

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

CAMBRIDGE LIBRARY COLLECTION

Books of enduring scholarly value

Mathematical Sciences

From its pre-historic roots in simple counting to the algorithms powering modern desktop computers, from the genius of Archimedes to the genius of Einstein, advances in mathematical understanding and numerical techniques have been directly responsible for creating the modern world as we know it. This series will provide a library of the most influential publications and writers on mathematics in its broadest sense. As such, it will show not only the deep roots from which modern science and technology have grown, but also the astonishing breadth of application of mathematical techniques in the humanities and social sciences, and in everyday life.

Statics

A.S. Ramsey (1867-1954) was a distinguished Cambridge mathematician and President of Magdalene College. He wrote several textbooks 'for the use of higher divisions in schools and for first-year students at university'. This book on statics, published in 1934, was intended as a companion volume to his Dynamics of 1929 and like the latter was based upon his lectures to students of the mathematical tripos, but it assumes no prior knowledge of the subject, provides an introduction and offers more than 100 example problems with their solutions. Topics include vectors, forces acting at a point, moments, friction, centres of gravity, work and energy, and elasticity.

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

Cambridge University Press has long been a pioneer in the reissuing of out-of-print titles from its own backlist, producing digital reprints of books that are still sought after by scholars and students but could not be reprinted economically using traditional technology. The Cambridge Library Collection extends this activity to a wider range of books which are still of importance to researchers and professionals, either for the source material they contain, or as landmarks in the history of their academic discipline.

Drawing from the world-renowned collections in the Cambridge University Library, and guided by the advice of experts in each subject area, Cambridge University Press is using state-of-the-art scanning machines in its own Printing House to capture the content of each book selected for inclusion. The files are processed to give a consistently clear, crisp image, and the books finished to the high quality standard for which the Press is recognised around the world. The latest print-on-demand technology ensures that the books will remain available indefinitely, and that orders for single or multiple copies can quickly be supplied.

The Cambridge Library Collection will bring back to life books of enduring scholarly value across a wide range of disciplines in the humanities and social sciences and in science and technology.

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

Statics

*A Text-Book for the use of the Higher Divi-
sions in Schools and for First Year Students at
the Universities*

ARTHUR STANLEY RAMSEY



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge New York Melbourne Madrid Cape Town Singapore São Paulo Delhi

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org

Information on this title: www.cambridge.org/9781108003155

© in this compilation Cambridge University Press 2009

This edition first published 1934

This digitally printed version 2009

ISBN 978-1-108-00315-5

This book reproduces the text of the original edition. The content and language reflect
the beliefs, practices and terminology of their time, and have not been updated.

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

STATICS

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

LONDON

Cambridge University Press

FETTER LANE

NEW YORK • TORONTO

BOMBAY • CALCUTTA • MADRAS

Macmillan

TOKYO

Maruzen Company Ltd

All rights reserved

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

STATICS

A Text-Book for the use of the
Higher Divisions in Schools
and for
First Year Students at the Universities

by

A. S. RAMSEY, M.A.

*President of Magdalene College
Cambridge*



CAMBRIDGE

AT THE UNIVERSITY PRESS

1934

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

PRINTED IN GREAT BRITAIN

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

PREFACE

THIS book has been written as a companion volume to my book on *Dynamics* published a few years ago and is intended mainly for the same class of students, namely, for mathematical specialists in the higher divisions of schools and for students preparing for a degree in mathematics in the Universities. It is based in part upon courses of lectures given during many years to first-year students preparing for the **Mathematical Tripos**; and though many readers will already possess some knowledge of the subject, no such knowledge is assumed and an attempt has been made in the early chapters to present the subject in as simple a way as possible and with very detailed explanations.

The book deals with all those parts of the subject which are usually covered by the term **Elementary Statics**, with special attention to **Graphical Statics**, **Friction** and **Virtual Work**. For the use of more advanced students there are also chapters on the statics of flexible strings and the bending of rods, and the book concludes with a brief account of force systems in three dimensions.

There are nearly five hundred examples for solution taken mainly from papers set in either **Scholarship**, **College**, **Inter-collegiate** or **Tripos Examinations**, and their sources are indicated by the letters **S**, **C**, **I** and **T**. More than a hundred examples are solved in the text, sometimes by alternative methods.

It has become the fashion of late to express mechanical relations in the symbolism of vector algebra and to use the methods of vector algebra in proving mechanical theorems. The method has its advantages; but I have not adopted it in this book, because to most readers it would represent a new technique. The effort necessary to acquire this technique would in many cases be a hindrance rather than a help to the grasping of the mechanical principles which the book is intended to teach, and should, I think, be made at a later

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

vi

PREFACE

stage. I have therefore made no use of vector analysis, but the way in which forces and couples obey the vector law of addition is fully explained, and the chapter on Vectors from the book on *Dynamics* appears here again in amplified form.

Readers who are familiar with the books of the late Dr Routh and of Sir Horace Lamb will realize something of my indebtedness to both these authors, but I am conscious of a greater debt than is apparent and I should like to take this opportunity of expressing my gratitude.

In conclusion I desire to thank the printers and readers of the University Press for their excellent work in setting up the book and eliminating mistakes, and in so far as the book still contains errors I shall be grateful to anyone who will point them out.

A. S. R.

November 1933

CAMBRIDGE

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

CONTENTS

Chapter I: INTRODUCTION

ART.		PAGE
1.1.	Force	1
1.2.	Rigid Bodies	2
1.3.	Types of Forces	2
1.4.	Law of Reaction	2
1.5.	Principle of Transmissibility of Force	2

Chapter II: VECTORS

2.1.	Vectors and Scalars	4
2.2.	Composition of Vectors	5
2.3.	Orthogonal Projections	6
2.4.	Analytical Method of Composition	6
2.5.	Multiplication and Division by Scalars	8
2.6.	Centroids or Mean Centres	8
2.7.	Centroid Method of Compounding Vectors	9
	Examples	10

Chapter III: FORCES ACTING AT A POINT

3.1.	Parallelogram of Forces	12
3.2.	Triangle of Forces	14
3.21.	Lami's Theorem	15
3.22.	Polygon of Forces	16
3.3.	Composition of Forces	17
3.31.	Expressions for the Resultant	18
3.4.	Conditions of Equilibrium	19
3.42.	Oblique Resolution	20
3.5.	Worked Examples	21
3.6.	Systems of Particles. Internal and External Forces	22
3.7.	Constraints. Smooth and Rough Bodies	23
	Examples	26

Chapter IV: MOMENTS. PARALLEL FORCES. COUPLES

4.1.	Moment of a Force about a Point	31
4.2.	Theorem of Moments	31
4.21.	Moment of a Force about a Line	32
4.3.	Parallel Forces	33
4.31.	Couples	35
4.4.	Theorem of Moments for Parallel Forces	35

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

viii

CONTENTS

ART.	PAGE
4.5. Centre of Parallel Forces	36
4.51. Centre of Gravity	37
4.53. Analytical Formulae for Centre of Parallel Forces	38
4.6. Couples	40
4.61-3. Equivalence of Couples	41
4.64. Specification of a Couple	44
4.65. Composition of Couples	45
Examples	50

Chapter V: COPLANAR FORCES

5.1. Reduction to a Force at any Point and a Couple.	56
5.2. Conditions of Equilibrium	57
5.3. Analytical Method	58
5.32. Worked Examples	60
Examples	63

Chapter VI: THE SOLUTION OF PROBLEMS

6.1. Equations of Equilibrium	67
6.2. Constraints and Degrees of Freedom	67
6.21. Three Forces . . . Coplanar and Concurrent or Parallel	68
6.3. Problems of two or more Bodies	72
6.4. Reactions at Joints	75
6.42. Working Rules	77
6.5. Chain of Heavy Particles	81
6.52. Chain of Heavy Rods	83
Examples	85

Chapter VII: BENDING MOMENTS

7.1, 7.2. Stresses in a Beam	95
7.3. Relations between Bending Moment and Shearing Force	98
7.4. Worked Examples	100
Examples	104

Chapter VIII: GRAPHICAL STATICS

8.1. Graphical Determination of Resultant	107
8.2. Pole of Force Diagram	109
8.3. Parallel Forces	111
8.4. Graphical Representation of Bending Moment	113
8.5. Reciprocal Figures	116
8.6. Frameworks	117

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

CONTENTS

ix

ART.		PAGE
8-63.	Bow's Notation	119
8-7.	Method of Sections	124
8-8.	Distributed Loads	125
	Examples	128

Chapter IX: FRICTION

9-1.	Laws of Friction	134
9-15.	Angle of Friction and Cone of Friction	136
9-17.	Rolling Friction	137
9-2.	Problems	138
9-22.	Indeterminateness of Problems	139
9-3.	Initial Motion	141
9-4.	Friction in Unknown Directions	145
9-5.	Miscellaneous Problems	149
	Examples	152

Chapter X: CENTRES OF GRAVITY

10-1.	Formulae	160
10-2.	Rod. Parallelogram. Triangle. Quadrilateral. Tetra- hedron. Pyramid. Cone	161
10-3.	Centres of Gravity by Integration	165
10-31.	Curves	165
10-32.	Areas and Surface Distributions	167
10-34.1.	Volumes of Revolution	171
10-35.	Zone of the Surface of a Sphere	172
10-4.	Orthogonal Projection	174
10-41.	Quadrant of an Ellipse	175
10-5.	Theorems of Pappus	176
10-6.	Lagrange's Formula	177
	Examples	181

Chapter IX: WORK AND ENERGY

11-1.	Work done by a Force	187
11-14.	Conservative Field of Force	188
11-2.	Virtual Work for a Single Particle	190
11-23.	Reactions which do no Work	193
11-3.	Virtual Work for a System of Bodies	195
11-31.	The Converse Theorem	197
11-33.	Applications	198
11-34-6.	Worked Examples	200
11-4.	Determination of Unknown Reactions	205

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

X		CONTENTS	
ART.			PAGE
11.5.	Deduction of Conditions of Equilibrium		209
11.6.	Potential Energy		211
11.62.	Energy Test of Stability		213
11.7.	Rocking Cylinders and Spheres		219
11.8.	Hooke's Law		220
	Examples		221

Chapter XII: FLEXIBLE CHAINS AND STRINGS

12.1.	Equations of Equilibrium	230
12.11-14.	String on Smooth and Rough Curves	231
12.2.	The Common Catenary	236
12.3.	The Parabolic Chain and Suspension Bridge	240
12.4.	Chain of Variable Density or Thickness	242
12.5.	Catenary of Uniform Strength	243
12.6.	Elastic Strings	244
12.62.	The Elastic Catenary	245
12.7.	Miscellaneous Examples	246
	Examples	249

Chapter XIII: ELASTICITY

13.1.	Isotropic Bodies. Uniform Extension	255
13.2.	Extension of Bars. Young's Modulus	255
13.21.	Variable Extension	256
13.23.	Elastic Energy of Longitudinal Strain	257
13.3.	Bending of Bars	258
13.4.	Applications	260
13.45.	Theorem of Three Moments	264
13.5.	Combined Extension and Bending	266
13.6.	Elastic Energy	267
13.7.	General Equations for a Thin Rod bent in One Plane	268
13.8.	Euler's Strut	269
13.9.	Loaded Column	270
	Examples	271

Chapter XIV: FORCES IN THREE DIMENSIONS

14.1.	Reduction to a Force and a Couple	275
14.2.	Conditions of Equilibrium	277
14.3.	Poinsot's Central Axis. The Wrench	278
14.33.	Condition for a Single Resultant Force	279
14.4.	The Invariants	281

Cambridge University Press

978-1-108-00315-5 - Statics: A Text-Book for the Use of the Higher Divisions in
Schools and for First Year Students at the Universities

Arthur Stanley Ramsey

Frontmatter

[More information](#)

CONTENTS

xi

ART.		PAGE
14.41.	Geometrical Representation of the Moment of a Force about a Line	282
14.5.	Wrench Equivalent to Two Forces	283
14.51.	Resultant of Two Wrenches	284
14.6.	Null Points, Lines and Planes	285
14.7.	Conjugate Forces	286
14.8.	Equilibrium of Four Forces	289
	Examples	291