

**PRINCIPLES OF MECHANICS, AND THEIR  
APPLICATION TO PRIME MOVERS, NAVAL  
ARCHITECTURE, IRON BRIDGES, WATER  
SUPPLY, &C. BEING AN ABSTRACT OF  
LECTURES DELIVERED TO THE CLASS OF CIVIL  
ENGINEERING AND MECHANICS IN THE  
UNIVERSITY OF GLASGOW, SESSION 1872-73**

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649510399

Principles of Mechanics, and Their Application to Prime Movers, Naval Architecture, Iron Bridges, Water Supply, &C. Being an Abstract of Lectures Delivered to the Class of Civil Engineering and Mechanics in the University of Glasgow, Session 1872-73 by W. J. Millar

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](http://www.triestepublishing.com)

**W. J. MILLAR**

**PRINCIPLES OF MECHANICS, AND THEIR  
APPLICATION TO PRIME MOVERS, NAVAL  
ARCHITECTURE, IRON BRIDGES, WATER  
SUPPLY, &C. BEING AN ABSTRACT OF  
LECTURES DELIVERED TO THE CLASS OF CIVIL  
ENGINEERING AND MECHANICS IN THE  
UNIVERSITY OF GLASGOW, SESSION 1872-73**



6

# PRINCIPLES OF MECHANICS,

AND THEIR APPLICATION TO

PRIME MOVERS, NAVAL ARCHITECTURE, IRON BRIDGES,  
WATER SUPPLY, &c.

THERMODYNAMICS, WITH SPECIAL REFERENCE TO THE STEAM ENGINE.

BEING AN ABSTRACT OF LECTURES

DELIVERED TO

THE CLASS OF CIVIL ENGINEERING AND MECHANICS IN THE  
UNIVERSITY OF GLASGOW, SESSION 1872-73.

BY

W. J. MILLAR, C.E.,

SECRETARY TO THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.



LONDON:

E. & F. N. SPON, 48, CHARING CROSS.

NEW YORK:

446, BROOME STREET.

1874.

Eng 258.74.5

**JUN 20 1917**

~~42018~~ TRANSFERRED TO  
MAYNARD COLLEGE LIBRARY

$\frac{2}{9}$

## P R E F A C E .

---

As indicated on the title-page, the subjects treated of in this book constituted in a more extended form a series of Lectures delivered to the Class of Civil Engineering and Mechanics in the University of Glasgow during the latter part of session 1872-73.

Shortly after the death of Professor Rankine, the author was appointed to conduct the class referred to during the Professorial vacancy; and the various subjects treated of formed part of the complete course as entered in the syllabus of the class.

It having occurred to the author that a carefully-revised abstract of these Lectures might be of use to students and others studying the various subjects treated of, the work as contained in the following pages is the result.

The subjects have been treated of as concisely as possible, numerical illustrations being occasionally given to assist the reader.

Various authorities have been consulted in the preparation of the present work; amongst others,

Professor Rankine's Works;  
Moseley's Engineering and Architecture;  
Fairbairn's Mills and Millwork;

Deschanel's Natural Philosophy, by Prof. Everett;  
Shipbuilding in Iron and Steel (Reed);  
Transactions Inst. Civil Engineers;  
Transactions Inst. Engineers and Shipbuilders in  
Scotland;  
Transactions Inst. Naval Architects;  
Report (British Assoc.) Sea-going Qualities of  
Ships, 1869;  
Annual of the Royal School of Naval Architecture  
and Marine Engineering;  
and the various Engineering and Scientific periodicals, &c.

W. J. M.

GLASGOW, October, 1874.



## CONTENTS.

---

|  | PAGE |
|--|------|
| ENERGY .. .. .   | 1    |
| PRIME MOVERS .. .. .   | 3    |
| DYNAMOMETERS .. .. .   | 3    |
| MUSCULAR POWER .. .. .   | 4    |
| WATER POWER .. .. .  | 5    |
| STORAGE OF WATER .. .. .   | 5    |
| WATER WHEELS .. .. .   | 7    |
| Vertical Water Wheels .. .. .  | 7    |
| Relation of the Terms Impulse, Momentum, and Actual Energy .. .. .     | 7    |
| Undershot Wheels, in which the Water acts by Impulse .. .. .           | 8    |
| Undershot Wheels, in which the Water acts by Weight .. .. .            | 11   |
| Overshot Wheels, in which the Water acts principally by Weight .. .. . | 11   |
| High Breast Wheels .. .. .   | 11   |
| Efficiency of Water Wheels .. .. .                                     | 12   |
| Speed of Water Wheels .. .. .  | 13   |
| Horizontal Water Wheels, or Turbines .. .. .                           | 14   |
| Reaction Wheel .. .. .   | 15   |
| WATER-PRESSURE ENGINES .. .. .   | 16   |
| HYDRAULIC RAM .. .. .  | 16   |
| WINDMILLS .. .. .  | 17   |
| NAVAL ARCHITECTURE .. .. .   | 18   |
| EQUILIBRIUM AND STABILITY OF FLOATING BODIES .. .. .                   | 18   |
| Application to Ships .. .. .   | 22   |
| Stability or Stiffness .. .. .   | 24   |
| Statical Stability .. .. .   | 24   |
| Dynamical Stability .. .. .  | 24   |
| Methods of finding the Metacentre .. .. .                              | 26   |
| Simpson's Rule for Areas .. .. .                                       | 26   |
| Rolling .. .. .  | 27   |

|  | PAGE |
|--|------|
| WAVES .. .. .  | 28   |
| To Draw a Trochoid .. .. .                                       | 30   |
| Action of Waves on a Ship .. .. .                                | 31   |
| Instruments for Measuring Roll .. .. .                           | 32   |
| Stream Lines .. .. .   | 33   |
| Resistance to the Motion of a Vessel .. .. .                     | 33   |
| PROPULSION OF VESSELS .. .. .                                    | 36   |
| Reaction of Propellers .. .. .                                   | 37   |
| Paddle-wheel Propellers .. .. .                                  | 40   |
| Screw Propellers .. .. .   | 42   |
| Hydraulic Propellers .. .. .                                     | 43   |
| Horizontal Propellers .. .. .                                    | 43   |
| CONSTRUCTION OF VESSELS .. .. .                                  | 44   |
| STRENGTH OF STRUCTURES .. .. .                                   | 51   |
| STRAINS IN GIRDERS .. .. .                                       | 51   |
| Factors of Safety .. .. .  | 61   |
| Method of Frames .. .. .   | 63   |
| Method of Sections .. .. .                                       | 65   |
| FORMS OF GIRDERS .. .. .   | 66   |
| Plate Girders .. .. .  | 66   |
| Lattice Girders .. .. .  | 67   |
| Bowstring Girders .. .. .  | 68   |
| Tubular Girders .. .. .  | 69   |
| Arch Ribs .. .. .  | 70   |
| Suspension Bridges .. .. .                                       | 71   |
| Continuous Girders .. .. .                                       | 73   |
| COMPOUND BEAMS .. .. .   | 75   |
| PLATFORMS OF BRIDGES .. .. .                                     | 76   |
| DEFLECTION OF BEAMS .. .. .                                      | 76   |
| STABILITY OF STRUCTURES .. .. .                                  | 78   |
| Retaining Walls to resist Fluid Pressure .. .. .                 | 78   |
| Retaining Walls to resist Earth Pressure .. .. .                 | 82   |
| Towers and Chimneys .. .. .                                      | 82   |
| STRENGTH OF SOLID CYLINDERS .. .. .                              | 85   |
| Shafts and Axles .. .. .   | 85   |
| STRENGTH OF HOLLOW CYLINDERS TO RESIST INTERNAL PRESSURE .. .. . | 87   |
| Thin Shells, such as Boilers .. .. .                             | 87   |
| Thick Hollow Cylinders, such as Hydraulic Cylinders .. .. .      | 87   |
| STRENGTH OF SPRINGS .. .. .                                      | 88   |

CONTENTS.

vii

|  | PAGE |
|--|------|
| THERMODYNAMICS .. .. .                               | 90   |
| SOURCES OF HEAT .. .. .                              | 91   |
| TRANSMISSION OF HEAT .. .. .                         | 92   |
| EXPANSION .. .. .                                    | 94   |
| HEAT INDICATORS .. .. .                              | 97   |
| LIQUEFACTION .. .. .                                 | 99   |
| SPECIFIC HEAT .. .. .                                | 100  |
| COMBUSTION .. .. .                                   | 102  |
| STEAM BOILERS .. .. .                                | 106  |
| Relations between Heat and Mechanical Energy .. .. . | 108  |
| STEAM ENGINES .. .. .                                | 110  |
| Indicated and Nominal Horse-power .. .. .            | 112  |
| Indicator .. .. .                                    | 117  |
| COMPOUND ENGINES .. .. .                             | 118  |
| CONDENSERS .. .. .                                   | 120  |
| HOT-AIR ENGINES .. .. .                              | 122  |
| GAS ENGINES .. .. .                                  | 122  |
| ELECTRO-MAGNETIC ENGINES .. .. .                     | 123  |
| WATER SUPPLY .. .. .                                 | 124  |
| FILTERS .. .. .                                      | 125  |
| CLEAR-WATER TANK .. .. .                             | 126  |
| PIPING .. .. .                                       | 126  |
| FLOW OF WATER THROUGH PIPES .. .. .                  | 128  |
| SPECTRUM ANALYSIS .. .. .                            | 130  |
| INDEX .. .. .  | 133  |