Program Name : **Diploma in Mechanical Engineering / Production Engineering / Production Technology**

Program Code : **ME / PG/ PT**

Semester : **Fifth**

Course Title : **Elements of Machine Design**

Course Code : **22564**

1. RATIONALE

Design department of industry is one of the major job areas for Diploma Technicians. Fundamental knowledge of Applied Mechanics, Strength of Materials, Engineering Materials, Theory of Machines and Computer Aided Design and Drafting is essential. To enable a student to work there he should know how to design the simple machine elements. He should also be aware of usual design procedures, selection procedures, codes, norms, standards and guidelines for selection of appropriate material. This subject aims at developing analytical and selection abilities in the student to give solutions to simple engineering design problems using standard procedures.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Design simple machine components.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Select suitable materials for designing machine elements.
b. Design joints and levers for various applications.
c. Design the power transmission elements like shafts, keys and couplings.
d. Recommend the power screws and suitable fasteners for different applications.
e. Choose springs for various applications.
f. Select standard components with their specifications from manufacturer's catalogue.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	4	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit;* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

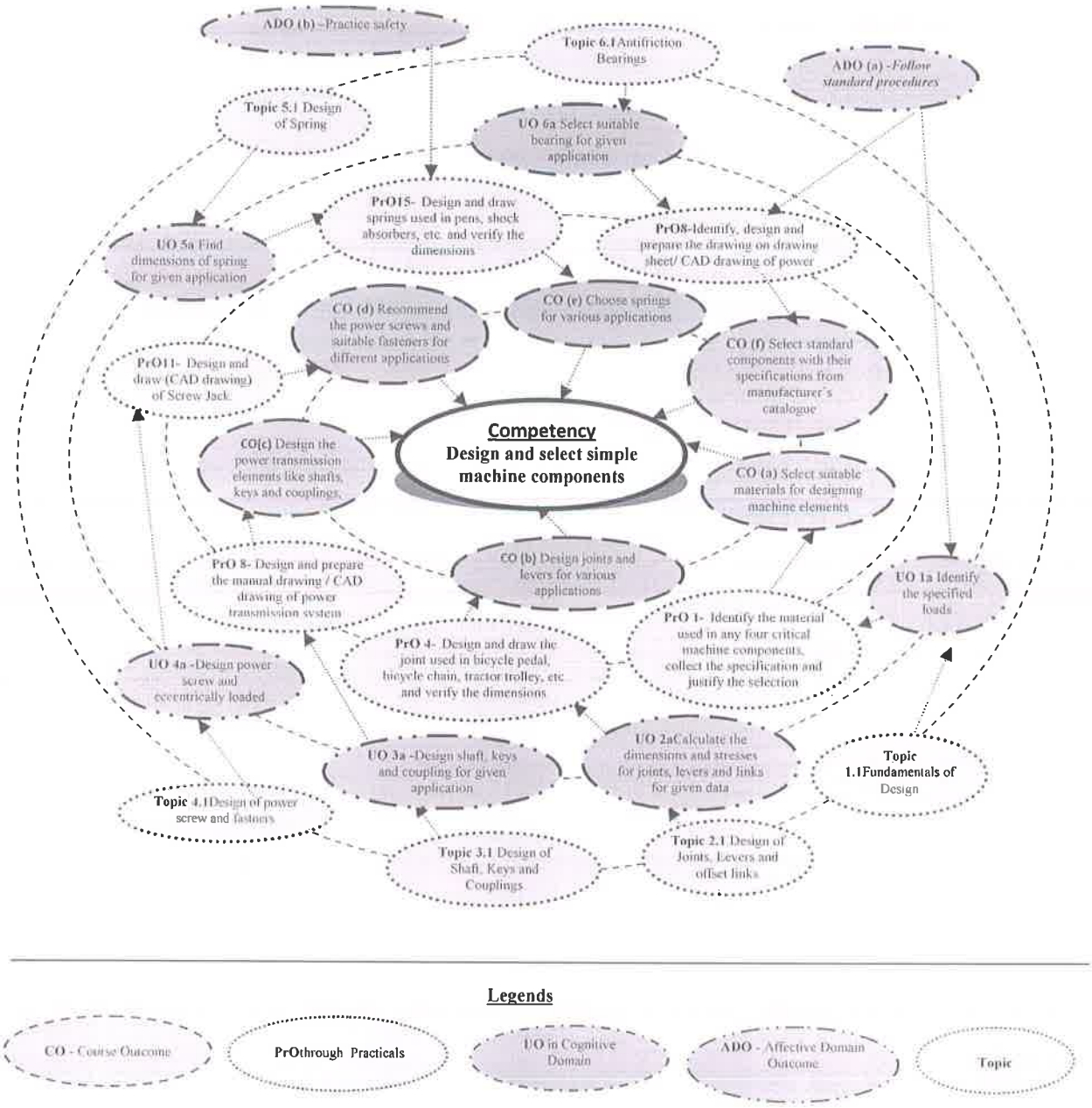

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify the material used in any four critical machine components,	I	02

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	collect the specification of the materials and justify the selection. (group of 4 students)		
2	Draw various modes of failure for the machine components used in various laboratories/ workshops, under different loading conditions.	I	02
3	Use IS codes for design of any two machine elements. (ISO metric threads, Cast iron Flexible coupling, Keys, Screws, Bolts, Nuts, similar components). (Group of 4 students)	I	02*
4	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches, and similar components and verify the dimensions. (Group of 4 students) (Part-I)	II	02
5	Design and draw the joint used in bicycle pedal, bicycle chain, tractor trolley, rail wagons/coaches and similar components and verify the dimensions. (Group of 4 students) (Part-II)	II	02
6	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-I)	II	02*
7	Design and draw the lever used in two/three-wheeler brake lever, four-wheeler accelerator pedal, lever of hand operated sugar cane juice machine, railway signal levers, safety valve levers, operating levers in different mechanisms/machines and verify the dimensions. (Part-II)	II	02*
8	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shafts, keys, couplings, bearings, pulley and belt drive used in various machine like lathe machine, flour mills,sewing machine and transmission system in different machines and justify the dimensions. (Part-I)	III	02*
9	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-II)	III	02*
10	Design and prepare the manual drawing / CAD drawing of power transmission system elements like shaft, keys, coupling, bearing, pulley and belt drive used in various machine like lathe machine, flour mills, sewing machine and transmission system in different machines and justify the dimensions. (Part-III)	III	02*
11	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-I)	IV	02
12	Design and draw (CAD drawing) of Screw Jack used for heavy vehicles, cars and other similar applications and verify the dimensions. (Part-II)	IV	02
13	Design and draw fasteners used in civil structures (Railway platform shades, bridges, Eccentric loaded brackets), bridges, household electrical panels, column brackets and similar	IV	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	components and verify the dimensions. (Four design cases) (Part-I)		
14	Design and draw fasteners used in civil structures (Railway platform shades, bridges, Eccentric loaded brackets), bridges, household electrical panels, column brackets and similar components and verify the dimensions.(Four design cases) (Part-II)	IV	02*
15	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components. (Four design cases) (Part-I)	V	02*
16	Design and draw springs used in pens, shock absorbers, rocker arm spring, safety valve, bicycle/ two-wheeler side stand, railway buffers and similar components and verify the dimensions. (four design cases) (Part-II)	V	02*
17	Design and draw Spur Gear used Agriculture machinery, Sugar Can Juice Machine and similar components and verify the dimensions. (One design case)	V	02
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Identification of loads and other boundary conditions	20
b.	Selection of material	20
c.	Apply suitable design procedure	20
d.	Identify exact mode of failure	10
e.	Neatness in drawing	20
f.	Answer to sample questions	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices in using drawing instruments and CAD workstations.
b. Follow neatness while preparing the drawings.
c. Practice good housekeeping.
d. Work as a leader/a team member.
e. Follow standard procedures and codes.
f. Use design data book and Manufacturer's catalogue.
g. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name	Specifications	PrO.S. No.
1	i) Cotter joint ii) Knuckle joint iii) Turn-Buckle	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	03
2	i) Foot, Hand, Bell-crank lever ii) Offset link	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	04
3	i) Pulley, Shaft, Keys and couplings. (all types) ii) Belt, Chain, Gear drive, Metallic rope.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
4	Models of lead screw of lathe, feed screw of machine tools, clamping screws, toggle jack screw, screw jack.	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	06
5	Ball bearing-single, double row, angular contact and thrust, rolling contact bearings- cylindrical, taper roller, thrust, pedestal, journal, pivot bearing, Spur gear, Helical gears	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	05
6	Different Springs, Nut-Bolt, Standard sections	Working models/ Acrylic/ Aluminum/Cast/ Scrap/Used component	All
7	Wall charts for- Types of levers Types of joints Tolerance, surface finish, limits and fits. Helical springs Bolted joints Welded joints Bearing designation Various types of bearings	All charts should be plastic or acrylic coated –size 3ft x 3ft	All

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Fundamentals of	1a. Write general design procedure for the given component under static	1.1 Machine design philosophy and phases in design, design considerations.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Design	loading. 1b. Identify the specified loads and stresses for the given component with justification. 1c. Identify the materials for the given machine components with justification. 1d. Select the relevant standards and codes for design of the given component. 1e. Explain various modern design considerations in the given situation.	1.2 Types of loads, concept of stresses, bearing pressure, bending and torsion stresses, principal stresses, strain, stress-strain diagram. (Simple Numerical) 1.3 Factor of Safety, conditions for selection of F.S 1.4 Stress concentration meaning, causes and remedies. 1.5 Designation of materials as per IS and introduction to International standards, advantages of standardization, use of design data book, use of standards in design and preferred numbers series. 1.6 Concept of creep, Fatigue, S-N curve, Endurance limit. 1.5 Maximum principal stress theory and Maximum shear stress theory. 1.6 Modern Design considerations Ergonomics and aesthetic considerations in design. Ecology, social consideration and Concept of Product Design.
Unit– II Design of joints, Levers and offset links	2a. Write design procedure for the given joint(s), lever(s) and link(s). 2b. Sketch the given joint(s), lever(s), link(s) and their resisting sections. 2c. Calculate the dimensions and stresses for the given joints, levers and links for given data. 2d. Calculate the dimensions and stresses for the given C-clamp for given data.	2.1 Design of Cotter Joint, Knuckle Joint, 2.2 Turnbuckle. 2.3 Design of Levers:- Hand/Foot Lever and 2.4 Bell Crank Lever, 2.5 Lever for lever safety valve, 2.6 Design of Off-set links, C-clamp, Overhang Crank
Unit– III Design of Shaft, Keys and Couplings	3a. Write design procedure for the given shaft, keys and couplings. 3b. Sketch the given shaft, key(s) and coupling(s). 3c. Design the given shaft, key and coupling for given application. 3d. Select the given shaft, keys and coupling for given application from manufacturer's catalogue/ design handbook with	3.1 Types of shafts, Shaft materials, Standard sizes, Design of solid and hollow shafts based on strength and rigidity criteria. 3.2 Design of hollow and solid shaft for combined bending and twisting moments and considering the effect of shock and fatigue. ASME code of design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley. 3.3 Types of keys, effect of keyway on the strength of shaft, design of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	rectangular and square sunk key. 3.4 Types of couplings, Design of muff coupling, flanged couplings (protected and unprotected) and Bushed pin type flexible coupling.
Unit-IV Design of Power screws and Fasteners	4a. Write strength equations for the given screw and nut combination. 4b. Sketch the given type of Jack. 4c. Design the given power screw and eccentrically loaded bolted joint for given data. 4d. Calculate the length of weld for the given application. 4e. Recommend the type of fasteners for the given situation based on catalogue with justification.	4.1 Basic concepts of power screw Thread Profiles used for power Screws, relative merits and demerits of each, Self locking and overhauling properties, Torque required to overcome thread friction, efficiency of power screws, types of stresses induced. 4.2 Design of Screw Jack, Toggle Jack (only screw and nut). 4.3 Stresses in Screwed fasteners, bolts of Uniform Strength, Design of Bolted Joints subjected to eccentric loading. 4.4 Design of parallel and transverse fillet welds, axially loaded symmetrical Section.
Unit –V Design of Springs	5a. Identify the type of spring used in the given application. 5b. Choose suitable material for spring with justification and write specification. 5c. Sketch the given type of spring. 5d. Write design procedure of the given type of helical compression/tension spring. 5e. Find dimensions of spring for the given application.	5.1 Classification and Applications of Springs, Spring - terminology, materials specifications. Stresses in helical tension and compression springs, Wahl's correction factor, Deflection of springs. Energy stored in springs. 5.2 Design of Helical tension and compression springs subjected to concentric applied loads like I.C. engine valves, weighing balance, railway buffers. 5.3 Leaf springs - construction and applications.
Unit-VI Selection of Antifriction Bearings and Gears	6a. Identify the given type of bearing. 6b. Explain the procedure of designing and selection of the given type of bearing. 6c. Select suitable bearing for given application from manufacturer's catalogue with justification. 6d. Select suitable Spur Gear for given application from manufacturer's catalogue with	6.1 Classification of Bearings – Sliding contact and rolling contact. 6.2 Terminology of Ball bearings – life load relationship, basic static load rating and basic dynamic load rating. 6.3 Selection of ball bearings using manufacturer's catalogue 6.4 Design of spur gear using Lewis and Buckinghams equation (Simple Numerical), selection of gears from standard sizes.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	

***Note**:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of Design	14	04	04	06	14
II	Design of Joints, Levers and Offset links	12	02	04	06	12
III	Design of Shafts, Keys and Couplings	14	02	04	08	14
IV	Design of Power screws and Fastners	10	02	04	06	12
V	Design of Springs	08	02	04	04	10
VI	Selection of Antifriction Bearings and Gears	06	02	02	04	08
Total		**64**	**14**	**22**	**34**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course. Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews.

a. Prepare journal of practicals.
b. Undertake micro-projects.
c. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
d. Collect different types of springs and write applications of the same.
e. Collect different types of used bearings and make display model and their application.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.

c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual failure and machine elements.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various failure modes.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually***undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Take any day to day life component, find load, stresses and also prepare chart/model for the same.
b. Make models of various joints and levers highlight resisting sections of different elements.
c. Make models of various shafts, keys and pulleys highlight resisting sections.
d. Make models of various couplings highlight resisting sections of different elements.
e. Make chart indicating different thread profile and sizes required for different loads in case of screw jack, toggle jack, C-clamps and lead screw of machines.
f. Prepare model of eccentrically loaded bolted and welded joint and highlight the maximum loaded section.
g. Prepare list of different types of bearings used in a bike and write their specifications and basis for selection.
h. Prepare list of different types of Gears used in Agriculture machinery, Sugar can juice machine, gear boxes of two and three wheelers and similar machines, write their specifications and basis for selection.
i. Prepare list of different types of levers and springs used in a bike, bicycle, Auto Rickshaw, Moped and write their specifications and basis for selection.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Design of Machine Elements	Bhandari V. B.	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221126
2	Machine Design	Khurmi R. S. and Gupta J. K.	S. ChandNew Delhi, 2005, ISBN 10:8121925371 ISBN13:9788121925372
3	Machine Design	Jindal U. C.	Pearson Education India New Delhi, 2010, ISBN13: 9788131716595
4	Machine Design	Pandya and Shah	CharotarPublishing house pvt. Ltd. Anand, Gujarat, 2015, ISBN-13:9789385039102
5	Mechanical EngineeringDesign	Shigley	McGraw-hilleducation India pvt. limited, New Delhi, 2017, ISBN-13:978-9339221638
6	Design Data Book	PSG	PSG College ofTechnology Coimbatore, 2012, ISBN-10: 8192735508
7	IS Codes: IS 4218: 1967 ISO Metric Threads IS 2693: 1964 Cast Iron Flexible Couplings IS 2292: 1963 Taper keys and Keyways IS 2293: 1963 Gib Head Keys and Keyways IS 2389: 1963 Bolts, Screws, Nuts and Lock Nuts IS 4694: 1968 Square threads IS 808: 1967 Structural Steel SKF/NBC Catalogue for Bearings	ISO	Indian Standard Bureau New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112105124/
b. https://www.youtube.com/watch?v=CLeLFUrvO2g
c. www.machinedesignonline.com
d. www.engineeringtoolbox.com
e. https://www.youtube.com/watch?v=N5SckoiTDxA
f. https://www.youtube.com/watch?v=GfbcxJmjn9s
g. http://www.ignou.ac.in/upload/Unit-5-60
h. https://sizes.com/numbers/preferred_numbers.htm
i. www.robot-and-machines-design.com/en/articles/mech
j. http://www.youtube.com/flangedcoupling
k. http://www.youtube.com/screwjack