# Fundamentals of Machine Design
# Volume I

Machine design is a part of Engineering Design. *Fundamentals of Machine Design* is compiled in two volumes. Vol. I provides extensive coverage and comprehensive discussion on the fundamental concepts and processes of machine design. Unit 1 of this volume starts by giving a background to the subject and then discusses the types of materials, their properties and their selection criteria for designing. Unit 2 covers different types of stresses including direct stress, bending stress, torsional stress and combined stress in detail. Unit 3 covers different types of temporary and permanent joints including pin joint, cotter joint, threaded joint, riveted joint and welded joint. The final unit covers the design procedure for keys, cotters, couplings, shafts, levers and springs in detail. It discusses applications of different types of joints used in boilers, bridges, power presses, automobile springs, screw jacks and couplings.

The chapters in the book are rich in pedagogical features like outcomes in beginning of a chapter summary at its end, many solved examples, review questions, multiple choice questions, design problems and questions of previous competition examinations are also provided. This textbook is primarily meant for undergraduate students of mechanical engineering for an introductory course on machine design. Design engineers will also find it useful. It is accompanied with teaching resources including a solutions manual for instructors.

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*Dedicated to my wife Mrs Kanwaljeet*

*Daughters Preety, Diljeet and Maneet*

*and our grand children*

*Gaganjit, Karanjit, Ananya, Neha, Tanvi and Simar*

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# Preface

Subject of *Machine Design* is a combination of engineering and art. The engineering part is important for the functional working of a machine, so that all the *machine elements* when assembled as a machine, work properly e.g. as an automobile, sewing machine, a lathe etc. The engineering may also include ergonomics, to cause minimum fatigue, if the machine has to be handled by human beings for a long time. The art part is adding aesthetic for appealing shapes, selecting suitable colors etc. which attract the customers.

*Fundamentals of machine design* considers the concepts of design for each element separately like for a shaft, bearing, pulley etc. Loads on a part/component are assessed, checked for the stresses, whether it is within the safe strength of the selected material. Deflection also should not be beyond a certain limit. The subject should not be confused with strength of materials as the designer has to selecting a suitable material and consider the production aspects also.

*Course content* is limited to topics, included in the syllabi of the universities and colleges. The subject is so wide that it is covered in two semesters, for mechanical engineering students in most of the universities. Hence the book is also divided in *two volumes*.

*English language* used in this book is direct and simple, so that an average student can understand easily. The sequence of the chapters is arranged in such a way that the concepts described in earlier chapters become useful for subsequent chapters.

*Symbols* used for mathematical derivations have been so assigned, that they are easy to remember. There is no list of symbols in the beginning of the book, they are defined wherever they have been used in the text.

*Volume - I* is for the first course on *Machine Design*, covering first semester topics offered by most colleges. The main objective of this volume is to provide rules for the design of general-purpose machine elements. This volume has four units.

*Unit 1* of the book is on *fundamentals* and has four chapters. The first chapter introduces *basic fundamentals* and types of machine design. Chapter 2 is on the selection of engineering *materials*, which will be useful for every part to be designed. Although manufacturing a part

is the job of a production engineer, however a designer should know the advantages and disadvantages of the different manufacturing processes. Hence a brief summary of various *manufacturing processes*, *limits and tolerances,* and *surface finish* are described in chapters 3 and 4. The tolerances and other production need to be specified on the working drawings, to be sent to shop floor.

*Unit 2* is on *design for strength* and has seven chapters. This unit is the backbone of the concepts of the subject, as the theory described here is applicable to the design of any machine member. Different types of stresses, like *direct, bending, torsion* are described in chapters 5, 6 and 7. Chapters 8 to 11 describe *principal stresses, stress concentration, fatigue failure* and *endurance strength* for *fluctuating loads*.

*Unit 3* is on design of *joints*, which is covered in six chapters. Chapter 12 is on *cotter* joints chapter 13 on *pin* joints, chapter 14 on *riveted* joints, chapter 15 on *welded* joints, chapter 16 on *bolted* joints and lastly chapter 17 on *eccentric loading,* which happens to any joint like rivet, weld or bolted.

*Unit 4* describes *design of simple machine elements* in six chapters. Chapter 18 is on *power screws*, chapter 19 on *shafts and keys*, chapter 20 on *couplings*, chapter 21 on *levers,* chapter 22 on *helical springs* and the last chapter 20 on *leaf springs*.

*Pedagogy features* of the book are excellent. Before starting a chapter, an *outcome* given in the beginning, gives an idea as to what a student is going to learn in that chapter. Each chapter is followed by theory questions, multiple choice questions, design problems. An effort has been made to explain theory with *490 figures.* To make the book further illustrative, license free *68 pictures* are pasted from the Internet and referenced in the text, wherever necessary. Students face a lot of difficulty in solving design problems, hence *238 solved examples* and *226 unsolved* design problem are given. Solution to the unsolved examples will be put in *solution manual* on the internet in due course of time. To practice for small quiz type questions, *270 multiple choice* questions have been given.

*Summary* is given at the end of each chapter for quick revision of the course and formulas at the time of examination.

*Competition examinations* questions of past 3-4 years from Engineering services examinations and *GATE* examinations are given at the end of chapter, to help students preparing for such examinations.

*S.I. units* have been used for mathematical calculations and design problems**.** *Indian Standards* and other standards have also been mentioned, wherever necessary.

*Volume - 2* is for the second course of the same subject. This volume has twenty chapters in four units. *Unit 1* covers mainly design of *drives* like belt, rope, chain and gears of various types, *Unit 2* is on sleeve and rolling bearings. *Unit 3* is on the deign of I.C. engine parts and *unit 4* covers miscellaneous parts like levers, clutches, brakes and pressure vessels.

After successful completion of the course, the student will be able to understand various aspects of the machine design process, and will be encouraged to seek opportunities for its satisfactory working. The mastering of the course is a pre-condition to a successful design.

*Audience* – This book can be easily recommended as a text book of the subject for undergraduate students. The book can also be used by practicing engineers, students appearing for competition examinations and for graduate admission tests.

Although every effort is made to minimize the errors, but a human being is likely to commit mistakes. Also, there is always a possibility of improving the book. Any errors, omissions or suggestions for the improvement of the book may please be written to the publisher or emailed to the author at ajeet41@yahoo.com.

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