Maharashtra State Board of Technical Education, Mumbai

Teaching and Examination Scheme for Post S.S.C. Diploma Courses

Program Name : Diploma in Automobile Engineering

Program Code : AE — **With Effect From Academic Year: 2017 – 18**

Duration of Program : 6 Semesters — **Duration : 16 Weeks**

Semester : Fourth — **Scheme - I**

S. N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme												Grand Total
								Theory							Practical					
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total	
				L	T	P			Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	Max Marks	Min Marks	
1	Theory of Machines	TOM	22438	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
2	Automobile Manufacturing Processes	AMP	22439	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
3	Advanced Automobile Engines	AAE	22440	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Heat Power Engineering	HPE	22441	4	-	2	6	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
5	Automobile Systems and Body Engineering	ASB	22442	4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
6	Mechanical Measurement	MME	22040	1	-	2	3	--	--	--	--	--	--	--	25@	10	25~	10	50	20	50
7	Solid Modeling and Additive Manufacturing	SMA	22041	-	-	2	2	--	--	--	--	--	--	--	25@	10	25~	10	50	20	50
			Total	**19**	**-**	**14**	**33**	--	**350**	--	**150**	--	**500**	--	**175**	--	**175**	--	**350**	--	**850**

Student Contact Hours Per Week: **33 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **850**

Abbreviations: ESE- End Semester Exam, PA- Progressive Assessment, L - Lectures, T - Tutorial, P - Practical

@ Internal Assessment, # External Assessment, *# On Line Examination , ^ Computer Based Assessment

* 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 LOs required for the attainment of the COs.

~ For the courses having ONLY Practical Examination, the PA marks Practical Part - with 60% weightage and Micro-Project Part with 40% weightage

- **If Candidate not securing minimum marks for passing in the "PA" part of practical of any course of any semester then the candidate shall be declared as "Detained" for that semester.**
- **In-Plant Training during Summer vacation for minimum Six Weeks at the end of Fourth Semester (Second Year).**

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

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*

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.

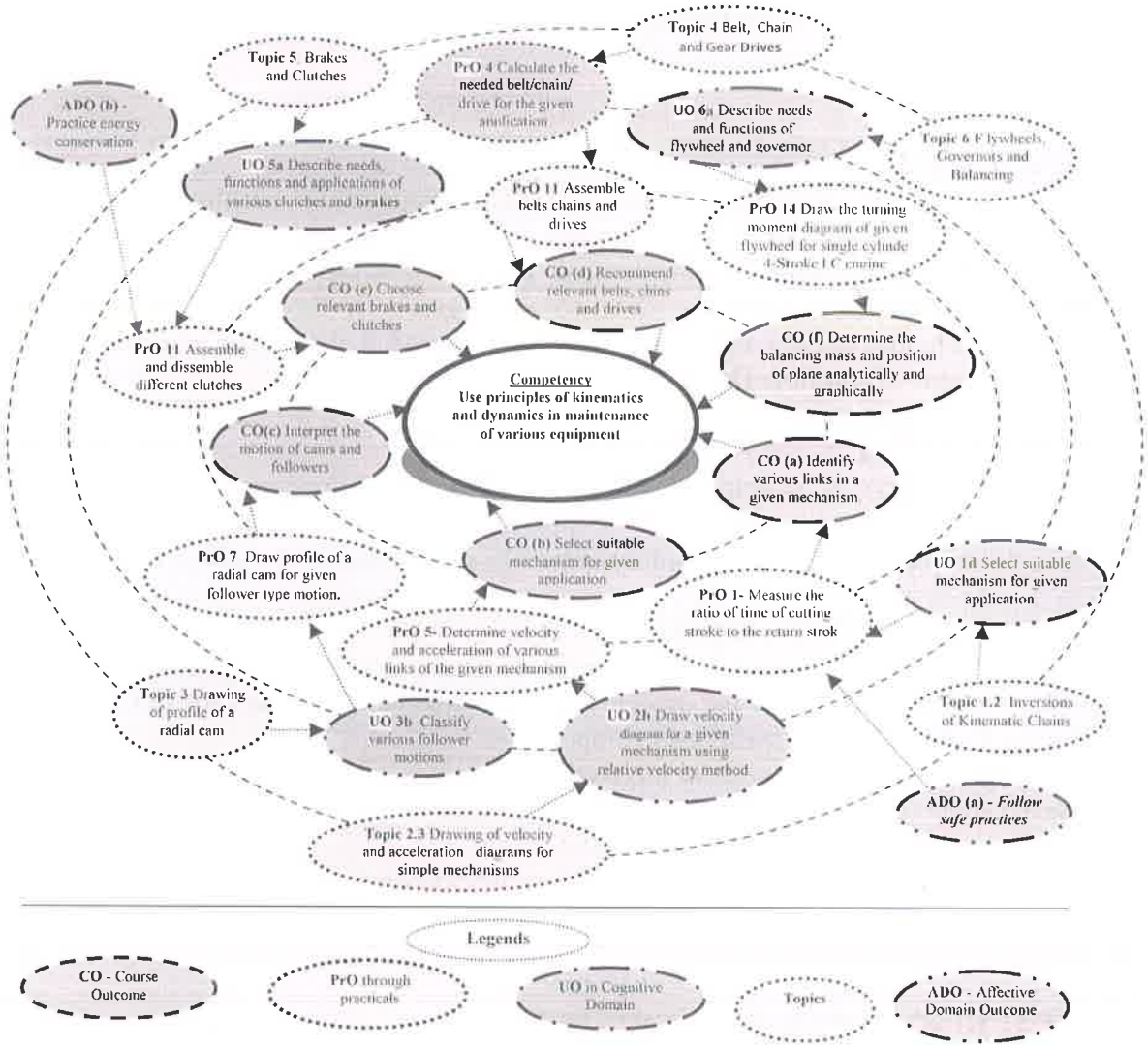

Figure 1 - Course Map

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 c. Labeling of sketch	I	02*
2	Measure the ratio of time of cutting stroke to the return stroke in	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	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		
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	02*
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	02
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 brakes and clutches. (Part I)	V	02*
12	Assemble and dismantle different brakes and clutches. (Part II)	V	02
13	Assemble and dismantle belts and chains.	V	02*
14	Draw the turning moment diagram of given flywheel for single cylinder 4-Stroke I.C engine. (Part I)	VI	02*
15	Draw the turning moment diagram of given flywheel for single cylinder 4-Stroke I.C engine. (Part II)	VI	02
16	Measure radius and height of all types of governors for different rotational speeds, mass of balls and spring stiffness (in spring loaded governors)	VI	02
17	Perform balancing of rotating unbalanced system	VI	02
	Total		**34**

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.	10
6.	Various types of clutch assemblies.	11
7.	Single cylinder 4-Stroke I.C engine with flywheel	13, 14
8.	Working models of various types of governors.	15
9.	Working models of a. various belt drives, b. chain and sprocket, c. various gear drives.	For demo in theory class for unit-IV
10.	Working models of various types of brakes	02, and for demo in theory class for unit-V
11.	Working Models of Gear trains - all types.(Simple, compound, reverted, epicyclical).	For demo in theory class for unit-IV
12.	Balancing machines -Revolving masses, Reciprocating masses	16

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 Acceleratio	2a. Use analytical method (without derivation) to calculate the velocity and acceleration of given links	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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
n in Mechanisms	in the given single slider crank mechanism 2b. Estimate velocity and 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. 2.2 Analytical method and Klein's construction to determine velocity and 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	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,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	simple, compound, reverted and epicyclic gear trains using spur and helical gears. 4e. Select suitable gear for the given application with justification. 4f. Select suitable drives for the given application with justification.	demerits and selection of chains for given applications. 4.3 Gear Drives – Introduction to gear 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...
j. www.tecquipment.com/Theory_of_Machines.aspx
k. www.researchgate.net/.../0094-114X_Mechanism_and_Machine_Theory
l. www.journals.elsevier.com/mechanism-and-machine-theory/
m. journalseek.net/cgi-bin/journalseek/journalsearch.cgi?field=issn...
n. site.iugaza.edu.ps/wp-content/.../IUGAZA%20TOM2012_CH1-2.pdf
o. www.iftomm.org/
p. www.wiziq.com/online-tests/44047-mechanical-theory-of-machine
q. www.cs.ubc.ca/~murphyk/Teaching/CS340-Fall07/infoTheory.pdf

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Automobile Manufacturing Processes**

Course Code : **22439**

1. RATIONALE

Automobile manufacturing processes is a core technological subject. With advent of technology there are many advances in manufacturing processes and equipment. The knowledge of these advances is essential for a diploma student engaged in automobile manufacturing organizations and as prerequisite knowledge for subject like Automobile component design. Students should be able to prepare CNC part programs and apply it on CNC machine in manufacturing industry.

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 various manufacturing processes to produce automobile components.**

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 automobile industry oriented COs associated with the above mentioned competency:

a. Use relevant forging hand tools,material and methods in manufacturing.
b. Use relevant press tool dies and materials to produce components.
c. Execute relevant welding methods for different materials.
d. Execute relevant surface treatment processes for automobile components.
e. Execute CNC part programs.

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*

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.

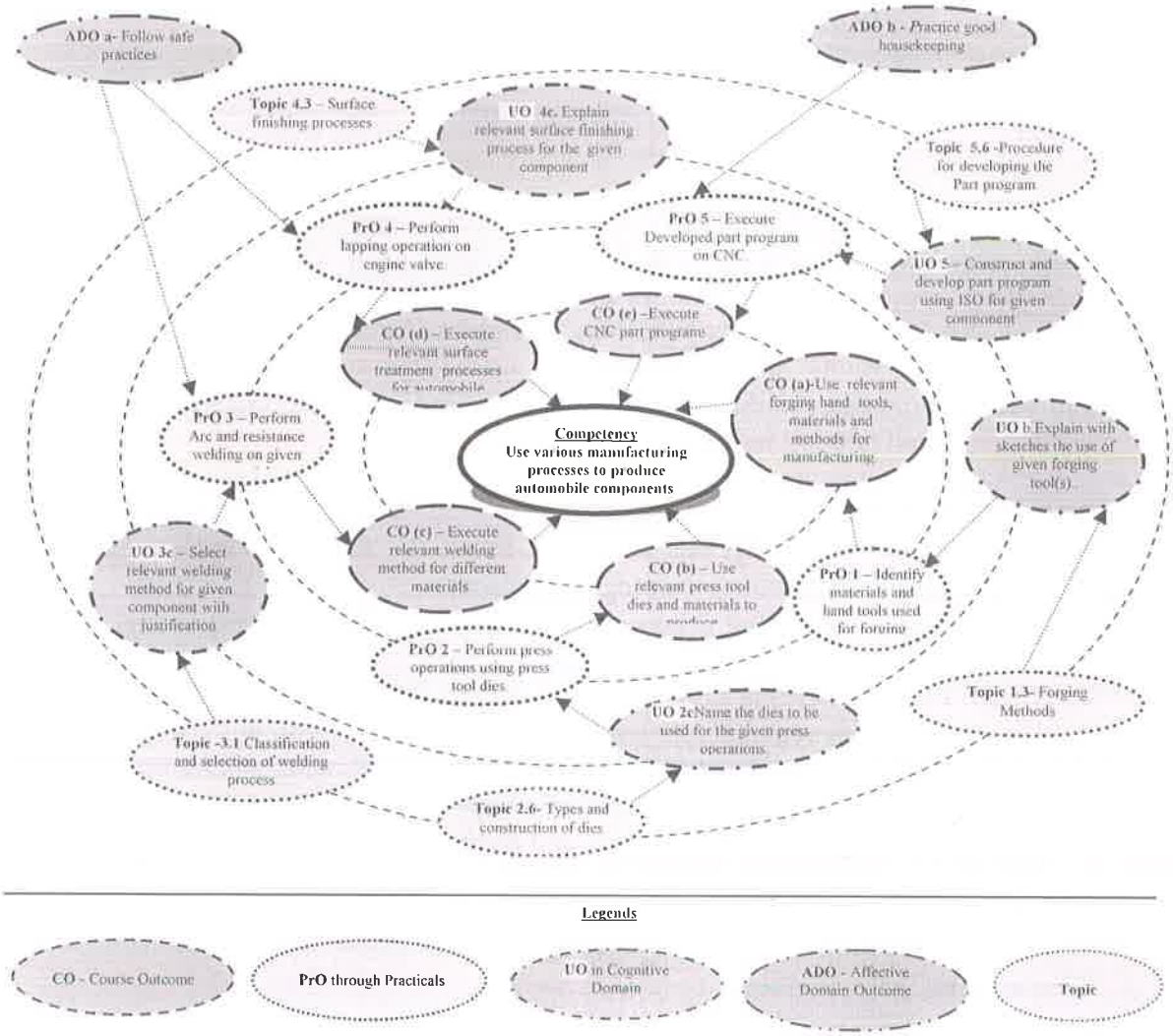

Figure 1 - Course Map

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.	Identify materials and hand tools used for forging.	I	01*
2.	Identify the parts of open die forging machine.	I	01
3.	Identify the parts of closed die forging machine.	I	01
4.	Shear the metal sheet as per dimensions.	II	01*
5.	Prepare the blank as per stamping shape	II	02
6.	Perform press operations using press tool dies.	II	02*
7.	Prepare the edge on metal piece for arc welding.	III	02
8.	Perform welding operation on any one of the arc welding machine.	III	02*
9.	Perform welding operation on any one of the resistance welding	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	machine.		
10.	Perform hand lapping operation on engine valve.	IV	02*
11.	Prepare part drawing and Determine the coordinates as per absolute coordinate method.	V	02*
12.	Cut the stock(raw material) of equal dimensions for a group of four students.	V	02*
13.	Prepare the part program using G codes and M codes.	V	02*
14.	Set the work and tool offset on CNC as per operations..	V	02*
15.	Feed the part program into CNC and simulate through dry run.	V	02
16.	Execute the part program for turning on CNC lathe.	V	02*
17.	Execute the part program for Drilling operation on VMC.	V	02*
18.	Execute the part program for Milling operation on VMC.	V	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, out of which, the practicals marked as '' 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 %
a.	Dimensional accuracy	40
b.	Surface finish achieved	20
c.	Use of protective equipment	10
d.	Following safety rules	20
e.	Submitting workshop diary 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 safe practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. 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	Fly press of 1 tonne capacity	6
2	Arc welding machine upto 14 kVA	7,8
3	Resistance welding machine upto 10kVA	9
4	CNC lathe(turning centre) Oi-mate TD. 02. CAPACITY	13,14,15,16
5	VMC Machine. 1200M. Table size, mm, 1200 x 510, 1500 x 630. Traverses X, Y & Z axes, mm, 1000 x 500 x 500l), 1200 x 600 x 600. Rapid rate, m/min, 12 (standard), 20/32 (optional),	17,18

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 Forging processes	1a. Select the material for the given forging operation with justification. 1b. Explain with sketches the use of given forging tool(s). 1c. Describe with sketches the salient features of the given forging method. 1d. Select the forging sequence(s) for the given forging method(s) with justification.	1.1 Forgeable materials and forgeability; Classification of forging processes 1.2 Forging hand tools. 1.3 Forging methods: open die, closed die, press and machine forging 1.4 Forging sequences for Auto components-Connecting rods, Crankshafts, Camshafts and Spanners.
Unit-II Press and Press Operations	2a. Select the material for the given press operation with justification. 2b. Describe with sketches the die accessories for the given press dies. 2c. Name the dies to be used for the given press operations with justification. 2d. List the relevant press operations for the given stampings.	2.1 Materials used in press work for automobile applications. 2.2 Classifications of presses and terminology used in presses 2.3 Major parts of Fly press 2.4 Parts of standard die set 2.5 Die accessories- Pilots, Stops, Strippers, Pressure pads and Knock outs 2.6 Types and construction of dies— Simple, progressive, compound and combination die. 2.7 Press operations – a) Cutting operations - Blanking,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Piercing, Lancing, Coining, Perforating, Notching, Embossing, Shaving. b) Forming Operations - Bending, Drawing, Squeezing.
Unit– III Welding Processes	3a. Categorize the welding processes for the given materials. 3b. Identify the type(s) of gas welding flame used for the given metal with justification. 3c. Select the relevant welding method for the given component with justification. 3d. Explain with sketches the use of filler and flux material for the given welding process.	3.1 Classification and selection of welding process. 3.2 Gas(Oxy-acetylene)welding and types of flames. 3.3 Arc welding – Shielded metal arc, TIG and MIG. 3.4 Resistance welding-Spot, Seam and Projection. 3.5 Brazing and soldering. 3.6 filler and flux materials in welding.
Unit– IV Surface Treatment Processes	4a. Select the relevant surface cleaning process for the given material(s). 4b. Explain with sketches the relevant surface coating process for the given component. 4c. Explain with sketches the relevant surface finishing process for the given component with justification 4d. State the applications of the given surface treatment processes with justification.	4.1 Surface cleaning processes- acid, alkaline, electrolytic cleaning, blasting and tumbling. 4.2 Metallic surface coating- Electroplating, Galvanizing, metal spraying and powder coating. 4.3 Surface finishing processes: Lapping, honing, super finishing, buffing, burnishing and their applications.
Unit –V CNC Machines and Programming	5a. Identify the specification of the given inserts with justification. 5b. Describe the absolute and incremental co-ordinate system for the given part program with examples. 5c. Develop part program using ISO codes for the given component. 5d. Describe with sketches the procedure to run the developed part program on CNC machine for the given component.	5.1 CNC machines:Classification. . 5.2 Insert spectification . 5.3 Absolute and Incremental Co-ordinate system; Axes configuration- X, Y and Z axes. 5.4 Procedure for developing the Part program; ISO Codes used in programming. 5.5 Simple Part programming as per ISO codes on CNC and VMC for operations like turning, drilling and Milling.

***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	Forging processes	08	2	4	4	10
II	Press and Press Operations	10	4	6	6	16
III	Welding processes	08	4	4	4	12
IV	Surface Treatment Processes	06	2	2	4	08
V	CNC machines and programming	16	4	8	12	24
Total		**48**	**16**	**24**	**30**	**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 specification of forging and press machines.
b. Prepare list of filler and flux materials used in welding.
c. List automobile components which require surface treatment process.
d. List G and M codes used in CNC machines.
e. Collect specifications of CNC machines and tools.
f. Prepare power point presentation or animation for understanding different manufacturing processes.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. Use Flash/Animations to explain various manufacturing methods.
g. Guide student(s) in undertaking micro-projects.
h. Invite expert from industry for guest lecture on advanced manufacturing methods.
i. Industrial visit to relevant manufacturing processes.

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. Select any one component of automobile for each group.
b. List the materials and manufacturing methods for the selected components.
c. Study,compare and select best suitable material and manufacturing method for the selected component.
d. Prepare sequence of operations in manufacturing of selected component.
e. Select relevant surface finishing process for the manufactured component.
f. Engrave student name on a flat work piece using end mill.
g. Collect information on special attachments used in CNC machine like Automatic tool changer etc.
h. Prepare a report on how to select machining parameters for Aluminum, Mild steel, Stainless steel and Nickel materials.
i. Prepare a list of domestic and industrial components on which Lapping, honing, buffing, polishing, Electroplating, Galvanizing, metal spraying and powder coating are performed. For each process collect information about the material, machines and other resources required. Also prepare list of industries in your state doing these processes.
j. Survey nearby welding/fabrication shops and prepare a report on the type of welding performed, machine devices used, filler and fluxes used, metal welded. Compare the Arc welding machine used for Mild steel and Stainless steel.
k. Visit a Industry/workshop to observe the process like seam, spot, TIG and MIG welding. Collect information on these machines, their specification and observe these processes critically to get information regarding various accessories (electrodes, current rating etc.) used in these processes.
l. Visit an industry where the operation like drop forging, rolling and extrusion are carried out. Collect information on types these machines, their specification and observe various activities performed and characteristics of output product.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Elements of Workshop Technology Vol. I and Vol. II	Hajra, Choudhury S.K. Hajra,	Media Promotors, Mumbai, 2010 Vol I-ISBN: 9788185099149 Vol II-ISBN: 9788185099156

S. No.	Title of Book	Author	Publication
		Choudhury A.K.	
2	Production technology	Sharma, P.C.	S. Chand, Mumbai, 2006 ISBN: 9788121911146
3	A Course in Workshop Technology, Vol. I and Vol. II	Raghuvanshi, B. S.	Dhanpat Rai and Company, New Delhi, 2015, Vol I-ISBN: 123456 7144613, Vol II-ISBN: 123456 7144375
4	CNC machines programming and applications	Pabla, Aditan	New age International Publication, New Delhi, 2012, ISBN:9788122434262
5	CAD/CAM Principles and applications	Rao, P.N.	McGraw-Hill Publishing Co. Ltd, New Delhi, 2012, ISBN:9780070681934
6	CAD/CAM/CAE	Chougule, N. K.	Scietech, Chennai, 2009 ISBN:9788183711753

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.mechanicalengineeringprojects.net/
b. www.npkauto.com/notes
c. http://www.nptelvideos.in/2012/12/physics-of-materials.html
d. http://gen.lib.rus.ec/search.php?req=automobile&open=0&res=25&view=simple&phrase=0&column=def
e. bookzz.org/automobile manufacturing processes

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Advanced Automobile Engines**

Course Code : **22440**

1. RATIONALE

This is a technology course. This course forms the basis for the Vehicle Systems Maintenance. Contemporary automotive vehicles have advanced technology for engine systems. Hence this course is essential for an auto technician. This course will enable the students in understanding procedure of inspection and maintenance of various types of engine systems, diagnosis of engines and other systems.

2. COMPETENCY

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

- **Maintain different types of Petrol and Diesel automotive engines.**

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 factors responsible for abnormal combustion.
b. Use diagnostic equipment to test and diagnose MPFI and CRDI engine systems.
c. Select fuel and alternative energy option for given engine.
d. Maintain gaseous fuel supply system of an engine.
e. Use advanced technological information for marketing a vehicle.
f. Tune I.C. engine to meet emission norms.

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
4	-	2	6	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*

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.

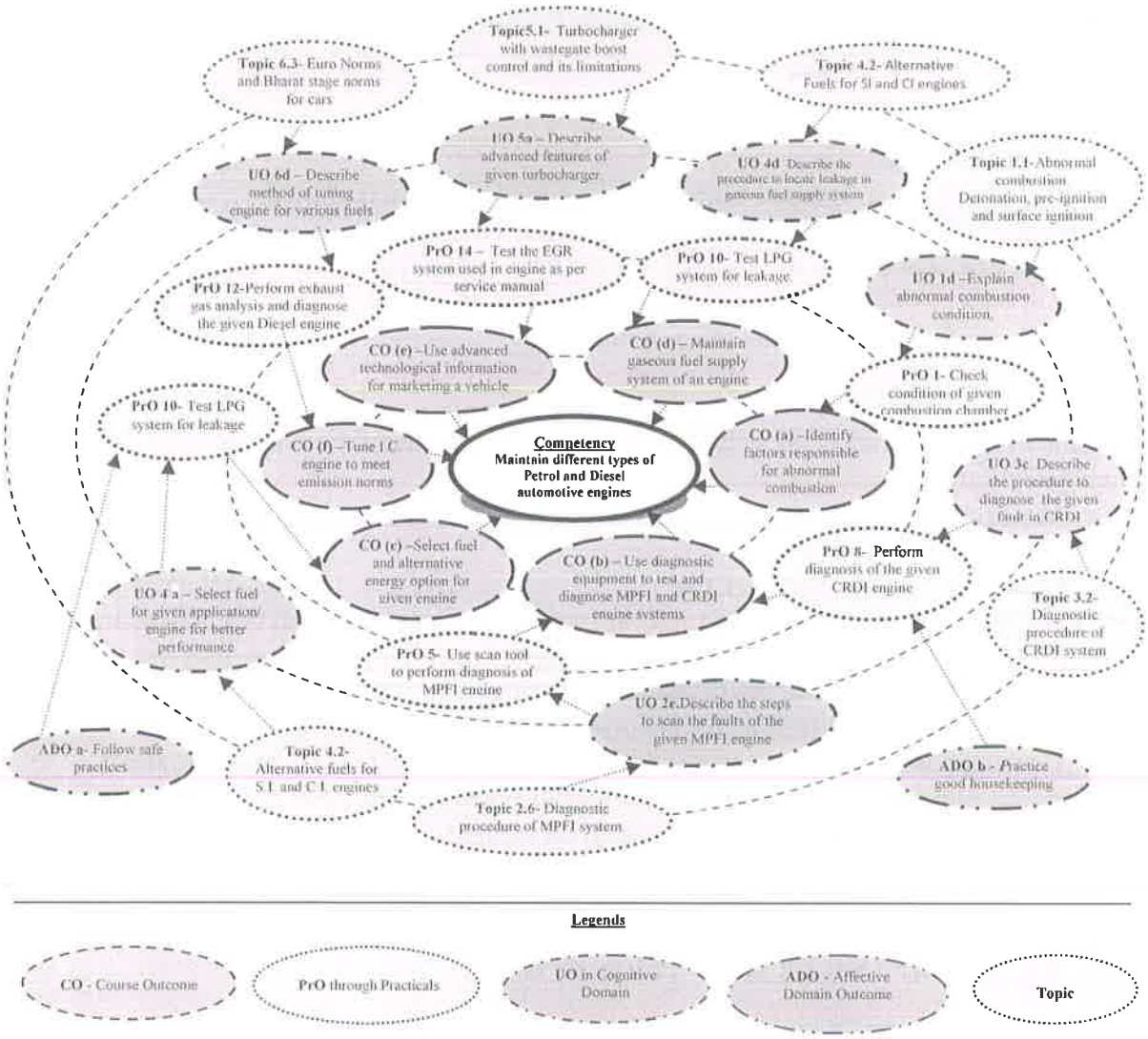

Figure 1 - Course Map

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.	Check condition of given combustion chamber of a multicylinder S.I. Engine.	I	02*
2.	Check given combustion chamber of a multicylinder C.I. Engine for valve leakage and deposits.	I	02*
3.	Perform diagnosis of the identified sensor in the given MPFI engine.	II	
4.	Dismantle and assemble electrical fuel feed pump of the given MPFI	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	System.		
5.	Use scan tool to perform diagnosis of MPFI engine.	II	02*
6.	Perform diagnosis of the given MPFI engine as per service manual.	II	02*
7.	Identify the components of the given Common Rail Direct Injection (CRDI) System.	III	02*
8.	Perform diagnosis of the given CRDI engine.	III	02*
9.	Perform maintenance of the given CRDI engine as per manufacturer's service manual.	III	02*
10.	Test the given LPG system for leakage.	IV	02*
11.	Perform exhaust gas analysis and diagnose the given S.I. engine condition using Exhaust gas analyzer.	VI	02*
12.	Perform exhaust gas analysis and diagnose the given Diesel engine condition. (Part I)	VI	02
13.	Perform exhaust gas analysis and diagnose the given Diesel engine condition. (Part II)	VI	02
14.	Test the EGR system used in an engine as per service manual.	VI	02*
15.	Test the PCV system used in an engine as per service manual.	VI	02*
16.	Test Exhaust-Gas recirculation valve.	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, out of which, the practicals marked as '' 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 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 safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment

f. 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	Four-stroke S.I. and C.I. engines: Make: Maruti/ Greaves Cotton/ Tata and alike, Power: 25 KW to 100 KW, Cubic Capacity: 800 CC to 2500CC	1,2
2	Multiport Fuel Injection engine with sensors, actuators and Electronic Control Module, Exhaust Gas Regulation valve and Positive Crankcase Ventilation valve; Make: Maruti/ Tata/ Ford/ Honda/ Hindustan Motors and alike Power: 25 KW @ 5000 rpm to 55KW@ 5000 rpm, Cubic Capacity: 800 CC to 2000 CC	3,4,5,6, 14,15
3	Scan tool: Make: BOSCH and alike; On Board Diagnostics (OBD) IInd Generation Scan Tool, Controller area network enabled, Colour Display, Operating Temperature: 0 to 50°C, Internal Storage: 4 AAA batteries, External Power: 7 to 18 volts; Generic tool; Accessories: Extender cable, OBD II Cable; Relevant optional accessories;	5,6,8
4	Digital Multimeter: LCD Display, 0 to 50°C Operating Temperature, DC voltage- 200mV to 1000 V DC, 2 to 1000 V Alternating Current, Current: 2mA to 20 A DC, Diode Test,Continuity Test- Audible buzzer, Resistance: 200 Ω to 200 MΩ; Accessories: Test leads, Current Clamp 300 A, Current Clamp Adapter.	5,6,8
5	Direct Current Clamp meter: Make: MECO/ FLUKE and álike, Current measurement – 400 Amperes DC / AC.	5,6,8
6	Tachometer: Make: MEXTECH/ KUSAM- MECO; Non contact or contact type, Speed range: upto 20000 rpm	5,6,8
7	Timing Gun: Make: ESEL/ ASAL/ Kennedy and alike; Ignition Advance: 0 to 45°, 12V DC system, Reverse polarity protection, Bright flash for daylight use	5,6,8
8	Common Rail Direct Injection Engine with sensors, actuators and Electronic Control Module: Make: Fiat/ Hyundai/ Tata/ Honda and alike; Cubic Capacity:1300 cc to 2200 cc ; Power: 55 KW to 100 KW @ 4000 rpm.	7,8,9
9	A car equipped with Liquified Petroleum Gas/ Compressed Natural Gas fuel supply system; Make: Maruti/ Hyundai; Power: 26 KW to 41KW; Cubic	10,11

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Capacity: 800cc; Fuel: LPG/ Petrol; Make: Maruti; Power: 40 KW to 65 KW ; Cubic capacity: 800 to 1350 cc; Fuel : CNG	
10	Exhaust Gas analyzer: ARAI Approved Device with relevant accessories; Measurement Range: CO- 0 to 10 %, HC- 0 to 10000 ppm, CO2- 0 to 20 %, O2- 0 to 25 %, A/F ratio- 7.35 to 29.40, Lambda- 0.500% to 2.000 % .	12,13

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs 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 Engine combustion	1a. Describe stages of combustion in the given I.C. Engine. 1b. Compare S.I. and C.I. engines on the basis of given parameters with justification. 1c. Select a combustion chamber for the given I.C. engine with justification. 1d. Explain abnormal combustion condition, its control and effects in the given engine. 1e. Identify factors responsible for abnormal combustion in the given engine.	1.1 Combustion in S.I. Engines i. Ignition limits ii. Stages of combustion in SI engine iii. Abnormal combustion: Detonation, pre-ignition, and surface ignition. iv. Effects of detonation and Control of detonation. 1.2 SI engine combustion Chambers: Wedge type, Inverted bath tub and Hemispherical combustion chambers. 1.3 Combustion in CI engine i. Stages of CI engine combustion. ii. Air Fuel ratio in Diesel engines iii. Diesel knock and its control. iv. CI engine combustion chambers.: DI and IDI combustion chambers. v. SI and CI engines on the basis of thermodynamic and operating variables, performance characteristics.
Unit-II Computer controlled Petrol engines	2a. Explain the construction and working of given Fuel injection system. 2b. Explain function and location of sensors, actuators and ECM of the given MPFI engine. 2c. Explain the working of the given pressure regulators and fuel injector. 2d. Describe the steps to scan the faults of the given MPFI engine	2.1 Drawbacks of carbureted (SI) engines: Fuel distribution, Emission, Drivability, Power out- put, Fuel consumption, Air fuel ratio. 2.2 Throttle body injection (TBI) and Port fuel injection (PFI) systems; Methods of fuel Injection: Sequential, Continuous, grouped, simultaneous injection. 2.3 Sensors and Actuators of MPFI engine. 2.4 Pressure regulators, fuel injector, and fuel pump. 2.5 Electronic Control Module: Input and output control functions as fuel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		injection, idle speed control, EGR, canister purge. 2.6 Diagnostic procedure of MPFI system: Use of Scan tool and reading fault codes
Unit– III Computer Controlled Diesel Engines	3a. Prepare block diagram of the given CRDI system and label the given components 3b. Describe operation of the given component of CRDI system with the help of schematic sketch/ circuit diagram. 3c. Describe the manufacturer's diagnostic procedure to diagnose the given fault in CRDI system using scan tools 3d. Interpret the given fault codes for the CRDI engine.	3.1 Features of Common rail direct injection system (CRDI): i. Major Components- Solenoid operated Fuel injector, High pressure fuel pump, High pressure accumulator. Introduction to Piezo injector. ii. Block diagram of Electronic diesel control unit (EDC). iii. CRDI System operation and advantages. 3.2 Diagnostic procedure of CRDI system;Use of Scan tool and reading fault codes 3.3 Diesel Engine Glow plugs: Construction, Circuit and operation of glow plug
Unit– IV Fuels and Alternative Energy Options for Automobile Engines	4a. Select fuel for the given application/ engine for better performance. 4b. Select alternative energy option for given application / engine for better performance. 4c. Construct fuel supply system layout for given fuel. 4d. Describe the procedure to locate leakage in gaseous fuel supply system of the given type of engine.	4.1 Properties of various fuels used in IC engines- Gasoline, Diesel, LPG, CNG, Hydrogen, Alcohol, Bio diesel. Fuels used in modern vehicles. 4.2 Alternative Fuels for SI and CI engines- i. LPG, CNG, Alcohol, Bio- diesel (Merits and demerits with respect to performance and emission) ii. LPG and CNG conversion kit block diagram. Leak detection procedure. 4.3 Electric cars and hybrid vehicles – need, advantages, limitations and working with block diagram
Unit –V Advances in Automobile Engines	5a. Describe advanced features of the given turbocharger. 5b. Select the engine with technology/ features suitable for the given application 5c. Compare the salient features of the given turbochargers. 5d. Compare the salient features of the given injection engine.	5.1 Turbocharger with wastegate boost control and its limitations 5.2 Variable Geometric Turbocharger (VGT) 5.3 Variable Valve Timing mechanism (VVT). 5.4 Gasoline Direct Injection (GDI) and Stratified-charge injection.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –VI Fuel Economy, Air pollution and Emission control	6a. Describe the properties of the exhaust emission for the given engine and the given fuel. 6b. Describe methods of emission control for the given engine. 6c. Describe Bharat Stage (BS) norms and Euro norms for given cars and two-wheelers. 6d. Describe emission control norms of the given engine based on prevailing norms.	6.1 Fuel economy and Air pollution i. Methods of improving fuel economy. ii. Pollutants from gasoline engines. iii. Gasoline engine emission control - engine design modification, treatment of exhaust gas, fuel modification. iv. Diesel emission, Diesel smoke and control 6.2 Emission control i. Exhaust-Gas recirculation (EGR) – EGR valve and control system ii. Positive crankcase ventilation (PCV) system iii. Evaporation emission control system 6.3 Euro Norms and Bharat stage Norms for cars.

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	Engine combustion	12	4	4	4	12
II	Computer controlled Petrol engines	16	4	4	8	16
III	Computer controlled Diesel engines	12	-	4	8	12
IV	Fuels and alternative energy options for automobile engines	8	4	4	4	12
V	Advances in automobile engines	6	-	4	-	4
VI	Fuel economy, air pollution and emission control	10	-	6	8	14
Total		**64**	12	**26**	**32**	**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. Observe videos relevant to practical task. Prepare a list of appropriate tool/ equipment considering its range/ application. For following applications, tools should be listed:
   i. Cylinder head dismantling, combustion chamber scrapping, spark plug checking, fit between valve guide and valve stem.
   ii. Electric fuel pump dismantling and assembly tools.
   iii. Diagnostic tools for MPFI engine
   iv. Diagnostic tools for CRDI engine
   v. LPG/ CNG leak detection tools
   vi. Exhaust gas analysis and engine tuning
   vii. EGR valve service procedure
   viii. PCV valve service procedure
b. Refer I.C. engine service manual/s during/before practicals. Follow relevant safety precautions. Carry out Library / Internet survey of maintenance procedures and operation of engine systems.
c. Prepare power point presentation or animation for understanding different components/ aggregates and systems.
d. Visit a modern garage to observe testing of EGR, PCV and observation of catalytic converter.
e. Visit https://www.youtube.com/watch?v=60P3aCNPtjk link for Throttle Body Injection system. Note your observations regarding relevant parameters like Injection pressure, Injector location, operation under different conditions.
f. Collect videos relevant to MPFI, GDI, CRDI, Catalytic converter, PCV, EGR, Hybrid vehicles and Electric vehicle operation. Note your observations as regards to specifications, service data, precautions and preventive measures to be taken for trouble free operation.
g. Select an I.C. engine for a car application: Consider requirements of a customer. Select an engine among the available engines, with relevant features and advanced technology to suit particular application. Recommend an engine to the customer and justify your choice.

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. ***'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. Guide student(s) in undertaking micro-projects.

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. **S.I. engine combustion chamber comparison**: Visit a modern garage/ internet source. Observe combustion chamber of an engine. Refer manufacturer's workshop manual for engine specifications. Use internet/ other sources to compare the combustion chamber design with other designs. Sketch the same. Prepare a report.
b. **C.I. engine combustion chamber comparison**: Visit a modern garage/ internet source. Observe combustion chamber of an engine. Refer manufacturer's workshop manual for engine specifications. Use internet/ other sources to compare the combustion chamber design with other designs. Sketch the same. Prepare a report.
c. **Maintenance of LPG kit**: Visit a dealer/ Internet source to observe LPG/ CNG kit fitment procedure. List troubles arising in the same. Prepare a table containing Symptoms causes and remedies for the troubles. Prepare a list of precaustions to taken while using it during normal use and in event of leakage. Prepare a report.
d. **Maintenance of CNG kit**: Visit a dealer/ Internet source to observe LPG/ CNG kit fitment procedure. List troubles arising in the same. Prepare a table containing Symptoms causes and remedies for the troubles. Prepare a list of precaustions to taken while using it during normal use and in event of leakage. Prepare a report.
e. **Diagnosis of MPFI engine systems:** Diagnose a system of an engine using scan tool/ multimeter. List out the steps of diagnosis. State limiting conditions (Range of variables like voltage, resistance, pressure temperature) for normal operation of the referred system. Prepare a report.
f. **Diagnosis of CRDI engine systems:** Diagnose a system of an engine using scan tool/ multimeter. List out the steps of diagnosis. State limiting conditions (Range of variables like voltage, resistance, pressure temperature) for normal operation of the referred system. Prepare a report.
g. **DTC Identification:** Refer Scan tool/ Internet source for diagnostic trouble codes relevant to a system of engine. List commonly observed DTCs with relevant procedures to rectify the fault and to restore the system. State the methods of erasing the trouble code. Prepare a report.
h. **Modern engine technology:** Identify a modern technology used in an engine. Collect relevant information on the technology and its features. Compare the same with older/ modern technologies adopted in other vehicles. Refer internet/ reference books/ manufacturer published literature for the same. Prepare a report.
i. **Customer Demand identification:** Visit a showroom/ modern garage to identify needs of customer as regards engine features and capabilities. Identify engine availing similar / certain features from a manufacturer. Prepare a report.
j. **Emission testing:** Visit a PUC testing center. Refer procedure of preparing the PUC tester for test. List steps in PUC test. List latest emission norms applicable to cars/ two wheelers. Test emission of a vehicle and record the same. Prepare a report.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A Course in Internal Combustion engine	Mathur M.L, Sharma R.P.	Dhanpat Rai Publication, New Delhi, 2016, ISBN 13:9789383182428
2	Internal Combustion engines	Ganeshan V.	Tata McGraw – Hill, New Delhi, 2013 ISBN 13 : 9781259006197
3	Internal Combustion engines	Haywood	Tata McGraw Hill, USA, 2013, ISBN 13: 9780070286375
4	Automotive Principles Volume –I	Knowles Don	Prentice Hall, US, New Jersey, 1988 ISBN 13: 9780130545459
5	Internal Combustion Engines	Ramalingam K.K.	SCITECH, Chennai, 2011, ISBN13: 9788183711029

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.araiindia.com/services_RnD_services_powertrain.asp
b. http://saeindia.org/magazine-mobility-engineering/
c. http://www.cirtindia.com/Safety_Homologation.html
d. http://nptel.ac.in/courses/112104026/
e. http://www.aa1car.com/common_car_problems.htm
f. https://www.youtube.com/watch?v=-rz4IcMg0Ng for combustion chamber designs
g. https://www.youtube.com/watch?v=jAqC0qxIiL8 for MPFI system
h. https://www.youtube.com/watch?v=LjJSbHxIvnM for GDI system
i. https://www.youtube.com/watch?v=KzF8ieiJ9UY for CRDI system
j. https://www.youtube.com/watch?v=M9dZUOr6n4g for camshaft and crankshaft sensor testing
k. https://www.youtube.com/watch?v= 8q6qZQJQEIU for automotive sensors and actuators
l. https://www.youtube.com/watch?v=qB8b8CCJdfg Glow plug checking video.
m. https://www.youtube.com/watch?v=RR8LsMBwL2I for Scan tool video
n. https://www.youtube.com/watch?v=NUvWnOd5lFw for Common Rail Diesel Injector Working and Common Failure Points
o. https://www.youtube.com/watch?v=ZMa0nom1iwc for cleaning a throttle body and Idle air control valve (iac)
p. https://www.youtube.com/watch?v=lnK00rtWf68 for Throttle Position sensor cleaning
q. https://www.youtube.com/watch?v=_skVHdgtMTU for Throttle Position sensor testing with or without wiring diagram
r. https://www.youtube.com/watch?v=JIa0nsrQXI0 to read car fault codes and to clear them.

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Heat Power Engineering**

Course Code : **22441**

1. RATIONALE

Heat energy is the basis for most of the power producing and power absorbing devices. In order to apply the principles of these devices, it is essential to inculcate the students with basic laws, concepts of thermodynamic processes, gas cycles, properties of steam, steam generators, steam condensers, turbines, air compressors, refergeration and air conditioning. Due to energy crunch of petroleum products worldwide hunt for alternative energy sources is being done for the last three decades. Hence students should also have comparative brief idea about various conventional non-conventional energy sources, calorific values, carbon value and evaporative power of fuels and exploration of various alternative energy sources.

2. COMPETENCY

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

- **Apply principles of thermodynamics and energy conservation techniques in equipment such as IC engine, steam-boiler/turbine/condenser and air compressor.**

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. Apply thermodynamic processes to analyse the performance of engine.
b. Select relevant fuels to control emmissions from vehicles.
c. Interpret the working of the steam related equipment.
d. Interpet relevant parameters related to the performance air compressors..
e. Evaluate the use of renewable energy sources for a sustainable environment.
f. Assess the situation for energy conservation.

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
4	-	2	6	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*

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.

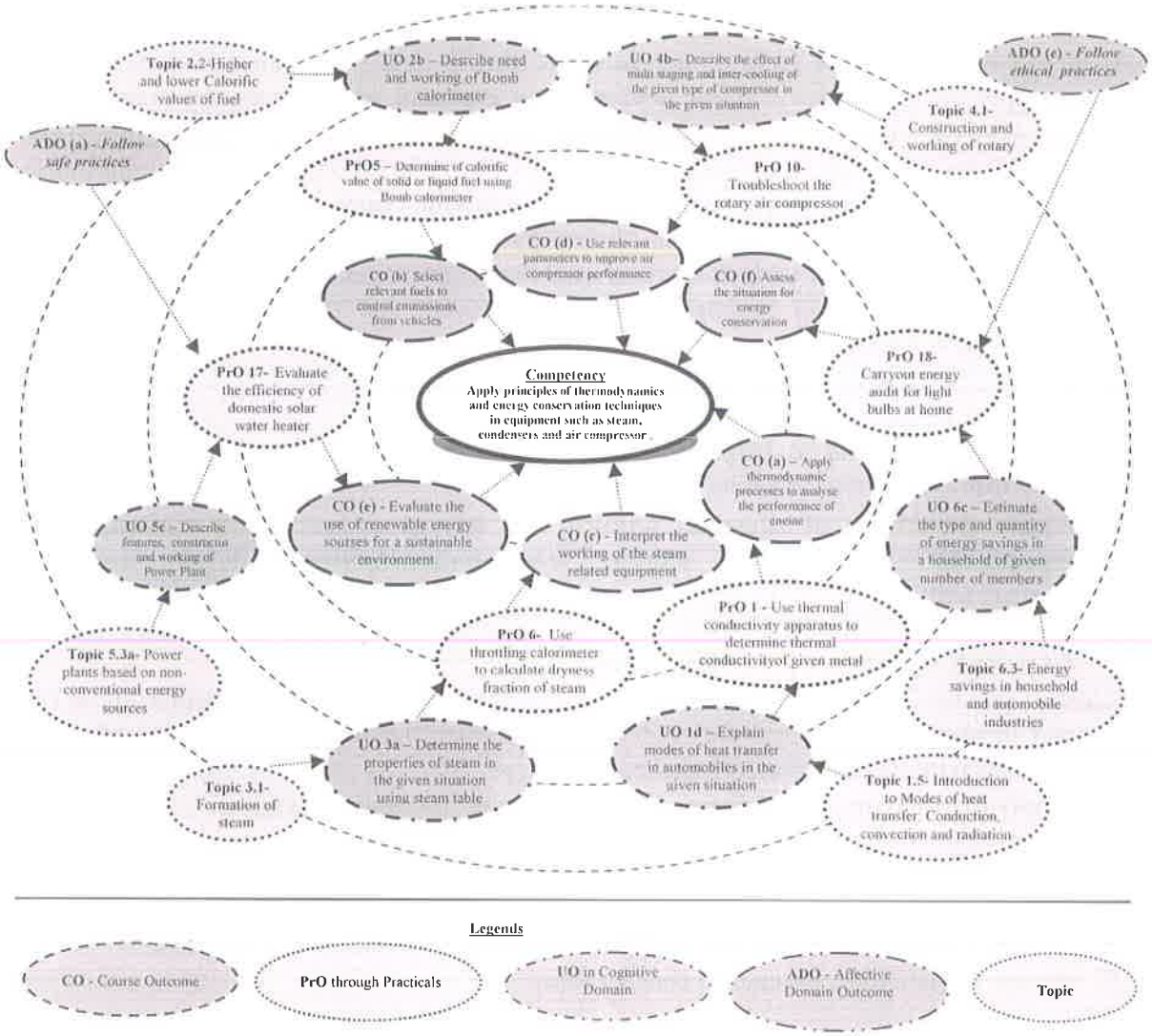

Figure 1 - Course Map

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.	Use thermal conductivity apparatus to determine thermal conductivity of the given metal rod.	I	02*
2.	Determine calorific value of solid or liquid fuel using Bomb	II	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Calorimeter.		
3.	Make a comparative study of energy efficient turbines, boilers used in industries on the basis of energy effieiency, cost, life, energy saving and saving in energy bill.	III	02
4.	Use the boiler model to trace the flue gas path and water steam circuit.	III	02*
5.	Use throttling calorimeter to calculate dryness fraction of steam.	III	02
6.	Use separating calorimeter to calculate dryness fraction of steam.	III	02
7.	Use steam turbine to calculate its power output and efficiency.	III	02
8.	Use the given condenser to calculate condenser efficiency.	III	02
9.	Dismantle the reciprocating or rotary air compressor.	IV	02*
10.	Troubleshoot the reciprocating or rotary air compressor.	IV	02
11.	Assemble the reciprocating or rotary air compressor to make bill of material.	IV	02*
12.	Determine the volumetric efficiency of single reciprocating air compressor.	IV	02
13.	Determine the volumetric efficiency of two stage reciprocating air compressor.	IV	02
14.	Determine the isothermal efficiency of single stage reciprocating air compressor.	IV	02
15.	Determine the isothermal efficiency of two stage reciprocating air compressor.	IV	02
16.	Performance measurement of photovoltaic array making use of energy instruments.	V	02
17.	Evaluate the efficiency of domestic solar water heater.	V	02*
18.	Carryout energy audit for light bulbs at institute/ house/industry.	VI	02*
	Total		**35**

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, out of which, the practicals marked as '' 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 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 safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. 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	Air compressor test rig.	7 to 9
2	Domestic solar water heater: Either small 10-25 liters per day working model or commercial 100 liters per day model along with temp gauges fitted at various locations.	12
3	Bomb calorimeter: 300 ml capacity and as per the requirement of IP 12/63 T of institute of petroleum codes.	15
4	Thermal conductivity apparatus	1

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 Thermodynamic systems and their applications.	1a. Apply relevant laws of thermodynamics in the given situation. 1b. Compare the processes of the ideal gas in the given situation. 1c. Interpret the processes of the given gas cycles. 1d. Explain modes of heat transfer in automobiles in	1.1 Thermodynamic systems, Classification of thermodynamic systems, Properties of system, State of system, thermodynamic process and cycles. 1.2 Laws of Thermodynamics- Zeroth Law, law of conservation of energy, First law of Thermodynamics, Second Law of Thermodynamics- Kelvin Planks, Clausius statements. 1.3 Represent Isobaric, Isochoric

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	the given situation.	Isothermal, Adiabatic and polytrophic processes on P-V and T-S diagram, formulae of work done, change in internal energy and change in enthalpy.(simple numericals on above processes) 1.4 Air cycles: P-V,T-S diagram and equations for air standard efficiency of Carnot, Otto, Diesel and Dual combustion cycle. 1.5 Introduction to Modes of heat transfer: Conduction, convection and radiation.
Unit –II Fuels and Combustion	2a. Describe minimum requirements of fuel for the given situation. 2b. Calculate different calorific values of fuels using the specified calorimeter. 2c. Describe the working of the Bomb calorimeter. 2d. Calculate minimum air required for complete combustion of fuel in the given situation. 2e. Estimate the contents of fuel using the given type of analysis.	2.1 Types of fuels – Definition, classification, properties, Calorific value of fuels.Ultimate analysis and proximate analysis of solid fuels. Liquid fuels- Comparative information about composition, specific gravity and gross calorific values of liquid fuel. Gaseous fuels- natural, LPG, CNG, and other artificially prepared gaseous fuels. 2.2 Higher and lower Calorific values of fuel and it's estimation, carbon value, evaporative power of fuel. Dulong's formula, construction and working of Bomb calorimeter. 2.3 Combustion of fuels – combustion chemistry of carbon, hydrogen and methane. Mass of air required for complete combustion of fuel, excess air.
Unit-III Steam and Steam Power	3a. Determine the properties of steam in the given situation using steam table. 3b. Identify specified components of the given chart/sketch of the given type of boiler 3c. Represent the steam path and the flue gases in the given situation using the relevant sketch. 3d. Calculate efficient use of heat energy stored in the steam into mechanical work for the given data. 3e. Describe the effect of air	3.1 Formation of steam at constant pressure with representation on various charts such as T-S, H-S. Properties of steam and use of steam table, Dryness fraction, Degree of superheat. 3.2 Steam Boilers: Classification, construction and working of Fire-tube and water-tube boiler. 3.3 Steam turbine: Classification of turbines, construction and working of Impulse and Reaction turbine. 3.4 Steam condenser: Function, locations in steam power plant, construction and working of two pass down flow Surface condenser, condenser efficiency and sources of air leakage in condenser.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	leakages in a condenser in a given situation. 3f. Prepare the report using the provisions of Indian boiler act with reference to duties of the given personnnel.	
Unit– IV Air compressors	4a. Compare given types of compressors based on the given parameters. 4b. Describe the effect of multi staging and inter-cooling of the given type of compressor in the given situation. 4c. Calculate the efficiencies and work done in the given situation and given data. 4d. Describe the applications of compressed air in the given type of automobile engines.	4.1 Classification of air compressor - Construction and working of single stage and two stage reciprocating air compressors with P-V. diagram. Necessity of multi-staging and inter cooling. Construction and working of rotary compressors i) Centrifugal compressor ii) Axial flow compressor iii) Screw compressor, Comparison of various compressors. 4.2 Overview of air compressor terminologies: i) Free air delivered, ii) Capacity of Compressor, iii) Piston displacement, iv) I. P., v) B. P., vi) Volumetric efficiency, vii) Isothermal efficiency, viii) Overall Isothermal or Compressor efficiency. Factors affecting volumetric Efficiency of reciprocating air compressors.
Unit – V Renewable Energy and environment	5a. Describe the strengths and limitations of the specified renewable energy in relation to human aspects of the environment. 5b. Describe the potential value of the specified renewable energy in India and the government policy for its harness . 5c. Estimate the efficiency of the specified solar energy system.	5.1 Strengths and limitations of solar energy, Wind power, biomass power, ocean energy and Geo-thermal energy in relation to human aspects of the environment. 5.2 Potential power of the above in India and government policy (MNRE) for harnessing of the above renewable energies 5.3 Solar energy: a. Power saved due to solar water heating, b. Power saved by solar lighting methods, c. Power saved due to concentrated solar power d. Power saved due to electricity generation through photovoltaic system.
Unit – VI Energy conservation and audit.	6a Identify the energy losses and wastage in given situation. 6b Suggest the energy conservation techniques in given sector.	6.1 Energy conservation: Definition, Importance of energy conservation, Impact on environment and economy. 6.2 Energy Audit: Energy flow diagram and its significance, Energy audit instruments and their use, Energy audit procedures.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	6c Estimate the type and quantity of energy savings in a household of given number of members. 6d Sketch energy flow diagram for given sector. 6e Suggest the suitable instrument for energy audit for given situation of plant.	6.3 Energy savings in household and automobile industries. 6.4 Energy conservation by cogeneration: Definition, need for cogeneration, classification on the basis of : sequence of energy use, technology 6.5 Factors governing the selection of cogeneration system, Advantages of cogeneration.

***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	Thermodynamic systems and their Applications.	14	02	06	06	14
II	Fuels and Combustion	10	02	04	04	10
III	Steam and Steam Power.	12	02	06	06	14
IV	Air compressors	12	02	06	04	12
V	Renewable Energy and Environment	08	02	06	04	12
VI	Energy Conservation and Energy Audit	08	---	04	04	08
Total		**64**	**10**	**32**	**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 journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various meters to test electric/electronic equipment and component.
d. Library / Internet survey of electrical circuits and network
e. Prepare power point presentation or animation for understanding different circuits behavior.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. Use Flash/Animations to explain various theorems in circuit analysis
g. Guide student(s) in undertaking micro-projects

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. Visit to any industry where boiler is installed with reference to observations of locations of boiler, mountings like safety valve and pressure gauge and boiler accessories like a) economizer b) super-heater. Prepare report containing specifications of boiler, mountings and accessories with their sketches and functions, and also make scale model of any one.
b. Visit to cogeneration plant of sugar factory or any other thermal power plant with reference to observation of components, path of steam, minimum and maximum r.p.m., governing, bleeding and maintenance schedule of steam turbine. Prepare report containing specifications of turbine, path of the steam, maximum and minimum r.p.m., governing, bleeding and maintenance schedule of steam turbine from collected data of visit, and make model of any power plant.
c. Build a solar water heater.
d. Build a parabolic solar dish.
e. Build a parabolic solar trough.
f. Visit to solar power plant with reference to the observations of components and their specifications. Prepare a report containing specifications of collector, generation capacity, maintenance schedule and make working model based on solar energy e.g.: (Solar car, solar robot, solar battery charger, solar boat, solar toys, solar inverter etc.)
g. Visit a wind power plant to study the various features containing specification, materials, operating speed range, wind speed data, locking mechanism, protective

coatings and efficiency. Prepare a report containing specification, materials, operating speed range, wind speed data, locking mechanism, protective coatings and efficiency for a wind mill, and make working model of wind mill.

h. Collect information about global and indian energy market from the websites and prepare the reports.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A text book of Thermal Engineering	Khurmi R.S., Gupta J.K.	S.Chand and Co., New Delhi, 2005 ISBN: 978-81-219-2573-0
2	Thermal Engineering	Kulshrestha S.K.	Vikas Publishing house Pvt.ltd, New Delhi, 2001, ISBN: 9780706977585
3	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2015
4	A Course in Thermal Engineering	Domkundwar S., Kothandaraman. C.P.; Domkundwar A.V.	Dhanpat Rai & co.(P) Ltd, New Delhi 2004. ISBN 13: 9788177000214
5	Thermodynamics An Engineering Approach	Cengel Yunus A. & Boles Michael A.	McGraw-Hill companies, Avenue of the Americas, New York, NY 10020. 2008 ISBN: 978-0-07-352932-5
6	Thermal Engineering	Sarkar B.K.	McGraw Hill Education pvt. Ltd, New Delhi, 2004; ISBN 13: 9780074633632
7	Thermal Engineering	Rajput R.K.	Laxmi Publications; New Delhi, 2017 ISBN-13: 978-8131808047

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
b. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf
c. http://mnre.gov.in/schemes/grid-connected/solar/
d. http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
e. http://mnre.gov.in/schemes/grid-connected/biomass-gasification/
f. http://mnre.gov.in/schemes/grid-connected/biogas/
g. http://mnre.gov.in/schemes/new-technologies/biofuels/
h. http://mnre.gov.in/schemes/grid-connected/small-hydro/
i. http://mnre.gov.in/schemes/new-technologies/geothermal/
j. http://mnre.gov.in/schemes/new-technologies/tidal-energy/
k. http://mnre.gov.in/schemes/new-technologies/hydrogen-energy/
l. www.livescience.com/50776-thermodynamics.html
m. www.youtube.com/thermodynamic-laws
n. www.nptelvideos.in/2012/12/basic-thermodynamics.html
o. www.learnerstv.com/Free-Engineering-Video-lectures-ltv301-Page1.htm
p. www.teachertube.com/video/renewable-and-non-renewable-resources-342237
q. www.directindustry.com/industrial-manufacturer/steam-generator-132382.html

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Automobile Systems and Body Engineering**

Course Code : **22442**

1. RATIONALE

This is Core Technology course of Automobile Engineering programme. Apart from engine and transmission system automobile chassis includes control systems such as steering, braking and suspension. This course provides the knowledge of automobile control systems and body which forms basis for learning automobile component design and vehicle maintenance courses. This course will help the students for analyzing the performance of automobile during inspection, installation, operation and maintenance.

2. COMPETENCY

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

- **Select relevant automobile control system parts and vehicle bodies.**

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. Select relevant steering gear-boxes and linkages for different vehicles.
b. Select suitable braking system and elements for different types of vehicles.
c. Select relevant suspension system for different types of vehicles.
d. Select relevant materials for components used in manufacturing of vehicle bodies.
e. Select relevant car air conditioning systems for human comfort.
f. Test the on-road performance of different types of vehicles.

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
4	-	2	6	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*

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.

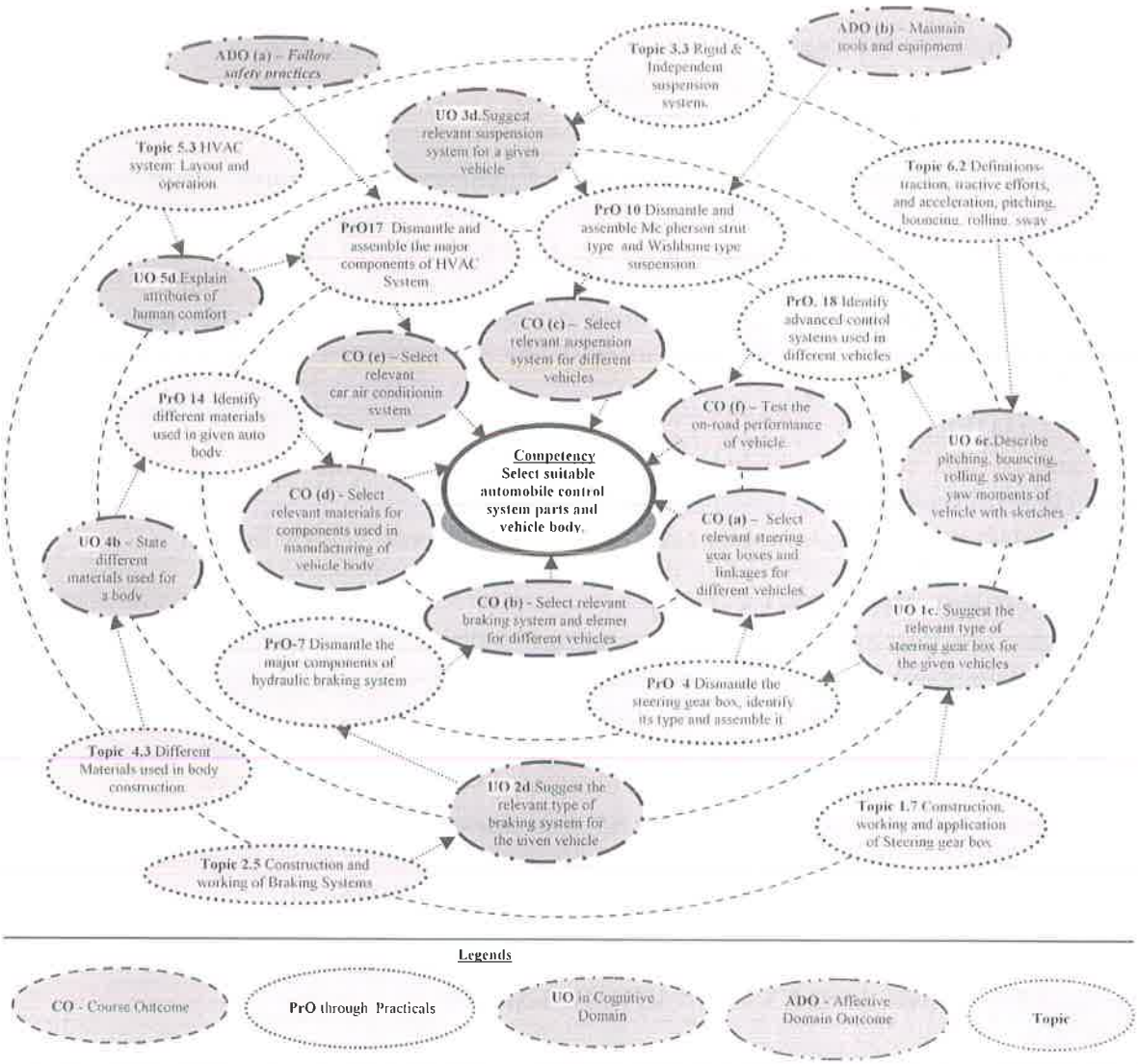

Figure 1 - Course Map

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	Identify the parts of a given type of steering system linkages.	I	01*
2	Identify the components of power steering.	I	01*
3	Identify the parts of the Front Axles arrangement.	I	02
4	Dismantle the steering gear box, identify its type and assemble it.	I	02*
5	Dismantle the front wheel from the axle.	I	02
6	Measure and analyze steering geometry parameters in given vehicle.	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Dismantle the major components of hydraulic braking system and assemble it.	II	02*
8	Dismantle and assemble the components of Air braking system/vacuum assisted braking system.	II	02
9	Dismantle and assemble the components of disc brake.	II	02
10	Dismantle and assemble Mc pherson strut type suspension and Wishbone type suspension.	III	02
11	Dismantle and assemble semi elliptical leaf spring type rigid axle suspension system.	III	02*
12	Dismantle and assemble telescopic type hydraulic shock absorber.	III	02
13	Identify the type of relevant auto bodies according to purpose.	IV	01*
14	Identify different materials used in the given auto body.	IV	01
15	Identify safety devices used in a given vehicle.	IV	02*
16	Identify tools and equipment required for painting and denting.	IV	02
17	Identify the components of Heating, Ventilation and Air Conditioning system of the given vehicle.	V	02*
18	Identify advanced control systems used in different vehicles.	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, out of which, the practicals marked as '' 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 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 safe practices
b. Practice good housekeeping
c. Practice energy conservation
d. Demonstrate working as a leader/a team member
e. Maintain tools and equipment
f. 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.

Sr No.	Equipment Name with Broad Specifications	PrO. No.
1	**Demonstration model of automotive steering system.** Cut section working model of steering of jeep/car with stub axle. The model shoud be made out of full size original used parts, suitably sectioned and arranged to demonstrate the internal construction details such as steering gear box, bell assembly, tie rod, linkages, stub axle and working of the same can be shown by steering the steering wheel provided. The entire model is mounted on a sturdy iron frame and be suitably painted.	1 , 2
2	**Different types of steering gear boxes-** Rack and pinion, Recirculating ball and nut type, Worm and roller type; Full size original used above mentioned types of gear boxes of any Car/LMV/HCV in good working condition, mounted on powder coated M.S.stand.	4
3	**Front axle of LMV, HMV, transaxle of FWD car.** Full size original front axles of above mentioned vehicles of Make Mahindra/TATA/ Ashok Leyland/ Maruti or alike in good working condition, mounted on powder coated M.S.stand.	2
4	**Demonstration model of front wheel assembly of car/heavy motor vehicle**. Cut section model made out of original used parts of car/heavy motor vehicle, suitably sectioned and arranged to demonstrate the internal construction details showing the minute information with suspension strut with spring and shock absorber, disc brake, calliper, wishbone drive shaft etc. , and working of the same can be shown. The entire model is mounted on a sturdy powder coated M.S.frame.	5
5	Demonstration model of power assisted steering.(Hydraulic/Electric) The complete working model of Hydraulic/Electric power assisted steering system made out of new/used original parts of Car/LMV/HCVand suitably mounted on powder coated M.S. stand and working of the same can be shown.	3
6	**Running model of car/jeep.** Original full size used car or Jeep in good working condition of make Maruti/TATA/Mahindra or alike.	6,15,18
7	**Working model of hydraulic braking system and its components.** The model made out of Used TATA Indica brake aggregates which will be suitably sectioned, Left Front disc and Left rear drum will be made working using necessary hydraulic connection from the Master cylinder. By operating	7

Sr No.	Equipment Name with Broad Specifications	PrO. No.
	the brake pedal connected to the Master cylinder through booster, the functioning of disc and drum brake can be demonstrated. The aggregates on the other side will be suitably sectioned to show the internal details and will be kept dummy. All the aggregates should be paint finished. The entire setup will be mounted on a sturdy iron frame.	
8	**Working model of air braking and its components.** The model made out of original parts such as Air compressor, Unloader valve, foot valve, Booster, Wheel assembly, air tank, control valve etc The Brake system will be fitted with two front wheel assembly complete (with out axle) and the drum will be suitably sectioned to show the working of the brake shoe. Other system will be mounted as it is and will be made to function (foot brake, hand brake etc will be functional). The entire system will be mounted on a sturdy iron frame. A F.H.P Single phase220/230 V AC motor will be coupled to the compressor for generation of the air, which is used for the operation of the model.	8
9	**Working model of vacuum assisted braking system and its components** TATA, LEYLAND, MAHINDRA any other reputed automobile manafacturer.	8
10	**Disc brake assembly.** The Model made out of Orginal parts such as Two Brake disc, two Caliper assembly (one sectioned), two master cylinder (one sectioned) etc, the model is mounted on a sturdy iron frame and can be demonstrated by operating the lever provided.	9
11	**Suspension systems - Mac-pherson, wishbone, leaf spring.** Mac-pherson suspension- Cut section model of compelete both side macpherson suspension strut with drive shaft, disk brake.This model is made out of original used parts, will be suitably sectioned And Arranged to demonstrate the internal construction details showing the minute information With Suspension Strut with spring and shock absorber, disc brake, calipers, drive shaft etc., and working of the same can be shown, the model will be suitably painted and The entire model is mounted on a sturdy iron frame. Wishbone Suspension - Cut section model of compelete both side with double wishbone suspension with drive shaft. This model is made out of original used parts, will be suitably sectioned And Arranged to demonstrate the internal construction details showing the minute information With Suspension Strut with spring and shock absorber, disc brake, calipers drive shaft etc., and working of the same can be shown, the model will be suitably painted and The entire model is mounted on a sturdy iron frame. Leaf Spring - Cut section model of compelete leaf spring suspension system with rear axle. This model is made out of original used parts, will be suitably sectioned And Arranged to demonstrate the internal construction details showing the minute information With leaf spring is arranged along with shock absorber etc., and working of the same can be shown, the model will be suitably painted and the entire model is mounted on a sturdy iron frame.	10,11
12	Working model of telescopic type hydraulic shock absorber. The working model of original used telescopic type hydraulic shock absorber of mounted on powder coated M.S. Stand.	12
13	Body of car/jeep. Body of used car/ Jeep of Make Maruti/ Mahindra/TATA	13,14

Sr No.	Equipment Name with Broad Specifications	PrO. No.
	etc.	
14	HVAC system- **Cut section working model of air conditioning system of a car.** This model is made out of original used parts, will be suitably sectioned and arranged to demonstrate the internal construction details showing the minute information such as AC compressor, condenser, radiator, its pipe lining, blower/fan assembly etc., the model will be suitably painted and The entire model is mounted on a sturdy iron frame.	17

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 Front Axle and Steering	1a. Identify the given types of front axle and stub axles in the given figure with justification. 1b. Name the parts of the steering geometry in the given figure. 1c. Suggest the relevant type of steering gearbox for the given vehicle(s) with justification. 1d. Explain with sketeches the working principle of the given type of power steering. 1e. Describe with sketeches the salient features of the given type of steering.	1.1 Types of front axle- Dead axle, Live axle. 1.2 Types of stub axle arrangements- Elliot, Reverse Elliot, Lamoine and Reverse Lamoine; Front wheel assembly. 1.3 Steering linkages- for the vehicle with rigid axle, independent suspension system. 1.4 Ackerman steering gear mechanism. 1.5 Steering geometry parameters: Caster, Camber, King-pin inclination, Toe in-Toe out, Correct steering angle, Understeering and Oversteering, Turning radius. 1.6 Construction, working and application of Steering gear box: Rack and pinion type, recirculating ball type and worm and roller type steering gear box. 1.7 Power assisted steering and its types (Hydraulic and electrical).
Unit-II Brakes	2a. Explain with sketches the construction and working of the given brake(s). 2b. Describe the different characteristics of the specified friction material(s) with sketches 2c. Describe the various properties of the given brake fluid. 2d. Suggest the relevant type of braking system for the given	2.1 Necessity of brakes. 2.2 Classification of brakes. 2.3 Construction and working: Disc brake and drum brake. 2.4 Friction materials and its characteristics: Brake fade, coefficient of friction, dry friction and wet friction. 2.5 Construction and working of Braking Systems: Mechanical

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	vehicle with justification.	braking system, Hydraulic Braking system, Air braking system, Vacuum assisted braking system, parking brake, Exhaust brake. 2.6 Properties of brake fluids. 2.7 Operation of Antilock braking system.
Unit– III Suspension Systems	3a. Name the components of the given automobile suspension system. 3b. Explain with sketches the construction, working and applications of the given suspension system. 3c. Describe with sketches the working of the given air suspension system with sketches. 3d. Suggest relevant suspension system for the given vehicle with justification.	3.1 Necessity of suspension system. 3.2 Classification of suspension system. 3.3 Rigid suspension system. 3.4 Independent suspension system- Front end and rear end. 3.5 Damper (Shock absorber) construction and working: Telescopic and Gas filled. 3.6 Different types of spring – Leaf spring, Coil spring, Torsion bar, Air spring, Hydrodynamic spring. 3.7 Anti roll bar or stabilizer bar. 3.8 Air Suspension System. 3.9 Linked suspension System.
Unit– IV Body Engineering and Safety Devices	4a. List the different types of auto bodies used for the given chasis. 4b. State different materials used for the given body construction with justification. 4c. List the different body accessories used for a given vehicle. 4d. Describe painting and denting procedure for the given auto body with sketches . 4e. Select glass, door and body insulation trims for the given body with justification.	4.1 Functions of auto body. 4.2 Types of Auto bodies. 4.3 Different Materials used in body construction. 4.4 Body accessories and its functions. 4.5 Protective and anticorrosive treatments, painting and denting procedure. 4.6 Streamlining of vehicle body and its effect. 4.7 Miscellaneous Body services- Interior trim and upholstery, Glass and door service, Body insulation and sealing, Exterior trim. 4.8 Safety devices – Air bags, Seat belt, Central locking, Collapsible steering, Keyless entry, Traction control, Reverse parking sensor and Rear view camera.
Unit –V Car Heating Ventilation	5a. Draw a layout of the given car air conditioning system with labeled components. 5b. Describe the layout of the given	5.1 Fundamentals of Refrigeration and air conditioning; Introduction to Vapour compression cycle. 5.2 Car Heating Ventilation and Air

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
and Air Conditioning System	HVAC system. 5c. Explain properties of the given refrigerant. 5d. Select relevant car air conditioning system for human comfort in the given vehicle with justification.	Conditioning System (HVAC): Layout and operation 5.3 Refrigerants:Types and their properties. 5.4 Human comfort conditions: Temperature control system, humidity control.
Unit –VI Vehicle Performance	6a. Describe the given resistance(s) faced by vehicles at rest and in moving conditions with sketches. 6b. Explain the following terms related to vehicle performance. 6c. Describe with sketches the pitching, bouncing, rolling, sway and yaw moments of vehicle. 6d. Explain with sketches the procedure to test on-road performance for the given vehicle.	6.1 Resistance faced by the vehicle- Air resistance , rolling resistance, gradient resistance 6.2 Definitions- traction, tractive efforts, drawbar pull, gradeability and acceleration, pitching, bouncing, rolling, sway and yaw. 6.3 Stability of vehicle on turn and slopes (No mathematical treatment).

***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	Front axle and steering	14	06	04	06	16
II	Brakes	14	02	06	06	14
III	Suspension system	10	02	04	06	12
IV	Body engineering and safety devices	12	02	08	04	14
V	Car heating, ventilation and air conditioning system	08	00	04	04	08
VI	Vehicle performance	06	04	00	02	06
Total		**64**	**16**	**26**	**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 journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various tools to remove, dismantle, assemble and refit components.
d. Library / Internet survey of automobile systems and components.
e. Prepare power point presentation or animation for understanding different automobile control systems and Body components.
f. Visit to automobile service station of heavy vehicle to observe air suspension system, air brakes, power steering system and draw layout. Write a report on it.
g. Visit to Automobile Body Building shop and Prepare a report.

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. ***'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. Guide student(s) in undertaking micro-projects.

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. **Collect the information of steering gear boxes and compare it:** Collect the information of steering gear boxes of any four vehicles from the market/internet. Compare the data and write report on the same.
b. **Collect the data of steering geometry parameters and compare them :** Collect the data of steering geometry parametes of any four different vehicles from internet/service manuals. Compare this data. Describe the effects of these parameters on vehicle performance.

c. **Develop a demonstration model of hydraulic braking system:** Develop a demonstration working model of hydraulic braking system with old used parts and describe its working .
d. **Collect information of anti lock braking system:** Prepare power point presentation and deliver a seminar.
e. **Collect different types of brake pads and brake shoes:** Collect different forms of used brake shoes and brake pads from the market. Analze their construction and materials and prepare a report on it.
f. **Collect different types of shock absorbers:** Collect different types of used shock abosrbers from the market. Analyze their use and working. Make a cut-section of any one type to know the internal parts.
g. **Collect the information of types leaf springs:** Collect the information of leaf springs from dfferent types of vehicles and compare these on the basis of load carrying capacity. Describe the purpose of helper spring alongwith its application.
h. **Collect the information of different types of auto bodies:** Collect the information of different types of auto bodies available in the market. Classify these according to their purpose and justify their use.
i. **Collect the information of types of paints and painting equipments:** Collect the information of various types paints and painting equipments used in auto body manufacturing. Write a report on it.
j. **Prepare to run a vehicle:** Analyse and check the automobile systems to prepare a vehicle for run. Apply the key, start the engine, analyze steering, clutch, gear box, brake etc. and stop the engine. Prepare a report regarding do's and don't's.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automobile Engineering	Ramlingam, K.K.	Scitech Publication, Chennai, 2011 ISBN: 9788188429486
2	Automobile Engineering	Singh, Kirpal	Standard Publication, New Delhi, 2008 ISBN 13: 9788180141034
3	Automobile Engineering	Chikara, Anil	Satya Prakashan New Delhi, 2007, ISBN-13: 9788176843515
4	Automobile Engineering	Gupta, R.B.	Satya Prakashan New Delhi, 2016 ISBN: 9788176848589
5	Automobile Mechanics	Srinivisan, S.	McGraw – Hill, New Delhi, 2003 ISBN-10: 0070494916
6	Automobile Mechanics	Crouse / Anglin.	McGraw – Hill, Dallas, TX, U.S.A , 1984, ISBN 13: 9780070148604
7	Automobile Engineering	Narang, G.B.S.	Khanna Publication, New Delhi, 2007 ISBN-13: 1234567144518
8	Automobile Technology	Giri, N.K.	Khanna Publication, New Delhi, 2009 ISBN: 9788174091789

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/107101001/
b. https://www.youtube.com/watch?v=_D_vg8gnMms&list=PLZOnML5kZsJIzots8zExy ijNjawWQ2qfy- Steering geometry
c. https://www.youtube.com/watch?v=nMQxqsyuJKE – suspension system

d. https://www.youtube.com/watch?v=Z7VBm8d8X84- Rigid axle suspension
e. https://www.youtube.com/watch?v=CzEBVdZeyQs – Hydraulic braking system
f. https://www.youtube.com/watch?v=OZ6l9J6NK5s – Air braking system
g. https://www.youtube.com/watch?v=wkznwbKnIGM – Telescopic shock absorber
h. https://www.youtube.com/watch?v=fKy9YwfLQ6U – Painting procedure of a car
i. https://www.youtube.com/watch?v=ru4JIZ-x8yo – Antilock braking system
j. https://www.youtube.com/watch?v=R4ekbB5EzZM – Air bag and seat belt operation
k. https://www.youtube.com/watch?v=nHZEAe08sE8 – HVAC system operation


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Mechanical Measurement**

Course Code : **22040**

1. RATIONALE

The art of measurement plays an important role in the development of engineering field. With advances in technology, measurement techniques have also taken rapid strides with precision, innovations, and refinements in instruments. The course aims at making an Automobile Engineering student familiar with the principles of measurements and working of instruments for automobile engineering applications.

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 relevant analog and digital measuring devices to assure quality in automobile components.**

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. Use relevant linear measuring instruments in automobile engineering situations.
b. Measure various parameters like displacement, pressure, temperature, force and sound related to automobile components.
c. Perform angular measurements on automobile components.
d. Perform measurement of various thread and gear parameters.
e. Measure various geometrical tolerances on automobile components.
f. Apply modern quality improving techniques in industrial situations.

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
1	-	2	3	--	--	--	--	--	--	--	25@	10	25~	10	50	20

*(#): No theory Exam; (~[1]): For the **practical only** courses, the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 15 marks) and micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.*

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

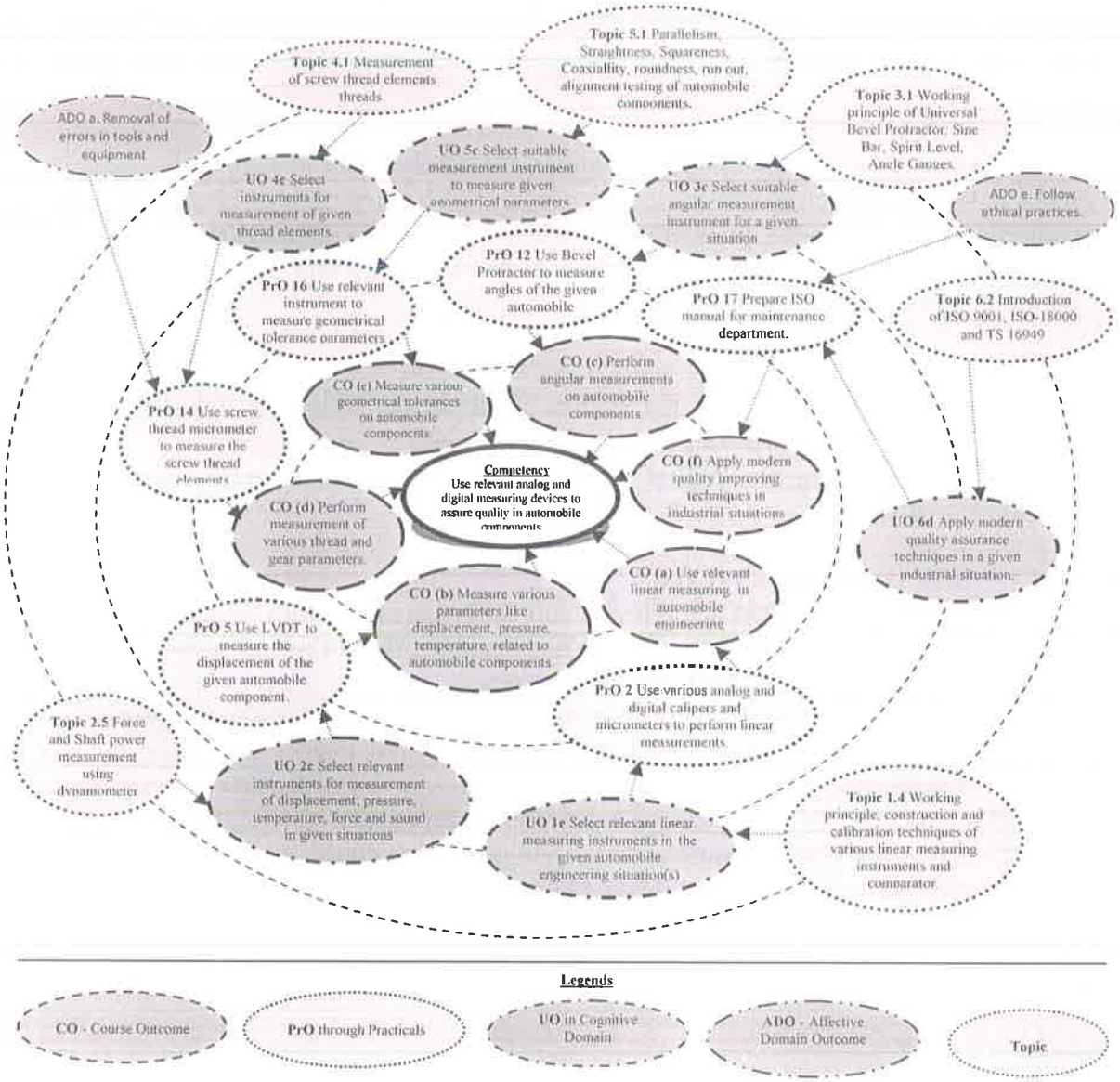

Figure 1 - Course Map

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	Use radius gauge, screw pitch gauge, feeler gauge, straight edge, plug gauge, thread gauge, thread ring gauge, adjustable snap gauge to measure relevant parameters in given automobile components.	1	02*
2	Use various analog and digital calipers and micrometers to perform	1	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	linear measurements on the given automobile components.		
3	Use dial indicator to measure the given size attribute and compare it with slip gauge as a standard to inspect the given components.	I	02
4	Use pneumatic comparator for inspection of the given size attribute of the given automobile component.	I	02
5	Use LVDT to measure the displacement of the given automobile component.	II	02
6	Use compression gauge to measure the compression and vacuum of the given cylinder.	II	02*
7	Use temperature gauge to measure the temperature of engine.	II	02
8	Use decibel meter to measure noise level in the given engine.	II	02
9	Use contact type and non contact type tachometer to measure the speed of the given engine shaft.	II	02*
10	Use dynamometer to measure the power of the given output shaft.	II	02
11	Use surface roughness measuring instruments to measure the surface roughness of the given engine components.	II	02
12	Use Bevel Protractor to measure angles of the given automobile components and verify it with Sine bar.	III	02*
13	Use Angle dekkor / autocollimator to measure the angles of the given automobile components	III	02
14	Use screw thread micrometer to measure the screw thread elements and compare the same using tool maker's microscope or optical profile projector.	IV	02*
15	Use gear tooth vernier caliper to measure the given gear tooth elements and verify it by optical profile projector/ micrometer using over pin method.	IV	02
16	Use relevant instrument to measure geometrical tolerance parameters for the given automobile components.	V	02*
17	Perform quality audit and prepare quality manual using ISO procedure for maintenance department of your institute.	VI	02*
	Total		**34**

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, out of which, the practicals marked as '*' 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	Proper handling of measuring instruments.	10
2	Operating and measurement using appropriate instrument.	40
3	Comparison between various measuring devices.	20
4	Answer oral questions.	20

S. No.	Performance Indicators	Weightage in %
5	Submission of report 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. Removal of errors in tools and equipment.
b. Calibration of instruments.
c. Plan, construct, compile for measurement of complex components.
d. Demonstrate working as a leader / a team member.
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 and
- '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	Set of Radius gauge, At least 26 leaves, Range 0.5-13mm by 0.5mm	1
2	Set of screw pitch gauge (Inch/Metric), At least 28 Leaves, Range- 4 to 56 TPI, 0.5mm to 6mm	1
3	Set of filler gauge-At least 20 leaves, Range 0.05-1mm by 0.05mm	1
4	Straight edge- Grade 0,Grade 00, Grade 1, Grade 2 (IS-2220)	1
5	Plug gauge- At least one from Range-1 mm to 40 mm, (IS-6137 – I983)	1
6	Thread plug gauge- At least one from Range 1 to 25 mm	1
7	Thread ring gauge- At least one from Range 1 to 25 mm	1
8	Go-No Go single ended- At least one from Range 1 to 25 mm	1
9	Double ended snap gauge- At least one from Range 1 to 25 mm	1
10	Adjustable snap gauge- At least one from Range 1 to 25 mm	1
11	vernier caliper-Range 0-300 mm,	02
12	Dial type vernier caliper-Range 0-300 mm	02
13	Digital vernier caliper-Range 0-300 mm.	02
14	vernier height gauge-0 to 300 mm.	02
15	vernier depth gauge-0 to 300mm ,	02
16	Inside- micrometer-Range 0-25,25-50,50-100 mm.	02
17	Outside micrometer-Range 0-25,25-50,50-100 mm.	02
18	Digital outside micrometer-Range 0-25,25-50,50-100 mm.	02
19	Dial indicator with magnetic stand-Range 0-10 mm, Range 0-100 mm	03

S. No.	Equipment Name with Broad Specifications	PrO. No.
20	Standard Slip gauge set- At least one from M 45,M87,M112	03
21	Pneumatic comparator unit-0 to 10 bar	04
22	LVDT-Measuring range 270 mV/V (bridge output per 1 V supply voltage)	05
23	Compression gauge unit for Petrol 0-300psi (kg/cm^2) and Diesel 0-1000 psi(kg/cm^2)	06
24	Vacuum gauge unit for Petrol 0-30 in. Hg and Diesel 0-30 in. Hg.	06
25	Pressure gauge diaphragm type Range 0- 20 Bar	06
26	Pressure gauge bellows,40,50,63mm dial, diaphragm seal, static pressure upto 60kg/cm2g	06
27	Bourdon tube C type with LVDT Display 3.5 digit display for pressure/ displacement	06
28	Clinometer: Base length: 200 mm / 1000 mm • Measuring range: ± 17.5 mm/m (± 1°) • Sensitivity per Digit: ± 0.001 mm/m • Accuracy: < ± 0.2% (full scale) • Linearity: < ± 0.2% (full scale) • Operating temperature: – 10° to + 40°C	07
29	Temperature gauge bimetallic strip gauge. Ÿ Scale °F, K, Dual Scale °C/°F. Ÿ Over range protection 130% FSD. BMT	07
30	Temperature gauge thermocouple Type J, Iron (+) Constantan (-), 0 to 760°C, Suitable for vacuum, reducing, or inert atmospheres.	07
31	Standard Disable meter for sound measurement	08
32	Eddy Current Dynamometer Power rating: 0.18 KW to 55 KW Max Speed: 4,000 RPM; Torque Indicator: Spring Balance OR Digital Indicator with Zero, Span, Calibration presets; Max Torque: 100 KgM (1000 Nm); Speed Sensor: 60-Tooth wheel with Magnetic Speed Pick up Sensor Torque Sensor: Spring Balance with Pulley and rope, Load cell or Rotary Torque Sensor; Cooling: Self Cooled or FAN Cooled, to avoid Water Cooling hassles.	10
33	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm contact	09
34	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm Non contact	09
35	Surface measuring instrument-Talysurf	11
36	Universal bevel protractor: Graduation: 5min.(0°- 90°- 0°) Blade 150, 300 mm.	12
37	Sine bar, Sine Centre (0-200mm)	12
38	Angle dekkor/Auto collimator(0 to 30')	13
39	Set of Angle gauges box, Grade 1.	13
40	Screw thread micrometer.	14
41	Tool maker's microscope: Dimensions 152 x 152mm; Stage glass size 96 x 96mm; Feeding range 50 x 50 mm; Maximum height 115mm x 107mm; Work piece 5Kg; Light source :24V, 2W (special bulb); Continuously adjustable light intensity; Green filter.	14
42	Profile projector with gear profile/Thread profile Templates: Opaque fine grained ground glass screen with 90°, 60°. 30° cross line Location; fitted with graduated ring (0-360°) L.C. 1min; Optics Std10X, 20X, Measuring Range Std 100mm x 100mm; Opt X axis upto 400mm, Y axis upto 200mm; Focusing Travel 100mm; Magnification Accuracy Contour	14

S. No.	Equipment Name with Broad Specifications	PrO. No.
	±0.05% Surface ±0.05%; Illumination Counter 24V/150W halogen lamp with illumination control; Resolution 0.005/0.001/0.0005 mm.	
43	Gear tooth vernier caliper. (0-25mm)	15

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs 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 Basics of measurement.	1a. Explain the given standard(s) of measurement. 1b. Calculate least count of the given linear measuring instrument. 1c. Identify the sources of errors in instruments in the given component with justification. 1d. Describe with sketches the procedure for linear measurements using the given measuring instruments. 1e. Select relevant linear measuring instruments in the given automobile engineering situation(s) with justification.	1.1 Definition of metrology, objectives of metrology, types of metrology, Need of inspection, Precautions while using instruments. 1.2 Errors in measurements- environmental errors signal transmission errors, observation errors (parallex), operational errors. 1.3 Standards for measurement- line standard end standard, Wavelength standard. 1.4 Working principle, construction and calibration techniques of various linear measuring instruments and comparator.
Unit– II Miscellaneous Measurement.	2a. Identify different available instruments for measurement of given quantities. 2b. Describe with sketches the procedure to measure displacement, pressure, temperature, sound, force and sound using the given measuring instruments. 2c. Select relevant instruments for measurement of displacement, pressure, temperature, sound, force and sound in the given automobile engineering situations with justification. 2d. Describe with sketches the procedure to measure surface finish of the given component.	2.1 Displacement Measurement: working principal of Capacitive transducer, Potentiometer, LVDT 2.2 Pressure Measurement: Working principal of Pressure gauge-Diaphragm, Bellows, Bourdon tube, Electrical resistance type pressure measurement devices. 2.3 Temperature Measurement: Working principal of Bimetallic strip gauge, thermometer, RTD, Thermistor, thermocouple, Pyrometers-radiation and optical type. 2.4 Sound Measurement: Measurement of sound using Electro dynamic microphone and Carbon microphone. 2.5 Force and Shaft power measurement: Tool Dynamometer (Mechanical

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Type), Eddy Current Dynamometer, Strain Gauge Transmission Dynamometer. 2.6 Speed measurement - Working principal of tachometer, Mechanical , Electrical tachometer- Inductive Pick Up. Capacitive Pick Up. Stroboscope
Unit– III Angular Measurement	3a. Identify the parameters of angular measurement in the given case. 3b. Describe procedure to measure angles using the given angular measuring instrument. 3c. Select suitable angular measurement instrument for the given situation with justification.	3.1 Working principle of Universal Bevel Protractor, Sine Bar, Spirit Level, Angle Gauges, Angle dekkor or autocollimator
Unit-IV Thread and Gear Measurements.	4a. Identify errors in threads and their effects in the given assembly. 4b. Describe procedure to measure thread related elements using the given thread measuring instrument. 4c. Select instrument for measurement of the given thread elements with justification. 4d. Identify types of errors in gear tooth and effects in assembly. 4e. State the relevant instrument for measurement of the given Gear tooth parameters with justification.	4.1 Measurement of screw thread elements such as major diameter, minor diameter, effective diameter, pitch, thread angle for internal and external threads. 4.2 Working principle of screw thread micrometer, optical profile projector, tool maker's microscope. 4.3 Measurement of tooth thickness by constant chord method, base tangent method, gear tooth vernier, 4.4 Errors in gears such as backlash, run out, composite, concentricity. 4.5 Dimension over pin measurement
Unit-V Alignment and Geometrical testing	5a. Describe the given Geometrical relationships for the given components. 5b. Describe the alignment checking procedure for the given automobile components assembly. 5c. Select suitable measurement instrument to measure the given geometrical parameters with justification. 5d. Describe relevant tests for the given automobile component	5.1 Parallelism, Straightness, Squareness, Coaxiallity, roundness, run out, alignment testing of automobile components.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Quality control	6a. Explain principles of modern quality improving techniques. 6b. Describe the features of the given type of ISO for the given industry. 6c. List quality assurance activities in the given industry. 6d. Explain relevant quality assurance techniques in the given industrial situation.	6.1 Quality Control- Quality assurance, cost of quality, value of quality, 6.2 Introduction of ISO 9001, ISO-18000 and TS 16949. 6.3 Concept of quality circle,7QC Tools, TQM, Six-sigma, Pokayoke, Kaizen-5s, Kanban.

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 (INTERNAL)

Unit No.	Unit Title	Practical Hours	Distribution of practical Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of measurement.	04	01	01	02	04
II	Miscellaneous Measurement	14	02	01	05	08
III	Angular Measurement	04	-	01	03	04
IV	Thread and Gear Measurements	04	-	02	02	04
V	Alignment and Geometrical testing	04	-	01	01	02
VI	Quality control	04	-	01	02	03
Total		**34**	**03**	**07**	**15**	**25**

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 based on practicals performed in laboratory.
b. Give seminar on relevant topic.
c. Prepare power point presentation or animation showing measurement applications.
d. Collect and analyze precision and accuracy of various measuring instruments.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. No. of practical's selection to be performed should cover all units.

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 is 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 is given here. Similar micro-projects could be added by the concerned faculty:

a. Collect the data and information from internet/ automobile industry regarding modern measuring techniques and instruments.
b. Collect quality policy of at least two industries.
c. Identify various ISO certifying agencies with rules for certification.
d. Form a group of quality circle and solve any one quality related industrial problem.
e. Observe the Quality audit activity and prepare report.
f. Develop control charts used in automobile industry.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechanical Measurements and Control	Kumar, D.S.	Metropolitan Publications, New Delhi, 2009 ISBN: 978-8120004238
2	Mechanical and Industrial Measurements	Jain, R.K.	Khanna Publications, New Delhi, 2008, ISBN NO. -978-81-7409-191-2
3	Engineering Metrology	Jain, R.K.	Khanna Publications, New Delhi, 2015, ISBN NO. 978-81-7409-153-X
4	Mechanical Measurements and Instrumentation	Sawhney, A.K.	Dhanpat Rai and Sons, New Delhi. 2005, ISBN NO. 456714564X, 1234567145642
5	Measurement Systems	Doebelin, E.O.	McGraw Hill Publications, New Delhi, 2016, ISBN No., 9780070616721
6	Instrumentation Devices and Systems	Narang C.S.	McGraw Hill Publications, New Delhi, 2011, ISBN NO. 0074633503.

S. No.	Title of Book	Author	Publication
			9780074633502
7	Instrumentation, Measurement and Analysis	Nakra, B. C. , Chaudhary K.K.	McGraw Hill Publication, New Delhi, 2004, ISBN NO. 0070482969, 9780070482968
8	Mechanical Measurement	Beckwith, Thomas	Pearson Education, New Delhi, 2007, ISBN NO. 8131717186,
9	Total Quality Management	Dale, H. Besterfield and others	Pearson Education, Delhi, 2014, ISBN NO. 9788131717189
10	Instrumentation for Engg. Measurement	Dally, James W	Wiley India, Bangalore, 1993, ISBN NO. 13: 9780471551928

14. SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=lc4dsNvm2Ks
b. www.slideshare.net/anandpatange05/mechanical-measurement-control
c. https://www.howacarworks.com/engine/how-to-measure-the-engine-temperature
d. https://www.howstuffworks.com/engine/how-to-measure-the-engine-temperature
e. http://www.sabcable.net/fileadmin/user_upload/pdf/catalog_gb/Thermotechnik_gb/Temperature_Measurement_in_Test_Vehicles.pdf
f. https://web.mst.edu/~cottrell/ME240/Resources/Temperature/Temperature.pdf
g. https://law.resource.org/pub/in/bis/ais/arai.in.ais.020.2008.pdf
h. http://www.ntc.gov.au/Media/Reports/(9745A524-E60D-9B7C-835B-CDAF7DC19D8B).pdf
i. https://en.wikipedia.org/wiki/Pressure_measurement
j. https://en.wikipedia.org/wiki/MAP_sensor
k. https://www.youtube.com/watch?v=242tbZPKEXc
l. https://www.youtube.com/watch?v=37oJtcUTpL8
m. https://www.youtube.com/watch?v=jeBQJI-YwVc
n. https://www.youtube.com/watch?v=0JXCw5pOecg
o. https://www.youtube.com/watch?v=F7uCEeipdCw
p. https://www.youtube.com/watch?v=vu5-A_ythtM
q. textofvideo.nptel.iitm.ac.in/103105064/lec43.pdf

Program Name : **Diploma in Automobile Engineering**

Program Code : **AE**

Semester : **Fourth**

Course Title : **Solid Modelling and Additive Manufacturing**

Course Code : 22041

1. RATIONALE

Mechanical, Plastic, Automobile and allied Industries need to build model based applications which are being developed using "**solid modeling software**". This course deals with concepts of solid modeling to enhance solid modeling skills of diploma students. This course will enable the students to inculcate solid modeling and additive manufacturing concepts and methodology to solve engineering problems.

2. COMPETENCY

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

- **Develop 'Solid Models' of given machine components using any parametric CAD software.**

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. Prepare 2D Drawing using sketcher workbench of any parametric CAD software.
b. Generate 3D Solid models from 2D sketch using Part workbench of any parametric CAD software.
c. Prepare assembly of part models using Assembly workbench of any parametric CAD software.
d. Generate orthographic views of 3D solid models/assemblies using drafting workbench of any parametric CAD software.
e. Plot a drawing for given part model/assembly.
f. Print components using 3D Printer/Rapid prototyping machine.

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
-	-	2	2	--	--	--	--	--	--	--	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*

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.

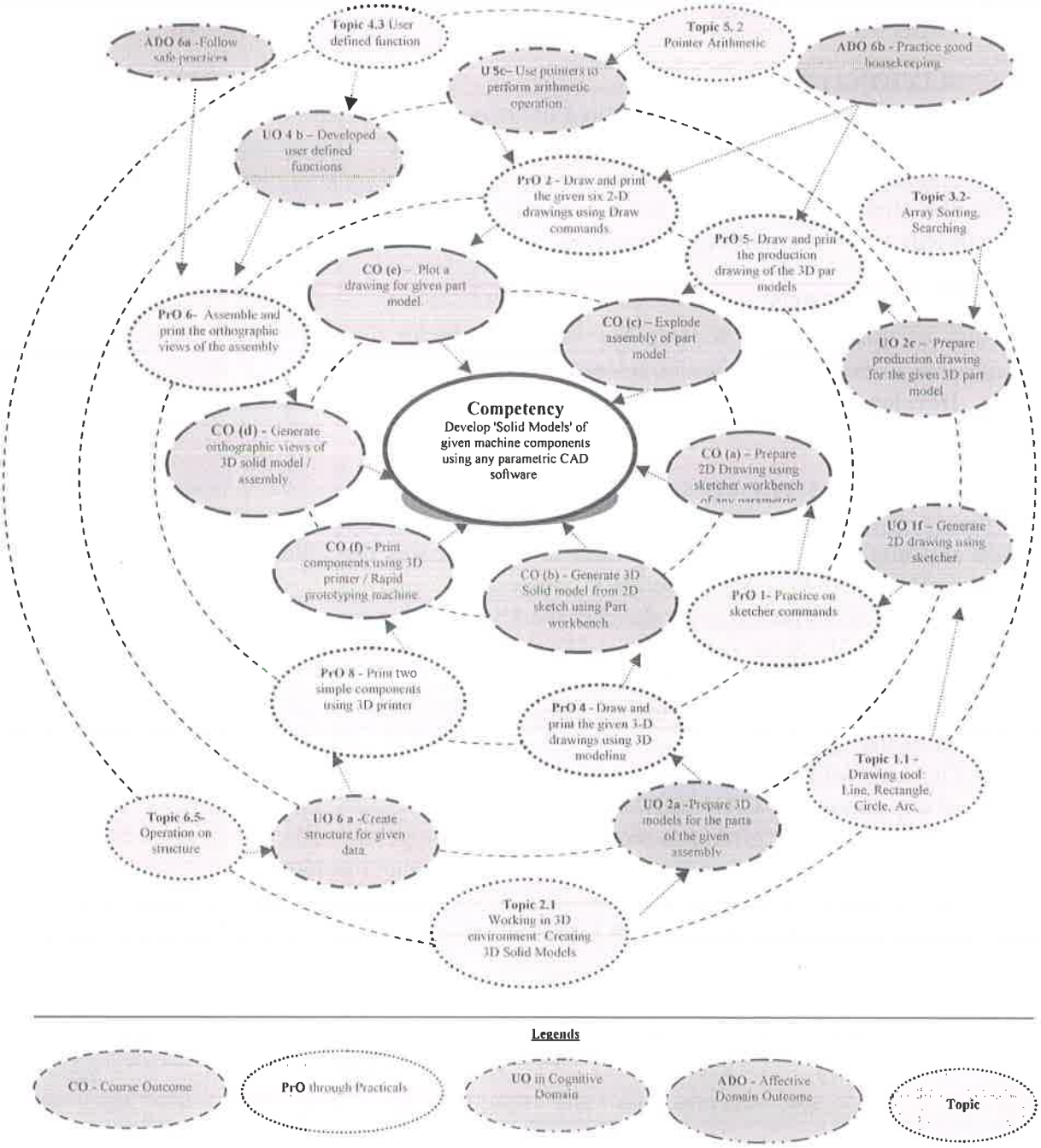

Figure 1 - Course Map

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.	Prepare drawing template consisting of Name plate boundary lines and projection symbol.	I	02
2.	Draw and print two simple 2D geometries using sketcher commands	I. V	02*
3.	Draw and print two complex 2D geometries using sketcher commands	I, V	02
4.	Draw and print the given two simple 3-D drawings using 3D modeling commands	II. V	02*
5.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem-1)	II. V	02
6.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II. V	02
7.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
8.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
9.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - I)	III, IV, V	02
10.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – I continued)	III. IV, V	02
11.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem - II)	II. V	02
12.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
13.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
14.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II. V	02
15.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any	III, IV,	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	assembly consisting of at least five parts. (Problem - II)	V	
16.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – II continued)	III, IV, V	02
17.	Print simple component using 3D printer / Rapid prototyping machine.	VI	02
18.	Print a complex component using 3D printer / Rapid prototyping machine. (Problem – I)	VI	02
	Total		**36**

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 24 or more practical need to be performed, out of which, the practicals marked as '*' 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	Use of proper commands	40
2	Completion of drawing with minimum size of model tree	20
3	Generation and printing of drawing views, tables, etc. and their arrangement on different sheet sizes.	20
4	Able to answer oral questions.	10
5	Completion of work 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. Practice energy conservation.
d. Handle solid modeling software carefully.
e. Plan for creation of solid model.
f. Demonstrate working as a leader / a team member.
g. Maintain software tools and equipment.
h. 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 and
- '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	Expt. Sr. No.
1	Hardware: Personal computer. (i3/ i5 or higher). RAM minimum 4 GB, A3 / A4 size printer / plotter. Display-wide Screen preferably.	For all Experiments
2	Operating system: Windows XP/Windows 7/ Windows 8/Windows 10 or higher.	
3	Software: Any parametric solid modeling software.	
4	3D printer / Rapid prototyping Machine.	17. 18

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs for achieving the COs to attain the identified competency.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Working in 2D environment.	1a. Describe the given sketcher commands. 1b. Demonstrate the given modify commands. 1c. Apply dimensioning and Constraints	1.1 Drawing tool: Line, Rectangle, Circle, Arc, Ellipse, Spline, etc. 1.2 Editing tool: Trim, Extend, Erase, Mirror, etc. 1.3 Modify tool: Chamfer, Fillet, Copy, Move, etc. 1.4 Linear, angular dimensions. 1.5 Dimensioning constraint and Geometrical constraint. 1.6 Drawing template: prepare drawing template consisting of Name plate boundary lines and projection symbol.
Unit– II Development of Solid Models.	2a. Prepare 3D models for the parts of the given assembly using different commands with minimum tree. 2b. Describe intersection of the given Solid. 2c. Prepare production drawing for the given 3D part model / assembly.	2.1 Working in 3D environment: Creating 3D Solid Models of simple machine parts. 2.2 Part tool: Extrude, Hole, Revolve, Rib, Sweep, Swept blend, Pattern, etc. 2.3 Part Editing tool: Trim, Extend, Erase, Mirror, 2.4 Part Modify tool: Chamfer, Round, Copy, Move, Draft, etc. 2.5 Intersect 2 solid components by inserting new body option. Boolean operations: Union, subtract, intersection.
Unit– III Computer aided	3a. Use of assembly tools to prepare assembly using given 3D solid models.	3.1 Assembly Drawing: Preparation of assembly drawing by using assembly command.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Assembly	3b. Use of explode command for the given assembly.	3.2 Exploded view: Explode the assembly.
Unit-IV Drafting of 3D assembly	4a. Use drawing module to create orthographic views for the given assembly. 4b. Generate Bill of material for given assembly Drawing.	4.1 Orthographic projections: Generate orthographic projections of the assembly. 4.2 Bill of material: Prepare part list table.
Unit –V Plotting	5a. Use different settings for plotting. 5b. Use printer to plot drawing on A3 or A4 size sheet.	5.1 Printer selection, paper size, orientation. 5.2 Page set up.
Unit-VI Additive Manufacturing	6a. Describe the process of Additive manufacturing. 6b. Study construction and working of 3D printer / Rapid prototyping machine. 6c. Describe materials use for 3D printer / Rapid prototyping machine.	6.1 Additive manufacturing: 3D printing. Rapid prototyping. 6.2 File format: STL (Stereo Lithography). 6.3 3D printer software: part import, orientation, processing and printing.

***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 (INTERNAL) DESIGN

Unit No.	Unit Title	Practical Hours	Distribution of practical Marks			
			R Level	U Level	A Level	Total Marks
I	Working in 2D environment	04	01	01	02	04
II	Development of Solid Models	14	02	01	05	08
III	Assembly Drawing	04	-	01	03	04
IV	Drafting of 3D assembly	04	-	02	02	04
V	Plotting	02	-	01	01	02
VI	Additive Manufacturing	04	-	01	02	03
Total		**32**	**03**	**07**	**15**	**25**

***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 journals based on practical performed in laboratory.
b. Give seminar on relevant topic.
c. Library/E-Book survey regarding 'Solid modeling' used in manufacturing industries.
d. Prepare power point presentation or animation for drafting/solid modeling/assembly/exploded view/3D printing.
e. List applications of 3D printing.
f. Visit to institute/industry having 3D printer/Rapid Prototyping machine.

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. ***'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. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual design and additive manufacturing.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain 3D printing and Rapid prototyping manufacturing methods.

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. **2D drawing**: Each student will collect one or two drawings from the nearby industry/workshop and prepare a 2D drawing from it.
b. **3D model**: Each student will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches.

Using sketches prepared 3D model of parts and assembly. Plot the assembly and detail drawings. (eg. Bench vice, Machine vice, Tool post, Couplings, Joints, Bearings etc.)

c. **3D printing/RPT**: Each student will visit a nearby institute/industry. Collect information regarding troubleshooting of 3D printer/Rapid prototyping machine and prepare a report.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	CATIA V5R17 for Designers	Sham Tickoo	Softcover, Cadcim Technologies
2	Pro/Engineer Wildfire for Designers	Sham Tickoo	Softcover, Cadcim Technologies
3	Solid Works For Designers Release 2006	Sham Tickoo	Softcover, Cadcim Technologies
4	Autodesk Inventor for Designers: Release 10	Sham Tickoo	Softcover, Cadcim Technologies
5	NX 4 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
6	Solid Edge V19 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
7			

14. SOFTWARE/LEARNING WEBSITES

a. http://www.solidworks.in/sw/products/3d-cad/3d-solid-modeling.htm
b. http://web.iitd.ac.in/~hegde/cad/lecture/L30_solidmod_basics.pdf
c. https://en.wikipedia.org/wiki/Solid_modeling
d. http://npkauto.com/solid-modeling/
e. https://www.youtube.com/watch?v=vjX4PDJcFOI
f. https://www.youtube.com/watch?v=5BDHS4FN2-
g. https://www.youtube.com/watch?v=JjKs-lePlPY