LABORATORY EXERCISES IN ELEMENTARY PHYSICS

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Laboratory Exercises in Elementary Physics by Charles R. Allen

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CHARLES R. ALLEN

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IN

ELEMENTARY PHYSICS

BY

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PREFACE.

Most of the experiments in this collection exact of the pupil measurements of some sort, that is, are quantitive. A few, included for the training in accurate work they afford or for their suggestiveness, demand the investigations of the conditions under which certain phenomena develop. They require, however, the use of some physical instrument. Those purely illustrative are given because they demand more careful observation than the pupil can give to a lecture experiment. In the course will be found, I think, illustrations of many of the more common methods of physical research. The exercises are planned for young pupils with no previous training in physics, employ no unduly expensive apparatus, and require no more than forty-five minutes each in the laboratory. The subjects selected are among those bearing on the commoner applications of physical science. Pains have been taken to so frame the instructions that the pupil can prepare himself beforehand to make the most of his laboratory time with the least help from his instructor. This I regard of prime importance. Unless the instructor assures himself before each exercise that the pupils understand what they are to do and how to do it, they will pretty surely exceed the time-limit, and may even make wreck of the whole exercise. Five unprepared pupils require more attention than fifteen who have thoroughly mastered the preliminary work. When entirely new or especially complicated apparatus is to be used, I

find it advisable to place a "dummy" set before the class, and spend part or the whole of one period in requiring individual pupils to go through the motions with it, to answer questions on the general method and the special manipulations, and, in case of a complicated calculation, to work out results from imaginary data.

The arrangement and even the phrasing of the material is the outgrowth of much searching for a general form which would be most effective in stimulating clear and independent thinking. Each exercise is introduced by some preliminary explanation and a distinct statement of its object. This puts before the pupil the precise thing he is after, and the general course of his investigation. The manipulation is then described with what some may deem unnecessary minuteness, but I find this minuteness part of the secret of speed and success. I have added questions where I have found them convenient in guiding the pupils' thought, but in no instance, I believe, do they contain their own answer. In a few cases I have given alternative exercises on the same topic, for the purpose of suiting the varying experimental aptitude of pupils.

In the order of subjects, the exercises form a somewhat roughly graded course, from magnetic phenomena, where work is simplest and most stimulative to attention, through experiments involving the measurement of a single value by means of some single instrument, to the more complicated quantitive determinations of Dynamics. This order places the most difficult part of Physics last, where the pupil can bring to his aid, in grasping abstract ideas and performing intricate experiments, the training acquired in the previous parts of the course. But since the instructions in one subject do not assume a previous knowledge of any other, there is nothing to prevent the subjects being taken up in any order desired, though of course practice in mensuration should precede the quantitive exercises.

The book is made up mainly of the author's instructions to his own pupils for their laboratory work. The course of which this forms a part includes also the performance of all necessary descriptive experiments before the class, and the use of a text-book. Before the pupil goes to work in the laboratory at all, he should be given a general idea of how knowledge is acquired experimentally, and the steps involved in carrying on an experimental investigation. The instruction on these points should be illustrated by some simple typical experiments by the teacher. Afterwards the relative order of text-book and laboratory work will naturally depend upon the nature of the laboratory exercises. In exercises involving the study of conditions, as in those on Magnetism, and some of those on Electricity and Heat, the author prefers that the laboratory work precede the text-book work; but in exercises involving definite measurement, as in Specific Gravity and Specific Heat, this order may well be reversed. Certainly, in the determination of a physical law by measurements of two values, as in the exercises on Elasticity or on the Pendulum, the laboratory work should come first.

In order to reduce the volume to a convenient size for the laboratory table, all matter meant chiefly for the instructor is appended to the Teachers' Edition and omitted from the Pupils' Edition, the two being identical in other respects. Appendix A offers general suggestions for arranging the pupil's work and economizing his and the instructor's time, together with directions for applying the ordinary 110-volt Edison electric current to laboratory work, and for the care of mercury. Appendix B gives complete lists of all the apparatus needed for each exercise, hints as to substitutes and duplicates, and itemized estimates of cost with references to dealers' catalogues. Appendix C contains full instructions for making the more important pieces of apparatus. Appendix D furnishes

topical references to Avery's "First Principles of Natural Philosophy" and "Elements of Natural Philosophy," to Gage's "Elements of Physics" and "Introduction to Physical Science," and to Hall and Bergen's "Text-Book of Physics," supplemented by hints on conducting the various exercises, the educational purpose each is meant to serve, the degree of accuracy to be expected, etc.

While, so far as I know, none of the experiments will be found elsewhere in exactly their form here, many have been modified from other manuals. No attempt is made to credit each exercise to the source of the original idea. The chief books laid under contribution are Worthington's "Laboratory's Practice," Stewart and Gee's "Physics," Pickering's "Physical Manipulations," the Harvard College Course of Experiments, and Maxwell's "Matter and Motion." The metric system has been employed because it is the language of quantity in physical laboratories, scientific text-books and journals, and the higher scientific manufacturing processes the world over. Pupils learn with such ease to use so much of it as this book requires, that it forms no bar to their progress.

C. R. A.

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