UNIVERSITY PHYSICS

EXPERIMENT AND THEORY

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PREFACE

The study of physics is a process in which we learn to apply logically a sequence of operational definitions. Starting with a few fundamental concepts and using operational definitions, we construct new concepts which help us probe our natural surroundings. When we design and perform experiments we apply the definitions as we make the necessary measurements, and when we solve problems we apply the operational concepts to a set of given numbers or data. Ideally, the student should carry out simple experiments while learning each operational definition. In doing these experiments he will obtain a much better feeling for the physical quantity involved.

Most teachers of general physics feel that simple demonstrations will aid the student in learning how to apply the definitions. Although demonstrations are not designed with entertainment as their sole purpose, they often have this added feature; and they lead to a much better rapport between the teacher and the students in a large class.

This book was written in the hope that it might serve as a collection of simple demonstrations set into a rigorous theoretical development of the subject matter in physics. A teacher using this book will want to do some of the demonstrations for his class, while the student who takes a lecture demonstration course in physics will find that the material presented in this book can serve as a useful record of the experiments that he has seen. The demonstrations presented here are certainly not all-inclusive and they are not always the best that can be done to illustrate a certain point, but in each case it is hoped that they will suggest some experiment that can be adapted to available apparatus. The descriptions of the demonstrations are supplemented by perspective drawings which show only essential parts of the apparatus. Through these drawings the student can have a more complete visualization of the experiment even though it may not always be performed.

Possibly, there is too much material for an ordinary course in physics, but this depends on the student's background. All the fundamentals are included so that the student with no previous training in physics can acquire the necessary background, while the student with good pre-college training can quickly review the fundamentals and be challenged by more complex concepts. In the present structure of courses taken by students, a second course in physics is either of a theoretical nature or of a detailed experimental nature where the student either does no experiments or does highly detailed work on a few special experiments. In either case this book describes many experiments which he is not able to perform himself.

No special effort is made to adapt the principles to engineering disciplines. The units are mostly in terms of the meter, kilogram, and second. Although other units are often defined and used, it will remain for the teacher to develop them. The engineering student himself must learn the facility for handling them. If the operational definitions are properly learned and followed, the problem of units should be trivial. Until the student learns his physics in this way, he is always going to have trouble with units and have to resort to formula plugging.

Some modern physics has been included. Special relativity is introduced from an experimental standpoint and is treated as a problem in measurement where the velocity of light is a universal constant for all observers. Relativistic mechanics is introduced as a plausible outcome of an application of the conservation laws. The student can thus become acquainted with relativistic properties of physical quantities and then return to them later for a more rigorous development in a course in theoretical physics. Wherever possible an effort has been made to lead the student to the forefront of physics and point out to him the problems which are currently under investigation.

The material has been kept quite general in order to acquaint students with the broad range of subject matter found in the studies of physics. Often the mechanisms learned in one field of physical investigation suggest useful models for study and analysis in another. In case the student has not yet formulated a definite interest for specialization we hope that this book will challenge him to pursue further any interest that may develop during this course of study.

The author is deeply grateful to the many teachers before him who have taken time and effort to develop the demonstrations presented in this book. The author is particularly grateful to Professor Richard M. Sutton for many helpful suggestions in preparing the manuscript. We hope that the teachers and students who use this text will find ways to improve the experiments and apply them in their own work.

G.D.F.

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