

**A MANUAL OF
PHYSICAL
MEASUREMENTS**

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A manual of physical measurements by John O. Reed & Karl E. Guthe

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BY

JOHN O. REED, Ph.D.
PROFESSOR OF PHYSICS IN THE UNIVERSITY OF MICHIGAN

AND

KARL E. GUTHE, Ph.D.
PROFESSOR OF PHYSICS IN THE UNIVERSITY OF MICHIGAN

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PREFACE.

This manual has been prepared to meet the needs of students beginning work in the Physical Laboratory of the University of Michigan. Such a book must inevitably possess a certain local coloring peculiar to the conditions it has been designed to meet. A manual equally suited to all laboratories, has not been and probably will not be written. Each laboratory reflects in greater or less degree the individual trend of the man who stands at its head; and its exercises and methods are the result of an extended process of adaptation and assimilation. Hence it happens that one laboratory is largely devoted to the study of the phenomena of light, another to those of electricity, and a third to those of elasticity, heat, or electrochemistry, as the case may be. The moral of all this is, that the practice and traditions of each laboratory are best conserved by a text representative of its own methods, and if no better reason should be found, perhaps this may serve to explain the appearance of this, another laboratory manual.

The exercises herein described embody the work required of students in Physics and in Engineering in their first course in Physical Laboratory Practice. Such a course is expected to occupy three laboratory periods of two hours each for one semester, and embraces some thirty-six to forty of the exercises in this manual. Owing to the diversity of the work prescribed in the various courses in Engineering, no one student is expected to complete all the exercises in this book in a single semester.

In accordance with the practice in the University of Michigan, it is expected that the laboratory work shall be supplemented by lectures upon the theory of the exercises, and recitations upon the work actually done and the results obtained. In this way it is believed that the student is brought to a clearer understanding of the significance of the exercise and of the accuracy attainable

under given conditions. To this end the exercises are numbered consecutively throughout the text, and those under any specific subject are preceded by sufficient theory to render the formulæ and methods clear to persons familiar with the fundamental principles of Physics as set forth in any standard textbook.

Being designed for beginners in the Physical Laboratory, this manual makes no claim to completeness, either in subject matter or in exposition. The aim has been to furnish a coherent and logical series of graded exercises in Physical Measurement, such as will best furnish an introduction to Practical Physics, and at the same time afford opportunity for developing ability in recording and interpreting observations, and skill in the manipulation of delicate and sensitive apparatus.

For convenience of reference a series of tables of the more important physical constants, of squares, cubes, square roots and multiples of π , of the logarithms of numbers, and the trigonometric functions have been added. A thorough drill in the use of logarithmic tables in the computation of results, should form a feature of any successful course in Laboratory Practice. To this end an orderly method of procedure in such computation has at all times been insisted upon.

The authors have drawn freely from many standard works on Practical Physics, notably from those of Kohlrausch, and Stewart and Gee in General Physics, and from Carhart and Patterson's Electrical Measurements.

In conclusion we wish to thank our colleagues, Professors Carhart and Patterson, for helpful suggestions and criticisms during the preparation of the work.

University of Michigan, March, 1902.

FROM THE PREFACE TO THE SECOND EDITION.

The necessity for a second edition of this book has presented an opportunity for a careful revision of the text, both in the elimination of errors and in the addition of certain features which experience has shown to be desirable and necessary to make the manual truly representative of modern laboratory practice. In making these additions the needs of the average student have been kept constantly in mind both as regards his previous preparation and the requirements laid upon him by his subsequent University work.

In the first part several articles are devoted to the measurement of angles, and a chapter has been added upon Surface Tension and Viscosity. In order to meet more fully the demands made upon students of Mechanical and Electrical Engineering the chapters upon Heat and Electricity have been practically rewritten. Several of the articles in these chapters contain new and important matter, notable among which are the discussion of the ballistic d'Arsonval galvanometer, and the exercises involving the use of the potentiometer and of the thermoclement.

While the additions have in general been such as to render the work more advanced in character, with the possible exception of some exercises in the measurement of angles, still it is hoped that the book will not be found less useful for elementary work than before. The forms for recording results and the outlines for computation have abundantly justified the wisdom of their insertion in the immense saving of time and energy to the busy instructor. While it has been urged by some that students readily and intuitively devise explicit, symmetrical and logical arrangements for their data and computations, such students have as yet entirely escaped our observation.

September, 1906.

PREFACE TO THE THIRD EDITION.

The third edition of this manual has been prepared mainly because it was felt that the arrangement of the subject matter should correspond more closely to that found in the authors' COLLEGE PHYSICS, recently published by the Macmillan Company.

The book has also been thoroughly revised, the treatment been changed in a number of places and a few exercises, notably some elementary exercises in electricity, been added.

The authors are greatly indebted to their colleagues, Professor H. M. Randall and Mr. W. W. Sleator, for assistance in reading the proof sheets of the present edition.

JOHN O. REED.
KARL E. GUTHE.

August, 1912.

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