GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Theory of Machines and Mechanisms
(Course Code: 4331901)

Diploma Programs in which this course is offered	Offered in
Mechanical Engineering, Mechatronics Engineering	Third

1. RATIONALE

No matter how computerized, remote, online, bluetoothicized, internet-based and virtualized the world becomes, Mechanisms will always be important! Modern machines (e.g. Cars, boats, aircraft, space crafts, appliances, air and water handling, machine tools, robots, etc.) are a complicated combination of structures, mechanisms and controls.

In industries, the mechanical engineers/technicians are supposed to manage functioning of equipment with proper planning, operation and maintenance of machines and equipment. Students need to know about the combination of force and movement defines power and a mechanism that **manages power to achieve the desired set of forces and movement**. A mechanism is usually a piece of a larger process, known as a mechanical system or machine. This course includes such necessary knowledge and skill and ultimately becomes key course for mechanical engineering students.

2. EXPECTED COMPETENCY

The importance of this course is closely related to the ability of the student to understand and analyze to find problem solutions for machines and automation processes.

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire the following competency: "Use principle of kinematics and dynamics in operation and maintenance of various mechanisms, machines, and equipment"

3. COURSE OUTCOMES (COs)

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

a) Understand Kinematics and Dynamics of different machines and mechanisms.

b) Understand different types of Cams and their motions along with the drawing ability of Cam profiles for various motions.

c) Justify the role of Flywheel, Governor, Brakes, Bearings and Clutchesalong with selection of suitable drives in Mechanical applications.

d) Appreciate concept of balancing and vibrations.

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	ESE	PA	ESE	PA	150
3	0	2	4	70	30	25	25	

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

5. SUGGESTED LIST OF EXERCISES/PRACTICALS

Sr. No.	Concerned Unit No.	Practical Exercises (Outcomes' in Psychomotor Domain)	Hrs. Required
1	ALL	**Preparatory Activity:** a. Interpret and write various course-relatedQuantities, SI units, and their conversions. b. Recall and write scalar and vector quantities. c. Demonstrate various mechanisms.	02
2	II	**Cam Profile:** a. Demonstrate working of any type of cam and followers. b. Prepare one sheet on construction of cam profile for given data (without offset). This should include one problem of knife-edge follower, and roller follower. c. Prepare one sheet on the construction of cam profile for given data (with offset). This should include one problem for knife-edge and another for roller follower.	04
3	III	**Demonstration of Clutches:** To demonstrate the working of plate/cone/centrifugal/diaphragm clutch.	02
4	III	**Demonstration of Brakes:** To demonstrate the working block/band/block & band/ Disc	02
5	III	**Study of Dynamometers:** To demonstrate the working of Rope Brake/Hydraulic/Eddy current dynamometer.	02
6	IV	**Demonstration of Power Transmission Systems:** a. Identify various power transmission systems by observing different machines and equipment used in the Mechanical engineering laboratory/workshop. Examples- IC Engine test rigs, Compressors, Machine tools, Elevators, etc. Sketch at least four mechanisms with labeling on each. b. Demonstrate the working of each.	02
7	V	**Demonstration of Governors:** To demonstrate the working Watt/Porter/Proell governor.	02

8	VI	**Balancing:** Prepare one sheet on balancing using graphical and analytical methods for a given data. This should include a minimum of two problems.	04
9	III, IV and V	**Tutorials:** a. Calculate at least one problem of power loss due to friction in bearings and clutches from given problems/experimental data. b. Solve at least two problems of power transmission systems by a belt drive and gear drive from given problems/ experimental data. c. Calculate and prepare at least one turning moment diagram from given problems/experimental data. d. Calculate the mass of the flywheel from given problems/ experimental data. Note: Teachers will provide the data for tutorial problems well in advance to the students. (Within two weeks of the commencement of the semester) So that the students can complete the numerical problems timely and submit the solutions simultaneously. Teachers will solve the given problem/data in the lab if needed in this duration.	02
10	ALL	**Mini Project and Presentation:** a. Compile information from the internet related to various mechanisms/elements like piston, crank, connecting rod, cam, clutch, brake, flywheel, governor, or animation of mechanism, etc. along with functions of each. b. Select any one mechanism (preferably that which is NOT part of the syllabus) from mechanical laboratory/workshop/real life. Sketch the same. Take a photograph of the same. Also, record the movie of its working. c. Prepare any simple model of a subject-related mechanism. This has to be proposed by the student/sand has to be approved by the teacher. d. Present that detail of selected simple model in above point C with a PowerPoint presentation. This has to include: i. Compile and synchronize the information. ii. Explain the mechanism selected at b above. Use photographs and movie recordings. iii. Explain the working of the model prepared at cabove. iv. Photographs/movies of students working on aproject. e. Present student activities also	06

11	ALL	**Student Activities & Report presentation** a. Select any machine tool's mechanism available in the institute's workshop and perform the following activity: • Measuring dimensions of different links of a given shaper machine/any machine • Sketching • Labelling the sketch b. List the mechanisms which you are using in your day-to-day life. Sketch any three from these and explain in brief. c. Identify the type of clutches used in different automobiles and explain how it works. d. Identify the type of brakes used in different automobiles and bicycles. Explain how it works. e. Write the names of the five mechanical power transmissions you have seen in your daily life. f. Choose any vehicle and tell what kind of brakes it has and give a brief description of how it works. g. Make a note of that 'Is there "friction" in your routine?' and Justify your viewpoint.	-
		Total Hours	28

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Theory of Machine practicals need following Lab Equipment

- Cam Analysis Apparatus.
- Journal Bearing Apparatus.
- Setups to show different modes of transmissions
- Universal Governor apparatus
- Rope Brake and Dynamometer.
- Epicyclic Gear Train Apparatus.
- Working / Wooden / Thermocol Models & Mechanisms of:
    1. Kinematic links and pairs.
    2. Single slider-crank.
    3. Four bar chain.
    4. Types of cams, followers, and cam/follower arrangements.
    5. Friction bearing- all types.
    6. Dynamometers - all types.
    7. Friction clutches - all types.
    8. Friction brakes - all types.
    9. Rope/belt – All types of flat and Vs (ve).
    10. Gear trains - all types. (Simple, compound, reverted, epicyclical).
    11. Balancing machines -Revolving masses.
    12. Steam engine, Internal combustion engine.

13. Governors - all types.
14. Vibration -spring and mass model.
15. Any machine having a flywheel.

7. AFFECTIVE DOMAIN OUTCOMES

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

a) Work as a leader/a team member.
b) Follow ethical practices.
C) Vision of finding faults in defective machines and different modes of maintenance for shop floor.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level of Revised Bloom's taxonomy that is formulated for development of the COs and competency. If required, more such higher level could be included by the course teacher to focus on attainment of COs and competency.

Unit Nos.	Major Learning Outcomes /Unit Outcomes	Topics and Sub-topics
Unit I **Motions & Mechanisms**	1a. Define various terms related to mechanisms. 1b. Explain different Inversions of Mechanism. 1c. Explain the construction and working of various mechanisms. 1d. Understand various terms and methods related to velocity and acceleration diagrams.	1.1 Theory of machines: Introduction, need, scope and importance in design and analysis, basic terminology that has already been studied in Engineering Mechanics. 1.2 Kinematics of Machines: Definition of Kinematics, Dynamics, Statics, Kinetics, Kinematic link, Kinematic pair, and its types, constrained motion and its types, Kinematic chain and its types, Mechanism, inversion, machine, and structure. 1.3 Inversions of four-bar chain, Single Slider Crank chain and Double Slider Crank Chain. 1.4 Concept of velocity and acceleration of a point on link by relative velocity method in four-bar chain and single slider crank mechanism (without numerical).

Unit– II **Cams and Followers**	2a. Define the terms related to Cam and followers. 2b. Classify Cams and Followers. 2c. Draw cam profile as per the given problems.	2.1 Concept, definition and application of Cams and Followers. 2.2 Classification of Cams and Followers. 2.3 Different follower motions and their displacement diagrams like Uniform velocity, Simple harmonic motion (SHM), Uniform acceleration and retardation. 2.4 Drawing of a profile of radial cam with a knife-edge, roller & flat-faced follower with and without offset with reciprocating motion (Graphical method).
Unit– III **Bearings, Clutches, Brake & Dynamometer**	3a. Differentiate between uniform pressure and uniform wear theories. 3b. Explain construction and working of various thrust bearing 3c. Explain construction and working of various clutches. 3d. Calculate torque and power lost in friction in bearing & clutch. 3e. Differentiate between brake sand dynamometers. 3f. Construction and working of various brakes and dynamometers.	3.1 Concept, definition, basic terminology of friction, types and application of friction. 3.2 Uniform pressure and Uniform wear theories. 3.3 Types of thrust bearing, Torque and Power lost in i) Flat pivot, ii) Conical pivot, v) single collar v) muti-collar bearing and it's numerical. 3.4 Function of Clutch and its application, Construction and working of i) Single plate clutch, ii) multi-plate clutch, iii) Centrifugal Clutch iv) Cone clutch v) Diaphragm clutch. (Simple numerical on single and multi-plate clutch) 3.5 Function of brake and its application, Construction and working of i) block brake ii) band brake iii) Band & block brake iv) internal expanding shoe brake v) disc brake (without numerical). 3.6 Dynamometer- Function, Construction and working of i) Rope Brake, ii) Hydraulic iii) Eddy current.

Unit– IV Power Transmission	4a. Explain the need and modes of power transmission. 4b. Calculate velocity ratio, belt tensions, slip, angle of lap, and power transmitted in belt drives. 4c. Calculate the train ratio for the given gear drives. 4d. Select suitable drives for the given application withjustification.	4.1 Concept need and types of power transmission. 4.2 Types of Drives-Belt, Chain, Rope, Gear and their comparison with applications, advantages & limitations. 4.3 Flat belt, V-belt & its applications, material, angle of lap, belt length. Slip and Creep. Determination of velocity ratio, the ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission (Numerical on belt drives) 4.4 Rope Drives- types; application; Advantages & limitations of steel ropes 4.5 Chain Drives- Advantages & disadvantages; Selection of chain & sprocket wheels 4.6 Gear Drives- Classification of Gears - Nomenclature of a gear - explanation and applications of spur, helical and bevel gears, worm and worm wheel, rack and pinion; types of gear trains; their selection for different applications. 4.7 Train value & Speed ratio for Simple, Compound, and Riveted gear trains using spur gears (Numerical of gear drive for finding Speed ratio or Train ratio excluding epicyclic gear train).
Unit- V Flywheel and Governors	5a. Construct a Turning moment diagram. 5b. Calculate the energy fluctuation and variation in speed of the Flywheel. 5c. Demonstrate the working of different types of Governors. Differentiate the working of Flywheel and Governor.	5.1 Flywheel- Concept, function and application of flywheel with the help of turning moment diagram for Single cylinder double acting steam engine, Single cylinder 4 -Stroke I.C. Engine, Co-efficient of fluctuation of energy, Co-efficient of fluctuation of speed, Energy stored in a Flywheel and its significance. Simple numerical. 5.2 Governor- Concept, function and application & terminology of Governors. Types, Explanation of Watt, Porter, Proell. 5.3 Comparison between Flywheel and Governor.

Unit- VI Balancing and Vibrations	6a. Calculate balancing mass and its position for masses revolvingin the same plane. 6b. Identify different types of vibration, its causes and remedies.	6.1 Concepts and types of balancing. 6.2 Effects of unbalanced masses. 6.3 Balancing of single rotating mass. Analytical and graphical method for balancing of several masses revolving in the same plane. 6.4 Concept, types and terminology used in vibration, causes of vibrations in machines, their harmful effects and remedies.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hrs.	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
I.	Motions & Mechanisms	9	6	8	0	14
II.	Cams and Followers	5	2	0	7	9
III.	Bearings, Clutches, Brake & Dynamometer	11	2	6	8	16
IV.	Power transmission	9	2	5	8	15
V.	Flywheel and Governors	5	2	2	4	8
VI.	Balancing and Vibrations	3	2	2	4	8
	Total	42	16	23	31	70

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

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

Recommendation / General Notes:

- If only one mid-sem test is the part of continuous evaluation system, Examiner is free to decide the topics for the exam. But it is recommended to cover atleast 65 % of the CO's / Topics in the mid test exam.
- Ask the questions from each topic as per Bloom's taxonomy weightage marks. Numerical questions are to be asked as per the instructions of the syllabus only. Optional questions must be asked from the same topic / unit with consideration of same Bloom's taxonomy's level (RUA). Each question must be mapped with their UOs (Unit Outcomes) COs (Course outcomes), and Bloom taxonomy in Mid sem exam. A sample is provided here for the convenience of the teacher.

Question No.	Questions	Marks	UOs	COs	BTL
Q-1					

10. SUGGESTED STUDENT ACTIVITIES

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

a) Charts can be prepared.
b) A short report on any topic given by concerned faculty
c) Small groups of students can be formed for assigned work. Assigned work should be such that it encompasses market survey, Model making, Powerpoint presentation, time management... etc.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

Unit	Unit Name	Strategies
I	Motions & Mechanisms	Model, Education charts & videos, and Real-life examples. Demonstration of real industrial parts used in different devices, Movies/ Animations.
II	Cam and cam profile	Demonstration of cams, Movies/Animations.
III	Bearings, Clutches, Brakes,and dynamometers	Model, Education charts & videos, and Real-life examples. Demonstration of real industrial parts used in different devices, Movies/ Animations.
IV	Power transmission	Demonstration of real industrial parts, Movies/Animations, and Models of different power transmission elements
V	Flywheel and Governors	Industrial visits, Animations/movies, Models of different types of governors.
VI	Balancing and vibrations	Industrial visits, Animations/movies.

These are sample strategies, which the teacher can use to accelerate the attainment of thevarious outcomes in this course:
Massive open online courses (MOOCs) may be used to teach various topics/sub topics
Guide the student(s) in undertaking mini-projects.

12. SUGGESTED LEARNING RESOURCES

Sr. No.	Author	Title of Books	Publication
1.	Jagdish Lal	Theory of Machines	Metropolitan book New Delhi.
2.	Abdulla Shariff	Theory of Machines	Dhanpatray and Sons, New Delhi
3.	S S Ratan	Theory of Machines	Tata McGraw Hill New Delhi
4	A Ghosh & A K Malik	Theory of Machines	East-West Press (Pvt) Ltd. New Delhi
5.	Thomas Bevan	Theory of Machines	C S B Publishers and distributors
6.	Joseph Edward Shigley	Theory of Machines	McGraw Hill
7.	P L Bellaney	Theory of Machines	Khanna Publications, New Delhi
8.	Sadhu Singh	Theory of Machines	Pearson Education, India
9.	R S Khurmi & J K Gupta	Theory of Machines	S Chand, New Delhi
10.	Gordon R. Pennock & Joseph E. Shigley John J. Uicker	Theory of Machine and Mechanisms	Oxford University Press
11.	Dr. V. P. Singh	Theory of Machines	Dhanpat Rai Publishing Co Pvt Ltd

13. LIST OF SOFTWARE/LEARNING WEBSITES

- https://nptel.ac.in/courses/112106270
- https://nptel.ac.in/courses/112104121
- https://nptel.ac.in/courses/112103108
- https://youtu.be/ASIl3HWTT4U
- https://youtu.be/MAuVDB-G-HQ
- https://youtu.be/ApuBEn2zct8
- https://youtu.be/SJGFX1Nub1A
- https://youtu.be/devo3kdSPQY
- https://youtu.be/HY_PjmHRxuE
- https://youtu.be/6DL0j0eKD8Y
- https://youtu.be/lqo0_StXf4M
- https://youtu.be/m4UmBbS7mfI
- https://youtu.be/uwZGtFRtGoU
- https://youtu.be/zDRc01bD6a8
- https://youtu.be/uW1CvgfJuEg
- https://youtu.be/Ibs10c9FX0M
- https://youtu.be/j6woGQdUPFs
- https://youtu.be/u5nwkm5IbqY
- https://youtu.be/LmYhzHnMH9o

14. PO - COMPETENCY - CO MAPPING

Semester III	THEORY OF MACHINES & MECHANISMS						
	POs						
Competency & Course Outcomes -Cos (concerned Units)	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
Understand Kinematics and Dynamics of different machines and mechanisms. (Unit No I)	3	1				1	2
Understand different types of Cams and their motions along with the drawing ability of Cam profiles for various motions. (Unit No II)	3	3				1	3
Justify the role of Flywheel, Governor, Brakes, Bearings and Clutches along with selection of suitable drives in Mechanical applications. (Unit No III, IV & V)	3	3		2		1	3
Appreciate concept of balancing and vibrations. (Unit No VI)	3	3	2	2		1	3

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE GTU Resource Persons:

Sr. No	Name and Designation	Institute	Contact No.	Email
1	Prof. G R Khunt Sr Lecturer in Mech Engg. Dept	R C Technical Institute SOLA, Ahmedabad.	8128291616	grkhunt@gmail.com
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