THE PRINCIPLES OF HYDROSTATICS, AN ELEMENTARY TREATISE ON THE LAWS OF FLUIDS, AND THEIR PRACTICAL APPLICATIONS

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649168903

The principles of hydrostatics, an elementary treatise on the laws of fluids, and their practical applications by Thomas Webster

Except for use in any review, the reproduction or utilisation of this work in whole or in part in any form by any electronic, mechanical or other means, now known or hereafter invented, including xerography, photocopying and recording, or in any information storage or retrieval system, is forbidden without the permission of the publisher, Trieste Publishing Pty Ltd, PO Box 1576 Collingwood, Victoria 3066 Australia.

All rights reserved.

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

This book is sold subject to the condition that it shall not, by way of trade or otherwise, be lent, re-sold, hired out, or otherwise circulated without the publisher's prior consent in any form or binding or cover other than that in which it is published and without a similar condition including this condition being imposed on the subsequent purchaser.

www.triestepublishing.com

THOMAS WEBSTER

THE PRINCIPLES OF HYDROSTATICS, AN ELEMENTARY TREATISE ON THE LAWS OF FLUIDS, AND THEIR PRACTICAL APPLICATIONS

Trieste

W.

THE PRINCIPLES

OF

HYDROSTATICS;

AN ELEMENTARY TREATISE

ON

THE LAWS OF FLUIDS,

AND THEIR PRACTICAL APPLICATIONS.

By THOMAS WEBSTER, M.A.

OF TRINITY COLLEGE

SECOND EDITION, ENLARGED.

CAMBRIDGE:

PRINTED AT THE UNIVERSITY PRESS, FOR

J. AND J. J. DEIGHTON, CAMBRIDGE:

AND

JOHN W. PARKER, LONDON.

M.DCCC.XXXVIII.

9644b
2/6/09

PREFACE.

In the following pages I have endeavoured to exhibit the Laws of Fluids, and the principles of the practical applications of the science in a form adapted to all students of Mathematical and Natural Philosophy.

Many very valuable treatises have been published on this subject; but from their being almost exclusively mathematical, and from the physical parts of the science having been detached from the theoretical, the student cannot derive much real advantage from them, unless he is very well acquainted with the Differential and Integral Calculus. For unless he is so prepared, he must content himself with adopting the results which he finds in them without being thoroughly acquainted with the processes by which they are obtained. It is obvious that this method of arriving at an end, without understanding the means, may weary but cannot improve the mind.

From this consideration, I have endeavoured in the following treatise to develop the principles of the science with the use of none but the most elementary mathematics; so that the student, who now either partially or wholly neglects this beautiful branch of Natural Philosophy from the uninviting character which Analysis presents to those who are not familiar with it, may at once proceed to its study, if he is only acquainted with the first principles of Algebra and Mechanics. It is not

from thinking other methods preferable or even comparable with the analytical, that I have adopted this plan; but with the view of bringing the subject within the reach of those who have not been initiated in analysis.

The plan here adopted is similar to that which has been pursued by Mr Whewell in the kindred science of Mechanics; and being already peculiarly indebted to him, not only on account of the advantage which I derived from his college lectures on this subject, but for his advice during the progress of this work, I feel pleasure in laying myself under additional obligation, by availing myself of his language*, (which appears equally applicable to all branches of Natural Philosophy), in further vindication of the plan here pursued.

"These principles may be familiarized to many who may never become dexterous analysts, and there are advantages in not introducing the general analytical methods till some of the more simple cases have been separately considered; for these methods suppose a command of analysis which can only be acquired in time, and which therefore should not be taken for granted at an early period. And it is desirable that this science should be studied by persons who do not ever acquire a knowledge of more than the elementary parts of mathematics.

"In a system of study like that of our University, it would be a mistake to present the introductory subject in a manner which supposes that the learner is necessarily to advance far in mathematical pursuits. We ought to lay our foundation so as to admit of such a superstructure, but not so as to be useless without it."

For the convenience, however, of those who are acquainted with the Calculus, I have added a chapter on

* Preface, *Elementary Mechanics*.

the analytical conditions of the Equilibrium of Fuids; I have also added some important mathematical propositions connected with the application of the barometer to levelling. Thus the present work contains all the propositions usually read in the course of University study. The chain of propositions and of reasoning is complete without the mathematical propositions referred to, and the student unacquainted with the Calculus is directed to omit these portions of the work.

After stating the general properties of fluids, I have proceeded with the usual propositions respecting equilibrium and pressure, floating bodies and specific gravity.

In the chapter on Elastic Fluids, I have given Dalton's Theory; this theory, whether true or false, is very beautiful, and affords an explanation of a great variety of phenomena. If true, it ought to be generally received: and if false, its publication is the means of leading to a detection of its fallacy.

I have given a lengthened account of the Hydro-mechanical or Bramah Press, because I consider that it exhibits most distinctly the statical properties of a fluid considered as a machine, and is in itself, so to speak, a commentary on one branch of Hydrostatics, since it affords the best illustration of the transmission of pressure, of the equilibrium of a fluid mass, and of the compressibility and elasticity of water. By the known liberality of the Messrs Bramah and the assistance of my friend Mr Renton, I have been enabled to lay before the student a detailed account of the construction and practical working of this machine, which surpasses all other machines for the purposes to which it is applicable.

In the chapter on Capillary Attraction I have endeavoured to exhibit in a simple manner the Theory of

Laplace, and the explanation which that theory affords of the most important phenomena. This chapter will, I trust, be a valuable addition to the usual course of elementary instruction. The subject has generally been treated in a manner which excluded it from the student who did not possess considerable knowledge of mathematics. But though the calculations can only be effected by the application of analysis of the highest order, the physical principles and the hypotheses employed may readily be apprehended by every student, and the phenomena properly treated furnish evidence of the existence of the actions and forces by which the intimate constitutions of bodies are controlled.

T. W.

LONDON,
May 1838.

CONTENTS.

CHAPTER I.

PAGE

ON THE PROPERTIES OF FLUIDS..... 1

Arts. 1—2. INTRODUCTION. 3. Fluidity. 4. Liquids and Gases. 5. Dilatability. 6. Effect of Heat. 7. Constitution of Bodies. 8. Every particle has weight. 9. Gravitation of Fluids. 10. Fluids subject to same laws as Solids. 11. Measure of Gravity. 12. Density. 13. Measure of Weight. 14. Compressibility. 15—16. Elasticity and Compressibility. 17—19. Water and all Fluids compressible and elastic.

CHAPTER II.

ON THE EQUILIBRIUM OF FLUIDS SUBJECT TO PRESSURE... 13

Arts. 21. Transmission of Pressure. 22—23. Action and Reaction. 24. Piston Experiment. 25. Unit of Pressure. 26. Practical Illustrations. 27. Principle of Bramah's Press. 28. Equation of Virtual Velocities.

CHAPTER III.

ON THE EQUILIBRIUM OF FLUIDS SUBJECT TO GRAVITY..... 21

Arts. 29. Observations. 30. Any part of a fluid may become rigid. 31. Pressure equal at surface.

CHAPTER IV.

ON THE PRESSURE OF A FLUID SUBJECT TO GRAVITY..... 32

Arts. 32. Surface Horizontal. 33. Level Surface. 34. Fluids maintain their level. 35. Water Works. 36. Level. 37. Spirit Level. 38. Depression. 39. Examples. 40. Levelling. 41. Remarks. 42. Pressure proportional to the depth. 43. Pressure on a plane. 44—46. Pressure on any surface. 47. Centre of Pressure. 48—49. Hydrostatic Bellows and Paradox. 50. Geological Phenomena.

CHAPTER V.

ON THE GENERAL EQUATIONS OF EQUILIBRIUM..... 41

Arts. 51. Remarks. 52. The General Equation. 53. Surface of free Fluid, and a level surface. 54. Resultant perpendicular to surface. 55. Pressure at any point. 56. Pressure on any surface. 57—61. Centre of Pressure and Examples.

CHAPTER VI.

PAGE
ON THE EQUILIBRIUM OF FLOATING BODIES..... 53

Arts. 62—63. Floating body. 64. Moving force of body immersed. 65. Camel. Life Preservers. 66—67. Conditions of rest. 68—69. Equilibrium Stable, Unstable and Indifferent. Metacentre. 70. Stable and Unstable Equilibrium recurs alternately. 71. Intersection of two planes of floatation. 72. Nature of equilibrium of floating body. 73. To find Metacentre. Example.

CHAPTER VII.

ON SPECIFIC GRAVITY..... 65

Arts. 74—76. Definition, &c. of Specific Gravity. 77. Specific Gravity as the density. 78. Weight lost on immersion as the Specific Gravity of the Fluid. 79. Hydrostatic Balance. 80. Specific Gravity of a Compound. 81. Specific Gravity of a Fluid. Common Hydrometer. 82. Sikes' Hydrometer. 83. Nicholson's Hydrometer. 84. Corrections. 85. Specific Gravity of Air and Gases. 86. True Specific Gravity and Weight. 87. Tables of Specific Gravity and Examples.

CHAPTER VIII.

ON ELASTIC FLUIDS..... 80

Arts. 88—90. Elastic force inversely as the space, and directly as the density. 91. Expansion of all Gases the same. 92. Amonton's Law. 93. Diffusion of Gases. 94. Dalton's Law. 95. Gases exert the pressure due to their volume. 96. Law of Gaseous Diffusion. Graham's Experiments. 97. Common Air Pump. 98. Density decreases in Geometrical Progression. 99. Practical Limits. 100. Siphon Gauge. 101. Smeaton's Air Pump. 102. Cuthbertson's. 103. Condenser. 104. Density increases in Arithmetical Progression. 105. Siphon Gauge. 106. Air Gun. 107. Diving Bell. 108. Space clear of water in Diving Bell sunk to given depth.

CHAPTER IX.

ON THE ATMOSPHERE..... 102

Arts. 109. Remarks. 110. Discoveries of Toricelli and Pascal. 111. Barometer. 112. Atmospheric Pressure equals weight of Barometric Column. 113. Correction for relative capacity of Tube and Basin. 114. True Barometric Column. 115. Imperfect Barometer. 116. Diagonal Barometer. 117. Wheel Barometer. 118. Weather. Dalton's Rules. 119. Densities of Strata are in Geometrical Progression. 120. Measurement of Heights. 121—122. Difference of altitude of two stations and corrections. 124. Height of a homogeneous Atmosphere. 125. Pressure on a square inch. 126. Effects of Atmosphere. 127. Inverted Vessels, Pneumatic Trough, Gasometer. 128—129. Constitution and Limit of Atmosphere.