Program Name : **Diploma in Automobile Engineering / Mechanical Engineering**

Program Code : **AE / ME**

Semester : **Fourth**

Course Title : **Theory of Machines**

Course Code : **22438**

1. RATIONALE

Knowledge of various mechanisms and machines is a pre-requisite for enabling a mechanical engineer to work in an industry. This course provides the knowledge of kinematics and dynamics of different machine elements and popular mechanisms such as four link mechanisms, cam-follower, belt-pulley, chain sprocket, gears, flywheel, brake and clutch to enable a diploma holder to carry out maintenance of these and it also serves as a prerequisite for course 'Elements of Machine Design' to be studied in later semester.

2. COMPETENCY

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

- **Use principles of kinematics and dynamics in maintenance of various equipment.**

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. Identify various links in popular mechanisms.
b. Select suitable mechanism for various applications.
c. Interpret the motion of cams and followers.
d. Recommend relevant belts, chains and drives for different applications.
e. Choose relevant brakes and clutches for various applications
f. Select suitable flywheel and governor for various applications.

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	
3	-	2	5	3	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* ,@ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based 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.

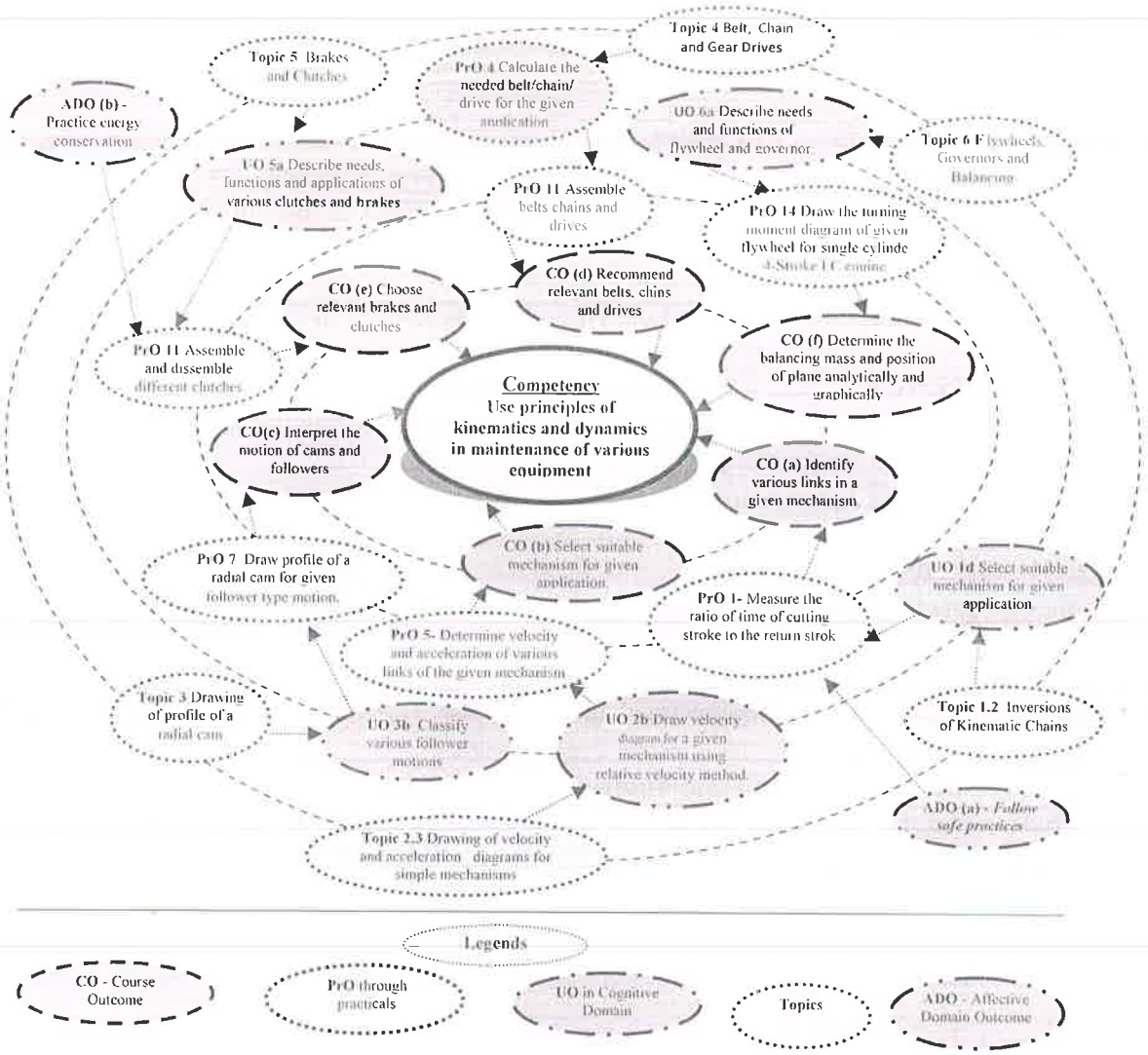

Figure 1 - Course Map

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.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure the ratio of time of cutting stroke to the return stroke in shaping machine by varying the stroke length. Following activities need to be performed: (Part I) a. Measuring dimensions of different links of given shaper machine b. Sketching	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	c. Labeling of sketch		
2	Measure the ratio of time of cutting stroke to the return stroke in shaping machine by varying the stroke length. Following activities need to be performed: (Part II) a. Measuring dimensions of different links of given shaper machine b. Sketching c. Labeling of sketch	I	02*
3	Estimate important kinematic data related to following mechanisms to sketch them. a) Bicycle free wheel sprocket mechanism b) Geneva mechanism	I	02
4	Estimate important kinematic data related to following mechanisms to sketch them. a) Ackerman's steering gear mechanism b) Foot operated air pump mechanism	I	02
5	Determine velocity and acceleration of various links of the given mechanism (any two) by relative velocity method for analysis of motion of links (Minimum 2 problems on A2 size drawing sheet).	II	04*
6	Determine velocity and acceleration in an I. C. engine's slider crank mechanism by Kleins's construction (Minimum 2 problems on A2 size drawing sheet).	II	02
7	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part I	III	02*
8	Draw profile of a radial cam for given follower type to obtain the desired follower motion (Minimum 2 problems on A2 size drawing sheet). Part II	III	04
9	Estimate slip, length of belt, angle of contact in an open and cross belt drive.	IV	02*
10	Calculate breaking torque required in different breaks at different speeds and load situations.	IV	02
11	Assemble and dismantle different clutches. (Part I)	V	02*
12	Assemble and dismantle different clutches. (Part II)	V	02*
13	Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	V	02*
14	Perform balancing of rotating unbalanced system	VI	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, all practicals 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 %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report/sheets in time	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 safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. 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/ INSTRUMENTS REQUIRED

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 with Broad Specifications	PrO. No.
1.	Working models of bicycle free wheel sprocket mechanism, geneva mechanism, Ackerman's steering gear mechanism and foot operated air pump mechanism, slider crang mechanism, elliptical trammel, skotch yoke mechanism, oldham's coupling, hooks joint, inversions of four bar mechanisms.	03, 04, 05, 06 and for demo in theory class for unit-I and II
2.	Working models of locomotive coupler, Beam engine, Pantograph, Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper, Scotch Yoke mechanism, Elliptical trammel and Oldham's Coupling.	03, 04, 05, 06 and for demo in theory class for unit-I and II
3.	Working models of various cam follower arrangements for demonstration.	07, 08

S. No.	Equipment Name with Broad Specifications	PrO. No.
4.	Working models with different belts in different arrangements.	09
5.	Working and cut section models of various types of brake assemblies.	For demo in theory class for unit-V
6.	Various types of clutch assemblies.	11
7.	Working models of various types of governors.	13
8.	Working models of a. various belt drives, b. chain and sprocket, c. various gear drives.	For demo in theory class for unit-IV
9.	Working Models of Gear trains - all types.(Simple, compound, reverted, epicyclical).	For demo in theory class for unit-IV
10.	Balancing Machines -Revolving masses, Reciprocating masses	14

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 and type of Mechanisms	1a. Identify various links in the given figure of the mechanism with justification. 1b. Describe with sketches the constructional details of the given type of mechanism 1c. Select suitable mechanism for the given application with justification. 1d. Select suitable material of the mechanism for the given application with justification.	1.1 **Kinematics of Machines:** Introduction to Statics; Kinematics, Kinetics, Dynamics; Kinematic links, joints, pairs, chain and its types; Constrained motion and its types, Inversion, Mechanism, Machine and Structure. 1.2 **Inversions of Kinematic Chains and their materials:** Four bar chain – Locomotive coupler, Beam engine and Pantograph. Single slider Crank chain – Pendulum pump, Rotary I.C. engine mechanism, Oscillating cylinder engine, Whitworth quick return Mechanism, Quick return mechanism of shaper; Double Slider chain - Scotch Yoke mechanism, Elliptical trammel, Oldham's Coupling.
Unit– II Velocity and Acceleration in Mechanisms	2a. Use analytical method (without derivation) to calculate the velocity and acceleration of given links in the given single slider crank mechanism 2b. Estimate velocity and	2.1 Concept of relative velocity and relative acceleration of a point on a link, angular acceleration, inter-relation between linear and angular velocity and acceleration. 2.2 Analytical method and Klein's construction to determine velocity and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	acceleration of any link at any instant in the given mechanism. 2c. Describe with dimensioned sketch of the given mechanism. 2d. Describe with velocity diagram for a given mechanism using relative velocity method. 2e. Describe with acceleration diagram for the given mechanism. 2f. Explain with velocity and acceleration diagram for the given mechanism using Klein's construction.	acceleration of different links in single slider crank mechanism. 2.3 Drawing of velocity and acceleration diagrams for simple mechanisms. Determination of velocity and acceleration of point on link by relative velocity method (Excluding Coriollis component of acceleration)
Unit– III Cams and Followers	3a. Identify the type of motion of follower in the given situation with justification. 3b. Describe with dimensioned sketch of the given cam and follower arrangement. 3c. Describe with cam profile for the given motion of knife-edge and roller follower with and without offset application using Graphical method.	3.1 Introduction to Cams and Followers. Cam and follower terminology. Classification of Cams and Followers. Applications of Cams and Followers. 3.2 Types of follower motions and their displacement diagrams -Uniform velocity, Simple harmonic motion, uniform acceleration and retardation. 3.3 Drawing of profile of a radial cam based on given motion of reciprocating knife-edge and roller follower with and without offset.
Unit-IV Belt, Chain and Gear Drives	4a. Calculate velocity ratio, belt tensions, slip and angle of contact in the given belt drive. 4b. Estimate power transmitted and condition for maximum power transmitted in the given belt drive for given data. 4c. Select suitable belt for the given application with justification. 4d. Calculate Train value and velocity ratio for the given simple, compound, reverted and epicyclic gear trains using spur and helical gears.	4.1 Belt Drives – Introduction to Flat belt, V-belt and its applications, materials used for flat and V-belts. Introduction of timing belt and pulley. Angle of lap, length of belt, Slip and creep. Determination of velocity ratio of tight side and slack side tension, centrifugal tension and initial tension, condition for maximum power transmission. Merits, demerits and selection of belts for given applications. 4.2 Chain Drives – Introduction to chain drives, Types of chains and sprockets, Methods of lubrication. Merits, demerits and selection of chains for given applications. 4.3 Gear Drives – Introduction to gear

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	4e. Select suitable gear for the given application with justification. 4f. Select suitable drives for the given application with justification.	drives, Classification of gears, Law of gearing, gear terminology, Types of gear trains, Train value and velocity ratio for simple, compound, reverted and epicyclic gear trains using spur and helical gears. Merits, demerits and selection of gear drives for given applications.
Unit-V Brakes and Clutches	5a. Calculate braking force, braking torque and power lost in friction in the given shoe and band brake for the given data. 5b. Explain with sketches the various parts of the given brakes with their functions and constructional details. 5c. Describe with sketches the needs, functions and applications of the given clutches. 5d. Explain with sketches the various parts of the given clutch with their functions and constructional details.	5.1 Introduction to Brakes – Types, Functions and Applications. 5.2 Construction and principle of working of i) Shoe brake, ii) Band brake iii) Internal expanding shoe brake iv) Disc Brake. 5.3 Braking force, braking torque and power for shoe and band brake. 5.4 Clutches-Uniform pressure and Uniform Wear theories. Introduction to Clutch - Types, Functions and Applications, Construction and principle of working of a. Single-plate clutch, b. Multi-plate clutch, c. Centrifugal Clutch d. Cone clutch e. Diaphragm clutch.
Unit –VI Flywheels, Governors and Balancing	6a. Explain with sketches the method of balancing a rotating mass as per the given conditions. 6b. Estimate the balancing mass and position of plane analytically and graphically in the given situation for the given data. 6c. Explain with sketches the turning moment diagram for the given single cylinder 4-Stroke I.C Engine for the given data.	6.1 Flywheel-Introduction to flywheel – need, function and application of flywheel with the help of turning moment diagram for single cylinder 4-Stroke I.C Engine. 6.2 Coefficient of fluctuation of energy, coefficient of fluctuation of speed and its significance. 6.3 Governors- Introduction, types, functions and applications, Terminology of Governors. Comparison of Flywheel and Governor. 6.4 Balancing- Need and types of balancing, Balancing of single rotating mass, Analytical and Graphical methods for balancing of several masses revolving in same plane.

***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 FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals and type of Mechanisms	10	04	06	04	14
II	Velocity and Acceleration in Mechanisms	06	02	04	04	10
III	Cams and Followers	08	04	04	04	12
IV	Belt, Chain and Gear Drives	10	04	04	06	14
V	Brakes and Clutches	06	02	02	04	08
VI	Flywheels, Governors and Balancing	08	02	04	06	12
Total		**48**	**18**	**24**	**28**	**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. Compile information from internet related to various mechanisms/elements like piston, crank, connecting rod, cam, clutch, brake, flywheel, governor, or animation of mechanism etc. along with functions and areas of application of each.
d. List the mechanisms which you are using in your day to day life. Sketch any three from these.
e. List the different mechanisms used in a typical car.
f. Identify and measure the dimensions of Flywheel used in automobile engines, generators, punching and riveting machines.
g. Identify the type of clutches used in different automobiles and also the type of brakes in automobile and bicycle.
h. Visit the market and collect the data of items which are used in any mechanisms. Data includes specifications, cost, applications, etc. Also name the mechanism/s in which such item/s is/are used.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning 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. Use Flash/Animations to explain various mechanisms.
f. Guide student(s) in undertaking micro-projects
g. Encourage students to refer different websites for deeper understanding of the course.
h. Monitor the performance of students in Lab.
i. Show models, education charts and videos, real life examples of various mechanisms.
j. Demonstration of real industrial parts and mechanisms used in different devices.
k. Demonstration of different real industrial parts, cams, power transmission elements through movies/animations.
l. Industrial visit, animations/movies, models of different types of governors.

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. Prepare working model of any one mechanism using low cost materials.
b. Prepare animations of various mechanisms using free software's available on internet.
c. Market survey of belts for collecting specifications,.
d. Field survey to collect information about applications of timing belts.
e. Field survey to collect information about applications of flywheels and governors.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Theory of Machines	Rattan S. S.	McGraw-Hill Education, 1986 ISBN: 9780070591202
2	Theory of Machines	Khurmi R. S., Gupta J. K.	S. Chand Publications, New Delhi, 2015 ISBN: 9788121925242
3	Theory of Machines	Bevan Thomas	Pearson Education India, New Delhi, 1986. ISBN: 9788131729656

S. No.	Title of Book	Author	Publication
4	Theory of Machines and Mechanisms	Ballaney P.L.	Khanna Publisher, New Delhi, 2003, ISBN 9788174091222
5	A Text Book of Theory of Machines	Bansal R.K., Brar J. S.	Laxmi Publication, New Delhi, 2004, ISBN 9788170084181

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.iitm.ac.in/video.php?subjectId=112104121
b. http://www.technologystudent.com/gears1/gears7.htm
c. http://kmoddl.library.cornell.edu/model.php?m=20
d. http://www3.ul.ie/~kirwanp/whatisacamandfollowersyste.htm
e. http://nptel.iitm.ac.in/courses/Webcourse-contents/IIT-
f. Delhi/Kinematics%20of%20Machine/index.htm
g. http://elearning.vtu.ac.in/12/enotes/Des_Mac-Ele2/Unit6-RK.pdf
h. en.wikipedia.org/.../Canadian_Committee_for_the_Theory_of_Machines...
i. global.oup.com/.../theory-of-machines-and-mechanisms-978019537123...
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