ENGINEERING MECHANICS

with Lab Manual

Bhankhar Bharat Gokaldas
Vandana Somkuwar

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by Bhankhar Bharat Gokaldas
Vandana Somkuwar

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FOREWORD

Engineering has played a very significant role in the progress and expansion of mankind and society for centuries. Engineering ideas that originated in the Indian subcontinent have had a thoughtful impact on the world.

All India Council for Technical Education (AICTE) had always been at the forefront of assisting Technical students in every possible manner since its inception in 1987. The goal of AICTE has been to promote quality Technical Education and thereby take the industry to a greater heights and ultimately turn our dear motherland India into a Modern Developed Nation. It will not be inept to mention here that Engineers are the backbone of the modern society - better the engineers, better the industry, and better the industry, better the country.

NEP 2020 envisages education in regional languages to all, thereby ensuring that each and every student becomes capable and competent enough and is in a position to contribute towards the national growth and development.

One of the spheres where AICTE had been relentlessly working from last few years was to provide high-quality moderately priced books of International standard prepared in various regional languages to all it's Engineering students. These books are not only prepared keeping in mind it's easy language, real life examples, rich contents and but also the industry needs in this everyday changing world. These books are as per AICTE Model Curriculum of Engineering & Technology – 2018.

Eminent Professors from all over India with great knowledge and experience have written these books for the benefit of academic fraternity. AICTE is confident that these books with their rich contents will help technical students master the subjects with greater ease and quality.

AICTE appreciates the hard work of the original authors, coordinators and the translators for their endeavour in making these Engineering subjects more lucid.

(**Anil D. Sahasrabudhe**)

ACKNOWLEDGEMENT

The author(s) are grateful to AICTE for their meticulous planning and execution to publish the technical book for Diploma students.

We sincerely acknowledge the valuable contributions of the reviewer of the book Prof. Parekh Divyakumar Narendra, for making it students' friendly and giving a better shape in an artistic manner.

This book is an outcome of various suggestions of AICTE members, experts and authors who shared their opinion and thoughts to further develop the engineering education in our country.

It is also with great honour that we state that this book is aligned to the AICTE Model Curriculum and in line with the guidelines of National Education Policy (NEP) -2020. Towards promoting education in regional languages, this book is being translated in scheduled Indian regional languages.

Acknowledgements are due to the contributors and different workers in this eld whose published books, review articles, papers, photographs, footnotes, references and other valuable information enriched us at the time of writing the book.

Finally, we like to express our sincere thanks to the publishing house, M/s. Khanna Book Publishing Company Private Limited, New Delhi, whose entire team was always ready to cooperate on all the aspects of publishing to make it a wonderful experience.

Bhankhar Bharat Gokaldas
Vandana Somkuwar

PREFACE

The book titled "Engineering Mechanics" is an outcome of the rich experience of my teaching of basic course. The initiation of writing this book is to expose the fundamentals of mechanics as well as enable to get an insight of the subject. Keeping in mind the purpose of wide coverage as well as to provide essential supplementary information, I have included the topics as per AICTE model curriculum, in a very systematic and orderly manner throughout the book. Efforts have made to explain the fundamental concepts of the subject in the simplest possible way.

During the process of preparation of the manuscript, emphasis has also been laid on definitions, technical terms, laws and also on comprehensive synopsis of formulae for a quick revision of the basic principles. The book covers all types of medium and advanced level problems and these have presented in a very logical and systematic manner. The gradations of those problems have tested over many years of teaching with wide variety of students.

I have enriched the book with numerous solved problems in every unit for proper understanding of the related topics. It is important to note that in this the book, I have included the relevant laboratory practical pertain to each unit. In addition, besides some essential information for the users under the heading "Know More" & clarified some essential basic information in the appendix and annexure.

As far as the present book is concerned, "Engineering Mechanics" meant to provide a thorough grounding in applied mechanics on the topics covered. This book will prepare students to apply the knowledge of engineering mechanics to tackle 21st century and onward engineering challenges and address the related aroused questions to field work.

I sincerely hope that the book will inspire the students to learn and discuss the ideas behind basic principles of engineering mechanics and will surely contribute to the development of a solid foundation of the subject. I would be very much thankful to all benefices for comments and suggestions, which will contribute to the improvement of the future editions of this book. It gives us immense pleasure to place this book in the hands of the teachers and students. It was indeed a big pleasure to work on different aspects covering in this book.

Bhankhar Bharat Gokaldas
Vandana Somkuwar

OUTCOME BASED EDUCATION

Outcome based education (OBE) is based on three pillars; outcome- based curriculum (OBC), outcome-based learning teaching (OBLT) and outcome-based assessment (OBA). The learning outcomes can be at program levels (POs), course level (COs), unit level (UOs) and session level outcomes (attained in classroom learning, practical's and using other basic and advanced instructional methods). The mapping between, POs and COs & COs and UOs, is given in the book so that student can connect learning at any different level directly to the program level outcomes. Assessment is an integral part of teaching – learning process. Hence, to assess learning outcomes, the difficulty level of solved and unsolved problems given in the book matches with the cognitive level of unit learning outcomes. The course level outcomes can be attain through unit outcome and practical outcomes. At the end of the programme running with the aid of outcome-based education, a student will be able to arrive at the following programme outcomes.

PO1 : Basic and Discipline specific knowledge : Apply knowledge of basic mathematics, science and engineering fundamentals and engineering specialization to solve the engineering problems.

PO2 : Problem analysis : Identify and analyze well-defined engineering problems using codified standard methods.

PO3 : Design/development of solutions : Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

PO4 : Engineering Tools, Experimentation and Testing : Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO5 : Engineering practices for society, sustainability and environment : Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO6 : Project Management : Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO7 : Life-long learning : Ability to analyze individual needs and engage in updating in the context of technological changes.

COURSE OUTCOMES

After completing this course, student will be able to:

1. Identify the force systems for given conditions by applying the basics of mechanics.
2. Determine unknown force(s) of different engineering systems.
3. Apply the principles of friction in various conditions for useful purposes.
4. Find the centroid and centre of gravity of various components in engineering systems.
5. Select the relevant simple lifting machine(s) for given purposes.

Course Outcomes	Expected Mapping with Programme Outcomes (1 - Weak Correlation; 2 - Medium correlation; 3 - Strong Correlation)						
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7
CO-1	3	-	-	2	1	-	-
CO-2	2	3	3	3	2	-	-
CO-3	2	3	3	2	2	1	1
CO-4	2	3	2	2	2	1	1
CO-5	2	2	2	3	3	1	2

ABBREVIATIONS AND SYMBOLS

List of Abbreviations

General Terms			
Abbreviations	**Full form**	**Abbreviations**	**Full form**
CG	Center of gravity	RHS	Right Hand Side
CO	Course Outcome	UDL	Uniformly Distributed Load
LHS	Left Hand Side	UO	Unit Outcome
MA	Mechanical Advantage	VR	Velocity Ratio
PO	Programme Outcome		
Units Used			
Abbreviations	**Full form**	**Abbreviations**	**Full form**
cm	centimeter	mm^2	Square milimeter
GN	Giga Newton	mm^3	Cubic milimeter
kg	kilogram	MN	Mega Newton
kN	Kilo Newton	N	Newton
kN m	Kilo Newton meter	N m	Newton meter
kN/m	Kilo Newton per meter	N mm	Newton meter
m	meter	m^o	Degree
mm	millimeter		

LIST OF SYMBOLS

Symbols	Description	Symbols	Description
A	Area	d	Distance
C	Center	k	Kilo / Kinetic
E	Equilibrium force	m	Mass / Meter
F	Force / Frictional force	s	Static
H	Horizontal	w	Intensity of Uniformly Distributed Load (UDL)
L	Length	$(\bar{x}, \bar{y})$	Coordinates of Center of Gravity (CG)
M	Moment of force	α (Alpha)	Angle / Angle of friction
N	Newton / Normal reaction	β (Beta)	Angle
O	Origin of Axis	η (Eta)	Efficiency
P	Force / Effort	γ (Gama)	Angle
R	Reaction / Resultant force	μ (Mu)	Co-efficient of friction
T	Time / Tension force	Θ, ϕ (Phi)	Angle / Angle of repose
V	Vertical / Volume	Σ (Sigma)	Algebraic summation
W	Load / Self Weight	θ (Theta)	Angle
X, Y, Z	Axis		

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GUIDELINES FOR TEACHERS

To implement Outcome Based Education (OBE) knowledge level and skill set of the students should beenhanced. Teachers should take a major responsibility for the proper implementation of OBE. Some of the responsibilities (not limited to) for the teachers in OBE system may be as follows:

- Within reasonable constraint, they should manoeuvre time to the best advantage of all students.
- They should assess the students only upon certain defined criterion without considering any other potential ineligibility to discriminate them.
- They should try to grow the learning abilities of the students to a certain level before they leave the institute.
- They should try to ensure that all the students are equipped with the quality knowledge as well as competence after they finish their education.
- They should always encourage the students to develop their ultimate performance capabilities.
- They should facilitate and encourage group work and team work to consolidate newer approach.
- They should follow Blooms taxonomy in every part of the assessment.

Bloom's Taxonomy

Level	Teacher should check	Student should be able to	Possible mode of assessment
Creating	Students ability to create	Design or Create	Mini project
Evaluating	Students ability to justify	Argue or Defend	Assignment
Analysing	Students ability to distinguish	Differentiate or Distinguish	Project/Lab Methodology
Applying	Students ability to use information	Operate or Demonstrate	Technical Presentation/ Demonstration
Understanding	Students ability to explain the ideas	Explain or Classify	Presentation/Seminar
Remembering	Students ability to recall (or remember)	Define or Recall	Quiz

GUIDELINES FOR STUDENTS

Students should take equal responsibility for implementing the OBE. Some of the responsibilities (not limited to) for the students in OBE system are as follows:

- Students should be well aware of each PO before the start of the programme.
- Students should be well aware of each CO before the start of the course.
- Students should be well aware of each UO before the start of a unit in each course.
- Students should think critically and reasonably with proper reflection and action.
- Learning of the students should be connected and integrated with practical and real life consequences.
- Students should be well aware of their competency at every level of OBE.

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