EXPERIMENTAL ELASTICITY: A MANUAL FOR LABORATORY

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PREFACE

THE present volume has its origin in the manuscript notes which I have prepared from time to time for the use of the students attending my class in practical physics at the Cavendish Laboratory. When, in 1890, I was appointed to my present post of Demonstrator in Experimental Physics, I found that the then existing text-books of practical physics did not entirely meet the needs of the students, partly because they did not, as a rule, show how the formulae required in the experimental work are derived from the principles of the subject. The students themselves added to the difficulty, for their ideas as to those principles were often indistinct. I was thus led to devise some experiments intended to illustrate principles as simply and directly as possible. I also wrote notes explaining how the necessary formulae are obtained from the principles involved in those experiments and describing in detail how the practical work is to be conducted. The students showed very kind appreciation of these earlier notes and thus I was encouraged to prepare others; this work has proved so interesting that I have continued it, as opportunities have occurred, with the result that at the present time the students attending my practical class rely mainly upon these manuscript notes for the necessary instructions.

Many of the students have made almost complete copies of some hundreds of pages of manuscript and have perhaps learned

more in that way than by merely reading a printed book containing the same matter. But the plan of using manuscript notes has numerous disadvantages. For instance, the limited number of copies of any one manuscript makes it difficult to arrange for more than two or three students to do the same experiment at one time and often prevents the students from preparing themselves beforehand for the experiments assigned to them. There is, besides, the risk of the loss or the destruction of the manuscripts themselves. For the safety of the manuscripts I have relied on the consideration of the students and this has hardly ever failed.

To throw together into a small volume the manuscripts dealing with one branch of physics would seem an easy task. But the result would hardly be satisfactory, for some of the earlier manuscripts require revision in the light of later experience, while many of the manuscripts contain mathematical arguments which are repeated in others of the series. This repetition was necessary for the practical working of the class but would be intolerable in a book.

For these and other reasons I decided that it would be more satisfactory to rewrite the whole of the manuscripts, and to arrange the material, with additions, in the form of a series of small text-books, in which a fairly full account of the mathematical treatment should accompany a detailed description of the experimental work.

To make a beginning, the present volume is published and this, I hope, will be followed in a few months by a similar volume on Experimental Optics. I hope, if life and health be given me, to complete the scheme by writing volumes on Mechanics, on Electricity and Magnetism and on Heat and Sound.

The present volume cannot lay claim to any sort of completeness. Its purpose is simply to give the substance of my

course of instruction in the subject in a form which may be useful to students at the Cavendish Laboratory and elsewhere.

The first chapter contains an account of the elements of the mathematical theory of elasticity, with one or two necessary propositions in thermodynamics. In the second chapter will be found the mathematical solutions of some problems which make their appearance in several experiments. The uniform bending of rods and blades is discussed rather fully, but I was anxious to make the arguments apply to small *finite* curvatures as distinguished from merely infinitesimal curvatures. To the preparation and revision of this chapter, Dr L. N. G. Filon has contributed so much from his store of expert knowledge of the mathematical theory of elasticity that the chapter is almost more his work than mine.

The third chapter contains descriptions of a number of experiments together with such necessary mathematical discussions as are not given in the first two chapters. Each description is followed by a practical example giving detailed arithmetical results taken from an actual experiment; these examples may perhaps assist students in recording their own observations.

Some notes bring the book to a close. The last of these contains hints on practical work in physics; the rest deal mainly with a few dynamical theorems which experience suggests may be useful to students who have not received a mathematical training.

Most of the apparatus required for the experiments is of a simple description. Though in some cases accuracy would be gained if the apparatus had less of the "home made" character and more of the engineer's workmanship, this roughness of the appliances is not a serious disadvantage to the students who use the apparatus at the Cavendish Laboratory. Those who after-

wards make physics a part of their work, either as teachers or as investigators, will probably have to struggle on with a good deal of "home made" apparatus. To the rest, who distribute themselves over very wide fields of human activity, a knowledge of principles is of greater value than an acquaintance with the details of highly finished instruments.

In the design of the apparatus I have often been aided by Mr W. G. Pye and by Mr F. Lincoln, the past and present instrument makers at the Cavendish Laboratory, and by their assistants.

To assist those teachers who may not be able to construct the apparatus for themselves, I have authorised Messrs W. G. Pye and Co., of Cambridge, to supply apparatus made to my designs. I have done this because, in some cases, instrument makers, without consulting me, have connected my name with apparatus in which they have made "improvements" of doubtful value.

I owe much to the many generations of students who have attended my class. Their never failing enthusiasm has been a source of much encouragement to me, and the honest work and the satisfactory progress of the great majority has been a real reward.

I also owe much to the kindness of those who have assisted me as demonstrators during eighteen years, and especially to the unwearying help which my oldest colleague, Mr T. G. Bedford, has given in many ways for many years.

This volume owes much to the generous help rendered me by friends. The proofs have been read and criticised by Mr Bedford; his knowledge of physical principles, of the work of teaching the experimental methods described in this book and of the difficulties of students makes his aid of great value. Dr Alexander Russell, who has had a long experience of students' work, has made many helpful criticisms upon the proofs. Dr L. N. G. Filon

has spent much labour upon the first and second chapters, and Mr W. C. D. Whetham, F.R.S., a former colleague, has given editorial assistance.

Mr D. C. Jones of Pembroke College, Mr P. D. Innes of Trinity College and my wife have assisted in preparing the manuscript for the press, while Mr A. J. Bamford of Emmanuel College has helped in the revision of the proofs. To all these, as well as to those who have aided in minor ways, my thanks are given.

The following words, from Psalm cxi (*v.* 2), which are carved on the gates of the Cavendish Laboratory, shall end this preface: *Magna opera Domini: exquisita in omnes voluntates ejus.*

G. F. C. S.

August, 1908.