GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

Semester-II

Course Title: Engineering Mechanics

(Course Code: C4300008)

Diploma programme in which this course is offered	Semester in which offered
Automobile Engineering, Civil Engineering, Environment Engineering, Fabrication Technology, Mechanical Engineering, Mechatronics Engineering, Metallurgy Engineering, Mining Engineering.	Second Semester

1. RATIONALE

The primary purpose of the study of Engineering Mechanics is to develop the capacity to predict the effects of force while carrying out the creative design functions of engineering. This course is an introduction to learning and applying the principles required to solve engineering mechanics problems. The course addresses the modeling and analysis of static equilibrium problems with an emphasis on real world engineering applications and problem solving. It bridges the gap between physical theory and its application to technology.

2. COMPETENCY

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

- **Use the principle of Engineering Mechanics to solve broad-based engineering related problems.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Identify the force systems for given conditions by applying the basics of mechanics.
b) Determine unknown force(s) of different engineering systems.
c) Find the centroid and centre of gravity of various components in engineering Systems.
d) Apply the principles of friction in various conditions for useful purposes.
e) Select the eco-friendly relevant simple lifting machine(s) for given purposes.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+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 integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the 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. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Verify and calculate resultant force through Law of Parallelogram using analytical and graphical methods.	II	02*
2	Verify Law of Triangle using analytical and graphical methods.	II	02*
3	Verify and calculate resultant force through Polygon Law of Forces using analytical and graphical methods.	II	04*
4	Verify and calculate the value of unknown force through Lami's Theorem.	II	02*
5	Verify and calculate support reactions of a simply supported beam using analytical and graphical methods.	III	02*
6	Calculate centroid of a lamina having regular and irregular shapes.	IV	04*
7	Calculate angle of repose for different surfaces – Wood , Glass, Steel, plastic, wrought iron etc.	V	02*
8	Calculate coefficient of sliding Friction for different surfaces – Wood , Glass, Steel, plastic, wrought iron etc.	V	02*
9	Verify and calculate theoretical and practical velocity ratios of any four simple lifting machines. (Simple wheel and axle, Differential axle and wheel, simple screw jack, worm and worm wheel. Single purchase crab, Double purchase crab.)	VI	04*
10	Derive and draw a graph of law of machine for any two simple lifting machines and verify the effort required to lift a particular load. (Simple wheel and axle, Differential axle and wheel, simple screw jack, worm and worm wheel. Single purchase crab, Double purchase crab.)	VI	04*
	Total hours		**28 Hrs.**

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 suggestive list.*

ii. *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	Weightage in %
1	Identify components	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 practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Apparatus for Law of Parallelogram.	1,2 & 4
2	Universal Force table with all accessories.	3
3	Beam reaction apparatus with two circular dial types supports having 10 kg capacity each.	5
4	Stand, Regular Lamina, Irregular Lamina, Inextensible string, weight	6
5	Friction apparatus with scale on it, with wood, glass, steel, plastic surfaces, dish, string, weights	7,8
6	Simple wheel and axle, Differential axle and wheel Single and double purchase crab, simple screw jack, worm and worm wheel. Vernier caliper, weights, dish, string	9,10

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Work as a leader/a team member.
b) Follow safety practices while using equipment.
c) Realize importance of green energy. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. 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

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If

required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Basics of Mechanics	1a. Define scope of Engineering Mechanics. 1b. Use the relevant units of various quantities in the given situation. 1c. Explain effect of force on given object. 1d. Identify the force system in given situation.	1.1 Significance and relevance of Mechanics, Applied mechanics, Statics, Dynamics. Space, time, mass, particle, flexible body and rigid body. 1.2 Scalar and vector quantity, Units of measurement (SI units) - Fundamental units and derived units. 1.3 Force – unit, representation as a vector and by Bow's notation, characteristics and effects of a Force. 1.4 Principle of transmissibility of force, Principle of Superposition 1.5 Force system and its classification.
Unit – II Coplanar Concurrent Forces	2a. Resolve the given single force. 2b. Draw the free body diagram for the given condition. 2c. Use laws and principles of coplanar concurrent forces. 2d. Calculate the resultant of given force system analytically. 2e. Determine graphically the resultant of given force system. 2f. Determine unknown force in given situation using Lami's theorem.	2.1. Resolution of a force - Orthogonal components of a force 2.2. Equilibrium and Equilibrant, Free body and Free body diagram, conditions of equilibrium, 2.3. Resultant of forces using analytical and graphical methods for the forces acting at a point: 1. Law of Parallelogram 2. Law of triangle 3. Law of Polygon 2.4. Lami's Theorem – statement and explanation, Application for various engineering problems.
Unit– III Moment of Force and Parallel Forces	3a. Differentiate Coplanar non - concurrent and parallel forces. 3b. Compute resultant & Equilibrium forces for given coplanar non-concurrent force system. 3c. Identify the types of beam for given situation. 3d. Determine reactions for given types of beam analytically and graphically.	3.1 Moment of a force, Varignon's Theorem, Couple, application, properties of couple, conditions of equilibrium. 3.2 Resultant of force, Equilibrium forces and its position using analytical methods for the coplanar non - concurrent force system. 3.3 Types of beam, supports (simple, hinged, roller and fixed) and loads acting on beam (vertical and inclined point load, uniformly distributed load, couple).

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		3.4 Beam reaction for cantilever, simply supported beam with or without overhang – subjected to combination of Point load and uniformly distributed load. 3.5 Beam reaction graphically for simply supported beam subjected to vertical point loads only.
Unit– IV Centroid & Centre of Gravity	4a. Differentiate between Centroid and Centre of Gravity. 4b. Calculate Centroid of different geometrical plane and composite figures using first moment of area. 4c. Calculate Centre of Gravity of Simple and Composite Solids using first moment of mass.	4.1 Concept of Centroid, Centre of Gravity. 4.2 Axis of reference and Axis of Symmetry. 4.3 Centroid of One Dimensional geometrical figures using principle of moment. 4.4 Centroid of Two Dimensional geometrical Plane figures (Square, Rectangle, Triangle, Circle, Semi-circle, Quarter-circle) & Composite figures (not more than three figures) using first moment of area. 4.5 Centre of Gravity of Simple solids (Cube, Cuboid, Cone, Cylinder, Sphere, Hemisphere) & Composite solids (not more than two solids) using first moment of mass..
Unit– V Friction	5a. Identify Friction and its engineering application. 5b. Calculate coefficient of friction for different surfaces. 5c. Calculate frictional forces in engineering problems. 5d. Analyse various problems on block friction.	5.1 Friction, Types of Friction and laws of friction, limiting equilibrium, limiting friction. 5.2 Coefficient of friction, angle of friction, angle of repose, relation between coefficient of friction and angle of friction. 5.3 Equilibrium of bodies on level surface subjected to force parallel and inclined to plane. 5.4 Equilibrium of bodies on inclined plane subjected to force parallel to the plane only.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit– VI Simple Lifting Machines	6a. Describe the components of the given lifting machine. 6b. Determine mechanical advantage, velocity ratio, efficiency and law of the given simple lifting machines. 6c. Compare reversible & irreversible machines. 6d. Select the relevant eco-friendly lifting machine required for the given purpose with justification.	6.1 Simple lifting machine, load, effort, mechanical advantage, applications and advantages. Velocity ratio, efficiency of machines. 6.2 Application of law of machine. Ideal machine, friction in machine, maximum Mechanical advantage and efficiency. 6.3 Reversible and non-reversible machines, conditions for reversibility. 6.4 Velocity ratios of Simple wheel and axle, Differential axle and Wheel and, Worm and worm wheel, Single purchase and double purchase crab winch, Simple screw jack. Relevant problems on simple lifting machines.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Basics of Mechanics**	**04**	**4**	**2**	**0**	**06**
II	**Coplanar concurrent Forces**	**08**	**2**	**4**	**8**	**14**
III	**Moment of Force and Parallel forces**	**08**	**2**	**4**	**8**	**14**
IV	**Centroid and Centre of gravity**	**06**	**2**	**2**	**6**	**10**
V	**Friction**	**06**	**2**	**2**	**8**	**12**
VI	**Simple Lifting Machines**	**10**	**2**	**4**	**8**	**14**
Total		**42**	**14**	**18**	**38**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*
Note*: This specification table provides general guidelines to assist student for 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 slightly 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) Collect five different situations with photographs indicating concurrent, parallel, general force system in equilibrium.
b) Collect five different situations with photographs where law of moment plays an important role.
c) Prepare charts showing various types of supports.(hinged, roller and fixed)
d) Prepare models in the form of geometrical figures and solids and locate centroid and centre of gravity of them.
e) Prepare a chart for friction examples which you are facing in day to day life and also interpret whether it is useful and harmful.
f) Prepare a list with photographs of simple lifting machines used in your daily life in your branch.

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) 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 simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for using data manuals.

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 (group of 3 to 5). However, **in the fifth and sixth semesters**, 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 duration of the micro-project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Prepare spreadsheet or computer program to calculate the resultant force by the law of parallelogram and the law of polygon.
b) Using Drafting software calculate graphically the resultant force by the law of parallelogram and the law of polygon for at least five different conditions.
c) Prepare a spreadsheet or computer program to find out reactions for at least five different loading conditions on a simply supported beam.
d) Prepare spreadsheet or computer program to calculate centroid and centre of gravity for different geometrical sections.
e) Compare coefficient of sliding Friction for different surfaces (Wood , Glass, Steel, plastic, wrought iron etc.) with & without lubricant
f) Compare a suitable simple lifting machine used in your daily life in your branch.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with 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 Mechanics 7th 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

14. SOFTWARE/LEARNING WEBSITES

a) https://youtube.com/playlist?list=PLD85An3RPybx5psW5HwPtUGH7AXtBjhLm (Bisag Video Lectures by DTE, Gujarat)
b) https://youtube.com/playlist?list=PLyqSpQzTE6M_MEUdn1izTMB2yZgP1NLfs (NPTEL Video Lectures by IIT, Kanpur)
c) https://nptel.ac.in/courses/122/104/122104015/ (NPTEL Video Lectures by IIT, Madras)
d) www.vlab.co.in (Virtual Lab by Ministry of Education, Government of India)

15. PO-COMPETENCY-CO MAPPING

Semester II	Engineering Mechanics (Course Code: C4300008)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	Use the principles of Engineering Mechanics to solve broad-based engineering related problems.						
Course Outcomes COa) Identify the force systems for given conditions by applying the basics of mechanics.	3	2	-	3	2	2	2
COb) Determine unknown force(s) of different engineering systems.	2	3	-	3	2	2	2
COc) Find the centroid and centre of gravity of various components in engineering systems.	2	3	-	3	2	2	2
COd) Apply the principles of friction in various conditions for useful purposes.	2	3	-	3	2	2	2
COe) Select the eco-friendly relevant simple lifting machine(s) for given purposes.	2	3	-	3	3	2	2

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

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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