Maharashtra State Board of Technical Education, Mumbai

Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechnical Engineering

Program Code : ME **With Effect From Academic Year: 2017 - 18**

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

Semester : Sixth **Scheme - I**

S. N.	Course Title	Course Abbrev iation	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	Emerging Trends in Mechanical Engineering	ETM	22652	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	Industrial Hydraulics and Pneumatics	IHP	22655	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
3	Automobile Engineering	AEN	22656	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
4	Industrial Engineering and Quality Control	IEQ	22657	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Elective (Any One)																				
5	Computer Integrated Manufacturing	CIM	22658	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Refrigeration and Air Conditioning	RAC	22660	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Renewable Energy Technology	RET	22661	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
6	Enterprenureship Development	EDE	22032	2	-	2	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40	100
7	Capstone Project Execution and Report Writing	CPE	22060	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
			Total	**17**	**-**	**14**	**31**	--	**350**	--	**150**	-	**500**	--	**200**	--	**200**	--	**400**	--	**900**

Student Contact Hours Per Week: **31 Hrs.** Medium of Instruction: **English**

Theory and practical periods of 60 minutes each. Total Marks : **900**

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.**

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME/PG/PT/AE**

Semester : **Sixth**

Course Title : **Emerging Trends in Mechanical Engineering**

Course Code : **22652**

1. RATIONALE

Over the coming years, technological developments such as Robotics, IOT, Artificial intelligence, smart controls are likely to have a significant impact on the world of work and employment as well as to trigger far reaching changes. Looking towards the era in Technology advancement, Mechanical/Automobile/Production Engineering offers addition of new Dynamic subjects and new versions of core subjects. Diploma Mechanical/Automobile/Production Engineers should be familiar with new technologies from the fields of Automobile Engineering, Energy Management, Advanced Manufacturing Processes, Agriculture and Farm Machines and many more. This Dynamic course will give insight to the recent practices adopted by the Mechanical Industries and awareness of these techniques will enhance career opportunities of Diploma Mechanical/Automobile/Production Engineers.

2. COMPETENCY

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

- **Relate basic principles of Mechanical Engineering with Recent Technologies available in Industry.**
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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 different New Systems available in Automobile.
b. Apply Heat engineering principles in process Boilers and waste heat Recovery systems used in Process Industry
c. Cite examples of Modern manufacturing Technology in industry
d. Use different standards for energy Management and Audit of a given system.
e. Select recent agricultural equipment for pre and post harvesting.
f.

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	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(*): 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 MULTI CHOICE QUESTION 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.

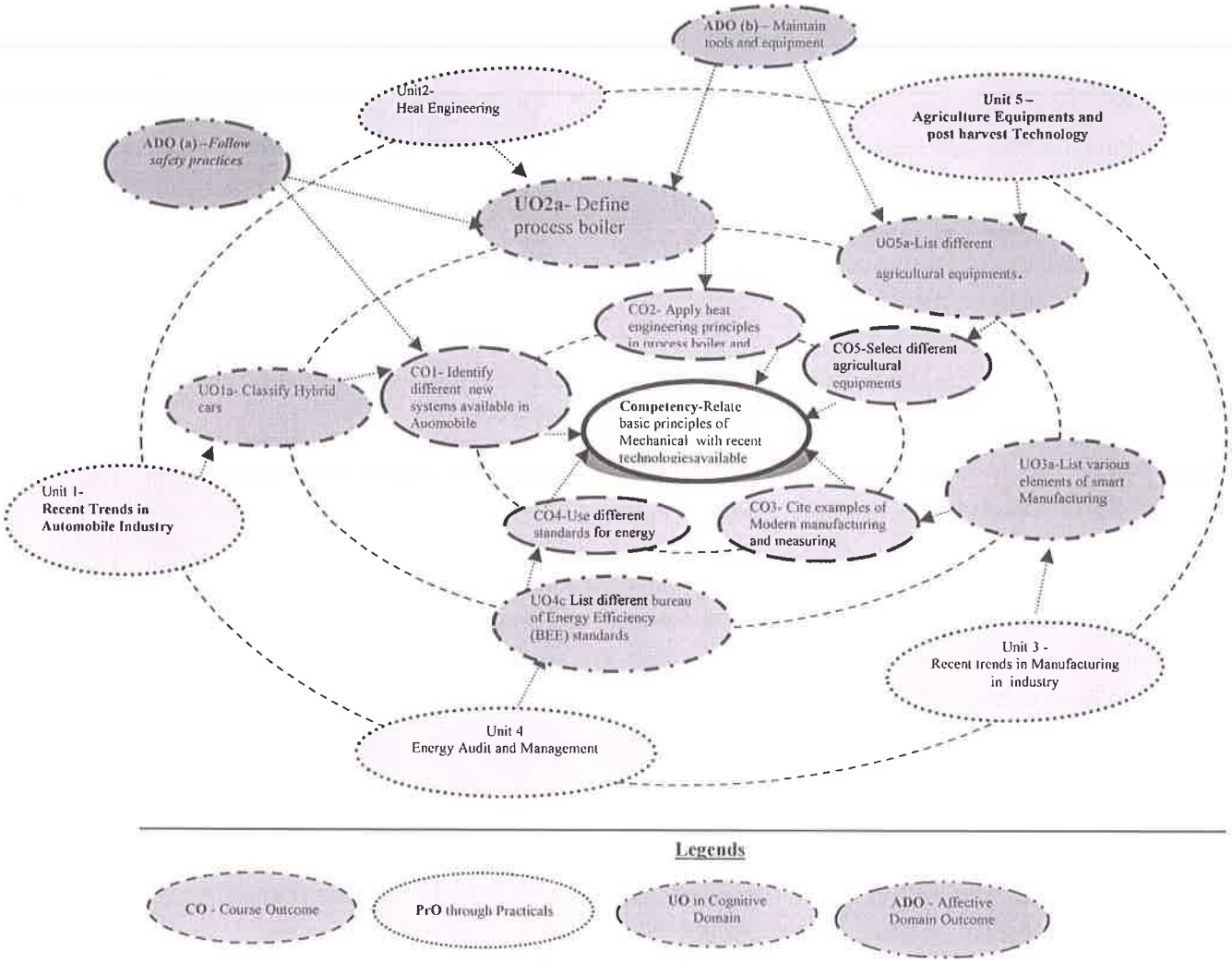

Figure 1 - Course Map

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	NA		

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 %
a.	NA	

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. 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
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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	LCD Projector	-

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	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Recent Trends in Automobile Industry	1a. Classify Hybrid cars 1b. List different batteries used in E-Vehicles 1c. Name different safety systems used in given vehicle.	1.1 Hybrid cars-manufactures, Types- Micro Hybrid, Mild Hybrid, Full Hybrid, Series hybrid, Parallel Hybrid 1.2 E-vehicles- Manufacturers, specifications, Types of Batteries, Li-ion batteries, Sodium Nickel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Chloride Batteries ,Sodium Sulphor Batteries, Fuel Cell, Charging- Charging Methods and Modes. Issues with e-vehicles 1.3 Safety in Automobile- Air bags, Automatic Emergency Braking, Adaptive Cruise Control, Electronic stability programmer, Anti Collision system, Active Passive Integration system.
Unit– II Process Engineering	2a. Define process boiler 2b. State principles of ultra-super critical boilers. 2c. List commerciality viable waste heat recovery devices.	2.1 Process Boilers-Steam and Condensate loop in process industries 2.2 Introduction to ultra-super critical Boilers. 2.3 Hyperbolic cooling towers. 2.4 Waste heat recovery-process industry
Unit –III Recent Trends in Manufacturing in industry	3a. List various elements of smart Manufacturing 3b. Interpret the Automation in Mechanical Industry 3c. List Different types of Automation 3d. Select Robot for given application 3e. Compare 4 D printing technology with 3D printing technology. 3f. Describe the importance of 3-D scanning with reverse engineering.	3.1 **Smart Manufacturing Technology** introduction, Elements and applications 3.2 **Automation**: Need, Basic elements of automated systems, automation principles and strategies, Benefits. 3.3 **Types of automation:** fixed, programmable, flexible, hard and soft automation. 3.4 **Industrial robotics**: robot anatomy, robot control systems, end effectors, sensors in robotics, industrial Robot applications 3.5 4-D printing Technology- Printing Techniques, 3D scanning Technology-Function, ,Applications
Unit-IV Energy Audit and Management	4.a List different bureau of Energy Efficiency (BEE) standards. 4.b Describe methods of Energy Monitoring and Targeting 4.c Identify steps for conducting Energy Audit.	4.1 Standards and labelling standard(HVAC) 4.2 Energy Monitoring and Targeting. 4.3 Energy Management and Audit
Unit-V Agriculture Equipment and post harvest Technology	5.a Explain working of different agricultural equipment. 5.b Name different elements of Cold Chain 5.c List the features of NCAP	5.1 Tillers, Sowing and planting equipment, Weeding Machines, Spraying Machines, Harvesting, Post harvesting Machineries 5.2 Elements of Cold chain 5.3 National Cooling Action Plan (NCAP)

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 FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Recent Trends in Automobile Industry	14	06	10	04	20
2	Process Engineering	06	02	06	02	10
3	Recent Trends in Manufacturing in industry	14	06	10	04	20
4	Energy Audit and Management	08	02	06	02	10
5	Agriculture Equipment and post-harvest Technology	06	02	06	02	10
	Total	**48**	**18**	**38**	**14**	**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. Visit any industry and collect information of recent trends in Industry.
b. Undertake a market survey of local dealers for agricultural equipments, machineries, HVAC equipments and prepare a report.
c. Visit to any Industrial press shop and prepare a report consisting
    i. Safety precautions observed.
    ii. Identify problems related to energy conservations faced by industry

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. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.

h. Observe continuously and monitor the performance of students in Lab.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Guide student(s) in undertaking micro-projects.
l. Arrange visit to nearby industries for understanding various tool engineering operations
m. Show video/animation films to explain tool design processes.
n. Give Micro projects.
o. Use different instructional strategies in classroom teaching.
p. In respect of item no.10 above the teachers need to ensure to create opportunities and pursue for such co-curricular activities.

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 energy audit report of any one Lab rotary.
b. Collect data with respect to safety systems available in Modern cars
c. Identify different heat losses in Furnace available in workshop.
d. Compile the different products manufactured by 4-D printing Technology
e. Prepare report of pre and post harvesting using recent agricultural equipment
f. Collect information of District cooling.
g. Collect information of Robotics
h. Visit the local industry nearby and study the manufacturing systems. Thereby prepare the low cost automation plan for improvement in the productivity and quality of the industry

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electric and Hybrid Vehicles	Tom Denton	IMI (Institute of Motor Industry) ISBN-13: 978-1138842373 ISBN-10: 1138842370
2	The Electric car	M H Westbrook	IET,2001, ISBN-0852960131
3	Hybrid, Electrical and Fuel Cell Vehicles	Jack Erjavec	Cengage Learning,2012 ISBN-1285415051
4	Boilers for Power and process	Kumar Rayaprole	CRC Press,2009, ISBN-1420075373
5	Steam generators and	V Ganpathy	CRC press,

S. No.	Title of Book	Author	Publication
	Waste heat Boilers		ISBN 1482247127
6	Introduction to process Technology	C.E Thomas	Cengage Learning,2009 ISBN 1435454251
7	Industry 4.0 Smart manufacturing for the future	William MacDougall	Germany trade and Investe,2014
8	Energy Management and Conservation	K V Sharma	I K International Publishing House Pvt ltd, 2011, ISBN- 9381141290
9	Energy Management, Audit and Conservation	B K De	Vrinda Publication, Indiana University,2007, ISBN-8182810930
10	Farm Tools and Equipments for Agriculture	Surendra Singh	New India Publishing,2015 ISBN-9385516221
11	Cold storage, cold chain, ware houses	NPCS Board of Consultant	3rd Edition,2018 ,NIR project consultancy services, Delhi ISBN-978-93-81039-66-3
12	4 D Printing- the next generation technology	Dirk Schreder	ISBN-13-978-8963495
13	Additive Manufacturing to 3 D/4D Printing 1	J D Andre	John Eiley & Sons,2017 ISBN 1119437393
14	Automation, Production Systems, and Computer Integrated Manufacturing	Groover, Mikell. P.	PHI, ISBN-13: 978-8120334182
15	Computer based Industrial Control	Kant, Krishna.	PHI Learning ISBN 13: 9788120339880

SOFTWARE/LEARNING WEBSITES

1. https://www.youtube.com/watch?v=MdFWgat9ddA(Agri Equipments)
2. https://www.chargepoint.com/about (Electrical Vehicle)
3. http://www.plugndrive.ca/ev-models (Electrical vehicle)
4. http://www.oorja.in/what-is-radiant-cooling/types-of-radiant-cooling-systems/(Cold Chain)
5. https://www.beeindia.gov.in/content/standard-labeling (Energy audit)
6. www.beestarlabel.com/ 9energy audit)
7. htttps:// Four-dimensional product/about (4 Dprinting)

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Industrial Hydraulics and Pneumatics**

Course Code : **22655**

1. RATIONALE

Hydraulic and pneumatic operated machines and equipment are widely used in various industries due to its versatility and adaptability to automation. Mechanical engineering technologists are required to maintain such systems in different segments of industries. This competency needs the knowledge of construction and working of different components of hydraulic and pneumatic systems. This course will give the students, the basic skills and knowledge to use and maintain different types of hydraulic systems and pneumatic 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:

- **Use different types of hydraulic and pneumatic systems for engineering applications.**

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 components of hydraulic & pneumatic systems.
b) Select pump and actutators for given fluid operated system.
c) Select appropriate control valves for given fluid operated system.
d) Select compressor and appropriate accessories for given fluid operated system.
e) Develop different hydraulic circuits for given simple application.
f) Develop different pneumatic circuits for given simple application.

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.

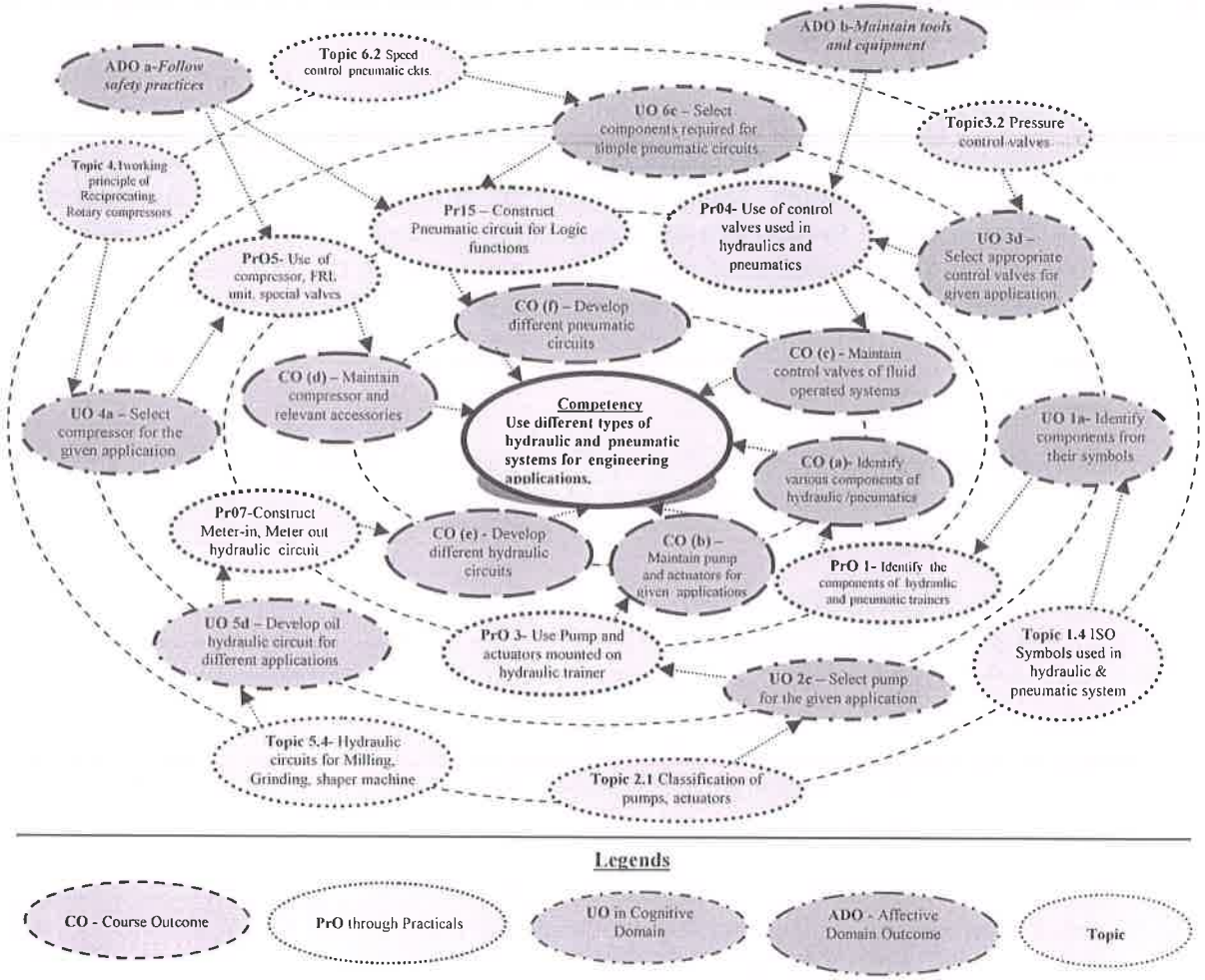

Figure 1 - Course Map

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 the components of hydraulic and pneumatic trainers.	I	02*
2	List and draw ISO symbols used in hydraulic and Pneumatics.	I	02
3	Use Pump and actuators mounted on hydraulic trainer.	II	02
4	Use of control valves used in hydraulics and pneumatics.	III	02*
5	Use of compressor, FRL unit, special valves and accessories of pneumatics.	IV	02
6	Construct and actuate hydraulic circuit for SAC and DAC, hydromotor	V	02
7	Construct and actuate Meter-in, Meter out hydraulic circuit.	V	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
8	Construct and actuate any suitable sequencing hydraulic circuit.	V	02
9	Develop circuit for simple machine tool applications such as milling machine, shaper machine, grinding machine	V	02*
10	Construct pneumatic circuits using Pneumatic simulation software	V	02
11	Construct and actuate Pneumatic circuit for SAC, DAC, Air motor	VI	02*
12	Construct and actuate speed control Pneumatic circuits.	VI	02
13	Construct and actuate indirect (pilot) control Pneumatic circuit.	VI	02*
14	Develop any suitable sequencing Pneumatic circuit.	VI	02
15	Construct and actuate Pneumatic circuit for Logic functions (AND/OR/TIME DELAY)	VI	02*
16	Construct Hydraulic circuits using Hydraulic simulation software	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 safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work 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

- 'Organisation Level' in 2nd year
- 'Characterisation 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	Cut sections of pumps, valves, cylinders, motors, accumulators, filters, etc	1,2,3
2	Hydraulic trainer with transparent /actual working components.	1,4,6,7,8,9
3	Pneumatic trainer with transparent/ actual working components.	4,5,12,13,14,15,16
4	Working / actual models of pumps, cylinders, valves, other components	1,2,3
5	Single /Multistage Reciprocating Compressor (pressure 0-10 bar)	4,5,12,13,14,15
6	Hydraulic and pneumatic simulation software	10,16
7	Electro-Pneumatic trainer	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 Introduction to Hydraulic and Pneumatic Systems	1a. Sketch the labeled general layout of the given type of Hydraulic system. 1b. Identify the given component(s) from their symbols. 1c. List the types of components in the given simple oil hydraulic circuits. 1d. List the desired properties of oil used in the given type of hydraulic system. 1e. Describe the general routine maintenance procedure of the given hydraulic/pneumatic system. 1f. List different Safety precautions required for handling Industrial hydraulics and pneumatics systems.	1.1 General layout of oil Hydraulic Maintain Pneumatic system. 1.2 Applications, Merits, limitations and oil hydraulic systems and Pneumatics systems. 1.3 Properties of fluids, ISO and SAE grades of oil. 1.4 ISO Symbols used in Hydraulic , Pneumatic system. 1.5 Hazard and Safety in Industrial hydraulics and pneumatics
Unit– II Pumps and Actuators	2a. Classify the given types of pumps with justification. 2b. Compare given two types of pumps on the basis of the given criteria. 2c. Select relevant pump for the given application with justification. 2d. Classify given types of actuators with justification. 2e. Describe with sketches the construction of the given actuator(s).	2.1 Classification of pumps. 2.2 Construction and working of Gear, Vane, Screw, piston pumps (axial and radial). 2.3 Performance characteristics and Selection of Pumps. 2.4 Classification of Hydraulic and Pneumatic actuators. 2.5 Construction and working of Linear and rotary actuators

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2f. Select the relevant actuator for the given application with justification. 2g. Describe the routine maintenance procedure of the given type of pump/actuator.	(Motors).
Unit-III Control Valves	3a. Classify the given types of valves with justification. 3b. Describe with sketches the construction of the given valve(s). 3c. Describe the actuation method of the valves for the given application. 3d. Select relevant control valve for the given application with justification. 3e. Describe the routine maintenance procedure of the given type of valve.	3.1 Classification of Control valves. 3.2 Pressure control valves- relief, unloading, sequence, counter balance, pressure reducing valves. 3.3 Direction control valves- Check valve, 2/2,3/2,4/2,4/3,5/2,5/3 D.C. Valves used in Hydraulics and Pneumatics. 3.4 Standard centre positions, Methods of actuation. 3.5 Flow control valves- Non-compensated, Pressure and temperature compensated.
Unit –IV Compressor, Pneumatic Components and Accessories in Fluid System	4a. Select the relevant compressor for the given application with justification 3f. Describe with sketches the construction of the given valve(s). 4b. List various accessories required in the given hydraulic/pneumatics. 4c. Select the relevant accessories for the given type of hydraulic/ pneumatic system with justification.	4.1 Types, construction, working principle of Reciprocating Maintain Rotary compressors. 4.2 Construction, working principle of FRL unit, Dual (twin) pressure valve, Shuttle valve, Quick exhaust valve, Time delay valve. 4.3 Accessories: Oil reservoir, pipes, hoses, fittings, oil filters, air filters, seals and gaskets, intensifiers, accumulators, heat exchanger, muffler.
Unit-V Oil Hydraulic Circuits	5a. Describe with sketches the construction of the given hydraulic circuit 5b. Explain with sketches the working of the given oil hydraulic circuit. 5c. Select the relevant components required for given simple hydraulic circuit with justification. 5d. Develop with sketches the oil hydraulic circuit for the given application. 5e. Describe the routine maintenance procedure of the given oil hydraulic circuit.	5.1 Simple oil hydraulic circuits - Single and Double Acting Hydraulic cylinders, motors. 5.2 Speed control Meter-in, Meter-out, Bleed Off circuit. 5.3 Regenerative, counterbalance, sequencing circuits, synchronizing, two pump unloading. 5.4 Hydraulic circuits for Milling machine, Grinding machine, Shaper machine, slotting machine. 5.5 Remedies and fault detection in Pneumatic circuits

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-VI Pneumatic Circuits	6a. Describe with sketches the construction of the given pneumatic circuit 6b. Explain with sketches the working of the given oil pneumatic circuit. 6c. Select the relevant components required for given simple pneumatic circuit with justification. 6d. Develop with sketches the oil pneumatic circuit for the given application. 6e. Explain Maintenance procedure for Hydraulics and Pneumatics system	6.1 Direct/Indirect Control of Single and Double Acting Air cylinders, motors. 6.2 Speed control circuit for cylinders and motors. 6.3 Sequencing circuits, Logic AND/OR circuits, Time delay circuits, piston continuous back and forth. 6.4 Simple Hydro-pneumatic applications. 6.5 Simple Electro-Pneumatic circuits. 6.6 Remedies and fault detection in Pneumatic circuits 6.7 Maintenance of hydraulic and Pneumatic systems

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	Introduction to Hydraulic and Pneumatic Systems	04	02	02	02	06
II	Pumps and Actuators	08	04	04	04	12
III	Control Valves	12	04	08	04	16
IV	Compressor, Pneumatic Components and Accessories in Fluid system	08	04	04	04	12
V	Oil Hydraulic Circuits	08	**00**	04	08	12
VI	Pneumatic Circuits	08	02	02	08	12
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 journal based on practical performed in Industrial fluid power laboratory. Journal consists of drawing, observations, required measuring tools, equipments, and date of performance with teacher signature.
b) Power Point Presentation on hydraulic and Pneumatic brakes by group of two/three students. (Duration:10 minutes)
c) Power Point Presentation on accessories used in hydraulics and pneumatics by group of two/three students. (Duration:10 minutes)
d) Prepare report of market survey of suppliers for fluid powered Earth moving equipments like JCB, Mahindra Earth master by group of four students.
e) Prepare chart on full imperial drawing sheet for ISO Symbols used in hydraulic Maintain pneumatic system by group of two students.
f) Prepare chart on full imperial drawing sheet for classification of pumps and actuators by group of two students.
g) Prepare Seminar/presentation on types of oil filters by group of two/three students. (Duration:10 minutes)
h) Prepare display chart on types of seals and gaskets (actual/ used samples) used in hydraulics.
i) Prepare visit report of any automobile service station to observe use of pneumatic hand tools.
j) Prepare visit report of construction sites to observe use of earth moving equipment /Other hydraulic /pneumatic equipments for automation.

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) Before starting practical, teacher should demonstrate the working of instrument.
g) Instructions to students regarding care and maintenance of measuring equipments.
h) Show video/animation films to explain functioning of various measuring Instruments
i) Teacher should ask the students to go through instruction and Technical manuals of instruments

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) Market survey of oil used in hydraulic system (Manufacturers, specifications, trade names, cost, packing size) (field-based/ Internet based)
b) Prepare working model of hydraulic crane using waste injections used by Doctors. (laboratory-based)
c) Prepare report of agriculture equipments working on hydraulics and pneumatics. (field-based)
d) Prepare report of specifications of Hydraulic power pack and Pneumatic service unit (FRL Unit) (Internet based)
e) Collect technical specifications of Gear pumps, Vane pumps/other pumps (Internet based).
f) Prepare visit report to observe use of Pneumatic system used by Dentist. (field-based)
g) Prepare visit report on automobile vehicle cleaning service station to observe the hydraulic actuator and system used. (field-based)
h) Prepare display board by collecting sample of pipes and pipe fittings with specifications of different manufactures. (New/Worn-out) (workshop-based)
i) Prepare a tabulated summary for types of pipes available in market. (Summary includes type, specification, size range, material, rate and applications). (workshop-based)
j) Prepare report on specifications, sketches of Linear actuators and mounting methods. (Internet based).
k) Prepare report on working of hydraulic jack and its system. (Industry application based)
l) Prepare prototype working model of hydraulically operated hospital bed. (Industry application based)
m) Prepare demonstration model of telescopic cylinder using PVC pipes. (workshop-based)
n) Develop working model of automation of bench vice used in carpentry/fitting shop. (workshop-based)
o) Prepare report of various pneumatic hand tools and its attachments. (Internet based).
p) Prepare cut section model of any hydraulic/pneumatic component. (laboratory-based)
q) Prepare report of hydraulic system used in Universal testing machine available in Strength of material laboratory. (laboratory-based)
r) Prepare report of construction and working of hydraulic press used in nearby machine/fabrication shop. (field-based)
s) Prepare visit report of service centre for common faults and remedies of hydraulic equipments. (field-based)
t) Prepare Hydraulic circuit layout with identification of all the components of a hydraulic circuit of heavy earth moving machineries/road construction machineries.
u) Prepare report of any actual pneumatic system used in low cost automation systems, material handling systems, etc.
v) Prepare visit report of any one mobile hydraulic system such as in earth moving equipment or any one stationary hydraulic system such as in any machine tool.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Oil Hydraulic system-Principles and maintenance	Majumdar, S.R.	McGraw Hill, New Delhi, (2002), ISBN: 9780074637487
2	Pneumatics Systems Principles and Maintenance	Majumda,r S.R.	McGraw Hill, New Delhi, (1996), ISBN-978-0-07-460231-7
3	Fluid Power with applications	Esposito, Anthony	Pearson Education, Inc New Delhi (2003), ISBN 81-7758-580-0
4	Hydraulics and Pneumatics	Stewart, Harry	Taraporewala Publication, (1984) ISBN:978-0672234125
5	Pneumatic Controls	Joji, B.	Wiley India Pub. New Delhi, (2008) ISBN:978-8126515424
6	Hydraulics Maintain Pneumatics A Technicians Maintain Engineers Guide	Parr, Andrew	Butterworth-Heinemann Publisher, (1991), ISBN: 9780080966755
7	Industrial Hydraulics Manual	-----	Vickers Systems International (Company Manual), (2010), ISBN 9780978802202
8	Product Catalogue of FESTO	-----	Company catalogue

14. SOFTWARE/LEARNING WEBSITES

a) www.cesim.com/simulations
b) Hydraulic Pumps: https://en.wikipedia.org/wiki/Hydraulic_pump
c) Hydraulic Pumps: www.hydraulicspneumatics.com/.../HydraulicPumpsM/.../TechZone-HydraulicPumps.
d) Animation of Hydraulic pumps: https://www.youtube.com/watch?v=Qy1iV6EzNHg
e) Animation of Hydraulic pumps: https://www.youtube.com/watch?v=pWuxYnqYDnk
f) Eaton Pump assembly: https://www.youtube.com/watch?v=sEVTIRYHoGg
g) Video lectures of IIT Faculty: http://nptel.ac.in/courses/112105047/
h) Lecture series and notes by IIT faculty: http://nptel.ac.in/courses/112106175/
i) Pneumatic control valves animation: https://www.youtube.com/watch?v=XAItnsUcES0
j) Control valve symbol generation: https://www.youtube.com/watch?v=yIot4shcOkE
k) Animation of D.C Valve: https://www.youtube.com/watch?v=jsMJbJQkGTs
l) Animation of 4/2,4/3 D.C Valves: https://www.youtube.com/watch?v=CQPwvWXbV3w
m) Animation of Hydraulic cylinder: https://www.youtube.com/watch?v=bovfDsAYSbc
n) Telescopic cylinder animation: https://www.youtube.com/watch?v=icaqvfAtccY
o) Pneumatic cylinder: https://www.youtube.com/watch?v=MmYpzgh6Gok
p) Speed control hydraulic circuit: https://www.youtube.com/watch?v=4eCuPVxezzY

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Automobile Engineering**

Course Code : **22656**

1. RATIONALE

Automobile sector has been helping the world for the overall development and it has been creating wage and self employment opportunities both in public and private sectors. A Mechanical engineering technologist should have an overall understanding of various aspects of Automobile Systems. This course provides a broad knowledge about the different vehicle layouts, transmissions and controls, electrical and electronics systems, vehicle safety and security, features of Motor Vehicle Acts along with automobile maintenance systems. This knowledge will be helpful to the students in co-relating various automobile systems with each other and provide good practical input with theoretical knowledge for technological advancement of the industry/society.

2. COMPETENCY

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

- **Interpret the required automotive component based on the analysis of the automobile specifications.**

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 vehicle layouts with chassis specification.
b. Interpret power flow diagrams of transmission systems.
c. Select suitable braking and steering systems for different applications.
d. Select suspension system for different applications.
e. Prepare simple electrical-electronic circuits for automobile systems.
f. Select service tools for relevant service operation in automobile shops.

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.

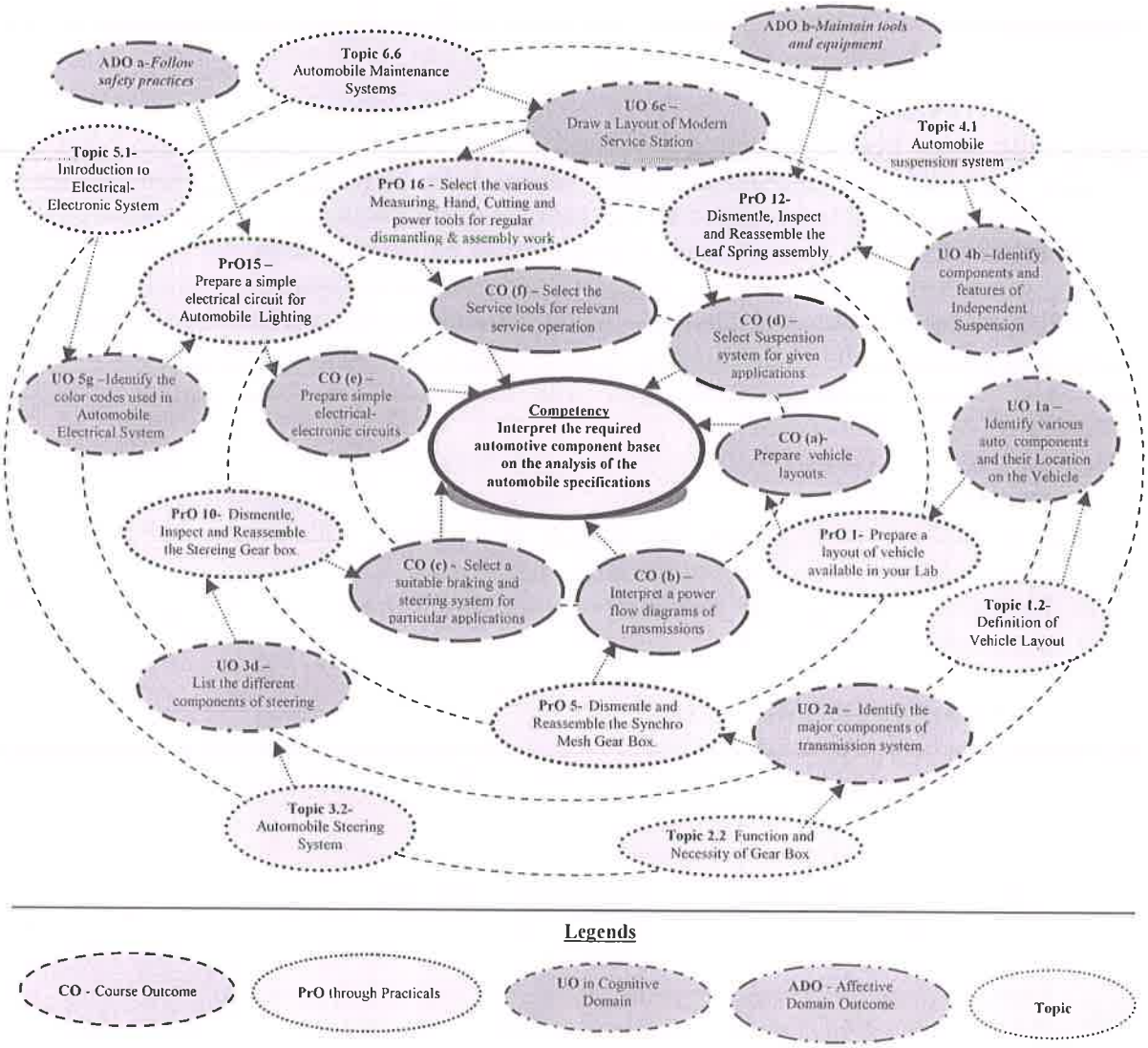

Figure 1: Course Map

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	Prepare a layout of vehicle available in your Laboratory.	I	02*
2	Dismantle, inspect and reassemble the Single Plate Clutch. (Coil Spring Type/Diaphragm Type)	II	02
3	Dismantle/Assemble the Multiplate Clutch.	II	02*
4	Dismantle/Assemble the Centrifugal Clutch.	II	02
5	Dismantle/Assemble the Synchro Mesh Gear Box.	II	02*
6	Dismantle/Assemble the Propeller shaft Assembly.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Dismantle/Assemble the Differential Assembly.	II	02*
8	Dismantle/Assemble the Drum/Disc Brake.	III	02
9	Dismantle/Assemble the Steering Gear box. (Rack and Pinion/Recirculating Type/Worm and Wheel)	III	02
10	Dismantle/Assemble the Power Steering system. (Hydraulic/Electronic Type)	III	02
11	Dismantle/Assemble the Leaf Spring assembly.	IV	02*
12	Dismantle/Assemble the Wheel and Tyre assembly.	IV	02
13	Test a Lead Acid Battery for Open Voltage and Specific Gravity.	V	02*
14	Dismantle/Assemble the Distributor used in Battery Ignition System.	V	02*
15	Prepare a simple electrical circuit for Automobile applications like Lighting/Horn/Wiper/Flasher/Indicators/Gauges etc.	V	02
16	Maintain given simple automobile component using various Service Tools.	VI	02*
	Total		**32**

Note:

i. *For Practical Nos. 2,3,4,5,8,9,10,12 students should rectify the particular troubles in respective system with probable causes and remedies for the same and prepare a Trouble Shooting Chart.*

ii. *For Practical Nos. 1,6,7,10,11,13,14 students should identify the various components of respective system and state their functions and location.*

iii. *A suggestive list of PrO's is given in the above table. More such PrO's can be added to attain the CO's 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.*

iv. *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 practical set up	10
2	Handling of service tools carefully while performing the practicals	20
3	Select the sequence of operation of dismantle and assembly	20
4	Safety measures and standard practices	10
5	Inspection, record keeping and reassembly	10
6	Identify the Probable Causes of the Troubles	10
7	Prepare the Trouble shooting chart with causes and remedies	10
8	Submission of the practical report with conclusion	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) Work 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
- 'Organisation Level' in 2nd year
- 'Characterisation Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of practicals, as well as aid to procure equipment by authorities concerned.

S. No	Equipment Name with Broad Specifications	PrO. No.
1	Any Two/Four Wheel drive (2WD/4WD) Vehicle	1
2	Working Model of Coil Spring Single Plate Clutch used in Cars	2
3	Working Model of Diaphragm Spring Type Single Plate Clutch used in Cars	2
4	Working Model of Multiplate Clutch used in Scooter/Motor cycles	3
5	Working Model of Centrifugal Clutch used in Mopeds	4
6	Working Model of Synchro Mesh Gear Box used in four wheelers	5
7	Propeller Shaft Assembly along with two U-joints and one slip joint	6
8	Working Model of Differential Assembly of four wheeler	7
9	Working Model of Drum Brake (Mechanical/Hydraulic Linkage)	8
10	Working Model of Disc Brake (Hydraulic Linkage)	8
11	Working Model of Rack and Pinion Steering Gear used in cars	9
12	Working Model of Recirculating Ball Type Steering Gear Box	9
13	Working Model of Worm and Wheel Steering Gear Box	9
14	Working Model of Hydraulic/Electronic Power Steering System	10
15	Working Model of Semi Elliptical Leaf Spring with shackle and Shock ups	11
16	Tyre Removing Tool Kit/Tyre Remover Tyre Inflator: 12 V Air Compressor Pump	12
17	Air Compressor: AC Single Phase, Air Cooled, Capacity: 160- 500 Litre, Speed: 690-925 RPM, Power: 2 to 20 HP, Working Pressure: 10.5-12 Kg/cm^3	
18	12 Volt Lead Acid Battery in Working Condition, 7-50 AH	13
19	Voltmeter, Ammeter, Cell Tester, Multi Meter	13
20	Hydrometer for Specific Gravity Test. (For Large and Small Battery with a Sp. Gravity range of 1.100-1.300, 77°F)	13
21	Working Model of Distributor used in Battery Ignition System.	14
22	Working Model of Auto. Electrical System (2/4 Wheeler) (Model consists; *Electrical Circuit*-Horn, Buzzer, Starting, Ignition, Earthing etc. *Lighting Circuit*-Head, Tail and Side Lamps, Indicators/Flashers, Parking Light)	15
23	Minimum 02 sets of Automobile Service Tool Kit preferably with Trolley. *(Service Tool Kit:* It includes Cutting Tools, Hand Tools, Measuring Tools, Power Tools, Torque Wrenches, Bearing Pullers.)	1,2,5,16
24	Axle Stand/ Scissor/ Hydraulic Screw Jack (Capacity of 4 to 50 Ton)	1,2,5,16

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 Introduction to Automobiles	1a. Identify various automobile components and their location on the given vehicle. 1b. Describe with sketches the the function of the given part of the specified automobile chassis/frame/ body 1c. Select relevant type of alternative fuel for the given application with justification. 1d. Draw labeled vehicle layout of the given vehicle.	1.1 Automobile: Definition, Classification of Automobiles, Major Components of Automobiles with their Function and Location 1.2 Vehicle Layout: Definition Significance of Vehicle Layout, Different types of Vehicle layouts (FEFWD, FERWD, RERWD, 4WD), Advantages, Disadvantages, Applications and Comparisons of Different types of vehicle layouts. 1.3 Function of Chassis, Frame and Body: Requirement of Chassis, Frame and Body, Load acting on Frame, Classification of Chassis Frames with advantages, disadvantages and applications (Conventional, Unitized Body, Sub Frame), Basic Body Nomenclature. 1.4 Significance of Body Streamlining: Need and Importance of aerodynamic Aspects, Basic terms related with Car Aerodynamics (e.g. Drag, Lift, Skin Friction, Form Drag, Wake, Coefficient of Drag) 1.5 Alternative Fuels: LPG and CNG: Need, Fuel Characteristics, Construction and Working, Advantages, Limitations; Layout of Electric Vehicles: Need, Working , Advantages, Limitations. Hydrogen as fuel.
Unit-II Automobile Transmission Systems	2a. Identify the major components of the given transmission system. 2b. Select type of transmission for the given application with justification. 2c. Explain with sketches the working principle of the given overdrive with labelled diagram. 2d. Differentiate the features of the given two components based on the specified criteria. 2e. Explain the working principle of Differential for the given vehicle.	2.1 Function and Necessity of Clutch: Requirement of Clutch, Classification of Clutch, Working Principle of Clutch, Construction and Working of Single Plate (Coil Spring and Diaphragm), Multiplate Clutch and Centrifugal Clutch. 2.2 Function and Necessity of Gear Box Manual Transmission: Classification of Gear Box, Construction and working of Constant Mesh and Synchro Mesh Gear Box with power flow diagrams. 2.3 Semi Automatic Transmission: Function, Construction and Working of Overdrive, Automatic Transmission: Fluid Flywheel: Function, Construction and Working of Fluid Flywheel;

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	2f. Interpret power flow diagram of the given transmission system.	Torque Converter: Function, Construction and Working of Torque Converter; Epicyclic Gear Train: Function, Construction and Working of Epicyclic Gear Train. 2.4 Propeller Shaft Assembly: Function, Necessity and Types of Propeller Shaft, Function and necessity of Universal and Slip Joint. 2.5 Final Drive: Function and Necessity of Final Drive, Differential, Working Principle, Construction and Working of Differential. 2.6 Axles: Significance of Live and Dead Axle, Function and Requirement of Front Axle, Types of (Front) Stub axle, Function, Construction and Working of Semi Floating and Fully Floating Rear Axle.
Unit– III Automobile Control Systems	3a. Sketch the labelled layout of the given type of Braking System. 3b. Explain with sketches the working of the given ABS. 3c. Explain with sketches the terms related to Steering System 3d. Explain with sketches the working principle of the given type of Steering gearbox for the given vehicle. 3e. Select relevant braking systems for the given application with justification. 3f. Select relevant steering systems for the given application with justification.	3.1 Automobile Braking System: Function and Requirement of Braking System: Principle of Braking, Basic Terms related to Braking (Stopping Distance, Braking Efficiency, Fading of Brakes) 3.2 Types of Braking System: Layout, Construction, Working of Drum, Disc, Hydraulic and Air Brakes. 3.3 Master Cylinder, Wheel Cylinder, Tandem Master Cylinder, Significance and general procedure of Bleeding of Brake. 3.4 Review of Anti lock braking System: Layout of ABS, Pressure Modulation, Types of ABS. 3.5 Automobile Steering System: Function and Requirements of Steering System: Basic Terms related to Steering (Steering Ratio, Turning Radius, Understeering and Oversteering), Basic Components of Steering Linkages. 3.6 Types of Steering Gear Boxes: Construction and Working of Rack and Pinion, Recirculating Ball Type Steering Gear Box, Necessity and Principle of Power Steering, Construction and Working of Hydraulic and Electronic Power Steering. 3.7 Steering Geometry: Necessity of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Steering Geometry, Significance and ranges of Caster (Positive, Negative), Camber (Positive, Negative), Toe-in, Toe out, King Pin Inclination (KPI), Steering Axis Inclination (SAI)
Unit– IV Automobile Suspension, Wheels and Tyres	4a Define the given terms related to the given suspension system. 4b Explain with sketches the working principle of the given type of Suspension System for the given vehicle. 4c Explain with sketches the working principle of the given type of Shock Absorbers/Air Suspension. 4d Select relevant procedure, tool and equipment for Wheel Alignmnet and Balancing for the given vehicle with justification. 4e Describe with sketches the terms related to Wheel alignment/wheel balancing. 4f Select relevant suspension systems for the given application with justification.	4.1 Automobile Suspension System: Function and Requirement of Rigid Suspension System: Basic Terms Related with Suspension System: (Jounce, Rebound, Sprung and Unsprung Weight, Spring Rate, Elasticity), Types and Constructional Features of Leaf Springs,. 4.2 Function and Requirement of Independent Suspension System: Advantages of Front Wheel Independent Suspension, Construction and Working of Mac-Pherson Strut Type, Wishbone Type Suspension system. 4.3 Shock Absorbers and Air Suspension: Layout, Construction and Working of Air Suspension, Function and Types of Shock Absorber, Principle of Hydraulic Shock Absorber, Construction and Working of Telescopic Shock Absorber, Constructional Features and working of Gas Filled Shock Absorber. 4.4 Wheels, Rims and Tyres: Function, Necessity and Requirement of Wheel, Rim and Tyres: Types of Wheels, Rims and Tyres, Construction and Working of Different Types of Wheels, Rims and Tyres. 4.5 Tyre Economy: Consideration in Tyre Tread Design, Factors affecting to Tyre Life, Tyre Wear and Rotation, Tyre Designation. 4.6 Wheel Alignment and Balancing: Purpose of Wheel Alignment, Procedure of Wheel Alignment, Purpose of Wheel Balancing, Significance of Static and Dynamic Balancing, Procedure for Static and Dynamic Balancing.
Unit –V Automobile Electrical and Electronics Systems	5a Define the given terms related to the automobile electrical system. 5b Select the relevant battery for the given	5.1 Introduction to Electrical-Electronic System: Basic Electrical-Electronics Principles (Current, Voltage, Resistance, Electricity, Magnetism, Electromagnetism, Induction,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	application. 5c Explain wit sketches the working principle of the given electrical component of the vehicle. 5d Differentiate between the given two terms related to the automobile electrical system. 5e Select the relevant sensors and actuators for the given application with justification. 5f Prepare simple electrical/electronic circuits for given type of automobile.	Rectification etc.) Basic Electrical-Electronics Components used in automobiles with their conventional symbols. 5.2 Battery: Function and Requirements of Battery, Types of Battery, Principle of Lead Acid Battery, Construction and Operation of Lead Acid Battery, Significance of Battery Rating and Battery Capacity, Battery Open Volt and Specific Gravity Test, Salient Features of Maintenance Free Battery. 5.3 Starting System: Function and Requirement of Starting System, Components of Starting System, Construction and Working of Standard Bendix Drive. 5.4 Charging System: Function and Requirement of Charging System, Components of Charging System, Construction and Working of Alternator. 5.5 Ignition System: Function and Requirement of Ignition System, Types of Ignition System, Construction and Working of Battery Ignition, Magneto Ignition and Electronic Ignition System with advantages, disadvantages, applications. . 5.6 Lighting System: Function and Requirements of Lighting Systems, Types of Lights, Necessity and Importance of Cable Color Codes, Wiring Harness. 5.7 Miscellaneous: A Brief Review of Different types of Gauges, Windscreen wiper, Function and Location of Major Sensors and Actuators used in Automobile Electronics.
Unit–VI Motor Vehicle Act, Road Safety and Garage Practices	6a. Explain the meaning of the given Road Traffic signs. 6b. Draw labeled layout of a Modern Service Station for the given situaton. 6c. Differentiate between the given two terms related to the motor vehicle act. 6d. Describe with sketches the the function of the	6.1 Introduction and Objectives of Motor Vehicle Act: Salient Features of M. V. Act 1988 and Central Motor Vehicle Rules 1989. 6.1.2 Types and Significance of Traffic Signs, Important Transport Terms (Definitions) in M. V. Act (Motor Vehicle, Motor Cycle, HGV, MGV, LGV, Public Service Vehicle, Transport Vehicle, Driver, Passenger, Accident)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	specified type of passenger comfort/safety component. 6e. Select the relevant service tools for relevant service operation in automobile shops with justification.	6.2 Organization Structure of Motor Vehicle (RTO) Department, Duties and Responsibilities of RTO, AIMV. 6.3 Passenger Comfort and Safety: Function and requirements of Passenger Safety System. Features of Air Bags, Seat Belts, Collapsible Steering Column. 6.4 Automobile Maintenance Systems: Significance of Garage, Workshop, Service Station, Dealership. 6.5 Types of Maintenance, Need and importance of Record Keeping, List of Records to be kept in Service Stations 6.6 Site selection and amenities/facilities required to set up your own Garage/Service Station, Role and Responsibilities of Service Manager, Service Supervisor, Customer Care Manager in Service Stations.

***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	Introduction to Automobiles	08	02	04	04	10
II	Automobile Transmission Systems	10	02	04	08	14
III	Automobile Control Systems	08	02	02	06	10
IV	Automobile Suspension, Wheels and Tyres	08	02	04	06	12
V	Automobile Electrical and Electronics Systems	08	02	04	08	14
VI	Motor Vehicle Act, Road Safety and Garage Practices	06	02	04	04	10
Total		**48**	**12**	**22**	**36**	**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) Attend, observe and Prepare a brief report for Computerized Wheel alignment of vehicles with various types of suspension and steering system at nearby service station.
b) Attend, Observe and Prepare a brief report for Computerized Wheel Balancing of Vehicles with static and dynamic conditions at nearby service station.
c) Apply for the Learner's Licence. Fill online form and appear for Virtual Driving Test at RTO Office. Prepare a brief report on "Procedure of Issuing Driving Licence by RTO".
d) Visit to nearby Authorised Service station preferabaly Four Wheelers/Heavy Vehicles and observe the organization structure, Different sections, Modern Tools and Equipments used, Records to be kept, Work Profile of Diploma Engineer in Service Station, and prepare a visit report with schematic layout and concluding remarks.
e) Visit to nearby MSRTC Divisional Workshop/Depot, observe the organization structure, Work profile of Diploma Engineer, different Sections and systems, Service activities at Workshop and prepare a brief report with schematic layout and concluding remarks.
f) Conduct a PUC test of 2/4 Wheeler on exhaust gas analyser according to M. V. Act and prepare a brief report on "Automobile Emission Norms in India".
g) Visit to 2/3/4 Wheeler Automobile Manufacturer's, observe the Organization Structure, Diffferent Sections, Work Profile of Diploma Engineer, Safety precautions to be followed and prepare a detail report with schematic layout.
h) Attend an expert talk of RTO Officials in your city/town arrange by Department/Institute for your Class on following Topics;
    i. Road Safety and Security:Challenges and Opportunity
    ii. Motor Vehicle Act 1988 and CMV Rules 1989
    iii. Career Opportunities to Mechanical Engineer in RTO Department.
    iv. Disaster Management at Road Accidents.
    v. Traffic Offences and penalties as per M.V. Act.
i) Try to attend the event of "Indian Auto Expo" joiltly organized by the Automotive Component Manufacturers Association (ACMA), Confederation of Indian Industry (CII) and Society of Indian Automobile Manufacturers (SIAM)]. Observe the various new production launches, their features and concepts behind design and technical specifications. Prepare a detailed report on visit and share the experience with collegues.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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) Before starting practical, teacher should demonstrate the working of System.

g) Instructions to students regarding care and maintenance of Model/Equipment.
h) Show video/animation films to explain functioning of various Automobile Systems.

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 a chart of Symbolic representation of different electrical-electronic components used in automobiles. (e.g. Earthing, Fuse, Circuit Breaker, Capacitor, Resistor, Coil, Switch, Diode, Motor, Semi conductor etc.)
b) Collect information of Chassis Specifications of different vehicles.
c) Perfrom comparative study of different alternative fuels available in India.
d) Visit to Modern Service Station and Prepare a Layout indicating various sections, Specialized Equipments, Machines and basic ameneties provided.
e) Prepare a case study on following topics related with Transport Management through Group Discussion:
    i. Current Public Transport Scenerion in India
    ii. RTO Policies for enhancing Road Safety
    iii. Importance of Metro Rail in Rapid transiotion System
    iv. Review of worldwide effective Rapid Transition Systems
    v. *(E.g. BRT System in Bogota, Singapore, Japan,Malesiya)*
    vi. Traffic crisis in Metro Cities: Causes and Cures
    vii. Role of Motor Vehicle Department in Transport Management
f) Information Search and Market Survey through Magazines like Overdrive, Autocar, Auto India, internet surfing and site visits on following topics:
    i. Automobile Manufacturers in India.
    ii. Aerodynamic Optimization in Automobiles.
    iii. Current (Indian/Worldwide) Automobile Market of 2/4 Wheeler Industry.
    iv. Upcoming vehicles on alterntive fuel sources in Indian Auto Industry.
    v. Adaptive Suspension System
    vi. On Board Diagnostics Systems (OBD-I/II)
g) Prepare a Chart of road traffic signs in categories of Mandatory, Cautionary, Informatory. Display it to your Departmnet/Institute and make aware to your collegues for the same.
h) Prepare a simple Automobile Lighting Circuit (2/4 Wheeler) Display and indicates the relevant cable color codes on it.
i) Information Search and Market Review on "Different types of Automobile Service tools and Specialized Equipment and Machines" used in Modern Service Stations.
a. Prepare a report on Electric and Hybrid vehicles.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	A Text Book of Automobile Engineering	Rajput R. K.	Laxmi Publications Pvt. Ltd., New Delhi, (2008) ISBN: 97881170089919
2	Automobile Engineering	Kamaraju Ramakrishna	PHI Learning Pvt. Ltd., New Delhi, (2012) ISBN: 9788120346109.
3	Automobile Engineering (Vol I and II)	Dr. Kirpal Singh	Standard Publishers, New Delhi. (2004) ISBN: 9788180141034.
4	Automotive Mechanics	Crouse W.H., Anglin D.W.	Tata McGraw Hill Publications, Delhi (1965) ISBN: 978007070148215
5	Motor Vehicle Act, 1988	CMV Rules	Eastern Book Company, Mumbai, (1989) ISBN: 8171771629.
6	Compendium of Transport Terms	CIRT, Pune	Central Insttute of Road Transport, (2007) CIRT Publications, Bhosari Pune
7	The Drivers Manual	Pasricha P.S.	Nasha Publications, (1994) Mumbai
8	Road Safety Guide	Pasricha P.S.	Nasha Publications, (1991) Mumbai
9	Automobile Electrical and Electronic Systems	Tom Denton	Elsevier Butterworth Heinemann, Oxford/ Routledge, (2013) ISBN: 9780750662192.
10	Indian Journal of Transport Management (Quarterly Published Journal)	IJTM, CIRT, Pune	Central Institure of Road Transport (CIRT), CIRT Publications, Bhosari, (1876, starting year) Pune ISSN: 0972-5695.

14. SUGGESTED VIDEOS AND LEARNING WEBSITES:

a) http://nptel.ac.in/courses. *(NPTEL)*
b) https://www.araiindia.com/Draft_AIS_Standards.asp. *(ARAI, Pune)*
c) http://www.cirtindia.com/testing_universalTyreTestingMachine.html. *(CIRT, Pune)*
d) www.pcra.org/pages/view/220. *(PCRA, New Delhi)*
e) https://www.saeindia.org/. *(SAE India)*
f) https://transport.maharashtra.gov.in/1161/Road-Signs. *(RTO, M. V. Department, M.S.)*
g) https://msrtc.maharshtra.gov.in/. *(MSRTC, M.S.)*
h) https://www.howstuffworks.com.
i) https://www.youtube.com/watch?v=Y1zbE21Pzl0. *(Automatic Transmission)*
j) https://www.youtube.com/watch?v=u_y1S8C0Hmc. *(Automatic Transmission)*
k) https://www.youtube.com/watch?v=wCu9W9xNwtI. *(Manual Transmission)*
l) https://www.youtube.com/watch?v=vOo3TLgL0kM. *(Manual Transmission)*
m) https://www.youtube.com/watch?v=aNGA5Ejq8A4. *(Differential)*
n) https://www.youtube.com/watch?v=VFu-6tckyc8. *(Rear Axle)*
o) https://www.youtube.com/watch?v=IrBE8k9rIr8. *(Radial and Tubeless Tyre)*
p) https://www.youtube.com/watch?v=mLCG1_ecC3g. *(Tubeless Tyre)*
q) https://www.youtube.com/watch?v=wKwvObmidh0. *(Repair of Tubeless Tyre)*
r) https://www.youtube.com/watch?v=LCMs-7K8nLk. *(Alloy Wheels)*
s) https://www.youtube.com/watch?v=hnsvkpOP8_g. *(Alloy and Cast Wheel)*
t) https://www.youtube.com/watch?v=F6ZZ_U_Fl1Y. *(Wheel Alignment)*
u) https://www.youtube.com/watch?v=1k6Yh6FhHvE. *(Wheel and Tyre Animation)*
v) https://www.youtube.com/watch?v=bg92_ytLm0M. *(Tyre Protector)*
w) https://www.youtube.com/watch?v=LffD2xx-7uw. *(Repair of Tubeless Tyre)*

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Industrial Engineering and Quality Control**

Course Code : **22657**

1. RATIONALE

In any mechanical industry, industrial engineering integrates men, machines, materials, method of production, information, and energy to make a product and hence enhance productivity by eliminating wastefulness in production processes. Mechanical engineering technologists needs to determine the standardized process, time for its completion known as work and time study, measuring the output in terms of productivity, evaluation of jobs, workers and determining the wages and incentives, measurement of quality of product. Total Quality Control is an effective system of integrating quality development, quality maintenance and quality improvement efforts of the various groups in industry, so as to enable production and services at most economical level which tends towards full customer satisfaction. Understanding of fundamental principles of industrial engineering and quality control helps a technologists in maximizing efficiency within a company by finding the best use of people, equipment, and facilities..

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 Industrial Engineering and Quality Control techniques for assuring quality of products and services.**

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 work study techniques to optimize manufacturing processes.
b) Prepare the detailed sequence of operations for manufacturing of components.
c) Apply Ergonomic principle for designing simple mechanical component .
d) Interpret the data obtained from the different quality control processes.
e) Interpret control charts for variable and attribute data.

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.

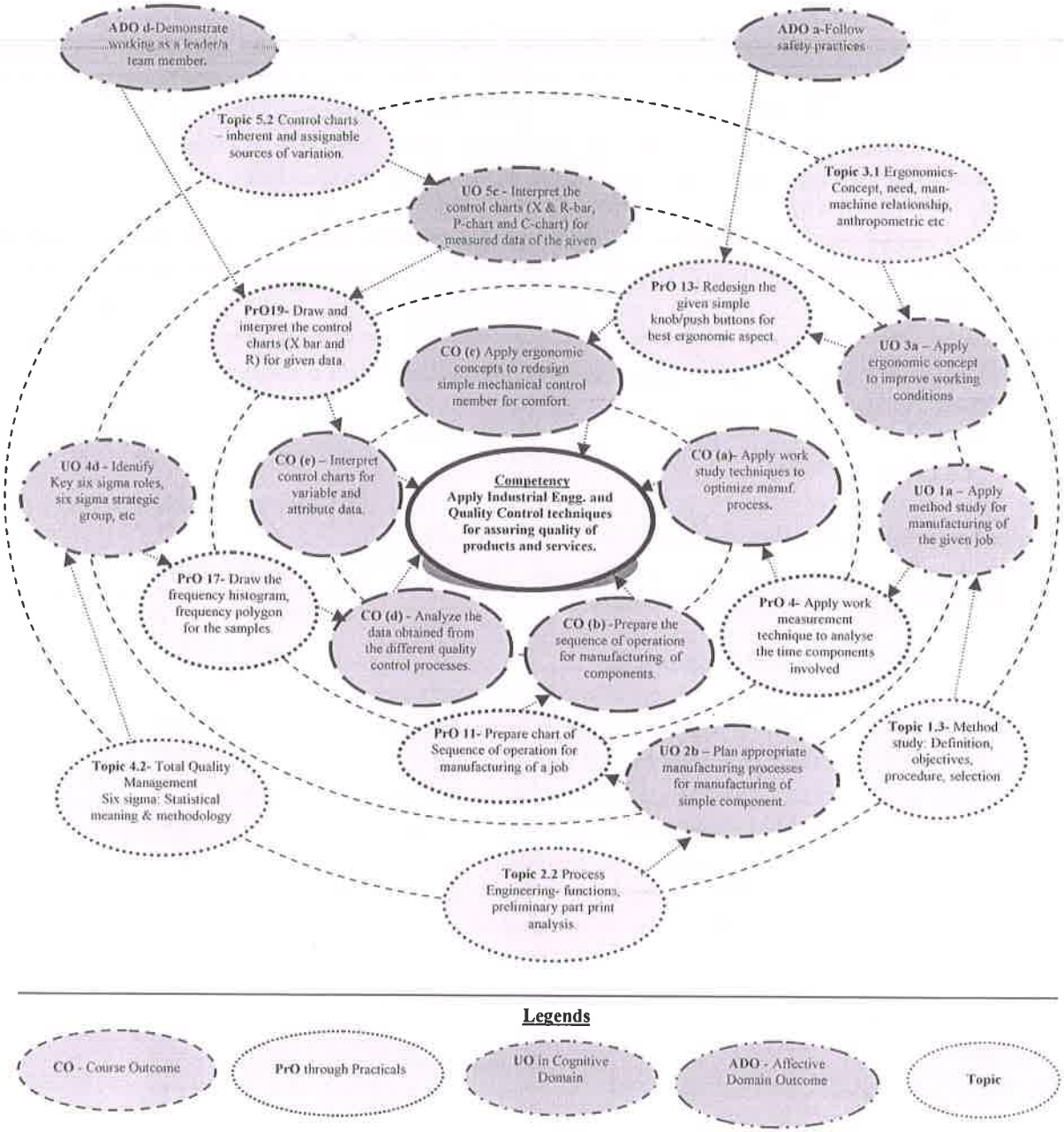

Figure 1 - Course Map

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	Apply method study approach Analyze the motions involved in machining operation of the given job	I	02*
2	Apply work measurement technique to analyze the time components involved machining operation of given job using stop watch.	I	02*
3	Calculate standard time for all the operations involved in step turning process.	I	02
4	Prepare motion chart of given activity using standard symbols of therbligs (max 18).	I	02
5	Prepare supply chain chart in day-to-day situation like supply of Cold drink/tooth paste/any grocery item.	II	02*
6	Prepare supply chain management chart for online purchase of goods/products.	II	02
7	Prepare detailed process plan for manufacturing of Hexagonal Nut/Hexagonal headed bolt/Stud/Wing Nut/Plain Washer.	II	02*
8	Prepare chart of Sequence of operation for manufacturing of simple job like manufacturing of hexagonal nut & bolt/ Manufacturing of V-Block on shaper machine.	II	02
9	Prepare Chart of sequence of operation for Single or Double riveted lap joint/Single riveted butt joint (single strap).	II	02*
10	Use Ergonomic principle for given component .	III	02*
11	Prepare and analyze steps to solve the given problem in institute/industry using quality circle concept.	IV	02*
12	Draw the frequency histogram, frequency polygon for the samples and calculate mean, mode and median for same.	V	02
13	Draw the normal distribution curve, calculate Deviation, Variance, Range and determine the process capability for $\pm 3\sigma$ or $\pm 6\sigma$.	V	02*
14	Draw and interpret the control charts (Xbar and R) for given data.	V	02
15	Draw and interpret the control charts (P-chart and C-chart) for given data.	V	02*
	Total		**30**

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 safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work 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
- 'Organisation Level' in 2nd year
- 'Characterisation 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	Stop Watch Timing capacity:23hrs, 59mins and 59.99secs, Accuracy: ±3 seconds/day	1,2,3,4,5,6
2	Digital Video Camera for Micro Motion Analysis with following specification (i) ISO 100-12800 (ii) Focal length f = 3.5-5.6 (iii) 24.2 MP (iv) lenses 18-55mm.	1,2,3,4,5,6
3	Steel Rule for Length Measurement Range 0-5 feet	4,5,6 ,10,11.12
4	Digital/manual Vernier Caliper Range 0-150 mm, L.C. 0.02mm	10,11,12
5	Digital / manual Screw thread Micrometer, Range 0-25 mm, L.C. 0.01mm	10,11,
6	Digital / manual Screw Thread Micrometer Range 25-50mm, L.C. 0.01mm	10,11,
7	Display Wall chart showing X bar Chart and R CHART	13.14.15
8	Display Wall chart showing "C Chart"	13,14,15
9	Display Wall chart showing Therbilgs with minimum 18 symbols	7
10	Standard samples like steel balls, bearings, turning operation jobs, gear samples for sample measurement	13,14,15
11	Different types of Ergonomic Charts	7

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 Work Study (Method Study and Work Measurement)	1a. Apply method study for manufacturing of the given job. 1b. Apply time study for manufacturing of the given job. 1c. Select relevant recording techniques for the given process with justification. 1d. Prepare relevant types of charts for the given process using the given recording techniques. 1e. Calculate standard time for the given activity using work measurement.	1.1 Industrial Engineering: Definition, Need, Objectives and Scope 1.2 Work study: Method study(Motion Study) and Time study(Work Measurement) 1.3 Method study: Definition, objectives, procedure, selection of work 1.4 Recording Techniques: - Process Charts – Outline process chart, Flow process chart, Two Handed process chart/Simo Chart, multiple activity Chart, Flow diagram, String diagram, Therbligs, Travel chart. 1.5 Work Measurement – Objectives, procedure, Time Study, Time Study Equipment. Stop Watch Time Study, Allowances, Calculation of Standard Time.
Unit– II Process Engineering	2a. Apply principles of supply chain management in the given industrial/domestic application. 2b. Plan appropriate manufacturing processes for manufacturing of the given simple job/component. 2c. Sketch precedence diagram for the given simple manufacturing task using line balancing concept. 2d. Apply CPM for the given project of the specified industry. 2e. Prepare the detailed sequence of operations for manufacturing the given component.	2.1 Production: Concept, factors of production, Supply Chain Management, 2.2 Process Engineering- functions, preliminary part print analysis, Selecting and planning manufacturing process; determining manufacturing sequence 2.3 Line Balancing: Heuristic approach of line balancing 2.4 Critical Path Method (CPM) and its application related to Project completion.
Unit-III Ergonomics	3a. Apply ergonomic concept to improve working conditions in the given industrial environment(s). 3b. Apply ergonomics principle to given simple component. 3c. Use ergonomic principle for	3.1 Ergonomics- Concept, need, man-machine relationship, anthropometric and functional anatomy data, 3.2 Ergonomic in design of control members – push button, knobs, levers, cranks, hand wheel. 3.3 Ergonomic considerations applied to

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	designing different controls and displays	types and location of display. 3.4 Compatibility in the design of control members.
Unit –IV Quality Control and Inspection	4a. Prepare quality characteristics chart which contribute to fitness for use of the given job/ component. 4b. List steps to solve the given problem in the industry using quality circle concept with justification. 4c. Identify Key six sigma roles , six sigma strategic group, Master Black Belt and Black Belt as coaches for the given industrial situation. 4d. Prepare cause and effect diagram/ Pareto chart/Scatter diagram for solving the given problem for root cause analysis. 4e. Select the type of inspection to be carried out at various stages of process/ product layout for the given situation relevant to industry with justification. 4f. Interpret the data obtained from the given quality control processes.	4.1 Meaning of quality of produce and services, Quality characteristics, Quality of design, Quality of conformance, Quality of performance, Concept of reliability, Cost, Quality assurance, Cost of rework and repair, Quality and Inspection, Quality Circle 4.2 Total Quality Management; Six sigma: Statistical meaning and methodology, Six sigma Black Belt concept. 4.3 KAIZEN, POKA-YOKE, 5S Techniques. 4.4 Introduction of ISO 9000, ISO-14000. 4.5 Quality Economics: Cost of quality, Value of quality, Economics of quality confirmation, Cost of quality appraisal, prevention, external and internal failure cost. Quality function deployment: Basic concept and areas of application. 4.6 Various Q-C tools: Cause-and-effect diagram (fishbone or Ishikawa diagram),Check sheet, Histogram, Pareto chart and Scatter diagram. 4.7 Inspection Definition and meaning, Difference between Inspection and quality control, Classification of Inspection –(i) Process Inspection (ii) Final Inspection (iii) Raw Material (finished/semifinished) Inspection (iv) Tool and Gauge Inspection. Role of Quality Control Inspector/supervisor.
Unit-V Statistical Quality Control	5a. Calculate mean, mode and median for the given sample(s) including the frequency histogram, frequency polygon. 5b. Represent the given data through normal distribution curve after calculating the standard deviation (σ), variance, range to determine the process capability. 5c. Interpret the control charts (X and R-bar, P-chart and C-chart) for measured data of the given sample(s). 5d. Prepare Single/Double	5.1 Basics of Statistical concepts, Meaning and importance of SQC. 5.2 Variable and attribute Measurement. Control charts – inherent and assignable sources of variation. Control charts for variables – X and R charts, control charts for attributes p, np, C charts. 5.3 Process capability of machine (±3σ or ±6σ), Cp and Cpk calculations. 5.4 Acceptance Sampling Concept, Comparison with 100% inspection, Operating Characteristics Curve, 5.5 Different types of sampling plans, sampling methods.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	sampling plan for the given Lot size (N), Sample size(n), acceptance number(c) 5e. Interpret control charts for the given variable and attribute data.	5.6 Merits and demerits of acceptance sampling.

***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	Work Study (Method Study and Work Measurement)	12	02	04	06	12
II	Process Engineering	08	02	04	06	12
III	Ergonomics	06	02	04	06	12
IV	Quality Control and Inspection	10	02	04	10	16
V	Statistical Quality Control	12	02	04	12	18
Total		**48**	**10**	**20**	**40**	**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) Collect examples related to improvements which can be implanted in manufacturing using concepts of ergonomics.
b) Explain with suitable examples of your choice interaction between human and machine (any machine). Explain the procedure of evaluation of this interaction w.r.t. ergonomics.
c) Prepare Wall Chart of 3 Sigma and Six Sigma Curves and Compare number of defectives/rejection in parts per million (PPM).
d) Prepare list of National/international industries working on principle of Six Sigma Technique.
e) Visit any production industry. Collect the actual data from production and quality control department. Calculate mean, mode and median for the collected data.
f) Prepare a wall chart using standard 18 Therblings, state meaning of each symbol

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) Before starting practical, teacher should demonstrate the working of instrument.
g) Instructions to students regarding care and maintenance of measuring equipments.
h) Show video/animation films to explain functioning of various measuring Instruments
i) Teacher should ask the students to go through instruction and Technical manuals of instruments

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) Calculate the predermine time and total time required for the delivery of food (pizza/Burger) from fast food centers available in your city or town. Prepare sequence of activity and represent with Therbligs.
b) Prepare the list on World class industries using Six sigma Technique at present. and write detail report on any one of industry.
c) Visit any manufacturing Industry and observe analyse actual Quality Control practices.
d) Visit any manufacturing local/nearby Industry and observe the working of type of inspection practices carried out and prepare a report.
e) Visit any manufacturing local/nearby Industry and observe the various statistical Quality controls techniques carried out. Prepare related chart.
f) Visit any manufacturing local/nearby Industry and observe the various sampling plan followed by the industry. Draw the same sampling plan.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Oil Hydraulic system-Principles and maintenance	Majumdar, S.R	Tata McGraw Hill, New Delhi, (2002), ISBN: 9780074637487
2	Industrial Engineering and management	Khanna, O.P.	Dhanapat Rai Publications(P) Ltd., New Delhi, (1980), ISBN-10: 818992835X
3	Statistical Quality Control	Mahajan, M.	Dhanpat Rai and Sons, New Delhi, (2006) ISBN-10: 817700039X
4	Statistical Quality Control	Montgomer,y Douglas C.	Wiley India Pvt. Ltd., New Delhi, (2009), ISBN:9781118146811
5	Total Quality Management	Besterfield, Dale, H.	Pearson New Delhi, (2011) ISBN-13: 9780130993069
6	A Guide to the Ergonomics of Manufacturing	Heylander, Martin	East West Press, Taylor and Fransis, UK, (1997) , ISBN 0748401229
7	Ergonomics : Man in his Working Environment :	Murrell, K. F.	Chhapman and Hall Ltd., U.S.A. (2012), ISBN 13: 9780412219900
8	Ergonomics at Work	Oborn, David J.	John Wiley and Sons, New York , (1982), ISBN-10: 0471909424
9	Motion and Time Studies	Ralph, M. Barnes	John Wiley and Sons, UK, (2009), ISBN-9788126522170
10	Hand Book of Industrial Engg	Gavriel, Salvendy	John Wiley and Sons, UK, (2001) ISBN-10: 0471502766
11	Six Sigma Project Management: APocket Guide	Lowenthal, J. N	Milwaukee, WI: ASQ Quality Press. (2001), Lowenthal, J. N ISBN: 087389-519-3
12	The Six Sigma Handbook.	Pyzdek, T.	McGraw-Hill, New York, (2018) ISBN-13: 978-0071372336

14. SOFTWARE/LEARNING WEBSITES

a) https://nptel.ac.in/courses/112107143/8
b) https://www.youtube.com/watch?v=SRV27U2LBf0
c) https://www.youtube.com/watch?v=I2Oz5cyr9qs
d) https://www.ifm.eng.cam.ac.uk/research/dstools/quality-function-deployment
e) https://www.pinterest.com/pin/342696471431684 77/
f) https://www.simplilearn.com/reasons-to-do-six-sigma-certification-article
g) https://www.youtube.com/watch?v=ZUZKtzhivQo
h) https://www.youtube.com/watch?v=4zrbfsAdEw0
i) https://www.youtube.com/watch?v=ENSb6BsM_q8
j) http://www.safetycare.com/en/shop/ergonomics-2/

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Computer Integrated Manufacturing (Elective-II)**

Course Code : **22658**

1. RATIONALE

Diploma Engineers need to acquire the knowledge of computer integrated Manufacturing (CIM) after getting conversant with conventional manufacturing methods. This subject encompasses entire range of product development and manufacturing activities with the help of different software packages. The course intends to help the students to work on Group Technology, Material Requirement Planning and collection of factory data system.

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 of computer integrated manufacturing (CIM) technology in current manufacturing system.**

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 Computer Aided Design (CAD)/ Computer Aided Manufacturing (CAM)/(CIM) product cycle different products cycle.
b) Apply CAM and CIM practices.
c) Apply business function software in CIM.
d) Apply networking in CIM.
e) Use of Flexible Manufacturing System (FMS) and Automation concepts in industries.
f) Use of Robotics technology in industries.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
				Paper	ESE		PA		Total		ESE		PA		Total	
L	T	P		Hrs.	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.

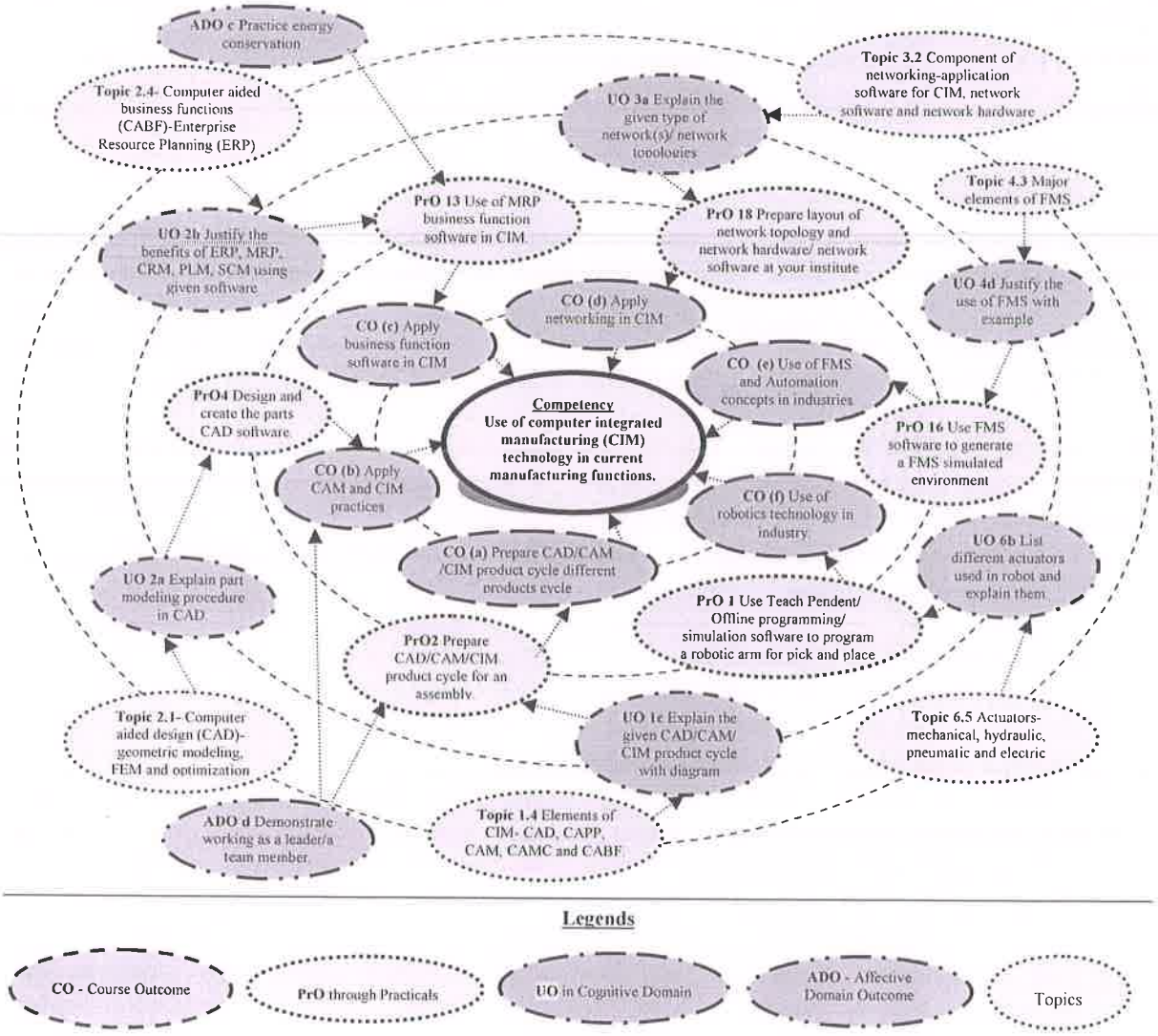

Figure 1 - Course Map

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	Prepare traditional product cycle for any one of the assembly.	I	2*
2	Prepare CAD/CAM/CIM product cycle for PrO1 assembly.	I	2*
3	Use of CRM (Customer Relation Management) software for maintaining customer relationship.	II	2
4	Design and create the individual parts of PrO1 assembly by using geometric modeling workbench of CAD software.	II	2*
5	Optimizing, evaluate and design review of parts modeled under PrO3 using any CAD/CAE software.	II	2*
6	Create drawings of parts modeled under PrO3 using drafting workbench of CAD software.	II	2*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Generate bill of material (BOM) and other data of PrO4 using CAD software.	II	2
8	Prepare Computer aided process plan for the selected part using variant type of CAPP (Computer Aided Process Planning) software.	II	2
9	Generate sample program for any part and verify tool path by simulation using CAM software.	II	2*
10	Generate tool path movement by Interfacing part program or manual part program to CNC machine.	II	2*
11	Inspection of part using CAQC software (Computer Aided Quality Control) by CMM/other system.	II	2
12	Use MRP (Material Resource Planning) software for CIM of and assembly.	II	2*
13	Use PLM (Product Life Management) software for CIM related to any product.	II	2*
14	Use Supply Chain Management software for CIM related to any product.	II	2
15	Prepare layout of network topology and network hardware/ network software at your institute place.	III	2*
16	Establish networking between two CNC machines, computers and supported peripherals of your institute to exchange manufacturing data and produce a simple component.	III	2*
17	Observe actual/video film of FMS system and identify various elements of FMS and its nature of controlling by computer.	IV	2*
18	Generate part family code for a machine component using Opitz/MICLASS methods.	IV	2*
19	Observe actual / video film of automation system and identify various elements, type of automation and its nature of controlling by computer.	V	2*
20	Use FMS simulation software to generate a Flexible Manufacturing System simulated environment to control and program Automatic storage and Retrieval system (ASRS), linear shuttle conveyor, Interfacing of CNC lathe/milling and with loading unloading.	V	2
21	Build Electro-Hydraulic circuits for given application and interfacing it to PLC using Electro-Hydraulic Training kit.	V	02*
22	Observe actual / video film of robotics system and identify various element, type of robot, it configurations and its nature of controlling by computer.	VI	2*
23	Use Teach Pendent/Offline programming/simulation software to program a robotic arm to perform pick and place and stacking of objects (2 programs)	VI	2*
	Total		**46**

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 setup/simulated environment	40
2	Effective use of related software/hardware.	20
3	Correlation with the real/industrial situation	10
4	Observations/survey and collection of information.	10
5	Answer to sample questions.	10
6	Submit 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 safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work 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
- 'Organisation Level' in 2nd year
- 'Characterisation 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	Computers minimum 4GB RAM and above	2,3 to 22
2	MRP/ ERP/ CRM/SCM and PLM software (1 + 10 user)	2,3,12,13,14
3	Database Management system Software (1 + 10)	2,3,12,13,14
4	Educational networking licensed CAD software (1 + 20 user)	2 & 4 To 7
5	Educational networking licensed CAM software (1 + 20 user)	2 & 4 To 7
6	CNC Milling Machine	9,10,15,16
7	CNC lathe machine	9,10, 15,16
8	Educational networking licensed CAQC software (Computer Aided Quality Control) or CMM/other system	11
9	Flexible Manufacturing System (FMS) model	20
10	Educational networking licensed FMS simulation software	20
11	Previous final year students sample projects containing low cost automation system.	All
12	Educational programmable robotics arm to manipulate objects.	22
13	Educational networking licensed Robotic system simulation software	22

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 Introduction to CIM	1a Explain the traditional product cycle with diagram and show all elements on it. 1b Explain advantages and benefits of the given CIM system. 1c Explain the given CAD/CAM/CIM product cycle with diagram and show elements on it. 1d Compare the given traditional product cycle with its counter CAD/CAM /CIM product cycle.	1.1 **Traditional product cycle diagram**-role of marketing, R&D, design, PPC, quality control and sales departments. Disadvantages and limitations of traditional product cycle. 1.2 **Current production needs-** production rate, quality, accuracy, repeatability, flexibility, survival. 1.3 **CIM**-concept, advantages and benefits of CIM. 1.4 **Elements of CIM-** computer aided design (CAD), computer process planning (CAPP), computer aided manufacturing control (CAMC), and computer aided business function (CABF). 1.5 **CAD/CAM/CIM product cycle diagram-** customer, marketing, computer aided design (CAD), computer aided process planning (CAPP), computer aided manufacturing control (CAMC), computer aided business function (CABF).
Unit– II Product Cycle Development through CIM	2a Explain part modeling procedure in CAD for the given component. 2b Explain analysis, optimization and evaluation for the given part using any CAE software. 2c Explain automated drafting procedure for the given component using any CAD software. 2d Differentiate given two methods of CAPP justifying with suitable examples 2e Explain the procedure of computerized part program generation for the given part using any CAM software. 2f Explain the procedure of part program interfacing to the given	2.1 **Computer aided design (CAD)**-geometric modeling, finite element analysis and optimization, evaluation and design review (CAE), concept of concurrent engineering, and list of software for CAE, simulation, automated drafting and generation of report. 2.2 **Computer aided process planning (CAPP)**-concept of CAPP, structure of processes planning software, methods of CAPP-variant, generative. Computerized material resource planning (CMRP), computerized work scheduling. 2.3 **Computer aided manufacturing control (CAMC)** – to generate computer program in machining. Interfacing part program to CNC. Computerized control monitoring and control, computer aided quality control (CAQC). Programmable logic control (PLC), software list like SCADA etc. 2.4 **Computer aided business functions (CABF)**-Enterprise Resource Planning (ERP)-role of ERP in business, advantage and applications of ERP softwares. Material Resource Planning (MRP)- role of MRP in business, advantage and benifits.MRP

	CNC machine. 2g Justify the benefits of ERP, MRP, CRM, PLM, SCM using the given corresponding software.	softwares. Customer Relationship Management (CRM) - role of CRM in business, advantage and applications.CRM software. 2.5 Product Lifecycle Management (PLM) - role of PLM in business, advantage and applications. PLM software. 2.6 Supply Chain management (SCM)- role of SCM in business, advantage and applications. SCM software.
Unit– III CIM Hardware, Software, Networking & Data Base Management System(DBMS)	3a. Explain the given type of network(s) and network topologies with diagram. 3b. Explain the given application software, network software, and network hardware with its purpose. 3c. State need of the given DBMS for the specified situation. 3d. Explain with sketches the given type of database.	3.1 **CIM networking**-types of network and its characteristics', applications. Types of network topologies-star, bus and ring topology. 3.2 **Component of networking**-application software for CIM, network software and network hardware. 3.3 **Data Base Management System (DBMS)**-data base types - hierarchical data base, network data base, relational data base, object oriented data base. Functions of data base management system. Advantages of DBMS.
Unit– IV Group Technology and Flexible Manufacturing System	4a. Justify the concept of Group Technology and its benefits for the given situation. 4b. Classify the FMS based on Flexibility for the given types of layouts. 4c. Compare the given two manufacturing systems based on the given criteria with examples. 4d. Justify the use of FMS for the given situation with example.s	4.1 **Group Technology**-concept, basis for developing part families, part classification and coding with example, concept of cellular manufacturing. Advantages and limitations. 4.2 **Flexible Manufacturing System-** Introduction, concept, definition and need, sub systems of FMS, comparing with other manufacturing approaches. 4.3 **Major elements of FMS**-workstations, material handling and storage system, computer control system and human resource. 4.4 **Classification based on flexibility**-dedicated FMS, random order. 4.5 **Classification based on types of layouts**-inline layout type, rotary layout, rectangular layout, loop layout type ladder layout type. 4.6 Applications and benefits of FMS, advantages and disadvantages of FMS.
Unit– V Automation	5a. Explain the main elements of the given automation system. 5b. Explain the given types of automations with respect to their characteristics.	5.1 **Automation**-Define, need of automation, high and low cost automation, examples of automations. 5.2 **Elements of automation** – power source, control unit and feedback control. 5.3 **Types of automations**- Fixed (Hard)

	5c. Justify the need of automation for the given situation. 5d. Explain the kind of strategies to be considered while designing automation in industry for the given situation.	automation, programmable automations and Flexible automations (Soft).Comparison of types of automations. 5.4 **Strategies in automation-** simplification, specializations of operations, multiple operations, integration of work stations, increased flexibility, automated material handling storage system, on line inspection, on line monitoring, processes control and optimization, control of plant operations and computer integrated manufacturing.
Unit–VI Robotics	6a. Explain with sketches the function of the specified actuators used in a robot. 6b. Explain given types of grippers used in robot with diagram. 6c. Explain with sketches the function of the given sensors used in a robot. 6d. Justify the use of Robot in the given industrial situation.	6.1 **Introduction to robotics-** definition of robot and robotics, advantages disadvantages. 6.2 **Basic components of robot**-manipulator, end effectors, actuators, sensors, controller, processor and software. 6.3 **Robot joints**-linear, orthogonal, rotational, twisting and revolving. 6.4 **Degree of freedom of robot**-vertical, radial, rotational traverse, wrist pitch, wrist yaw wrist roll. 6.5 **Actuators**-mechanical, hydraulic, pneumatic and electric. 6.6 **End effectors**-grippers and types. 6.7 **Robot sensors**-classification of sensors. 6.8 **Basic configuration of robot-** Cartesian, cylindrical, polar(spherical) 6.9 **Applications of robot**-loading unloading, material handling, processing operations, assembly and inspection.

***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	Introduction to CIM	06	02	04	04	10
II	Product Development through CIM	12	04	04	06	14
III	CIM Hardware, Software, Networking and Data Base Management System (DBMS)	08	02	04	06	12
IV	Group Technology and Flexible manufacturing System	08	02	04	06	12
V	Automation	06	02	04	04	10
VI	Robotics	08	02	04	06	12
Total		**48**	**14**	**24**	**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) Prepare journals based on practical performed in laboratory.
b) Follow the safety precautions.
c) Use various software and equipment related to CAD/CAM/CIM/CAE/CAPP
d) Read and use specifications various software and equipment related to CAD/CAM/CIM/CAE/CAPP
e) Library / Internet survey of CAD/CAM/CIM/CAE/CAPP/FMS.
f) Prepare power point presentation or animation for GT/FMS/CIM/PLM
g) Perform Market survey of business function such as flipkart /amazon service etc.
h) Visit Industries and Companies consisting CIM, FMS, automation and robot system.
i) Survey any one of the company and study of its product cycle and compare it with CIM product cycle.
j) Visit any industry to understand total CIM product cycle functions.

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) Arrange visit to nearby industries for understanding CIM functions.
g) Show video on films to explain functioning of CIM/FMS/automation/robot technology.

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 information of any one of the company and compare every step with CIM product cycle.
b) Prepare a report related to suggestions to control business function according to CIM product cycle.
c) Collect information of advanced techniques related with quality control from nearby industry
d) Collect the different ERP, MRP PLM, SCM, DBMS and CRM software names, company name, product name and its features.
e) Perform web search and prepare a report on latest advancements and industrial practices in India and abroad in the field of CAD/CAM/CAPP/CAE/CIM/FMS/ ERP, MRP/PLM/SCM/DBMS and CRM.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automation Production System and Computer Integrated Manufacturing	Groover. Mikell P.	Pearson Education, Canada, (2018), ISBN-978-93-325-4981-4
2	CAD/CAM/CIM	Radhakrishnan. P.	New Age International Publisher, New Delhi, (2008) ISBN-97-81-224-3980-9
3	Computer Aided Manufacturing	Rao. P. N.	McGrawhill Education, New Delhi, (2010) ISBN- 9780074631034
4	Principles of computer Integrated Manufacturing	Kant. S.	PHI Learning, New Delhi, (1995), ISBN-10: 812031476X
5	Cim: Principles of Computer- Integrated Manufacturing	Waldner. J. B.	John Wiley & Sons Inc. UK, (1992), ISBN- 9780471934509

14. SOFTWARE/LEARNING WEBSITES

a) http://nptel.ac.in/courses/112102103/17
b) http://nptel.ac.in/courses/112107077/module5/lecture2/lecture2.pdf
c) http://www.intelitek.com/pdf/DS01_BU_CIM-A_100761.pdf
d) https://nptel.ac.in/courses/112103174/module1/lec2/3.html
e) https://www.researchgate.net/publication/231832221_FMS_in_CIM_Flexible_Manufacturing_Systems_in_Computer_Integrated_Manufacturing
f) https://www.researchgate.net/post/What_are_the_differences_among_flexible_manufacturing_system_FMS_computer_integrated_manufacturing_CIM_and_totally_integrated_automation_TIA
g) http://www.me.nchu.edu.tw/lab/CIM/www/courses/Computer%20Integrated%20Manufacturing/Chapter2%20-CIM-introduction.pdf
h) https://brainmass.com/business/kaizen/cad-cae-cam-cim-fms-manufacturing-47731
i) http://www.alphace.ac.in/downloads/notes/me/10me61.pdf
j) http://www.me.nchu.edu.tw/lab/CIM/www/courses/Computer%20Integrated%20Manufacturing/Chapter2%20-CIM-introduction.pdf

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Refrigeration and Air Conditioning (Elective-II)**

Course Code : **22660**

1. RATIONALE

The 21st century predicts revolutionary developments in Heating, Ventilation and Air Conditioning. Considering the wide and increasing use of Heating, Ventilation and Air Conditioning for domestic, commercial and industrial applications and the challenges put in it is absolutely necessary that Diploma Engineers should learn these systems. They should know the processes, equipment, systems of Heating, Ventilation and Air Conditioning with their functioning, maintenance, repairs and measures to meet the current demand.

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 refrigeration and air-conditioning systems.**

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 refrigeration systems for given application.
b. Use relevant refrigerants for different applications.
c. Select different refrigeration components for given refrigeration system.
d. Select different air conditioning components for given air-conditioning system
e. Determine cooling loads for Air-conditioning systems.
f. Select relevant tools for maintaining air conditioning systems.

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.

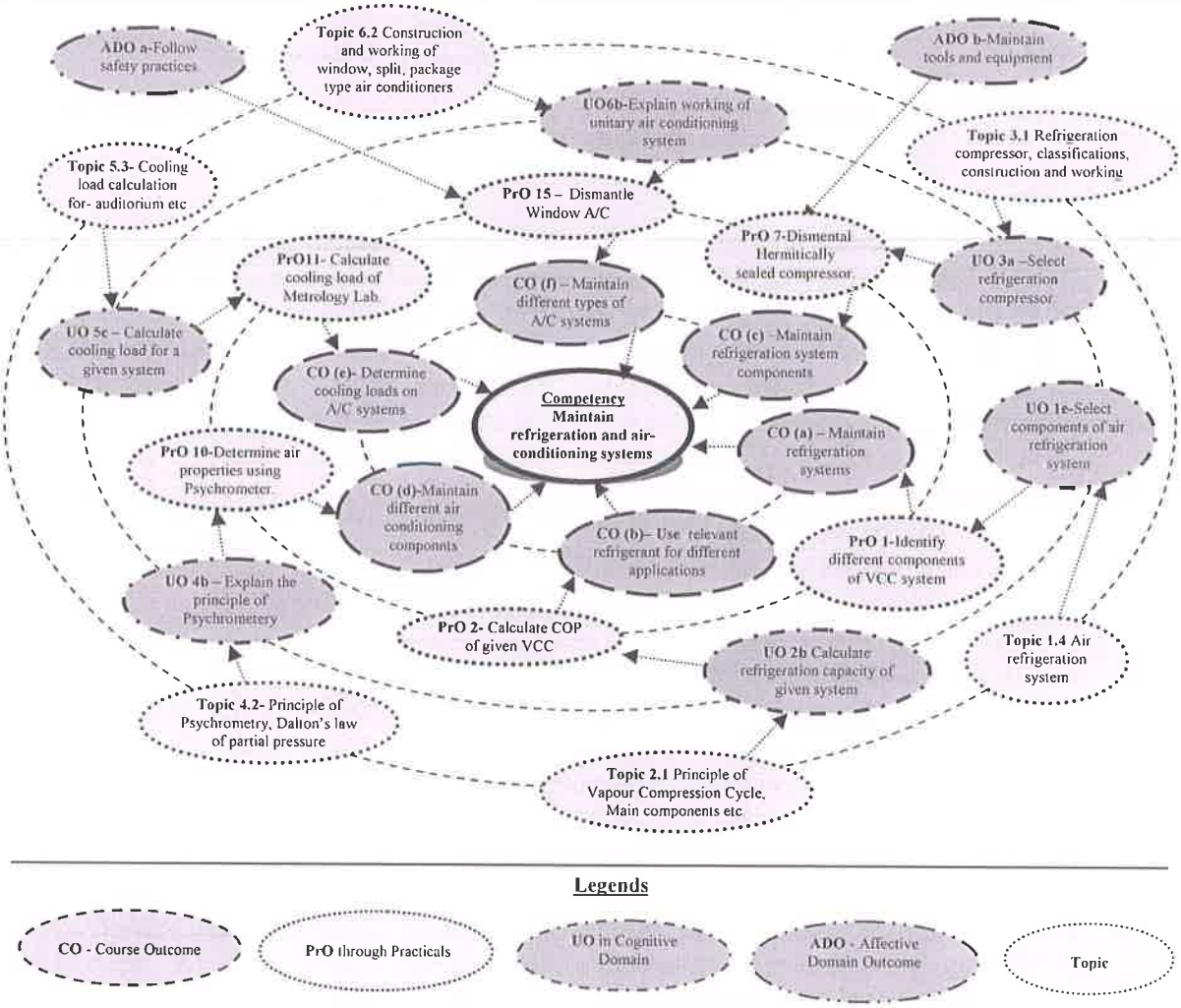

Figure 1 - Course Map

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 different components of Vapour compression cycle with their specification.	I	02*
2	Troubleshoot VCC system for Refrigerant leakage.	II	02
3	Charge the VCC system.	II	02
4	Identify the different components of House hold refrigerator with specification.	II	02
5	Dismantle Hermitically sealed compressor.	III	02*
6	Assemble Hermitically sealed compressor.	III	02*
7	Dismantle and assemble defrosting system of Household refrigerator.	III	02
8	Determine air properties using Psychrometer.	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Calculate cooling load of Institute's Metrology laboratory.	V	02*
10	Identify different components of Unitary Air conditioner with specifications.	VI	02
11	Dismantle the Window Air conditioner.	VI	02
12	Troubleshoot the Window Air conditioner.	VI	02*
13	Assemble Split Air conditioner.	VI	02
14	Troubleshoot the split Air conditioner.	VI	02*
15	Perform piping operations like tube/pipe cutting, swedging, brazing. insulation	VI	02
16	Dismantle Air conditioner of a car.	VI	02
17	Troubleshoot Air conditioner of a car	VI	02*
18	Assemble Air conditioner of a car.	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 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 safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work 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
- 'Organisation Level' in 2nd year
- 'Characterisation 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	Vapour compression Test rig consisting of Hermitically sealed compressor 1TR capacity, Air cooled condenser, Expansion devices like TEV and capillary tube, Evaporator coils.	1,2
2	Water cooler test rig up to 100 liters capacity	1,3
3	Testing equipment like halide torch	4,5
4	Charging system, Vacuum pump, Charging kit	4,5
5	Household refrigerator test rig	6
6	Hermitically sealed compressor	7,8
7	Psychrometer digital	9,10,11,12,13
8	Anemometer	9,10,11,12,13
9	Window air conditioner	14,15
10	Split air conditioner	14,15
11	Window/split air conditioner test rig 1.5 Tr capacity	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 Refrigeration	1a. Calculate COP of Carnot and Bell colemen cycle for the given condition 1b. Explain with sketches the significance of the given diagram 1c. Draw the PV and TS diagram for the given criteria 1d. Select components of air refrigeration system for given application with justification.	1.1 Necessity of Refrigeration, Unit of Refrigeration, concept of COP (actual and Theoretical) 1.2 Reversed Carnot cycle and its representation on PV and TS diagram 1.3 Bell colemen cycle and its representation on PV and TS diagram with simple numerical. 1.4 Air refrigeration system, component of air refrigeration system, Its applications
Unit-II Refrigeration Cycles and Refrigerants	2a. Calculate Actual and theoretical COP of given Vapour compression cycle. 2b. Calculate the refrigeration capacity for the given system 2c. Select relevant application of Multistage VCC for	2.1 Principle of Vapour Compression Cycle, Main components, Representation on P-H and T-S diagram, conditions- dry compression, effect of superheating, effect of undercooling, Calculation of Refrigeration capacity and Power required. Multistage Vapour Compression Refrigeration system, its

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given system with justification. 2d. Select relevant Refrigerant for given application with justification.	necessity, advantages and applications. 2.2 Vapour Absorption Cycle, principle, its component, working of Aqua – Ammonia Vapour absorption system, working of Li-Br absorption system, Electrolux refrigerator- working, main components, applications. Comparison between Vapour Compression system. and Vapour absorption system 2.3 Refrigerants, desirable properties, classification, designation of refrigerant, selection of refrigerant for relevant applications, System vaccumisation Charging processes, leak testing methods and process. 2.4 Montreal protocol, Kyoto protocol. Concept of Ozone Layer Depletion, Green House effect, Global warming, Eco friendly Refrigerants. 2.5 Applications of Refrigeration, House hold refrigerators, Water coolers, name of Manufacturers and their products with capacity.
Unit– III Refrigeration System Components	3a. Select relevant Refrigeration compressor for given refrigeration system with justification. 3b. Select relevant condenser for given refrigeration system with justification. 3c. Select relevant evaporator for given refrigeration system with justification. 3d. Select relevant Expansion device for given refrigeration system with justification. 3e. Explain the working of specified auxiliary devices used in refrigeration system 3f. Describe the process to maintain the given refrigeration systems component.	3.1 Refrigeration compressor, classifications, construction and working of hermitically sealed compressor, open type compressor, rotary compressors- centrifugal, Screw and Scroll compressors and their applications. 3.2 Condensers- classifications, working of air and water-cooled condensers, evaporative condensers, comparison and applications. 3.3 Evaporators- Classification- working of finned type, bared tube, plate type, flooded, shell and tube type evaporators, their applications. Chillers- Direct expansion and flooded type chillers, working and applications. 3.4 Expansion device- classifications, capillary tube, automatic expansion valve, Thermostatic expansion valve, selection, working and application. 3.5 Other components- Drier, Solenoid valve, Thermostatic switch, defrosting devices, working and applications.
Unit– IV Basics of Air Conditionin	4a. Explain the principle of Psychrometry for the given situation	4.1 Air conditioning- necessity, types of air conditioning- comfort air conditioning, industrial air conditioning, applications.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
g	4b. Represent the given psychrometric processes in Psychrometric chart 4c. Select relevant auxiliary components for given air conditioning system. 4d. Describe the procedure to maintain the given air conditioning component.	4.2 Principle of Psychrometry, Dalton's law of partial pressure, air properties. 4.3 Psychrometric processes, Representation of processes on Psychrometric. chart. Types and construction of Psychrometers. 4.4 Components used for air conditioning- Humidifiers, dehumidifiers, filters, heating and cooling coils.
Unit –V Cooling Load Calculation	5a. List human comfort conditions 5b. Identify the relevant sources of heat gain for the given situation with justification. 5c. Calculate cooling load for the given situation.	5.1 Comfort condition, heat exchange by human body with environment, factors affecting on human comfort. 5.2 Calculation of Sensible and Latent heat gain sources. 5.3 Cooling load calculation for- auditorium, Metrology laboratory, class room.
Unit –VI Air Conditioning Systems	6a. Classify Air conditioning system 6b. Explain working of Unitary air conditioning system 6c. Explain the constructional features of central air conditioning 6d. Select relevant components for given air distribution system 6e. Select the insulating material for given air conditioning system. 6f. Describe the procedure to maintain the given type of air conditioning system.	6.1 Classification of air conditioning system- Summer and winter, Year around air conditioning, construction, application, comparison. 6.2 Construction and working of window, split, package type air conditioners. 6.3 Central air conditioning- types, direct and indirect central air conditioning construction, capacity, application. 6.4 Concept of air handling unit, air distribution system- closed perimeter system, extended perimeter system, radial duct system, losses in ducts, construction and application of supply, return and make up ducts, grills diffusers, types of fans and blowers. 6.5 Insulation- purpose, types of insulation, material and their properties. 6.6 Introduction to Automobile Air conditioning system.

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	Refrigeration	06	02	02	04	08
II	Refrigeration cycles and Refrigerants	12	02	06	12	20
III	Refrigeration system components	08	02	02	06	10
IV	Basics of Air conditioning	06	02	02	06	10

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	Cooling load calculation	06	02	02	04	08
VI	Air Conditioning system	10	02	04	08	14
Total		**48**	**12**	**18**	**40**	**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 mechanical measuring instruments and equipment related to Heating, Ventilation and air conditioning
d) Read and use specifications of the Refrigeration and air conditioning equipment.
e) Library / Internet survey of HVAC systems
f) Prepare power point presentation or animation for understanding constructional details and working of different Centralised air conditioning systems.
g) Visit nearby malls/auditoriums/commercial complex/Dairy/Cold storages/Ice cream factory/Ice plant/Cinema Theaters to identify different components of Refrigeration and air conditioning system.

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 domestic and industrial Refrigeration and air conditioning systems.
g) Use proper equivalent analogy to explain different concepts related to Psychrometry.
h) Use Flash/Animations to explain various applications of Refrigeration and air conditioning.

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 a duct layout of your institute building from AHU
b) Prepare a chart of showing all the components of house hold refrigerator.
c) Prepare a demonstration model of cold storage.
d) Calculate Refrigeration capacity of split air conditioner.
e) Collect different air outlet devices used in Central air conditioning system
f) Download catalogue of Refrigeration compressors.
g) Prepare display chart of types of refrigerant used in commercial and Industrial applications.
h) Visit to nearby Central air conditioning plant/Malls/Showrooms and collect information regarding air conditioning
i) Conduct market survey of household refrigerators, make, capacity, arrangement, features, commercial terms etc.
j) Conduct market survey of window air conditioner make, capacity, arrangement, features, commercial terms etc.
k) Collect information of automobile air conditioning of different vehicles.
l) Comparative study of various types of compressors with detailed specification & market survey.
m) Comparative study of various types of condensers with detailed specification & market survey.
n) Comparative study of various types of evaporators with detailed specification & market survey.
o) Comparative study of various types of expansion devices with detailed specification & market survey.
p) Study of different types of refrigerants with properties, designation, selection & applications.
q) Comparative study of different types of central air-conditioning system with detailed specification and visit analysis report. (viz. AHU,FCU,VAV)

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Refrigeration and Air conditioning	Khurmi R. S.	S Chand publication, New Delhi, (2008), ISBN-10: 8121927811

S. No.	Title of Book	Author	Publication
2	Refrigeration and Air conditioning	Arora C. P.	Tata McGrawHill Publication, New Delhi, (2009), ISBN-13-978-07-008390-5
3	Basic Refrigeration and Air conditioning	Ananthnarayan P. M.	Tata McGrawHill Publication, New Delhi, (2013), ISBN- 9781259062704
4	Refrigeration and Air conditioning	Sapali S. N.	PHI publication, New Delhi, (2013) ISBN - 9788120348721
5	Refrigeration and Air conditioning	Prasad Manohar	New Age International, New Delhi, (2011), ISBN- 9788122414295
6	Refrigeration and Air conditioning	Ameen Ahmdul	PHI Publication, New Delhi, ISBN - 9788120326712
7	Principles of refrigeration	Dossat R. J.	John Wiley and Sons Ltd, UK, (2009) ISBN 978-0130272706

14. SOFTWARE/LEARNING WEBSITES

a) www.youtube.com/watch?v=52P0KbTNvok
b) www.youtube.com/watch?v=OXIZhqypNUI
c) www.youtube.com/watch?v=cobFAMZDS0o&start_radio=1&list=RDcobFAMZDS0o
d) www.youtube.com/watch?v=cobFAMZDS0o&list=RDcobFAMZDS0o&index=1
e) www.youtube.com/watch?v=Ll8Ku-mFQxE
f) www.youtube.com/watch?v=yQGFmBBvw1g&t=134s
g) www.youtube.com/watch?v=GSWt0zjLgIY
h) www.youtube.com/watch?v=PL0vU02QC4w
i) www.youtube.com/watch?v=lMqoKLli0Y4
j) www.youtube.com/watch?v=oSLOHCOw3yg
k) www.youtube.com/watch?v=6UMqdD6ejZQ
l) www.youtube.com/watch?v=7FxltQ41bZc


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Sixth**

Course Title : **Renewable Energy Technologies (Elective-II)**

Course Code : **22661**

1. RATIONALE

Use of renewable sources of energy is the need of the hour. Solar, Wind, micro-hydro and Bio-fuel systems have become reality now and the share of these systems in global energy market is increasing day by day. India has set high targets of employing renewable sources of energy for all possible applications to reduce the dependency on the fossil fuels. This has increased the demand of trained manpower for installation, operation and maintenance of various systems and equipment used in Solar, wind, micro-hydro and bio-fuel systems. This segment has huge potential for innovative solutions and opportunities for self-employment also. This course aims at equipping the technologists in installation, operation and maintenance of various mechanical equipment and systems used in Solar, Wind, Micro-hydro and bio-fuel 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 the mechanical components of renewable energy systems.**

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) Maintain mechanical components of solar thermal systems.
b) Maintain mechanical components of solar PV systems.
c) Maintain mechanical components of wind turbines.
d) Maintain mechanical components micro hydro turbines.
e) Maintain mechanical components of Biomass plants.
f) Maintain mechanical components hybrid renewable energy system.

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.

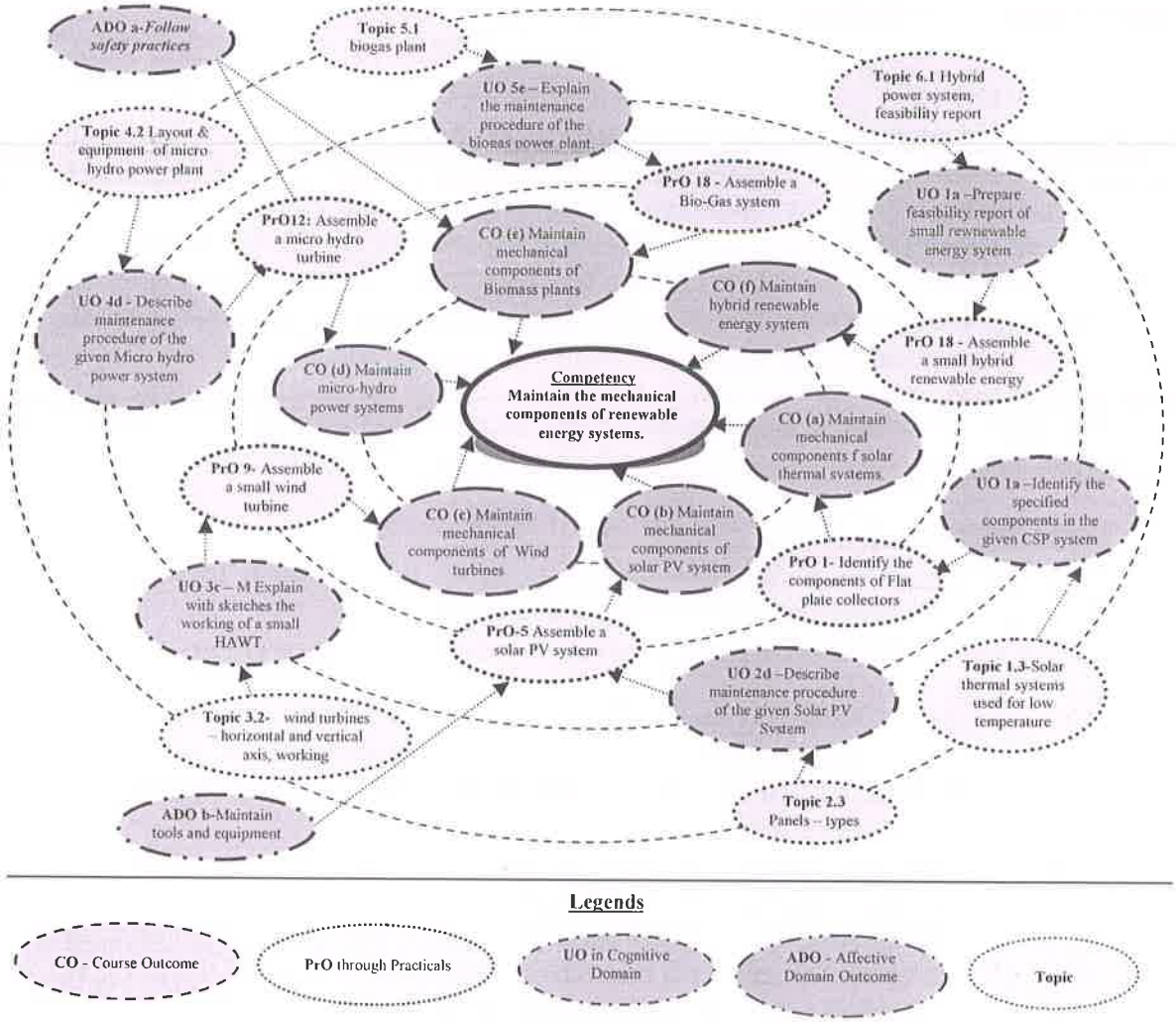

Figure 1 - Course Map

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 the components of solar Flat plate collector.	I	02*
2	Identify the components of evacuated tube solar thermal system.	I	02
3	Identify the components of Solar dryer system.	I	02
4	Use pyranometer for measurement of solar radiation flux density.	I	02*
5	Assemble a solar PV system with and without battery connection	II	02*
6	Measure heat output, Maximum power, power output efficiency of solar PV panel.	II	02*
7	Simulation software to calculate PV energy output.	II	02
8	Use vane anemometer for measurement of different locations for	III	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	site selection for wind mill.		
9	Assemble/dismantle a horizontal axis small wind turbines.	III	02*
10	Assemble/dismantle a vertical axis small wind turbines.	III	02
11	Measure the output power of the turbine, rotation speed of the turbine, wind speed, system voltage and system current.	III	02
12	Assemble/dismantle a micro hydro power system.	IV	02
13	Measure Power output, flow and head for micro hydro power system.	IV	02
14	Assemble/dismantle a biogas power system.	V	02*
15	Assemble/dismantle a biomass gassifier power system.	V	02*
16	Assemble/dismantle a wind-solar hybrid system	VI	02*
	Total		**32**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, 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 safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work 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
- 'Organisation Level' in 2nd year

- 'Characterisation 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	Poly crystalline/Mono crystalline solar PV panel 20W X	1,2
2	Solar dryer system.	3
3	Solar Cooker	4
4	Solar water heater (flat plate/tube type) -50 Ltrs.	3
5	Pyranometer any make available in the market.	5
6	Vane anemometer any make available in the market	8
7	3-bladed Geared Wind Turbine: 5/10/20/30 kW, Upwind with 20/30 m hydraulically operated tilt-up/tilt-down tubular tower or whichever lowest rating that is available in the market	9,10,11,12,13
8	Wind (1kW) - Solar PV (1kW) Hybrid System	16,17
9	Smokeless Chulhas, Burners, Heaters and Engines.	18
10	Voltmeter, Ammeter	1 to 21
11	Bio gas plant for lab	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 Solar Thermal Systems	1a. Identify specified components in the given CSP system. 1b. Select CSP for the given application with justification. 1c. Select Solar Dryer system for a given application with justification. 1d. Describe with sketches the maintenance procedure of the given CSP	1.1 Alternative energy sources: primary, secondary and tertiary energy. 1.2 Classification of solar thermal systems 1.3 Concentrated Solar Power (CSP) systems– Flat plate collectors, parabolic collectors, parabolic dish collector, solar tower. 1.4 Domestic-Water heating systems; Commercial-Heating systems used for process heating Installation- standard procedure, precautions, Plumbing – piping, Valves. 1.5 Maintenance: Routine maintenance, procedure for domestic and commercial water heater systems. • Failure maintenance – Major causes, remedies. 1.6 Solar dryers – Classification, construction, working and applications commercial, agro-products, domestic. 1.7 Choice of a system for a given Application-technical and financial criteria used for selection.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-II Solar Photovoltaic Systems	2a. Identify the specified components in the given rating of the solar PV system. 2b. Explain with sketches the working of the solar PV system 2c. Select Solar Photovoltaic systems for a given situation with justification. 2d. Describe maintenance procedure of the given Solar PV System.	2.1 Classification of Solar Photovoltaic systems – Grid connected, Off-grid, stand-alone systems. 2.2 PV cells – types, merits and demerits 2.3 Panels – types. 2.4 Battery and other accessories – types, rating, methods of selection 2.5 Recent trends and promotional schemes – Net metering. 2.6 Installation, commissioning and maintenance of Solar Roof Top systems, Stand-alone street light.
Unit– III Wind Energy Systems	3a. Explain with sketches of the working of the small HAWT. 3b. Explain with sketches the working of VAWTs 3c. Prepare the specifications of the specified type of small wind turbine 3d. Describe with sketches the functions of the given components of the large wind power plant 3e. Describe the procedure to undertake routine maintenance of small wind turbines. 3f. Describe the procedure to maintain large wind turbines.	3.1 Types of wind energy systems – large and small, commercial and domestic, grid connected and stand-alone. 3.2 Small Horizontal axis wind turbines (HAWTs): construction, working, specifications and maintenance procedure 3.3 Small veritcal axis wind turbines (VAWTs): construction, working, specifications and maintenance procedure 3.4 Large Horizontal axis wind turbines:: construction, working and maintenance procedure
Unit– IV Micro Hydro Power Systems	4a. Explain with sketches the construction and working of specified type of micro-hydro power systems. 4b. Identify various components in the give Micro hydro power systems. 4c. Select micro-hydro systems for a given situation with justification. 4d. Describe maintenance procedure of the given type of Micro power system(s).	4.1 Micro hydro power systems: Classification, Layout, construction and working. 4.2 Installation-procedure, precautions. 4.3 Operating procedures. 4.4 Maintenance of Micro hydro power systems.
Unit –V Bio-energy Systems	5a. Identify various components in the given type of biomass power system. 5b. Describe with sketches the	5.1 Classification of bio-fuels- biogas, biodiesel. 5.2 Biomass power plants – bio-gas plants, gasifiers, digestors, bio-diesel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	construction of the specified biomass power plant 5c. Explain with sketches the working of the specified biomass power plant 5d. Describe the procedure of installation of the given Bio-Gas plants. 5e. Describe the maintenance procedure of the given biomass power plant	plants: Layout, construction and principle of working and specification for small power plant of all these 5.3 Installation and maintenance procedure of Bio gas plant. 5.4 Applications of various bio-fuels Domestic – heating, cooking, Commercial – process heating, power generation 5.5 Systems used for utilization of bio-fuels – smokeless Chulhas, burners, heaters and engines.
Unit–VI Renewable Energy Hybrid Systems and Feasibility Studies	6a. Prepare layouts of the given hybrid power systems. 6b. Describe the different performance parameters related to the given Wind-Solar PV hybrid system. 6c. Describe the procedure to test the performance of the given Wind-Solar PV hybrid system. 6d. Prepare project feasibility report for installation of renewable energy systems.	6.1 Types of hybrid system: wind- solar, wind-biogas, solar-biogas: Specification, construction and specification of all these 6.2 Power output of hybrid system. 6.3 Installation-procedure, precautions, Operating procedures of Wind-Solar PV hybrid system. 6.4 Choice of systems –technical and commercial feasibility assessment, costing of renewable energy systems.

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	Solar Thermal Systems	10	02	04	08	14
II	Solar Photovoltaic Systems	08	02	04	06	12
III	Wind Energy Systems	08	02	04	06	12
IV	Micro Hydro Power Systems	08	00	04	06	10
V	Bio-energy Systems	08	02	04	06	12
VI	Renewable Energy Hybrid systems and feasibility studies	06	02	04	04	10
Total		**48**	**10**	**24**	**36**	**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. Participate in field visits to understand actual operation / working of following:

a) Flat plate collector used for domestic water heating application.
b) Flat plate collector used for process heating in commercial / industrial organization.
c) Stand-alone solar photovoltaic lighting Grid connected solar PV power plants
d) Grid connected wind power plants
e) Hybrid plants
f) Bio-gas plants (domestic or commercial)
g) Smokeless Chulhas

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 renewable energy based appliances and devices.
g) Use proper equivalent analogy to explain different concepts related to these renewable energy conversions.
h) Use Flash/Animations to explain function and construction of Flat plate collector used for domestic water heating application and used for process heating in commercial / industrial organization, Stand-alone solar photovoltaic lighting plant, Grid connected wind mill plant, Hybrid plants.
i) Arrange field or industrial visits to see manufacturing/working of renewable energy systems.

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 a feasibility report and present it (Group of max 3 students) for employing renewable energy system for any given situation where fossil fuels are used. Following guidelines may be followed.
   i. Various distinctly different industrial or household situations should be visited by the group.
   ii. Annual requirement of total energy for the situation (visited by the respective group) should be estimated using a survey and questionnaire technique.
   iii. Appropriate choice of renewable energy technology should be made based on the availability of local resources.
   iv. The budget required for the installation of the renewable energy system should be estimated by using prevalent market prices of various components and installation costs.

b) The feasibility report should be prepared using various financial parameters such as Return on Investment (ROI) and payback period.

c) Prepare small working models of already existing/improved/new Horizontal/vertical wind turbine, Flat plate collector used for domestic water heating application and used for process heating in commercial / industrial organization, Stand-alone solar photovoltaic lighting plant, Grid connected wind mill plant, Hybrid plants, Wind-Solar PV hybrid system, Smokeless Chulhas, Burners, Heaters and Engines, Biogas plant.

d) Prepare a report for selection of Solar lightning system for a small colony or your institute campus.

e) Prepare a small Solar charger/Solar car/Solar fan/Solar torch/Solar cooler/Solar street light etc.

f) Visit to a commercial or industrial solar water heating installation of at least 500 liters per day capacity and write a report about collector layout, piping and fittings and measurement of performance of the system.

g) Compare constructional details and performance of conventional FPC and evacuated tube FPC.

h) Prepare a layout of solar water heating system for domestic/commercial use. Comprises of plumbing, insulations, control valves and support systems in bad weather conditions.

i) Study various types of solar dryer designs and select best suited dryer for a given application.

j) Study of PV cells : classification - monocrystalline, polycrystalline, thick film, thin film, amorphous, organic.; energy generation mechanism; applications.

k) Study construction and working of horizontal axis wind mill or to visit a nearest wind farm and write a report.

l) Visits to a biogas plant or biomass gasification facility

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Solar Photovoltaic: A Lab Training Module	Solanki, Singh Chetan, Arora, Brij M., Vasi Juzer, Patil, Mahesh B.	Cambridge University Press, New Delhi, (2009), ISBN: 9789382264590
2	Solar Photovoltaic: Fundamentals, Technologies and	Solanki, Singh Chetan	PHI Learning, New Delhi, (2009), ISBN: 9788120351110

S. No.	Title of Book	Author	Publication
	Application		
3	Solar Energy	Sukhatme S.P., Nayak J.K.	Tata McGraw, New Delhi, (2010), ISBN: 9781259081965
4	Introduction to Photovoltaics	Balfour John R., Shaw Michael L., Jarosek Sharlave	Jones and Bartlett Publishers, Burlington, (2011), ISBN: 9781449624736
5	Solar Cells and Their Applications	Fraas Lewis M., Partain Larry D.	Wiley, UK, (2010), ISBN: 9780470446331
6	Concentrating Solar Power Technology	Lovegrove K., Stein W.	Woodhead Publishing, (2012), ISBN:9781845697693
7	Wind Power in Power Systems	Ackermann Thomas	John Wiley and Sons, UK, (2012) ISBN: 9781119942085
8	Renewable Energy Sources and Emerging Technologies	Kothari D.P. Singal K.C.	Prentice Hall India Learning Private Ltd., New Delhi, (2011), ISBN: 9788120344709
9	Solar Energy : Fundamentals and Applications	Garg H. and Prakash J.	McGraw Hill Education, New Delhi, (2017), ISBN: 978-0074636312
10	Introduction to Bioenergy	Nelson Vaughn C., Kenneth L. Starcher	CRC press, UK, (2015) ISBN 9781498716987

14. SOFTWARE/LEARNING WEBSITES

Solar thermal

a. https://mnre.gov.in/file-manager/UserFiles/pdf/Students%20Workbook%20-%20Solar%20Thermal%20System.pdf
b. http://www.climatetechwiki.org/technology/solar-thermal-hot-water
c. http://nptel.ac.in/courses/112105050/m111.pdf
d. http://nptel.ac.in/courses/108105058/15
e. https://www.youtube.com/watch?v=mpHZWYpKDJg

Solar photovoltaic

f. https://www.nrel.gov/workingwithus/re-photovoltaics.html
g. https://mnre.gov.in/solar-photovoltaic-systems
h. https://www.renewableenergyworld.com/solar-energy/tech/solarpv.html
i. https://www.youtube.com/watch?v=jxOvCnQfj_8
j. http://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/notused/Non-Conventional%20Energy%20Systems(28-05-07)/pdfs/chap04.pdf
k. https://www.youtube.com/watch?v=Fuyq6WrM1EA

Wind power

l. https://www.energy.gov/energysaver/buying-and-making-electricity/small-wind-electric-systems
m. http://synergyfiles.com/2015/04/small-scale-vs-large-scale-wind-turbines/
n. https://www.nrel.gov/workingwithus/re-wind.html
o. https://www.youtube.com/watch?v=JJDylOtr5yA
p. https://www.youtube.com/watch?v=NbZepCQUQTg
q. http://nptel.ac.in/courses/108108078/pdf/chap6/teach_slides06.pdf
r. http://nptel.ac.in/courses/108107028/module1/lecture1/lecture1.pdf

Micro, hydro power systems

s. http://www.renewablesfirst.co.uk/hydropower/hydropower-learning-centre/what-is-the-difference-between-micro-mini-and-small-hydro/
t. https://www.youtube.com/watch?v=eXljm_axyu0
u. http://nptel.ac.in/courses/108108078/pdf/chap5/teach_slides05.pdf
v. http://nptel.ac.in/courses/105105110/pdf/m5l01.pdf
w. https://www.youtube.com/watch?v=JBrdUoU2uTE
x. https://www.youtube.com/watch?v=i9yCpuiMze0

Bio energy systems

y. https://www.youtube.com/watch?v=DKvzVlN-sOQ
z. https://www.bioenergyconsult.com/biomass-energy-systems/
aa. https://mnre.gov.in/bio-energy
bb. http://nptel.ac.in/courses/108108078/7
cc. http://nptel.ac.in/courses/102104057/3
dd. http://nptel.ac.in/courses/102104057/
ee. http://nptel.ac.in/courses/102104057/5
ff. http://nptel.ac.in/courses/102104057/4

Program Name : **Diploma in Computer Engineering Group/ Diploma in Mechanical /Chemical Engineering /Diploma in Electronics Engineering Group/ Diploma in Fashion & Clothing**

Program Code : **CO/CM/CW/DC/EJ/ET/EN/EX/EQ/IE/ME/CH**

Semester : **Sixth**

Course Title : **Entrepreneurship Development**

Course Code : **22032**

1. RATIONALE

Globalisation, liberalization and privatization along with revolution in information technology have opened up new opportunities transforming lives of masses. In this context, there is immense opportunity of establishing manufacturing, service, trading, marketing and consultancy enterprises by diploma engineer. Our fast growing economy provides ample scope for diploma engineers to succeed as an entrepreneur. Entrepreneurship requires distinct skill sets which are attempted to be developed through this course. To begin with, this course aims to develop the competency and the related outcomes in order to start small enterprises.

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 project proposals to launch small scale enterprises.**

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 your entrepreneurial traits.
b. Identify the business opportunities that suits you.
c. Use the support systems to zero down to your business idea.
d. Develop comprehensive business plans.
e. Prepare plans to manage the enterprise effectively.

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	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40	

@ : Internal examination

(~): *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.30 marks) and micro-project assessment (seen in section 11) has a weightage of 40% (i.e.20 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.

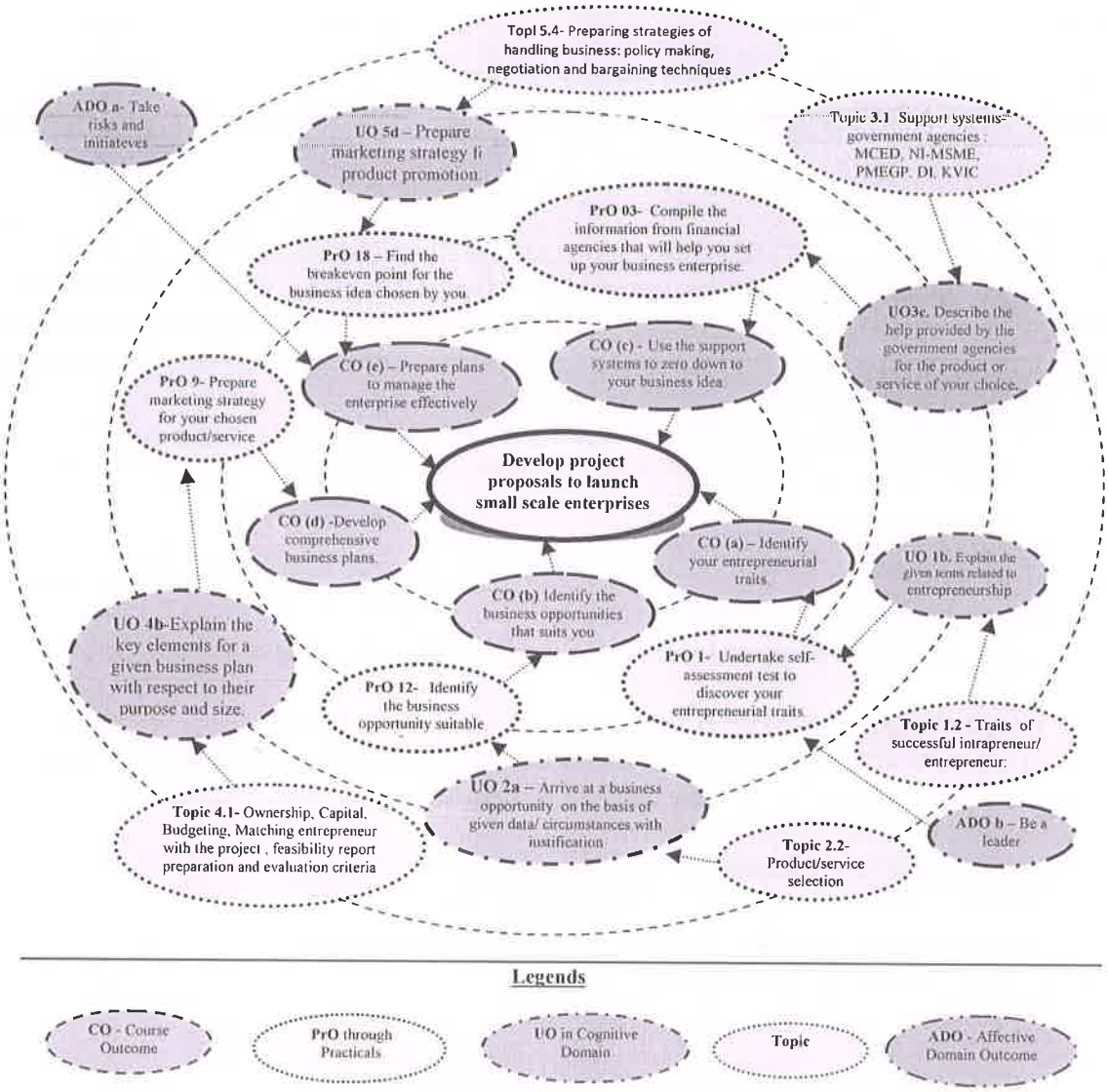

Figure 1 - Course Map

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	Submit a profile summary(about500words) of a successful entrepreneur indicating milestone achievements.	I	02*
2	Undertake SWOT analysis to arrive at your business idea of a product/service.	I	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
3	Generate business ideas(product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming.	II	02*
4	Undertake self-assessment test to discover your entrepreneurial traits.	II	02*
5	Identify the business opportunity suitable for you.	II	02
6	Arrange an exhibition cum sale of products prepared out of waste.	II	02
7	Survey industries of your stream, grade them according to the level of scale of production, investment, turnover, pollution to prepare a report on it.	II	02*
8	Visit a bank/financial institution to enquire about various funding schemes for small scale enterprise.	III	02*
9	Collect loan application forms of nationalise banks/other financial institutions.	III	02*
10	Compile the information from financial agencies that will help you set up your business enterprise.	III	02*
11	Compile the information from the government agencies that will help you set up your business enterprise.	III	02*
12	Prepare Technological feasibility report of a chosen product/service.	III	02*
13	Prepare financial feasibility report of a chosen product/service.	III	02*
14	Craft a vision statement and enabling mission statements for your chosen enterprise.	III	02
15	Prepare a set of short term,medium and long term goals for starting a chosen small scale enterprise	III	02*
16	Prepare marketing strategy for your chosen product/service.	IV	02*
17	Compile information about various insurance schemes covering different risk factors.	IV	02
18	Organize a funfair of your class and write a report of profit/loss	V	02
19	Find the breakeven point for the business idea chosen by you.	V	02
20	Arrange a discussion session with your institute's pass out students who are successful entrepreneurs.	V	02
21	Prepare a business plan for your chosen small scale enterprise	V	02*
	Total		**42**

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:

Sample Products that can be manufactured under SME

1. Badges cloth embroidered and metals

2. Bags of all types i.e. made of leather, cotton, canvas and jute etc. including kit bags, mail bags, sleeping bags and water-proof bag
3. Bandage cloth
4. Basket cane (Procurement can also be made from State Forest Corpn. and State Handicrafts Corporation)
5. Bath tubs of plastic
6. Battery Charger
7. Belt leather and straps
8. Bolts and Nuts
9. Boot Polish
10. Brooms
11. Domestic Brushes of different types
12. Buckets of all types of plastic
13. Button of all types
14. Chappals and sandals
15. Cleaning Powder
16. Cloth Covers for domestic use
17. Cloth Sponge
18. Coir mattress cushions and matting
19. Cotton Pouches
20. Curtains mosquito
21. Domestic Electric appliances as per BIS Specifications: Toaster Electric, Elect. Iron, Hot Plates, Elect. Mixer, Grinders Room heaters and convectors and ovens
22. Dust Bins of plastic
23. Dusters Cotton all types except the items required in Khadi
24. Electronic door bell
25. Emergency Light (Rechargeable type)
26. Hand drawn carts of all types
27. Hand gloves of all types
28. Hand numbering machine
29. Hand Pump
30. Hand Tools of all types
31. Handles wooden and bamboo (Procurement can also be made from State Forest Corpn. and State Handicrafts Corporation)
32. Haver Sacks
33. Honey
34. Invalid wheeled chairs.
35. Iron (dhobi)
36. Lamp holders
37. Letter Boxes
38. Nail Cutters
39. Oil Stoves (Wick stoves only)
40. Paper conversion products, paper bags, envelops, Ice-cream cup, paper cup and saucers and paper Plates
41. Pickles, Chutney and Pappads
42. Pouches for various purposes
43. Safe meat and milk
44. Safety matches
45. Safety Pins (and other similar products like paper pins, staples pins etc.)
46. Shoe laces

47. Sign Boards painted
48. Soap Liquid
49. Spectacle frames
50. Steel Chair
51. Umbrellas
52. Utensils all types

Sample Services that can be offered under SME

1. Marketing Consultancy
2. Industrial Consultancy
3. Equipment Rental & Leasing
4. Typing Centres
5. Photocopying Centres (Zeroxing)
6. Industrial photography
7. Industrial R & D Labs.
8. Industrial Testing Labs.
9. Desk Top publishing
10. Advertising Agencies
11. Internet Browsing/Setting up of Cyber Cafes
12. Auto Repair, services and garages
13. Documentary Films on themes like Family Planning, Social forestry, energy conservation and commercial advertising
14. Laboratories engaged in testing of raw materials, finished products
15. 'Servicing Industry' Undertakings engaged in maintenance, repair, testing or electronic/electrical equipment/ instruments i.e. measuring/control instruments servicing of all types of vehicles and machinery of any description including televisions, tape recorders, VCRs, Radios, Transformers, Motors, Watches.
16. Laundry and Dry Cleaning
17. X-Ray Clinic
18. Tailoring
19. Servicing of agriculture farm equipment e.g. Tractor, Pump, Rig, Boring Machines.
20. Weigh Bridge
21. Photographic Lab
22. Blue printing and enlargement of drawing/designs facilities
23. ISD/STD Booths
24. Teleprinter/Fax Services
25. Sub-contracting Exchanges (SCXs) established by Industry Associations.
26. Coloured or Black and White Studios equipped with processing laboratory.
27. Ropeways in hilly areas.
28. Installation and operation of Cable TV Network:
29. Operating EPABX under franchises
30. Beauty Parlours
31. Creches.

S. No.	Performance Indicators	Weightage in %
1	Leadership skills	20
2	Team work	20
3	Lateral/creative thinking	10
4	Observations and recording	10
5	Self learning	20

S. No.	Performance Indicators	Weightage in %
6	Answer the 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	Seminar Hall equipped with conference table,chairs and multimedia facilities	All
2	Modern desktop Computer with internet connection.	All

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 (In cognitive domain)	Topics and Sub-topics
Unit – I Entrepreneurship Development - Concept and Scope	1a. Describe the procedure to evaluate your entrepreneurial traits as a career option for the given product to be manufactured or services to be rendered. 1b. Explain the given terms related to Entrepreneurship	1.1 Entrepreneurship as a career 1.2 Traits of successful intrapreneur/ entrepreneur: consistency, creativity, initiative, independent decision making, assertiveness, persuasion, persistence, information seeking, handling business communication, commitment to work contract, calculated risk taking. 1.3 Entrepreneurship : scope in local and

Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
	1c. Describe the salient features of the resources required for starting the specified enterprise. 1d. Identify the characteristics for a given type of enterprise.	global market. 1.4 Intrapreneur and entrepreneur 1.5 Types of enterprises and their features : manufacturing, service and trading. 1.6 Steps in setting up of a business.
Unit – II Entrepreneurial Opportunities and selection process	2a. Arrive at a business opportunity on the basis of given data/circumstances with justification. 2b. Describe the scheme(s) offered by the government for starting the specified enterprise. 2c. Suggest a suitable place for setting up the specified enterprise on the basis of given data/circumstances with justification. 2d. Suggest the steps for the selection process of an enterprise for the specified product or service with justification. 2e. Describe the market study procedure of the specified enterprise.	2.1 Product/Service selection: Process, core competence, product/service life cycle, new product/ service development process, mortality curve, creativity and innovation in product/ service modification / development. 2.2 Process selection: Technology life cycle, forms and cost of transformation, factors affecting process selection, location for an industry, material handling. 2.3 Market study procedures: questionnaire design, sampling, market survey, data analysis 2.4 Getting information from concerned stakeholders such as Maharashtra Centre for Entrepreneurship Development[MCED], National Institute for Micro, Small and Medium Enterprises [NI-MSME], Prime Minister Employment Generation Program [PMEGP], Directorate of Industries[DI], Khadi Village Instries Commission[KVIC]
Unit – III Support Systems	3a. Describe the support system required for the specified enterprise. 3b. Describe the help provided by the government agencies for the specified product/service. 3c. Describe the help provided by the non-governmental agencies for the specified product/service. 3d. Compute the breakeven point for the specified	3.1 Categorisation of MSME, ancillary industries 3.2 Support systems- government agencies: MCED, NI-MSME, PMEGP,DI, KVIC 3.3 Support agencies for entrepreneurship guidance, training, registration, technical consultation, technology transfer and quality control, marketing and finance. 3.4 Breakeven point, return on investment and return on sales.

Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
	business enterprise, stating the assumptions made.	
UNIT IV Business Plan Preparation	4a. Justify the importance of the business plan for the given product/service. 4b. Explain the key elements for the given business plan with respect to their purpose/size 4c. Prepare the budget for the given venture. 4d. Prepare the details of the given component of the given startup business plan.	4.1 Sources of Product for Business : Feasibility study 4.2 Ownership, Capital, Budgeting, Matching entrepreneur with the project , feasibility report preparation and evaluation criteria 4.3 Business plan preparation
Unit –V Managing Enterprise	5a. Justify the USP of the given product/ service from marketing point of view. 5b. Formulate a business policy for the given product/service. 5c. Choose the relevant negotiation techniques for the given product/ service with justification. 5d. Identify the risks that you may encounter for the given type of business/enterprise with justification. 5e. Describe the role of the incubation centre for the given product/service.	5.1 Unique Selling Proposition [U.S.P.]: Identification, developing a marketing plan. 5.2 Preparing strategies of handling business: policy making, negotiation and bargaining techniques. 5.3 Risk Management: Planning for calculated risk taking, initiation with low cost projects, integrated futuristic planning, angel investors, venture capitalist. 5.4 Incubation centres: Role and procedure.

Note: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' of Bloom's 'Cognitive Domain Taxonomy'.

9. 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. Develop two products from household waste (attach photographs).
b. Download product development and innovative films from internet.
c. Prepare a collage for 'Traits of successful entrepreneurs'.
d. Invite entrepreneurs, industry officials, bankers for interaction.
e. Identify your hobbies and interests and convert them into business idea.

f. Convert you project work into business.
g. Choose a product and design a unique selling preposition, brand name, logo, advertisement (print, radio, television), jingle, packing, packaging, label for it.
h. Develop your own website. Share your strengths and weakness on it. Declare your time bound goals and monitor them on the website.
i. Choose any advertisement and analyse its good and bad points.
j. Decide any product and analyse its good and bad features.
k. Select any product and prepare its cost sheet.
l. Choose any product and study its supply chain.
m. Arrange brainstorming sessions for improvement of any product.
n. Study schemes for entrepreneurship promotion of any bank.
o. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
p. Open a savings account and build your own capital.
q. Organise industrial visit and suggest modifications for process improvement.
r. Interview at least four entrepreneurs or businessman and identify Charms of entrepreneurship and Traits of successful entrepreneurs.
s. Analyse case studies of any two successful entrepreneurs.
t. Perform a survey and identify local resources available for setting up of an enterprise.
u. Engage in marketing of products.
v. Carry out a demand supply gap analysis for a particular product.
w. Organise a prototype development competition.
x. Arrange fairs, events in the institute and try for sponsorships.
y. Select any performance criteria and continuously compete with yourself.
z. On any performance criteria continuously compete with others.
aa. Foresee your dream and make a long term plan for its accomplishment.
bb. Dream for something unique and make a write-up.
cc. Read articles, books on creativity.
dd. Using morphological analysis technique, reduce cost or increase quality of a product.
ee. Conduct a market survey for a project. Collect data on machinery specifications, price, output/hr, power consumption, manpower requirement, wages, raw material requirement, specification, price, competitor's product price, features, dealer commissions, marketing mix.
ff. Prepare a business plan and organize a business plan competition.
gg. Select a social cause, set objectives, plan and work for its accomplishment.
hh. Videograph as many as possible from the above and upload on your website, YouTube, facebook.

10. 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/UOs 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 maintenances techniquies.
f. Guide student(s) in undertaking micro-projects.
g. Instructors should emphasise more on deductive learning. Students should learn to recognise, create, shape opportunities, and lead teams for providing economic-social value to society.
h. Business simulations should be used to enhance behavioural traits of successful intrapreneurs and entrepreneurs amongst students. Emphasis should be on creating entrepreneurial society rather than only setting up of enterprise.
i. They must be encouraged to surf on net and collect as much information as possible.
j. Each student should complete minimum twenty activities from the suggested list. Minimum possible guidance should be given for the suggested activities.
k. Students should be promoted to use creative ideas, pool their own resources, finish their presentation, communication and team skills.
l. Alumni should be frequently invited for experience sharing, guiding and rewarding students.
m. Display must be arranged for models, collages, business plans and other contributions so that they motivate others.

11. SUGGESTED MICRO-PROJECTS

One Business Plan as a micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he should submit it by the end of the semester to develop the industry oriented COs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation in the middle of the semester and one at the end of the semester before submission of the project proposal incorporating the concepts taught during semester. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.

a. Choose any advertisement and analyse its good and bad points.
b. Decide any product and analyse its good and bad features.
c. Select any product and prepare its cost sheet.
d. Choose any product and study its supply chain.
e. Arrange brainstorming sessions for improvement of any product.
f. Study schemes for entrepreneurship promotion of any bank.
g. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
h. Open a savings account and build your own capital.
i. Organise industrial visit and suggest modifications for process improvement.

12. SUGGESTED LEARNING RESOURCES

S. No.	Title of Books	Author	Publication
1	The Entrepreneurial Instinct : How Everyone Has the Innate Ability to Start a Successful Small Business	Mehta, Monica	McGraw-Hill Education, New Delhi, 2012, ISBN 978-0-07-179742-9
2	Entrepreneurship	Hisrich, R. D.	McGraw-Hill Education, New Delhi, 2013 ISBN-13: 978-1259001635
3	Part I Readings in Entrepreneurship Education	Sareen, S.B.	Entrepreneurship Development Institute of India (EDI), GOI,

S. No.	Title of Books	Author	Publication
			Ahmedabad, 2016; ISBN: 978-0078029196 ..
4	Reading Material of Entrepreneurship Awareness Camp	Gujral, Raman	Entrepreneurship Development Institute of India (EDI), GOI, 2016 Ahmedabad,
5	Product Design and Manufacturing	Chitale, A K	PHI Learning, New Delhi, 2014; ISBN: 9788120348738
6	Entrepreneurship Development Small Business Entrepreneurship	Charantimath, Poornima	Pearson Education India, New Delhi; ISBN: 9788131762264
7	Entrepreneurship Development: Special edition for MSBTE	CPSC, Manila	Tata Mc-Graw Hill, New Delhi,
8	Entrepreneurship and Small Business Management	Khanka, S.S.	S.Chand and Sons, New Delhi, ISBN: 978-93-5161-094-6
9	Entrepreneurship Development	S, Anil Kumar	New Age International, New Delhi, ISBN: 9788122414349

13. SUGGESTED SOFTWARE/LEARNING WEBSITES

1	MCED Books links	http://www.mced.nic.in/UdyojakSpecial.aspx?linktype=Udyojak
2	MCED Product and Plan Details	http://www.mced.nic.in/allproduct.aspx
3	The National Institute for Entrepreneurship and Small Business Development Publications	http://niesbud.nic.in/Publication.html
4	Courses : The National Institute for Entrepreneurship and Small Business Development	http://niesbud.nic.in/docs/1standardized.pdf
5	Entrepreneur.com	https://www.entrepreneur.com/lists
6	GOVT. SPONSORED SCHEMES	https://www.nabard.org/content1.aspx?id=23andcatid=23andmid=530
7	NABARD - Information Centre	https://www.nabard.org/Tenders.aspx?cid=501andid=24
8	NABARD – What we Do	http://www.nabard.org/content1.aspx?id=8andcatid=8andmid=488
9	Market Review	http://www.businesstoday.in/markets
10	Start Up India	http://www.startupindia.gov.in/pdffile.php?title=Startup%20India%20Action%20Planandtype=Actionandq=Action%20Plan.pdfandcontent_type=Actionandsubmenupoint=action
11	About - Entrepreneurship Development Institute of India (EDII)	http://www.ediindia.org/institute.html
12	EDII - Centres	http://www.ediindia.org/centres.html
13	EDII - Publications	http://www.ediindia.org/publication.html
14	Business Plans: A Step-by-Step Guide	https://www.entrepreneur.com/article/247574
15	The National Science and Technology Entrepreneurship Development Board (NSTEDB)	http://www.nstedb.com/index.htm

16	NSTEDB - Training	http://www.nstedb.com/training/training.htm
17	Tata Exposures	http://www.tatasocial-in.com/project-exposure
18	Ministry Of Micro, Small And Medium EnterpriseS	http://www.dcmsme.gov.in/schemes/TEQUPDetail.htm
19	List of Business Ideas for Small Scale Industry	https://smallb.sidbi.in/%20/thinking-starting-business/big-list-business-ideas-small-business
20	Thinking of Entrepreneurship	https://smallb.sidbi.in/entrepreneurship-stage/thinking-entrepreneurship
21	List of services for Small Scale Industry	http://www.archive.india.gov.in/business/Industry_services/illustrative.php
22	NSIC Schemes and Services	http://www.nsic.co.in/SCHSERV.ASP

Program Name : **All Branches of Diploma in Engineering and Technology.**

Program Code : **CE/CR/CS/CH/CM/CO/IF/CW/DE/EJ/EN/EQ/ET/EX/IE/ MU/EE/EP/EU/IS/IC/AE/FG/ME/PG/PT/DC/TX/TC**

Semester : **Sixth**

Course Title : **Capstone Project – Execution & Report Writing**

Course Code : **22060**

1. RATIONALE

This course on 'Capstone Project–Execution and Report Writing' is the continuation of the previous semester course on 'Capstone Project–Planning'. So, in this semester, the students are to implement the detailed Capstone Project Plan, which they have prepared in the preceding semester. Therefore, to successfully complete this Capstone Project by the end of this semester, it is necessary to incorporate the suggestions of the guide/examiners of the preceding semester. Hence, it is of utmost importance for the student to again re-capitulate and comprehend the importance, concept and need of the 'Capstone Projects' which are well explained in the 'Capstone Project–Planning' course in the previous semester.

Often, the jobs in the industry, which the diploma holders will come across when they join it and will be in the form of small or large projects. Such projects are generally an integration of the various types of skills which cut across the three major domains of learning i.e. cognitive, psychomotor and affective domain which must have acquired during their journey from first semester to the last semester. Hence, it is essential that students are also given an opportunity to do large projects which require more time compared to the micro-projects in order to develop and integrate the highly essential industry oriented competencies and associated skills in the students. Therefore, in this semester the 'Capstone Project – Execution and Report Writing' will continue to integrate some more additional competencies along with those in the previous semester and hence build up greater confidence to face such situations in the world of work.

2. COMPETENCY

The course should be taught and implemented with the aim to develop the required course outcomes (COs) so that students will acquire following competency needed by the industry:

- **Implement the Capstone Project Plan to solve the identified problem/task faced by industry/user related to the concerned occupation by integrating the various types of skills acquired during the programme.**

3. COURSE OUTCOMES (COs)

Depending upon the nature of the projects undertaken, the following could be some of the major course outcomes that could be attained, although, in case of some projects few of the following course outcomes may not be applicable.

a) Implement the planned activity individually and/or as team.
b) Select, collect and use required information/knowledge to solve the identified problem.
c) Take appropriate decisions based on collected and analysed information.
d) Ensure quality in product.
e) Incorporate energy and environment conservation principles.
f) Consider the ethical issues related to the project (if there are any).
g) Assess the impact of the project on society (if there is any).
h) Communicate effectively and confidently as a member and leader of team.

i) Prepare project report after performing due plagiarism check using appropriate tools.

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	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	

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

5. Course details

As the implementation of the Capstone project progresses and which has to be submitted at the end of project work, one of the outputs of this course is a detailed ***Project Report*** that is continuously prepared by the student. There will also be regular progressive assessment by the teacher as per the criteria no 7 on the basis of rubrics mentioned in **Appendix –C** and in the formats as shown in **Appendix-B** and also for the end-of-semester examination.

5.1 Guidelines for Capstone Project–Execution and Report Writing

a) The students would like to revise the 'Capstone Project – Plan' based on the feedback received in the fifth semester examination.

b) This revised 'Capstone Project – Plan' would be again approved by the project guide. As soon as the revised plan is approved by the teacher, the student will begin to work according to it and would also continue to maintain a dated ***'Project Diary'*** for the whole semester. This is a sort of a 'weekly diary' indicating all the activities conducted by the student every week in the semester to complete the project. This 'Project Diary' should be got signed by the teacher at regular intervals for progressive assessment. If this is maintained sincerely and truthfully by the student, it will be very helpful in compiling the ***Final Project Report*** at the end of the semester by him/her.

6. Project report

During the final Semester, the student will prepare a 'Project Report' in continuation with the activities conducted in fifth semester under Project Planning having following sub-titles:

Suggested contents of the Project report

- Title page (with name of team members and mentor teacher)
- Certificate (in the Format given in this document as annexure A)
- Acknowledgements (this may need revision at the end of the final semester)
- Abstract (in one paragraph not more than 150 words)
- Content Page

Chapters

1. Chapter–1 Introduction (background of the Industry or User based Problem/Task)
2. Chapter–2 Literature Survey (to finalise and define the Problem Statement)
3. Chapter–3 Scope of the project
4. Chapter–4 Methodology
5. Chapter-5 Details of designs, working and processes

6. Chapter-6 Results and Applications
7. Chapter-7 Conclusions And future scope
8. Appendix (if any)
9. References and Bibliography

Note:

i. The report should contain as many diagrams, figures and charts etc as relevant for the project.
ii. Originality of the report (written in own words) would be given more importance rather than quality of printing and use of glossy paper or multi-colour printing

7. ASSESSMENT OF PROJECT WORK

Project work has two components, first is Progressive Assessment (PA), while another is End Semester Examination (ESE).

7. 1. Progressive Assessment (PA) Guidelines and Criteria

Project guide is supposed to carry out this assessment. It is a continuous process, during which for developing desired qualities in the students, faculty should orally give **informal feedback** to students about their performance and interpersonal behaviour while guiding them on their project work every week. **F**ollowing criteria should be considered while assessing students informally or formally during different stages of the project work.

The following factors need consideration for both Capstone Project-Planning and Capstone Project-Execution and Report Writing.

a) Students should be assessed during the project work so that students can also get feedback for further improvement.
b) It should be kept in mind that project work is mainly experiential learning and it is not the research work, so emphasis should be on work based learning or learning from experience and development of attitudes and skills as mentioned in course outcomes. So focus of assessment should also be on learning from the process of completing project work rather than on novelty or innovation in the project work.
c) For progressive assessment at the end, students should be asked to give the power point presentation before group of teachers and junior students (so that junior students may also get awareness about the major project work they have to carry out in future)
d) The students would be awarded marks for their efforts (In some cases it may happen that due to some reasons such as unavailability of some material or component or some other resources, students may not be able to complete the project, but they have tried their best, in such cases students would be given appropriate marks if they have done enough efforts.)
e) The students would not be awarded marks if they have completed the project by getting done the work from market or some professionals (taking some help and guidance is different as compared to getting the work or maximum part of the work completed from others on payment basis).
f) Originality of the report (written in own words) would be given more importance.
g) The Project Guide will assure the quality of project done by his group.

Criteria of Marks for PA for Capstone Project -Execution and Report Writing.

S. No.	Criteria	Marks
1	**Project Proposal /Identification**	10
2	**Punctuality and overall contribution**	
3	**Project Diary**	
4	**Execution of Plan during sixth semester**	20
5	**Project Report including documentation**	15
6	**Presentation**	05
	Total	**50**

7.2 END SEMESTER EXAMINATION (ESE)

Evaluation shall be carried out according to following criteria. For each project, students from the concerned group should be asked to make presentation of their project , in front of the external and internal examiners which should be followed by question answer session to ascertain the contribution made by each student.

Criteria of Marks for ESE for Capstone Project -Execution and Report Writing

S. No.	Criteria	Marks
1	Project Proposal	05
2	Punctuality and overall contribution	
3	Project diary	
4	Execution of Plan during sixth semester	10
5	Project Report including documentation	10
6	Presentation	10
7	Question and Answer	15
	Total	**50**

8. SPECIAL TEACHING STRETAGIES (If any)

a) Teacher's should not spoon feed the students and let them try on their own at different stages of the project work and cvcn first let them strive hard and only when efforts of students have failed, then teacher should guide them. Guidance should be in initially in the form of clues or hints rather than complete explanation, detailed explanation should be given only when students are not able to work based on clues/hints. The role of teacher should be limited to guide and facilitator

b) Teachers should help students in selecting a topic which is relevant and challenging (but within capacity) for students according to their abilities.

c) ***Teachers should come out of the mindset that there should be compulsorily some innovation and novelty in the project work. Because as discussed earlier, project is mainly opportunity for work based or experiential learning, the aim of which is to develop higher order cognitive skills and attitudes. Project at diploma level is not research or innovation.*** The main thing teachers have to ensure is that students choose a task or problem for their project work which is challenging but according to their capability i.e. a task which they can complete on their own without getting it done from market.

d) Teachers should ensure that students prepare the project plan in as much detail as possible, since this way only they would learn the importance of planning and how to do the detail planning. Teachers should allow students to proceed ahead only when they have detailed plan with them.

e) Teachers should motivate students to maintain project document project diary and project report. They should explain benefits of these activities to students and also train them in these activities, because most of them may be doing this first time.

f) Project Guide should ensure that students submit chapter of report one by one to him/her as per schedule and should check the content of the chapters. The Project guide should monitor that schedule is maintained and report writing is not left till last few weeks. It should not be a problem since first three chapters of the report should have been written in fifth semester itself.

g) Teachers should also encourage students to openly discuss their weaknesses and shortcomings .Teachers should develop confidence in students that admitting mistakes and weaknesses helps in improving them.

h) Teachers should continuously discuss with students about working of group and progress in the project and from this discussion should identify their personal qualities (both strengths and weaknesses) and suggest to them ways for improving those qualities.

i) Internal as well as external examiners should reward students for original work and efforts of students even if they are not fully successful or not able to complete the project in comparison to those students who have taken paid help from others to complete their project.

Appendix–A

CERTIFICATE

This is to certify that Mr./Ms.....

from .....Institute having Enrolment No: .....

has completed project of final year having title .....,.... during the academic year20__-20__. The project completed by individually/ in a group consisting of..... persons under the guidance of the Faculty Guide.

.....

.....

Name & Signature of Guide: .....

Telephone:.....

Appendix–B

PROGRESSIVE ASSESSMENT (PA) OF CAPSTONE PROJECT – EXECUTION AND REPORT WRITING

Evaluation Sheet for Internal Assessment

Name of Student: .....
Name of Programme..... **Semester: Sixth**
Course Title: Capstone Project : Execution and Report Writing **Code:22060.**
Title of the Capstone Project: .....
.....

A. **POs addressed by the Capstone Project** (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

B. **COs addressed by the Capstone Project** (Mention only those predominant POs)

a) .....
b) .....
c) .....
d) .....

C. **OTHER LEARNING OUTCOMES ACHIEVED THROUGH THIS PROJECT**

1. **Unit Outcomes (Cognitive Domain)**
   a) .....
   b) .....
   c) .....
   d) .....

2. **Practical Outcomes (in Psychomotor Domain)**
   a) .....
   b) .....
   c) .....
   d) .....

3. **Affective Domain Outcomes**
   a) .....
   b) .....
   c) .....
   d) .....

PROGRESSIVE ASSESSMENT (PA) Sheet		
S. No.	**Criteria**	**Marks**
1	Project Proposal /Identification	10
2	Punctuality and overall contribution	
3	Project Diary	
4	Execution of Plan during sixth semester	20
5	Project Report including documentation	15
6	Presentation	05
Total		**50**

Appendix–B

Suggested Rubric for Capstone Project – Execution and Report Writing

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
1	**Problem/Task Identification (Project Title)**	Relate to very few POs Scope of Problem not clear at all	i. Related to some POs ii. Scope of Problem/Task vague	i. Take care of at-least Three POs ii. Scope of Problem/task not very specific	• Take care of more than three POs ii. Scope of problem/task very clear
2	**Literature Survey /Industrial Survey**	Not more than ten sources (primary and secondary), very old reference	At-least 10 relevant sources, at least 5 latest	At –least 15 relevant sources, most latest	About 20 relevant sources, most latest
3	**Project proposal**	Methods are not appropriate, All steps not mentioned, Design of prototype not started (if applicable).	Appropriate plan but not in much detail. Plan B for critical activities not mentioned. Time line is not developed. Design of Prototype is not complete. (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, but clarity is not there in methods, time line is given but not appropriate. Design of prototype is not detailed (if applicable)	Appropriate and detailed plan with Plan B for critical activities mentioned, clarity in methods with time line, Detailed design of prototype (if applicable)
4	**Project Diary**	Entries for most weeks are missing. There is no proper sequence and details are not correct.	Entries for some weeks are missing, details are not appropriate, not signed regularly by the guide.	Entries were made every week but are not in detail. Signed and approved by guide every week	Entries were made every week in detail, signed and approved by guide every week
5	**Final Report Preparation**	Very short, poor quality sketches, Details about methods, material, precaution and conclusions	Detailed, correct and clear description of methods, materials, precautions and	Conclusions. Sufficient Graphic Description.	Very detailed, correct, clear description of methods, materials, precautions and conclusions. Enough tables,

S. No.	Characteristic to be assessed	Poor	Average	Good	Excellent
		omitted, some details are wrong			charts and sketches
6	**Presentation**	Major information is not included, information is not well organized .	Includes major information but not well organized and not presented well	Includes major information and well organized but not presented well	Well organized, includes major information ,well presented
7	**Defense**	Could not reply to considerable number of question.	Replied to considerable number of questions but not very properly	Replied properly to considerable number of question.	Replied to most of the questions properly

Appendix C

Suggestive Project Diary format

Week no:
Activities planned:
Activities Executed:
Reason for delay if any
Corrective measures adopted
Remark and Signature of the Guide

Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME/PG/PT/AE**

Semester : **Sixth**

Course Title : **Emerging Trends in Mechanical Engineering**

Course Code : **22652**

1. RATIONALE

Over the coming years, technological developments such as Robotics, IOT, Artificial intelligence, smart controls are likely to have a significant impact on the world of work and employment as well as to trigger far reaching changes. Looking towards the era in Technology advancement, Mechanical/Automobile/Production Engineering offers addition of new Dynamic subjects and new versions of core subjects. Diploma Mechanical/Automobile/Production Engineers should be familiar with new technologies from the fields of Automobile Engineering, Energy Management, Advanced Manufacturing Processes, Agriculture and Farm Machines and many more. This Dynamic course will give insight to the recent practices adopted by the Mechanical Industries and awareness of these techniques will enhance career opportunities of Diploma Mechanical/Automobile/Production Engineers.

2. COMPETENCY

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

- **Relate basic principles of Mechanical Engineering with Recent Technologies available in Industry.**

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 different new Systems available in Automobile.
b. Demonstrate automation systems in process industry.
c. Cite examples of Modern manufacturing Technology in industry
d. Use different standards for energy Management and Audit of a given system.
e. Select recent agricultural equipment for farming operations.

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	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	

(*): 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 MULTI CHOICE QUESTION 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.

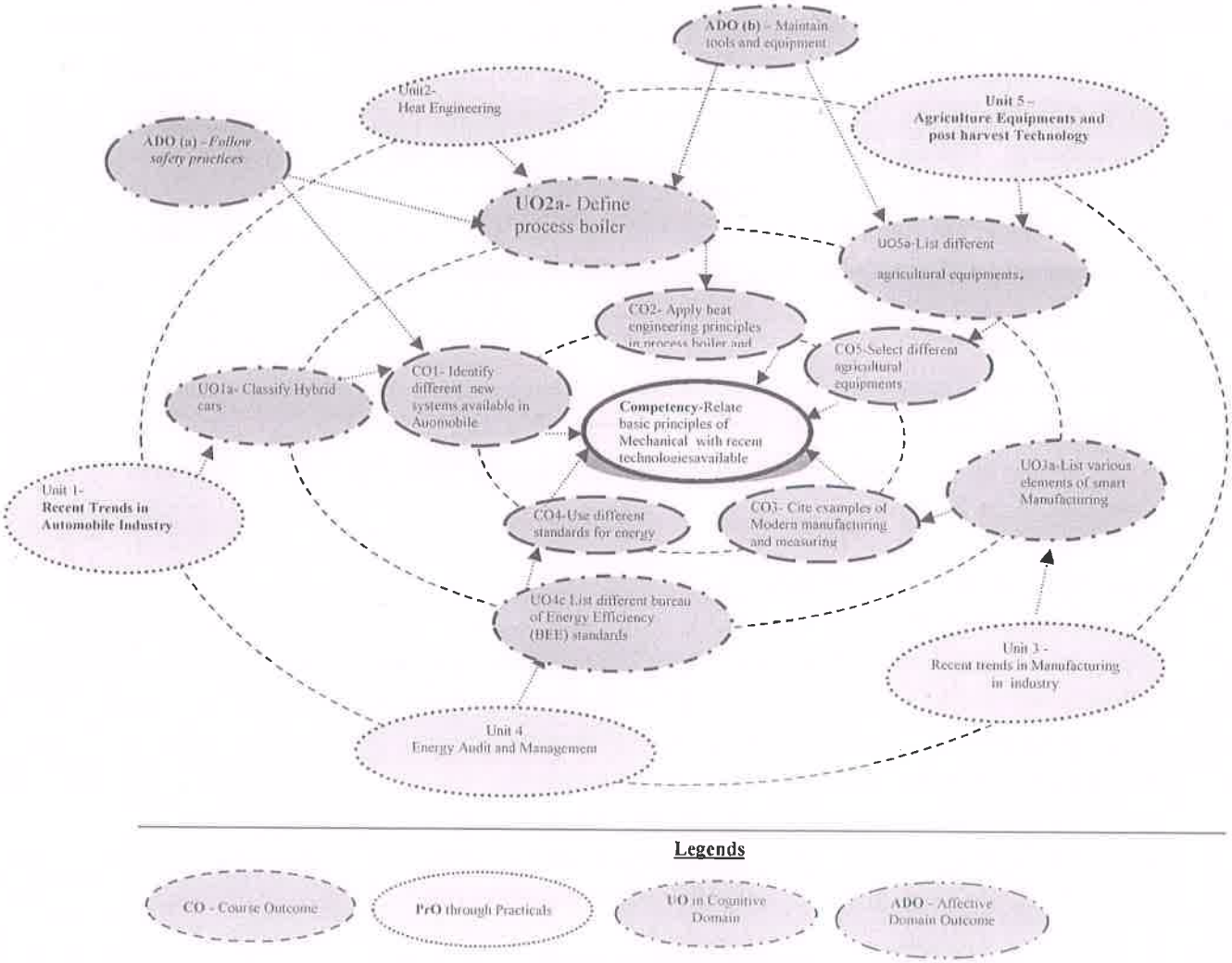

Figure 1 - Course Map

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	NA		

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 %
a.	NA	

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. 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
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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	LCD Projector	-

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	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Recent Trends in Automobile Industry	1a. Classify Hybrid cars 1b. Use different batteries and charging methods for E-Vehicles 1c. Name different safety systems used in given	1.1 Hybrid cars-manufactures, Types- Micro Hybrid, Mild Hybrid, Full Hybrid, Series hybrid, Parallel Hybrid 1.2 E-vehicles- Manufacturers, specifications, Types of Batteries, Li-ion batteries, Sodium Nickel

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	vehicle. 1d. Interpret concept of autonomous vehicles.	Chloride Batteries ,Sodium Sulphor Batteries, Fuel Cell, Charging- Charging Methods and Modes. Issues with e-vehicles 1.3 Safety in Automobile- Air bags, , Electronic stability programmer, Anti Collision system. 1.4 Autonomous Vehicle- introduction, necessity, Level, Manufacturer
Unit– II Recent Trends in Process Industry	2a. Define process boiler and Combi Boiler 2b. List commerciality viable waste heat recovery devices. 2c. Interpret process layout of different process industry 2d. List different elements of process automation.	2.1 Process Boilers, Introduction to Combi Boilers 2.2 Waste heat recovery-process industry 2.3 Process layout of process industry a. Food Industry b. Pharmaceutical c. Textile 2.4 Process Automation – Need, Basic Elements, Types
Unit –III Recent Trends in Manufacturing industry	3a. List various elements of smart factory 3b. Select Robot for given application 3c. List applications of Industrial robot 3d. Interpret Immersive Technology	3.1 **Smart Factory** -introduction, Elements and applications 3.2 **Industrial robotics**: robot anatomy, robot control systems, end effectors, sensors in robotics, 3.3 Industrial Robot applications • Welding Robot • Assembly Robot 3.4 Introduction to Immersive Technology • Virtual Reality • Augmented Reality • Mixed Reality
Unit-IV Energy Audit and Management	4.a List different bureau of Energy Efficiency (BEE) standards. 4.b Describe methods of Energy Monitoring and Targeting 4.c Identify steps for conducting Energy Audit. 4.d State concept of Home energy audit.	4.1 Standards and labelling standard 4.2 Energy Monitoring and Targeting. 4.3 Energy Management and Audit 4.4 Home Energy Audit- Concept
Unit-V Agriculture Equipment and post-harvest Technology	5.a Explain working of different agricultural equipment. 5.b Name different elements of Cold Chain 5.c List the features of NCAP	5.1 Farms tools and equipments 5.2 Advanced Technology in Post Harvesting 5.3 Elements of Cold chain 5.4 National Cooling Action Plan (NCAP)

***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 FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
1	Recent Trends in Automobile Industry	14	06	10	04	20
2	Recent Trends in Process Industry	08	02	06	04	12
3	Recent Trends in Manufacturing Industry	12	04	06	08	18
4	Energy Audit and Management	08	02	06	02	10
5	Agriculture Equipment and post-harvest Technology	06	02	06	02	10
	Total	**48**	**16**	**34**	**20**	**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. Visit any industry and collect information of recent trends in Industry.
b. Undertake a market survey of local dealers for agricultural equipments, machineries, HVAC equipments and prepare a report.
c. Visit to any Industrial press shop and prepare a report consisting
    i. Safety precautions observed.
    ii. Identify problems related to energy conservations faced by industry

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. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in Lab.
i. Demonstrate students thoroughly before they start doing the practice.
j. Encourage students to refer different websites to have deeper understanding of the subject.
k. Guide student(s) in undertaking micro-projects.
l. Arrange visit to nearby industries for understanding various tool engineering operations
m. Show video/animation films to explain tool design processes.
n. Give Micro projects.
o. Use different instructional strategies in classroom teaching.
p. In respect of item no.10 above the teachers need to ensure to create opportunities and pursue for such co-curricular activities.

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 energy audit report of any one Lab rotary.
b. Collect data with respect to safety systems available in Modern cars
c. Identify different heat losses in Furnace available in workshop.
d. Compile the different products manufactured by 4-D printing Technology
e. Prepare report of pre and post harvesting using recent agricultural equipment
f. Collect information of District cooling.
g. Collect information of Robotics
h. Visit the local industry nearby and study the manufacturing systems. Thereby prepare the low cost automation plan for improvement in the productivity and quality of the industry

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Electric and Hybrid Vehicles	Tom Denton	IMI (Institute of Motor Industry) ISBN-13: 978-1138842373 ISBN-10: 1138842370

S. No.	Title of Book	Author	Publication
2	The Electric car	M H Westbrook	IET,2001 ISBN-0852960131
3	Hybrid, Electrical and Fuel Cell Vehicles	Jack Erjavec	Cengage Learning,2012 ISBN-1285415051
4	Boilers for Power and process	Kumar Rayaprole	CRC Press,2009 ISBN-1420075373
5	Steam generators and Waste heat Boilers	V Ganpathy	CRC press, ISBN 1482247127
6	Introduction to process Technology	C.E Thomas	Cengage Learning,2009 ISBN 1435454251
7	Industry 4.0 Smart manufacturing for the future	William MacDougall	Germany trade and Investe,2014
8	Energy Management and Conservation	K V Sharma	I K International Publishing House Pvt ltd, 2011 ISBN- 9381141290
9	Energy Management, Audit and Conservation	B K De	Vrinda Publication, Indiana University,2007 ISBN-8182810930
10	Farm Tools and Equipments for Agriculture	Surendra Singh	New India Publishing,2015 ISBN-9385516221
11	Cold storage, cold chain, ware houses	NPCS Board of Consultant	3rd Edition,2018 ,NIR project consultancy services, Delhi ISBN-978-93-81039-66-3
12	Automation, Production Systems, and Computer Integrated Manufacturing	Groover, Mikell. P.	PHI ISBN-13: 978-8120334182
13	Computer based Industrial Control	Kant, Krishna.	PHI Learning ISBN 13: 9788120339880

SOFTWARE/LEARNING WEBSITES

1. https://www.youtube.com/watch?v=MdFWgat9ddA(Agri Equipments)
2. *https://www.chargepoint.com/about (Electrical Vehicle)*
3. http://www.plugndrive.ca/ev-models (Electrical vehicle)
4. http://www.oorja.in/what-is-radiant-cooling/types-of-radiant-cooling-systems/(Cold Chain)
5. https://www.beeindia.gov.in/content/standard-labeling (Energy audit)
6. www.beestarlabel.com/ 9energy audit)