# A TEXT-BOOK OF HYDRAULICS INCLUDING AN OUTLINE OF THE THEORY OF TURBINES

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649252688

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Edited by Trieste Publishing Pty Ltd.
Cover @ 2017



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# A TEXT-BOOK OF HYDRAULICS INCLUDING AN OUTLINE OF THE THEORY OF TURBINES

Trieste

# A TEXT-BOOK

ON

# HYDRAULICS

INCLUDING AN OUTLINE OF THE

## THEORY OF TURBINES

BY

L. M. HOSKINS

*Professor of Applied Mathematics in the Leland Stanford Junior University*

LONDON

ARCHIBALD CONSTABLE & CO. Ltd.

10 Orange Street, Leicester Square, W. C.

1907

ROBERT DRUMMOND, PRINTER, NEW YORK

# PREFACE.

THIS book is designed primarily for the use of students of engineering in universities and technical colleges. In its preparation the aim has been to present fundamental principles in a manner both sound and as simple as possible. The treatment presupposes a good elementary knowledge of the principles of mechanics, and a working knowledge of the elements of calculus; but to the student thus equipped, who is also well trained in arithmetic, algebra and trigonometry, it presents little mathematical difficulty. Many numerical examples are introduced, the complete solution of which should form an important part of the work of the student.

It is perhaps not too much to say that the key to a correct understanding of all problems in the steady flow of liquids is supplied by Bernoulli's theorem,—or, as it is usually called in the text, the general equation of energy. Familiarity with this principle is therefore much more important than a memory-knowledge of special rules, and for this reason the explanations of particular cases of flow have in most cases been based directly upon the fundamental equation. The meaning and importance of the term representing lost energy in this equation have also been emphasized. The corresponding theory applied to gases is given in Appendix A.

In the presentation of working rules for estimating flow in the various practical cases met by the engineer it has been aimed in every case to give a clear statement of the rational basis of the formula adopted, and also to make clear to what extent the theory is defective and the formula therefore empirical. It has also been attempted to avoid the appearance of

precise knowledge where the reality is absent. For example, no elaborate tables have been given purporting to show accurately how frictional loss of head in pipes depends upon velocity and diameter, or giving precise values of the friction factor for pipes of different kinds. A somewhat careful study of experimental data has failed to convince the author of the reliability of any such tables.

The treatment of turbines and water wheels has been restricted to an outline of the theory, but several illustrations showing typical American practice have been included. For these the author is indebted to the courtesy of manufacturers, to whom credit is in every case given in the text. The aim has been to unify the theory, the treatment of all specific cases being based upon the same general principles and equations, and a general notation for velocities and their direction-angles being adopted which it is hoped will be found simple and helpful. This unification includes the theory of turbine pumps.

In various discussions throughout the book reference is made to the author's text-book on Theoretical Mechanics for a fuller explanation of basal principles.

L. M. H.

Palo Alto, Cal., June, 1906.

# CONTENTS.

# HYDRAULICS

## CHAPTER I.

### PRELIMINARY DEFINITIONS AND PRINCIPLES.

**1. Definition of Subject.**—The mechanics of fluid bodies is called *Hydromechanics*. It embraces *Hydrostatics*, dealing with the principles of fluid equilibrium, and *Hydrokinetics*, dealing with the laws of fluid motion.

*Hydraulics*, the subject of this book, may be defined briefly as practical Hydromechanics. It deals especially with the flow of water in streams of various kinds, but may be taken to include all the principles and applications of Hydromechanics that bear directly upon problems of practical utility. Many of the laws of Hydraulics are largely empirical, but certain fundamental dynamical principles, especially the law of energy, serve to unify the subject and to put it upon a scientific basis.

The bodies dealt with in Hydromechanics may be either liquids or gases. Hydraulics deals mainly, but not exclusively, with liquids, and especially with water.

**2. Distinction between Solid and Fluid Bodies.**—A solid body can permanently resist change of shape; a fluid body cannot.

A fluid is either liquid or gaseous. A gas tends to expand indefinitely, so as to fill any continuous closed volume in any portion of which it may be placed. A liquid changes its volume only slightly under changes of pressure; a given portion may be wholly freed from external pressure without expanding beyond a certain volume.