS WITH ANSWERS

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500 PROBLEMS AND SOLUTIONS

A. R. King
University of Leicester

O. Regev
Technion – Israel Institute of Technology

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PREFACE

Physics is the most fundamental of the sciences, and some knowledge of it is required in fields as disparate as chemistry, biology, engineering, medicine, and architecture. Our experience in teaching physics to a wide variety of audiences in the U.S. and Europe over many years is that, while students may acquire some familiarity with formal concepts of physics, they are all too often uneasy about applying these concepts in a variety of practical situations. As an elementary example, they may be able to quote the law of conservation of angular momentum in the absence of external torques, but be quite unable to explain why a spinning top does not fall over. The physicist Richard Feynman coined the phrase "fragile knowledge" to describe this kind of mismatch between knowledge of an idea and the ability to apply it.

In our view there is really only one way of acquiring a robust ability to use physics: the repeated employment of physical concepts in a wide variety of applications. Only then can students appreciate the strength of these ideas and feel confident in using them. This book aims to meet this need by providing a large number of problems for individual study. We think it very important to provide a full solution for each one, so that students can check their progress or discover where they have gone wrong. We hope that users of this book will be able to acquire a working knowledge of those parts of physics they need for their science.

Calculation is an essential ingredient of physics: the ability to make quantitative statements which can be checked by observation and experiment is the basis of the enormous success of modern science and technology. Nevertheless, in this book we have tried to avoid mathematical complications which are not fundamental to understanding the physics. In particular we make no use of calculus. It is worth pointing out that many practical situations that scientists encounter are too complex to allow detailed calculations.

In these cases a simple estimate is often quite sufficient to give great insight, and is in any case an indispensable preliminary to any attempt at a more elaborate treatment.

The book contains problems organized in three chapters, on mechanics, electromagnetic theory, and the properties of matter and waves. We give brief summaries of the relevant theory at the beginning of each of the chapters. These are not extensive, as this is not intended as a textbook, but they do cover all of the topics, and establish the conventions we use. Solutions to each problem are given in the second half of the book. We hope that users of the book will attempt a problem before looking up the solution; even an unsuccessful attempt brings the subject into much sharper focus than simply reading the solution before appreciating the difficulty. Knowledge hard-won in this way is the essence of a working grasp of physics, just as an athlete's performance owes much to long hours of training. Realistically, however, we expect that some of the time this will not happen, particularly when the subject is new. We hope we have provided enough problems so that the reader may, if desired, use the first one or two solutions on any topic to "spot the pattern," and thus acquire the ability to attempt the later problems without having to look up the solution first. Accordingly, there is a general tendency for the problems in a given area to be easier at the beginning than the end. However, we have resisted any idea of doing this absolutely systematically, for the good reasons that (a) the degree of difficulty of a problem is often a rather subjective judgement, and (b) we do not want readers to *expect* the problems to get too difficult for them as the section proceeds. Indeed, we have deliberately sprinkled some simpler problems over the sections to avoid this, so our advice to the reader is always at least to try the problem before giving up!

We hope that this book will be useful to college and university undergraduates in the physical and life sciences, engineering, medicine and architecture, as well as for some high school and secondary school courses. With this in mind we have tried to include problems drawn directly from these subjects. The enormous range of applicability of physics, from understanding why black holes are black to why boiling frankfurters split lengthways, is for us one of its great fascinations, and we hope we have managed to convey a little of this in the book. We hope too that it will provide its readers with the basis of a sound and adaptable knowledge of physics. As a very important side-effect, we trust that it will be useful in preparing for examinations: most common types of physics problems set at this level will be encountered here. We make no apology to our colleagues in universities and schools for this – after all, in an important sense the subject is defined by the huge range of questions it can answer. A student who has acquired the ability to solve problems (and so pass examinations) has a good grounding in physics, and thoroughly deserves success.

NOTE ON UNITS

This books uses SI (meter–kilogram–second) units throughout, with one exception: we follow the customary usage of *gram* moles, rather than kilo-moles, in discussing gases. We sometimes state problems using conventional non-SI units (e.g. km/h for speeds), but these are converted into SI units in the solutions. Numerical answers are usually given to two significant figures.

PHYSICAL CONSTANTS USED IN THIS BOOK

Gravitational constant	$G = 6.7 \times 10^{-11}$ N m^2 kg^{-2}
Acceleration due to gravity	$g = 9.8$ m s^{-2}
Speed of light in vacuum	$c = 3 \times 10^8$ m s^{-1}
Coulomb constant	$\frac{1}{4\pi\epsilon_0} = 9 \times 10^5$ N C^{-2} m^{-2}
Permeability of vacuum	$\epsilon_0 = 8.84 \times 10^{-12}$ N^{-1} C^2 m^{-2}
Permittivity of vacuum	$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
Gas constant	$R = 8.31$ J mole^{-1} K^{-1} $= 0.082$ liter Atm K^{-1} $= 8.31 \times 10^3$ J kg^{-1} K^{-1}
Specific heat of water	$C_w = 4200$ J kg^{-1}°C^{-1}
Planck constant	$h = 2\pi\hbar = 6.63 \times 10^{-34}$ J s
Proton charge	$e = 1.6 \times 10^{-19}$C
Mass of electron	$m_e = 9.1 \times 10^{-31}$ kg
Mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
Atomic mass unit	$m_H = 1.67 \times 10^{-27}$ kg
Compton wavelength	$\lambda_c = 2.4 \times 10^{-12}$ m $= 0.024$Å
Rydberg	$E_0 = 13.6$ eV