GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: DESIGN OF MACHINE ELEMENTS
(COURSE CODE: 3351902)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	5th Semester

1. RATIONALE

For production of machine parts and components it is required that specific shape and size of machine parts are determined and their drawings are prepared. We also have to select specific material for that product. This process is called as design. In designing a machine component it is necessary to have a good knowledge of many subjects such as Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing. Students have learnt these subjects in previous semesters. This course curriculum provides the students' knowledge of design process, as well as familiarity with design of components subjected to various stresses and moments like direct stress, bending stress, twisting moment and combined stresses. In this course students will learn design of machine components/elements like cotter joint, knuckle joint, power screw, levers, helical and leaf springs, couplings, pressure vessels, bearings, etc.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

- **Design a simple machine element with appropriate material for given user defined boundary and loading conditions.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning objectives in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

i. Identify various failures and calculate resisting areas of machine elements.
ii. Use preferred numbers and standardization to select element/element dimension.
iii. Design machine element subjected to:
    a: Direct stresses.
    b: Bending stresses.
    c: Twisting stresses.
    d: Combined stress.
iv. Design of thin and thick cylinder pressure vessel.
v. Select appropriate bearing for given situation/application.
vi. Calculate important bearing characteristics.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

5. COURSE DETAILS.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I. **Introduction.**	1a. List various factors to be considered for design process. 1b. Identify and select materials that can be used for design of machine elements. 1c. Explain loads, stresses, stress concentration factor and factor of safety. 1d. List Types of loads, types of stresses 1e. Select standard items and preferred numbers for designing simple machine elements.	1.1 General consideration and factors influencing the design of machine elements and design process. 1.2 Various materials used in manufacturing of machine elements and their properties. 1.3 Types of loads, types of stresses, concept of stress concentration and factor of safety. 1.4 Standardization and preferred numbers, numeric examples on preferred numbers.
Unit– II **Design of machine elements subjected to direct stresses.**	2a. Describe the design process of simple elements like linkages, etc. 2b. Calculate resisting area of simple machine element subjected to direct independent stress. 2c. Explain the design of cotter joint and knuckle joint. 2d. Explain the design process of riveted joint, welded joint and	2.1 Illustration of simple machine elements subjected to direct stresses-independently and identification of resisting areas (simple numeric examples). 2.2 Design of simple machine elements subjected to uni-axial direct stresses-independently. 2.3 Design procedure (with numeric examples), steps, identification of resisting areas and design of: i. Knuckle joint. ii. Cotter joint. iii. Riveted joints. iv. Welded joint-fillet & lap joint .

	threaded fasteners.	v. Threaded fasteners & screw jack.
Unit– III **Design of machine elements subjected to bending stresses.**	3a. State the fundamental bending equation. 3b. State modulus of various sections subjected to pure bending like levers, beams and axles 3c. List types of levers. 3d. Design simple lever based on given input. 3e. Design leaf spring.	3.1 Principle of bending and its fundamental equation. 3.2 Modulus of various sections, example of pure bending like levers, beams, axle, etc. 3.3 Types of levers. 3.4 Design procedure (with numeric example) of levers including cross section of arms, bosses and pins. 3.5 Design procedure (with numeric example) of leaf spring.

Unit–IV **Design of machine elements subjected to direct and twisting moments.**	4a. State fundamental equation of twisting moment. 4b. List types of shafts with important features of each. 4c. List types of keys, couplings, spring & applications of each 4d. Explain the design procedure of shafts, keys and couplings. 4e. Define helical spring terminology and its applications. 4f. Calculate numerical on the design procedure of machine elements subjected to twisting moment.	4.1 Fundamental equation of twisting moment with design procedure. 4.2 Types of shafts with important features of each. 4.3 Design of shafts (with numeric examples). 4.4 Types of keys, applications of each and design procedure (with numeric examples). 4.5 Types of couplings and applications. 4.6 Design of muff and flange couplings (with numeric examples). 4.7 Types of spring, terminology related to helical spring and applications of helical spring.
Unit-V **Design of machine elements subjected to direct and bending stresses.**	5a. Define eccentric loading. 5b. Draw frame-clamp, Bracket, Foundation bolt, Bolts in flange, etc. 5c. Design machine components subjected to eccentric loading.	5.1. Eccentric loading- i. Concept. ii. Illustrations like frame, C-clamp, Bracket, Foundation bolt, Bolts in flange, etc. iii. Design of machine element like C-Clamp, bracket, foundation bolt and bolts in flange.(with numeric examples).
Unit-VI **Design of pressure vessels.**	6a. Define pressure vessels 6b. State types of pressure vessels with range of pressure. 6c. Design simple thick and thin cylinder pressure vessels. 6d. Design simple thin spherical shell.	6.1 Types and applications of pressure vessels used in industries. State Range of pressure also. 6.2 Design of thick and thin cylinders (with numeric examples). 6.3 Design of thin spherical shell (with numeric examples).
Unit-VII **Selection procedure for bearings.**	7a. Classify bearings. 7b. Explain designation of bearings. 7c. Select appropriate anti-friction bearings from manufacturer's catalogue. 7d. Calculate the load on the bearings.	7.1 Classification of bearings. 7.2 Bearing designation as per IS. 7.3 Antifriction bearings: types, advantages, applications. 7.4 Selection procedure of anti-friction bearings. 7.5 Calculation for anti-friction bearings: basic dynamic load, load rating, equivalent load, bearing life.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS AND MARKS (THEORY).

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction.	8	3	7	4	14
II	Design of machine elements subjected to direct stresses.	9	3	4	7	14
III	Design of machine elements subjected to bending stresses.	5	0	0	7	7
IV	Design of machine elements subjected to direct and twisting moments.	8	4	3	7	14
V	Design of machine elements subjected to direct and bending stresses.	4	0	3	4	7
VI	Design of pressure vessels.	4	0	3	4	7
VII	Selection procedure for bearings.	4	4	3	0	7
	Total	**42**	**14**	**23**	**33**	**70**

Legends: R = Remember U= Understand; A= Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

General Notes:

a. If midsem test is part of continuous evaluation, unit numbers I, II (Up to 2.3(ii) only, which are Knuckle and cotter joints only), VI and VII are to be considered.
b. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

7. SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. required
1	ALL	**Preparatory Activity :** a. Interpret and write various course related SI units and their conversions. b. Write normal values of ultimate tensile strength, yield strength, density, modulus of elasticity and Poisson's ratio of commonly used materials. c. List normal values of factor of safety for different situations. d. Recall area, volume, section modulus, moment of inertia, radius of gyration, etc. for commonly used various section and shapes. e. Draw orthographic projections symbols. f. Draw symbols of threads, surface roughness, geometrical tolerances symbols, section lines, etc. g. Recall by sketching the general systems for limits, fits and tolerances.	02
2	II,III, IV and V.	**Design of simple components:** a. A C15 rod is subjected to tensile load of ….kN. Determine diameter of rod if factor of safety is…… b. Teacher will assign the sketch of a component/s with loading that induces tensile/compression and shear stresses. Teacher will also assign material, load, and factor of safety. Students are asked to determine the dimensions. c. Teacher will assign the sketch of a component/s with loading that induces bending stress in addition to two more types of stresses (from tensile, compression, shear, crushing or other.). Teacher will also assign material, load, factor of safety and other data if required. Students are asked to determine specified dimensions. If required, additional data may be given. d. Teacher will assign the sketch of a component/s with loading that induces twisting moment. This may have additional one or two types of stress/es. Teacher will also assign material, factor of safety and other required data.(Like kW, rpm, Torque, etc.). Students are asked to determine the specified dimensions. e. Student will also prepare the report on this, which will include calculations, sketches in A4 size drawing papers with identification of areas subjected to induced stresses. (Note: Each student of the batch must have different values of data. Use design data book	04

		wherever is necessary. Also assume suitable data if required. State the assumptions.)	
3	II,IV	**Design of assemblies:** a. Take load =…….kN, b. Take material as…….. c. Factor of safety =…….. d. Design following showing other assumptions, steps and final dimensions. i. Knuckle joint. ii. Cotter joint. iii. Screw jack. iv. Flange coupling. (Note: Each student of the batch must have different values of data. However problem may be same. Students are also expected to solve these as partial assignments at home. Use design data book wherever is necessary. Also assume suitable data if required. State the assumptions.)	06
4	II,IV	**Sketches and drawings of design assemblies:** a. Sketch production drawings of details (individual parts). Show dimensions calculated above at experience number 3. Use A4 size paper only. b. Prepare assembly drawings with dimensions and scale (if required). Use A4 size paper only. **c.** Show areas under various stresses induced using color codes. (Students are also expected to solve these as partial assignments at home.)	02
5	II,IV	**Modeling:** a. Create 3D Models of all parts and assemblies (In group of 4 students. Each student will perform one) with dimensions designed at experience number 3 and drawn at experience number 4 using any parametric CAD software (like Creo, Solid Edge, and Inventor). b. Take printout of the 3D models and orthographic views (with dimensions) of all parts and assemblies. Attach all prints with term work.	06
6	III and VII	**Tutorials:** a. Tutorial on bell crank lever design.(Teacher will assign the data- one problem). b. Tutorial on bearing. (Teacher will assign the data- one problems). (Students are also expected to solve these as partial assignments at home.)	02
7	ALL	**Mini project:** a. Assign simple mechanical assembly (preferably from real life or thought by batch teacher. Students will be provided with a sketch having 5-6 machined/mechanical components (exclude gears,	06

		cotter, knuckle or other book oriented solved assemblies. Also ensure that such assembly can be manufactured at institute's workshop).Also give load conditions and other necessary information in a batch. b. Batch students will design this assembly with dimensions. Show calculations and steps. c. Sketch production drawings (details and assembly) in A4 size drawing paper manually. d. Present this mini project with photos/movies of mini project execution and with work distribution executed. Use power point presentation.	
			Total Hours	**28**

Note:

a) Students should bring any one reference design book (preferably English) and one design data book (By PSG Coimbatore) during theory and practical/exercises sessions.
b) It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher. PA component of practical marks is dependent on continuous and timely evaluation of exercises.
c) Term work report must not include any photocopies, printed manual/pages, litho, etc. It must be hand written / hand drawn by student only. However, teacher may allow related photographs/movie for experience number 8.
d) For 20 marks ESE, students are to be assessed for competencies achieved. They should be given following type of tasks:
    i. Design some elements of cotter joint/knuckle joint/ power screw.
    ii. Design of some mechanical elements subjected to three to four types of stresses.
    iii. Design of flange coupling.
    iv. Design of leaf spring/ lever.
    v. Problems on bearing, equivalent load, rating, etc.

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8. SUGGESTED LIST OF STUDENT ACTIVITIES.

SR.NO.	ACTIVITY
1	Download and present various presentations related to stresses in machine elements.
2	Download and present various presentations related to failure of machine elements.
3	Download and present various presentations related to design of machine elements.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any).

Sr. No.	Unit	Unit Name	Strategies
1	I	Introduction.	Power point presentations, live examples, demonstration of BIS on preferred numbers and standardizations,
2	II	Design of machine elements subjected to direct stresses.	Movies/ animations/ educational charts, videos & model of different machine elements subjected to various stresses, live demonstration of failed components,
3	III	Design of machine elements subjected to bending stresses.	Movies/ animations/ educational charts, videos & model of different machine elements subjected to bending, live demonstration of bending and induced stresses.
4	IV	Design of machine elements subjected to direct and twisting moments.	Movies/ animations/ educational charts, videos & model of different machine elements subjected to twisting, live demonstration of twisting.
5	V	Design of machine elements subjected to direct and bending stresses.	Movies/ animations/ educational charts, videos & model of different machine elements subjected to direct and bending stresses.
6	VI	Design of pressure vessels.	Movies/ animations/ educational charts, videos, demonstration of live pressure vessels.
7	VII	Selection procedure for bearings.	Movies/ animations/ educational charts, videos, live demonstration of bearings, demonstration of BIS catalogues.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

S.No.	Title of Book	Author	Publication
1.	Machine Design.	R.K.Jain.	Khanna Publishers.
2.	Machine Design	TVS Murthy and N.Shanmugam.	Anuradha publications.
3.	Machine Design	Pandya and Shah.	Charotar Publishing House Pvt. Limited.
4.	Machine Design	R.C.Patel and A.D.Pandya	Acharya Book Depot, 1959.
5.	Design of Machine Elements	Shigley.	Tata McGraw-Hill Education.
6.	Design Data Book	P.S.G. College of Technology, Coimbatore.	P.S.G. Publication.
7.	Design Data Book	K. Mahadevan & Balveera Reddy.	S. Chand.
8.	A Text book of Machine Design	R.S.Khurmi and J.K.Gupta	S. Chand.

9.	Design of machine elements.	V.B.Bhandari.	McGraw-Hill.

B) List of Major Equipment/ Instrument with Broad Specifications:

Sr.No.	Major Equipment/ Instrument	Broad Specifications
1	Wooden models (with cut sections) of knuckle joint, cotter joint, riveted joints, welded joints, screw jacks,	Two sets of each with design dimensions.
2	Assorted bearings.	As per BIS.
3	Miniature pressure vessels.	As per standards / design dimensions.
4	Assorted levers, shafts, couplings, flanges, keys, C-clamps, frames, other machine components.	Used as machine elements.
5	Assorted failed components.	Used as machine elements.

C) List of Software/Learning Websites

a. Chp:1 Introduction.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_home.html
b. Chp:2 Design of Machine elements subjected to direct stresses.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod4.html
c. Chp: 3 Design of Machine elements subjected to Bending stresses.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod7.html.
d. Chp:4 Design of Machine elements subjected to direct and twisting moments.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod4.html
   ii. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod5.html
   iii. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod8.html
e. Chp: 5 Design of Machine elements subjected to direct and bending stresses.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod11.html
f. chp: 6 Design of Pressure vessels.
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod9.html
g. Chp:7 Selection Procedure for bearings**.**
   i. http://nptel.ac.in/courses/Webcourse-contents/IIT%20Kharagpur/Machine%20design1/left_mod14.html
h. Chp:ALL
   i. https://www.machinedesignonline.com/MDO_Portal/design_component.html

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE.

Faculty Members from Polytechnics:

- **Prof. M.P.Jakhaniya**, Lecturer in Mechanical Engineering, C.U.Shah Govt.Poly., Surendranagar.
- **Prof. D.R.Katariya**, Lecturer in Mechanical Engineering, Government Polytechnic, Bhuj.
- **Prof.V.N.Patadiya,** Lecturer in Mechanical Engineering,N.M.Gopani Polytechnic, Ranpur.

Coordinator and Faculty Members from NITTTR Bhopal:

- **Prof. S.K.Pradhan,** Associate Professor, Mechanical Engg. NITTTR,Bhopal
- **Dr. A.K.Sarathe,** Associate Professor, Mechanical Engg. NITTTR,Bhopal