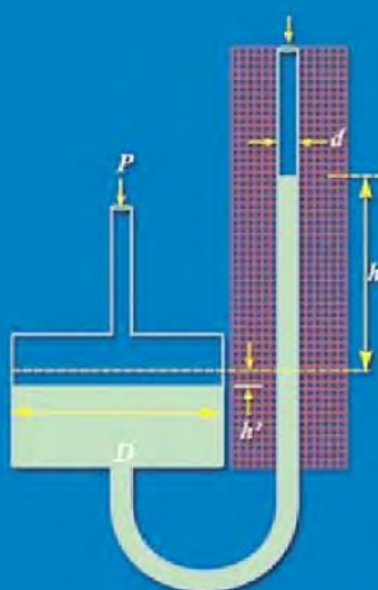


2nd
Edition

Mechanical Measurements



S.P. Venkateshan


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MECHANICAL MEASUREMENTS

(2nd Edition)

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Dedicated
to the
Shakkottai Family

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Preface

Preface to the second edition

The second edition of the book has been thoroughly revised and all errors that have come to my notice have been corrected. Additions have been made at various places in the book. Notable additions are in the statistical analysis of measured data in Module I. Important questions regarding normality of deviations and identification of outliers have been discussed in great detail. These should interest the advanced reader who is looking for an understanding of these issues. Thermistors have been described in greater detail in Chapter 4. Also, the line reversal technique of measuring gas temperature has been described in greater detail. Theory of the integrating sphere has been discussed in detail in Chapter 12. Module V has been augmented with more examples from laboratory practice. Exercises are now positioned at the end of each module. Many new exercise problems have been added in this edition.

The modules have been rearranged with the number of chapters going up by one to a total of sixteen chapters in this edition. Many references are indicated as footnotes in the text apart from the bibliography and the list of references given in the Appendix. All illustrations have been redrawn for this edition using 'tikz' - a program environment compatible with 'latex'. All graphs have been replotted for this edition using QtiPlot. In general these were done to improve the quality of the illustrations as also to bring uniformity in the format.

It is hoped that the second edition will be received with the same enthusiasm as the original edition by the student community.

S.P. Venkateshan

Preface to the first edition

In recent times there have been rapid changes in the way we perceive measurements because new technologies have become accessible to any one who cares to use them. Many of the instruments that one takes for granted now were actually not there when I started my engineering studies in the 1960's. Training we received in those days, in Mechanical Engineering did not include a study of "Mechanical Measurements". Whatever was learnt was purely by doing experiments in various laboratory classes! Electrical Engineers were better off because they studied "Electrical Measurements" for a year. The semester system was to be introduced far in the future. Even when "Mechanical Measurements" was introduced as a subject of study the principles of measurements were never discussed fully, the emphasis being the descriptive study of *instruments*! In those days an average mechanical engineer did not have any background in measurement errors and their analysis. Certainly he did not know much about regression, design of experiments and related concepts.

At that time the integrated chip was to appear in the future and the digital computer was in its infancy. We have seen revolutionary changes in both these areas. These developments have changed the way we look at experiments and the art and science of measurements. The study of measurements became divorced from the study of instruments and the attention shifted to the study of the measurement process. The emphasis is more on knowing how to make a measurement rather than with what. One chooses the best option available with reasonable expense and concentrates on doing the measurement well.

I have been teaching a course that was known as "Measurements in Thermal Science" for almost 20 years. Then the title changed to "Measurements in Thermal Engineering"! The emphasis of the course, however, has not changed. The course is one semester long and the student learns about the *measurement process* for almost third of this duration. After he understands the principles he is ready to learn about measurement of quantities that are of interest to a mechanical engineer. The course stresses the problem solving aspect rather than the mundane descriptive aspects. The student is asked to use library and web resources to learn about instruments on her/his own.

In the mean while I have produced a video series (40 lectures each of 55 minutes duration on "Measurements in Thermal Science") that has been widely circulated. Thanks to the NPTEL project (National Program for Technology Enhanced Learning) I had an opportunity to bring out another video lecture series (50 lectures of 55 minutes duration each, this time called "Mechanical Measurements"). This is being broadcast over the "Technology

Channel'. Also I have prepared a five module web course with the same title. Interested reader can access the web course through the IIT Madras web site. This effort has encouraged me to write a more detailed book version of "Mechanical Measurements" that is now in your hands.

I have arranged this book in five parts, each part being referred to as a module. Details of what is contained in each module is given in an abstract form at the beginning of each module. It has taken me close to three years to produce this book. Over this period I have improved the readability of the text and weeded out unnecessary material and have tried to give to the reader what I believe is important. I have tried to give a balanced treatment of the subject, trying hard to keep my *bias* for thermal measurements!

The text contains many worked examples that will help the reader understand the basic principles involved. I have provided a large number of problems, at the end of the book, arranged module wise. These problems have appeared in the examination papers that I have set for students in my classes over the years. The problems highlight the kind of numerics that are involved in practical situations. Even though the text is intended to be an undergraduate text book it should interest practicing engineers or any one who may need to perform measurements as a part of his professional activity! I place the book in the hands of the interested reader in the hope that he will find it interesting and worth his while. The reader should not be content with a study of the book that contains a large number of *line drawings* that represent instruments. He should spend time in the laboratory and learn how to make measurements in the real world full of hard ware!

S.P. Venkateshan

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