EXERCISES IN ELECTRICAL AND MAGNETIC MEASUREMENT

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EXERCISES

IN

ELECTRICAL AND MAGNETIC MEASUREMENT

BY

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LATE EVENING LECTURER IN EXPERIMENTAL PHYSICS
AT KING'S COLLEGE

NEW EDITION

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1884

PREFACE.

IN the composition of this little book I have endeavoured to arrange in a systematic form a collection of Exercises in Electricity and Magnetism for the use of students in general, and more especially for those who are not able to command the services of a private tutor.

My object has been to lay before the student, under the form of problems, numerical illustrations of the main facts of Electricity and Magnetism, with especial reference to the modern doctrine of Energetics.

It is now universally admitted that numerical exercises are necessary in the study of the experimental sciences, both as giving practice in the application of the various theories and as affording tests of ability to comprehend as well as to apply that which has been learned. A thorough grasp and realisation of the meaning of a formula in Physics can scarcely be acquired from lectures, or from seeing it in the form of algebraical symbols in a text-book, whereas the working out by the student himself of its application to a single concrete case is often sufficient to make him feel confidence in using it, and to give precision to ideas which would otherwise remain floating in his mind in a vague and comparatively useless form.

In support of this view, I need only quote the words used by Sir W. Thomson at the commencement of a lecture delivered on May 3, 1883, at the Institute of Civil Engineers. 'In physical science a first essential step in the direction of learning any subject is to find principles of numerical reckoning, and methods for practically measuring some quality connected with it. I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of *science*, whatever the matter may be.'

I am indebted to Mr. C. D. Webb, A.K.C., for much assistance in checking the numerical results, but, as we cannot hope to have been entirely successful, I shall feel obliged to any student who will inform me of any inaccuracies which may have escaped our notice.

The present edition differs so much from the former one that the book is practically a new one. The alterations are such as I have found to be desirable in order to make the book useful to my own students, many of whom are themselves science teachers, or are professionally engaged in Electrical Engineering.

R. E. DAY.

UNITS.

THE quantitative relations between the various forms of energy necessitate the reduction of all kinds of physical quantities to one common scale of comparison. To facilitate this process several systems of so-called absolute measurement have been suggested by scientific men, but the diversity which existed until recently in the selection of the fundamental units of length, mass, and time, has greatly interfered with their practical usefulness.

Until there is a general agreement as to the selection of the fundamental units, it is necessary for every person who wishes to specify a magnitude in what is called *absolute* measure to mention the three fundamental units of length, mass, and time, wh ch he has chosen as the basis of his system. This necessity is obviated if one definite selection is made once for all, and is accepted by the general consent of scientific men.

The result of the labours of a succession of committees has been the general adoption of the centimetre, the gramme, and the second as the three fundamental units; and the units of electrical and magnetic magnitude hence derived are distinguished from *absolute* units otherwise derived by the letters C.G.S. prefixed.

The word *absolute* does not here mean that the measurements or units are absolutely correct, but only that the measurement, instead of being a simple comparison with an arbitrary quantity of the same kind as that measured, and therefore a *relative* one, is made by reference to certain fundamental units of another kind, treated as postulates.

The absolute magnitude in many cases necessitates the use of exceedingly large or exceedingly small numbers, and the best way of writing these numbers is to express them as the product of two factors one of which is a power of 10, and to effect the resolution in such a way that the exponent of the power of 10 shall be the characteristic of the logarithm of the number. In practice, decimal multiples and sub-multiples of these units are generally adopted.

Fundamental Units.

Length = one centimetre = ·3937 inch.
Mass = one gramme = 15·432 grains.
Time = one second.

The C.G.S. unit of force is called the *dyne*. It is the force which, acting on a gramme for a second, generates a velocity of one centimetre per second.

Force is said to be expressed in *gravitation-measure* when it is expressed as equal to the weight of given mass. In order that such a specification should be exact, the value of g at the place of observation must also be given.

A force of one dyne is very nearly equal to the weight of 1·02 milligramme anywhere on the earth's surface.

The C.G.S. unit of work is called the *erg*. It is the amount of work done by one dyne working through a distance of one centimetre.

One gramme-centimetre is equal to g ergs. In London g is about equal to 981 C.G.S. units of acceleration. One foot-pound $= 13825 \times g$ ergs.

The C.G.S. unit rate of working, or *unit of power*, is one erg per second. Taking Watt's horse power at 550 foot-pounds per second, we should have one 'horse power' equal to $7{\cdot}46 \times 10^9$ ergs per second. The French *force de cheval* being defined as 75 kilogrammetres per second,