GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2022 (COGC-2022)
Semester-II

Course Title: Basics of Mechanical Design
(Course Code: C4326502)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering (CAD/CAM)	2nd Semester

1. RATIONALE:

Design is a key branch of study in mechanical engineering, as it is the process of designing parts, components and products with an understanding of design constraints and the environment. This course curriculum provides the students with basic knowledge of the design process and familiarity with various loads, stresses, strains, etc. A diploma holder in this course is required to assist in the Design and development of a prototype and other components. For this, they must be conversant with the basic principles related to the Design of components & machines and the applications of these principles for designing. The aim of the subject is to develop knowledge and skills about various aspects related to the basics of mechanical Design. In this course, students will learn basic concepts of Mechanics, concepts and applications of direct stress and strain, static load, stress & strain, bending stress and torsional shear stress centroid, the centre of gravity & moment of inertia.

2. COMPETENCY:

The course content should be taught, and the curriculum should be implemented to develop different skills leading to the achievement of the following competency.

Use the principle of Mechanics to design components and to solve broad-based engineering-related problems

3. COURSE OUTCOMES (COs):

The practical exercises, underpinning knowledge, and the relevant skills associated with this competency are to be developed in the student to display the following COs:

a) Identify the force systems for given conditions by applying the basics of mechanics.
b) Evaluate material properties under longitudinal and transverse loads.
c) Compute bending stress and shear stress in various components for the given situation.
d) Calculatethe centroid and centre of gravity of various components in engineering Systems.
e) Determine the moment of inertia of a section about a given axis.

4. TEACHING AND EXAMINATION SCHEME:

Teaching Scheme (In Hours)			Total Credits (L+T/2+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate the integration of COs and the remaining 20 marks should be the average of 2 tests to be taken during the semester for assessing the attainment 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, **CA** - Continuous Assessment; **ESE** -End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES:

The following practical outcomes (PrOs) are the sub-components of the COs.*These PrOs need to be attained to achieve the COs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Verify and calculate resultant force through the Law of Parallelogram using analytical and graphical methods.	1	2
2	Verify the Law of Triangle using analytical and graphical methods.	1	2
3	Verify and calculate the resultant force through the Polygon Law of Forces using analytical and graphical methods.	1	2
4	Demonstration of tension test on mild steel.	2	2
5	Demonstration of measurement of Thermal Stress and Strain of any suitable material/s.	2	2
6	Demonstration of measurement of Bending Stress and Strain of any suitable material/s.	3	2
7	Calculate the centroid of the different geometric plane sections.	4	2
8	Calculate the Center of Gravity of Standard Solids.	4	2
9	Compute the Moment of Inertia of a given section	4	2
		Total Hrs.	**18**

Note

i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry-relevant skills/outcomes to match the COs. The above table is only a representative list**.** While designing exercises, make sure that all COs are covered equally.

The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above-listed **Practical Exercises** of this course required, which are embedded in the COs and, ultimately, the competency.

Sr. No.	Sample Performance Indicators for the PrOs (1 to 7)	Weightage in %
1	Identify components for the experimental setup.	10
2	Prepare experimental setup.	20
3	Operate the equipment setup.	20
4	Follow safe practices	10
5	Record observations correctly.	20
6	Interpret the result and conclude.	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED:

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO No.
1	Apparatus for Law of Parallelogram.	1,2
2	Universal Force table with all accessories.	3
3	Centroids reference tables.	7
4	Centre of Gravity apparatus, Gravimeter etc.	8

7. AFFECTIVE DOMAIN OUTCOMES:

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the COs as mentioned above. More could be added to fulfil the development of this course competency.

a) Practice & follow valid Experimental, Calculation and Design Standards to assure quality work in the Design of mechanical components.

b) Follow ethical practices as a Team leader and enable team members to do so at work.

c) Design mechanical components considering human ergonomics.

d) The student should be able to identify eco-friendly or recycled material/s before selection for mechanical applications. (Environment related)

The ADOs are best developed through field-based exercises/project work. Moreover, the level of achievement of the ADOs, according to Krathwohl's 'Affective Domain Taxonomy', should gradually increase as planned below:

i. 'Valuing Level' in 1st year ii. 'Organization Level' in 2nd year

iii. 'Characterization Level' in 3rd year

8. UNDERPINNING THEORY:

Based on the higher-level UOs of Revised Bloom's taxonomy formulated for COs and competency development, the significant supporting theory is given below. If required, the course teacher could include more such higher-level UOs to focus on attaining COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit I Basics of Engineering Mechanics	1a Define the scope of Engineering Mechanics 1b Explain the effect of force on a given object. 1c Identify the force system for the given situation. 1d Calculate the resultant forces graphically and analytically.	1.1 Significance and relevance of mechanics,statics,Dynamics 1.2 Units of measurement (SI units) 1.3 Force,its characteristics and effects 1.4 Force system and its classification, 1.5 Resultant of forces using analytical and graphical methods.(law of parallelogram, law of triangle and law of polygon) 1.6 Free body diagram, Bow's notation, equilibrium condition, and Lami's theorem. 1.7 Moment of Force couple Characteristics of couple 1.8 Resultant of co-planer, nonconcurrent forces. (simple numerical examples of the topics mentioned above)

Unit II Direct Stress & Strain	2a Understand basic stress and strain 2b Evaluate Material Properties Under Longitudinal, Lateral Loads & Thermal Variation 2c Analyze Composite & Compound Sections for Stress & Strain. 2d Compute Strain Energy under Different Types of Loading on elements.	2.1 Different types of Loads and their effects 2.2 Direct Stress, linear Strain, Hook's Law, Stress-Strain Curve for mild steel under tension, Modulus of Elasticity, Yield, Creep, Breaking & Ultimate Stress and Factor of Safety. 2.3 Lateral Strain and Poisson's ratio. Bulk Modulus & Volumetric Strain.Shear Stress, Shear Strain & Shear Modulus. 2.4 Thermal Stresses & Strain for yielding & non-yielding conditions. 2.5 Differentiate Sudden, Gradual & Impact Load, Strain Energy & Proof Resilience (simple numerical examples of topics mentioned above)
Unit III Bending and Torsional Stress	3a Understand bending theory 3b Understand Torsional Moment 3c Understand Eccentric Axial Loading 3d State fundamental equation of bending and twisting 3e Calculate the numerical of bending stress, torsional stress	3.1 Concept and theory of pure bending, assumptions, Bending equation (without derivation), Equation of maximum bending moment in various beams with different loading conditions, Section Modulus, Bending stresses and their nature
	and Eccentric Axial Loading	3.2 Axial load, Eccentric load Concept of eccentricity, Limit of eccentricity, Eccentric Loading for rectangular and circular sections. 3.3 Twisting moment, Angle of twist, Shear stress in the shaft, the strength of shafts, Polar moment of inertia, Torsional rigidity, assumptions in the theory of torsion, Equation of Torsion (without derivation), Relationship of Power,Torsion and RPM (simple numerical examples of the topics mentioned above)

Unit IV Centroid, Center of Gravity & Moment of Inertia	4.a Differentiate between Centroid and Center of Gravity 4.b Calculate the centroid of different geometric plane section 4.c Calculate the CG of standard solids 4.d Compute the Moment of Inertia of symmetric and asymmetric section	4.1 Concept of Centroid and Centre of Gravity 4.2 Axis of Reference and Symmetry, Centroid of Standard and composite Shapes 4.3 Center of Gravity of Standard and composite Solids. 4.4 Moment of Inertia & Its significance. 4.5 Parallel & Perpendicular Axis Theorem. 4.6 Moment of Inertia of simple sections like T,I,L and C sections. (without Derivations) (simple numerical examples of the topics mentioned above)

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Engineering Mechanics	06	05	04	05	14
II	Direct Stress and Strain	12	04	06	10	20
III	Bending and Torsional Stress	12	03	05	10	18
IV	Centroid, Center of Gravity & Moment of Inertia	12	03	05	10	18
	Total	**42**	**15**	**20**	**35**	**70**

***Legends:R**=Remember, **U**=Understand, **A**=Apply and above (Revised Bloom's taxonomy)*

***Note**:* This specification table provides general guidelines to assist studentsin their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from the above table.

10. SUGGESTED STUDENT ACTIVITIES:

Other than the classroom and laboratory learning, the following are the suggested studentrelated ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct the following activities in groups and prepare short reports on each activity. They should also collect/record physical evidence for their (student's) portfolio, which will be helpful for their placement interviews:

a. Prepare charts showing force systems and their classifications, moment and couple of forces, resultant of forces etc. and their associated components with practical examples from the mechanical engineering domain.
b. Prepare charts showing different types of loads, stresses, strains and associated components with real practical examples from the mechanical engineering domain.
c. Prepare charts showing different types of Bending and Torsional Stresses and their associated components with practical examples from the mechanical engineering domain.
d. Prepare charts showing the Centroid, Center of Gravity, Moment of Inertia and its associated components with genuine practical examples from mechanical engineering.

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/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics,*** which are relatively more straightforward or descriptive,are to be given to the students for ***self-learning*** but assessed using different assessment methods.
e) Concerning ***section No.10***, teachers must create opportunities and provisions for ***cocurricular activities***.
f) Guide students on how to address issues on environment and sustainability
g) Theory, Tutorial & Practical aspects are covered in the best way, which every student must learn before undergoing actual mechanical component design.

12. SUGGESTED MICRO-PROJECTS:

Only one micro-project is planned to be undertaken by a student that needs to be assigned to the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be undertaken individually to build up the skill and confidence in every student to become a problem solver so that they contribute 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 an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contribution in the project work and give a seminar presentation before submission. The total duration of the micro-project should be about **14 - *16 (fourteen***

to sixteen) student engagement hours during the course. The student should submit a micro-project by the semester's end to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. **The concerned course teacher could add similar micro-projects:**

a) Take 2-3 objects around you(e.g.Fan,Chair,Table etc.) and identify their loading condition and types of stress generated with illustrated sketches.

b) Identify 5 to 7 elements around you having bending failure,the torsional shear failure and eccentric loading, static loading condition and maximum stress generated using illustration.

c) Preparean excel base sheet to calculate the centroid and centre of gravity for different Geometrical sections/solids.

d) Prepare an excel base sheet to calculate the Moment of Inertia for different Geometrical sections.

e) List different types of instruments/tools etc. used to calculate/measure different types of calculations/measurements listed in **Section No-5 Practical Outcomes (PrOs)** and write detailed specifications of such instruments/tools with their applications in the mechanical engineering domain.

f) Detailed comparison of traditional and advanced methods used for the calculations/measurements enlisted in **Section No-5 Practical Outcomes (PrOs).**

13. SUGGESTED LEARNING RESOURCES:

Sr. No.	Title of Book	Author	Publication with the place, year and ISBN
1	Engineering Mechanics	R. S. Khurmi	S. Chand, New Delhi. (2019) ISBN: 978-93-5283-396-2
2	Engineering Mechanics	D.S. Kumar	S. K. Kataria& Sons, New Delhi (2021 reprint) ISBN: 978-93-5014-311-7
3	Engineering Mechanics7th Edition	Bear & Johnston	New media-McGraw Hill (India), Noida (1999) ISBN: 978-00-7239-513-6
4	Applied Mechanics	Dr.H.J.Shah & S.B.Junnarkar	CHAROTAR Publication, Anand(2013) ISBN:978-93-803-5861-1
5	Engineering Mechanics	D.S.Bedi	Khanna Publications, New Delhi(2019) ISBN:978-93-861-7326-3
6	Applied Mechanics	R. S. Khurmi N. Khurmi	S. Chand & Co. Ltd, New Delhi (2018) ISBN: 978-8121916431

7	Applied Mechanics	S. B. Junnarkar, Dr. H. J. Shah	Charotar *Publishing* House Pvt. Ltd., Anand (2015) ISBN: 978-9385039065
8	Strength Of Material (Part-I &Ii)	Stephen Timoshenko	CBS Publishers & Distributors Pvt. Ltd., New Delhi (3rd Edition) ISBN: 978-0898746211
9	Strength Of Materials	Dr B. C. Punmia Er. Ashok Kr. Jain DrArun Kumar Jain	Laxmi Publications, New Delhi (2019) ISBN: 978- 8131809259
10	Strength Of Materials (Mechanicsofsolids)	R.S.Khurmi N.Khurmi	S Chand Publishing (2019) ISBN:97-893-528-339-79
11	Strength Of Materials	Dr R.K.Bansal	Laxmi Publications (P) Ltd. NewDelhi(2005) ISBN:97-881-700-814-70
12	Strength Of Materials	S. Ramamrutham & R.Narayanan	Dhanpat Rai Publishing Company(2011) ISBN:97-881-874-335-45
13	Strength Of Materials (Mechanics Of Materials)	R.S.Laheri A.S.Laheri	S.K. Karatia& Sons, Delhi. (2010) ISBN: 97-881-857-494-40

13. SOFTWARE/LEARNING WEBSITES:

a. https://swayam.gov.in/
b. https://nptel.ac.in/
c. https://www.youtube.com/playlist?list=PL63F5D8638872CC3E
d. https://www.asme.org/
e. https://www.astm.org/
f. https://www.iso.org/home.html
g. https://www.ansi.org/
h. https://www.aws.org/home
i. https://www.edx.org/
j. http://www.efunda.com/home.cfm
k. https://www.howstuffworks.com/
l. http://icrank.com/cgi-bin/pageman/pageout.cgi?path=%2Findex_html.html
m. https://www.matweb.com/
n. https://www.engineeringtoolbox.com/
o. https://www.coursera.org/learn/engineering-mechanics-statics

14. PO-COMPETENCY-CO MAPPING:

Semester II	Basics of Mechanical Design (1326502)

Competency & Course Outcomes	POs						
	PO 1 Basic & Disciplinespecific knowledge	PO 2 Problem Analysis	PO3 Design /development of solutions	PO4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency							
Identify the force systems for given conditions by applying the basics of mechanics.	3	2	-	3	-	-	3
Evaluate material properties Under Longitudinal and transverse loads	3	3	-	3	-	-	3
Compute bending stress and shear stress invarious components for a given situation.	2	3	2	3	-	-	3
Calculatethe centroid and centre of gravity of various components in engineering Systems.	2	3	2	-	-	-	3
Determine the moment of inertia of a section about a given axis	3	3	2	-	-	-	3

Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE:

GTU Resource Person

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16. GTU BOS and Branch Coordinator Person

BOS Resource Persons

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