Maharashtra State Board of Technical Education, Mumbai
Teaching And Examination Scheme For Post S.S.C. Diploma Courses

Program Name : Diploma in Mechatronics

Program Code : MK

Duration of Program : 6 Semesters

Semester : Fifth

With Effect From Academic Year: 2019 - 20

Duration : 16 Weeks

Scheme - I

S.N.	Course Title	Course Abbreviation	Course Code	Teaching Scheme			Credit (L+T+P)	Examination Scheme														Grand Total
				L	T	P		Theory							Practical							
								Exam Duration in Hrs.	ESE		PA		Total		ESE		PA		Total			
									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	Management	MAN	22509	3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--	100
2	PLC Programming & SCADA	PPS	22585	3	-	4	7	3	70	28	30*	00	100	40	50#	20	50	20	100	40	200
3	Automotive Mechatronics	AMK	22586	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
4	Industrial Robotics	IRB	22587	3	-	2	5	3	70	28	30*	00	100	40	25#	10	25	10	50	20	150
5	Entrepreneurship Development	EDE	22032	2	-	2	4	--	--	--	--	--	--	--	50@	20	50~	20	100	40	100
6	Solid Modeling and Additive Manufacturing	SMA	22053	-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	100	40	100
Elective (Any One)																						
7	Internet of Things	IOT	22588	3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150
	Computer Integrated Manufacturing	CIM	22658																			
	Total			17	-	16	33	--	350	--	150	--	500	--	225	--	225	--	450	--	950

Student Contact Hours Per Week: 33 Hrs.

Theory and practical periods of 60 minutes each.

**Medium of Instruction: English**

Total Marks : 950

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

@ Internal Assessment, # External Assessment, *# Online Examination, ^ Computer Based Examination.

* 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.**
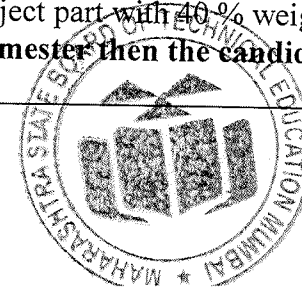
Program Name	**: Diploma in Mechanical Engineering / Electrical Engineering Group / Chemical Engineering/ Plastic Engineering/ Mechatronics**
Program Code	**: ME / EE / EP / EU / CH / PS / MK**
Semester	**: Fifth**
Course Title	**: Management**
Course Code	**: 22509**

1.   RATIONALE

An engineer has to work in industry with human capital and machines. Therefore, managerial skills are essential for enhancing their employability and career growth. This course is therefore designed to provide the basic concepts in management principles, safety aspects and Industrial Acts.

2.   COMPETENCY

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

- **Use relevant managerial skills for ensuring efficient and effective management.**

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 basic management principles to execute daily activities.
- b. Use principles of planning and organising for accomplishment of tasks.
- c. Use principles of directing and controlling for implementing the plans.
- d. Apply principles of safety management in all activities.
- e. Understand various provisions of industrial acts.

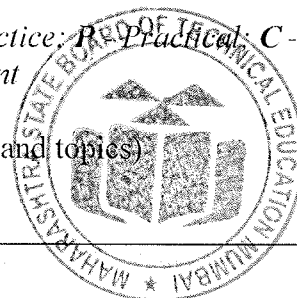## 4.   TEACHING AND EXAMINATION SCHEME

| Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Paper Hrs.	Theory						Practical					
					ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	-	3	90 Min	70*#	28	30*	00	100	40	--	--	--	--	--	--

(*#) Online Theory Examination.

(*): 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.(*#): Online examination

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.
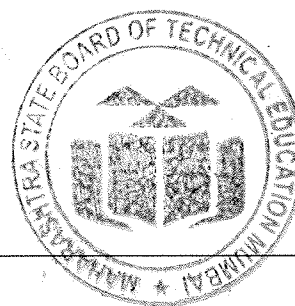

Figure 1 - Course Map
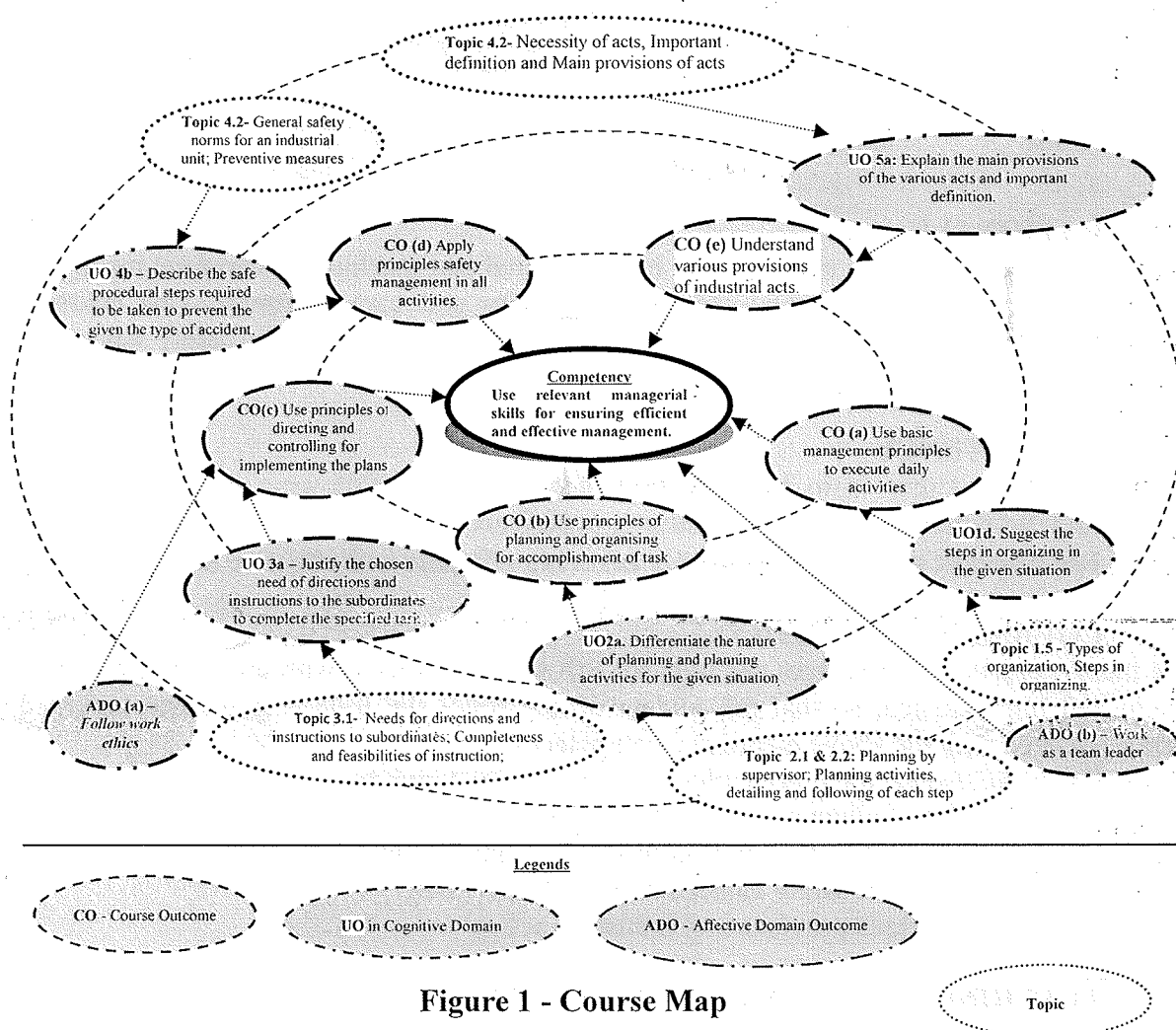
6.   SUGGESTED PRACTICALS/ EXERCISES
-    Not applicable -

7.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED
-    Not applicable -

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 management concepts and managerial skills**	1a. Differentiate the concept and principles of management for the given situation. 1b. Explain functions of management for given situation. 1c. Compare the features of the given types of planning 1d. Suggest the steps in organizing in the given situation. 1e. Suggest suitable type of organization for the given example. 1f. Identify the functional areas of management for the given situation 1g. Suggest suitable managerial skills for given situation with justification	1.1 Definitions of management, role and importance of management. 1.2 Management characteristics and principles, levels of management and their functions; management, administration and organization, relation between management and administration. 1.3 Functions of management: planning, organizing, leading/directing, staffing and controlling. 1.4 Types of planning and steps in planning 1.5 Types of organization, Steps in organizing 1.6 Functional areas of management. 1.7 Managerial skills.
Unit – II **Planning and organizing at supervisory level**	2a. Differentiate the nature of planning and planning activities for the given situation. 2b. Suggest the step wise procedure to complete the given activity in the shop floor. 2c. Prepare materials and manpower budget for the given production activity. 2d. Describe with block diagrams the organization of the physical resources required for the given situation. 2e. Describe the human needs to satisfy the job needs for the specified situation. 2f. List the tasks to be done by the concerned individuals for completing the given activity.	**Planning at supervisory level** 2.1 Planning by supervisor. 2.2 Planning activities, detailing and following of each step. 2.3 Prescribing standard forms for various activities. 2.4 Budgeting for materials and manpower. **Organizing at supervisory level** 2.5 Organizing the physical resources. 2.6 Matching human need with job needs. 2.7 Allotment of tasks to individuals and establishing relationship among persons working in a group
Unit– III **Directing and Controlling at supervisory level**	3a. Justify the chosen need of directions and instructions to the subordinates to complete the specified task. 3b. Select the feasible set of instructions to complete the given simple task, with justification 3c. Predict the possible mistakes for completing the given simple activity. 3d. Describe the managerial control	**Directing at supervisory level** 3.1 Needs for directions and instructions to subordinates; Completeness and feasibilities of instructions 3.2 Personal counselling advanced predictions of possible mistakes. 3.3 Elaborating decisions, laying disciplinary standards in overall working **Controlling at supervisory level**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	actions and remedial measures required to be taken for completing the given task successfully.	3.4 Managerial control; Understanding team and link between various departments in respect of process and quality standards; Steps in control process 3.5 Controlling methods; Control over the performance in respect of quality, quantity of production, time and cost. Measuring performance, comparing with standards, correcting unfavorable deviations.
Unit – IV **Safety** **Management**	4a. State the general safety norms required to be taken in the given case. 4b. Suggest preventive measures of plant activities in the given situation. 4c. Describe the safe procedural steps required to be taken to prevent the given the type of accident. 4d. Prepare a work permit in to conduct the given maintenance activity. 4e. Explain the causes of the specified type of accident in the given situation. 4f. Prepare the specifications of the firefighting equipment required for the given type of fire.	4.1 Need for safety management measures 4.2 General safety norms for an industrial unit; Preventive measures. 4.3 Definition of accident, types of industrial accident; Causes of accidents; 4.4 Fire hazards; Fire drill. 4.5 Safety procedure 4.6 Work permits.

Unit – V
 Legislative
 Acts
	5a. Explain the purpose of the act
	 5b. Explain the main provisions of the various acts and important definition.
		5.1 Necessity of acts, Important definition and Main provisions of acts.
		 5.2 Industrial Acts:
		    a. Indian Factory Act
		    b. Industrial Dispute Act
		    c. Workman Compensation Act
		    d. Minimum Wages Act

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 management	12	06	06	04	16

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
	concepts and managerial skills					
II	Planning and organizing at supervisory level	08	04	06	04	14
III	Directing and controlling at supervisory level	08	04	06	04	14
IV	Safety Management	08	04	06	04	14
V	Legislative Acts	12	02	06	04	12
	Total	**48**	**20**	**30**	**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. Write assignments based on the theory taught in classrooms. Assignments consist of ten questions having long answers including charts, symbols, drawing, observations etc.
  b. Prepare/Download information about various industrial acts.
  c. Visit to any Manufacturing industry and prepare a report consisting of:
     i.   Organization structure of the organization/ Dept.
     ii. Safety measures taken in organization.
     iii. Mechanism to handle the disputes.
     iv. Any specific observation you have noticed.
  d. Give seminar on relevant topic.
  e. Undertake micro-projects.

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.
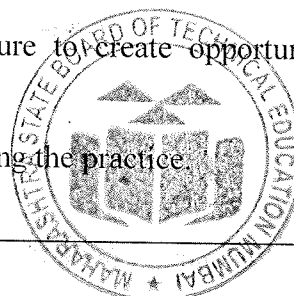
    g. Encourage students to refer different websites to have deeper understanding of the subject.

    h. Observe continuously and monitor the performance of students in Lab.

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:
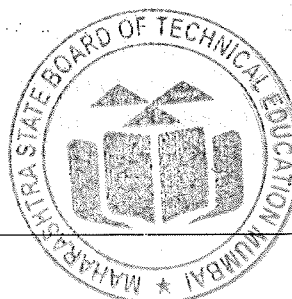
    a. Study of management principles applied to a small scale industry.
    b. Study of management principles applied to a medium scale industry.
    c. Study of management principles applied to a large scale industry.
    d. Prepare case studies of Safety measures followed in different types of organization.
    e. Study of measures to be taken for ensuring cyber security.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Management and entrepreneurship	Veerabhadrappa, Havinal	New age international publishers, New Delhi, 2014: ISBN: 978-81-224-2602-1
2	Principles of management	Chaudhry omvir Singh prakash	New Age international publishers, 2012, New Delhi ISBN: 978-81-224-3039-4
3	Industrial Engineering and management	Dr. O. P. Khanna	Dhanpath ray and sons, New Delhi
4	Industrial Engineering and management	Banga and Sharma	Khanna Publication, New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

    a. https://www.versesolutions.com/
    b. https://www.books.google.co.in/books?isbn=817758412X
    c. https://www. www.educba.com › Courses › Business › Management

Program Name	: Diploma in Mechatronics
Program Code	: MK
Semester	: Fifth
Course Title	: PLC Programming & SCADA
Course Code	: 22585

1.   RATIONALE

This course aims to acquaint students with vital components of automation such as typical input/output devices, Programmable Logic Controller (PLC), Motor Control Circuits (MCC), Supervisory Control and Data Acquisition (SCADA), Human Machine Interface (HMI) Distributed Control System (DCS). This will facilitate students to develop understanding and skills related with operation and maintenance of basic building blocks of industrial automation, which will in turn enable them to effectively upkeep the automated systems in industry.

2.   COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:
- **Use PLC & SCADA based automation 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.   Select relevant input/output components in industrial control circuits.
   b.   Interface IO devices with PLCs for different applications.
   c.   Test PLC program in different applications
   d.   Troubleshoot PLC ladder programs for simple applications.
   e.   Develop SCADA for simple applications.

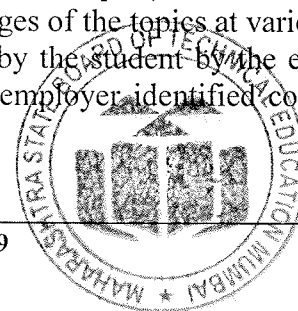## 4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Paper Hrs.	Theory						Practical					
L	T	P			ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	4	7	3	70	28	30*	00	100	40	50#	20	50	20	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 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, # - External 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.
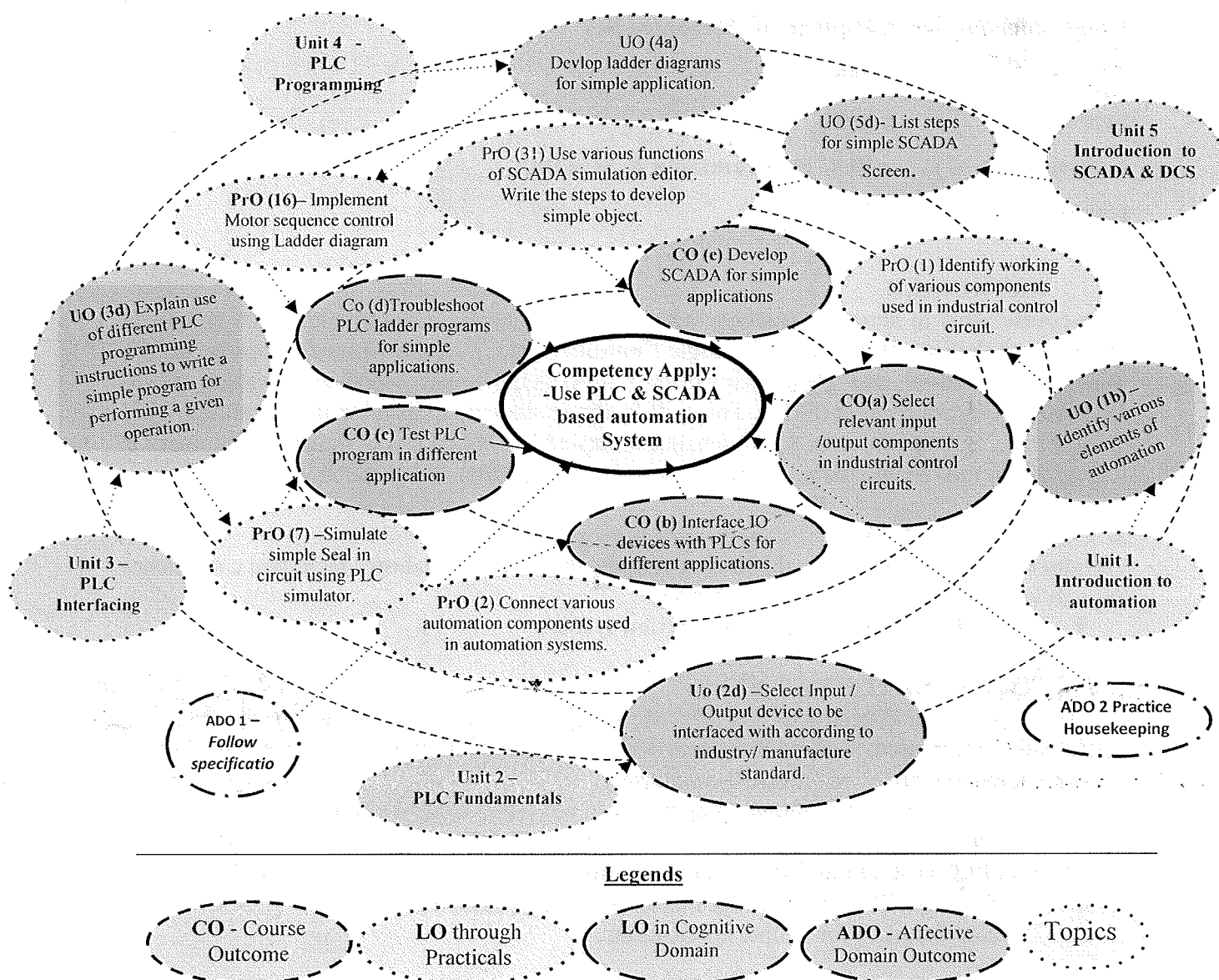
Figure 1 - Course Map

## 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 Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
1	Identify working of various components used in industrial control circuit.	I	02*
2	Connect various automation components used in automation systems.	I	02*
3	Connect DOL starter power & control circuit for 3 phase induction motor.	I	02*
4	Connect star delta starter power & control circuit for 3 phase induction motor.	I	02
5	Identify various parts of PLC. Draw front panel of PLC and state functions of each part of PLC.	II	02*
6	Implement ladder diagram to test functionality of the Logic Gates.	II	02*
7	Simulate simple seal in circuit using PLC simulator.	II	02*

8	Simulate latching circuit using ladder program.	II	02*
9	Simulate mathematical instruction using ladder program.	II	02*
10	Simulate ladder diagram for DOL starter	II	02*
11	Implement siren using timer instruction.	III	02
12	Simulate up counter for certain number of counts to turn on lamp.	III	02
13	Develop ladder program for up/down counter to make lamp ON/OFF.	III	02*
14	Develop ladder diagram for pulse counting using limit switch / proximity sensor	III	02*
15	Simulate automatic star delta starter using on delay timer.	III	02
16	Implement motor sequence control using ladder diagram	IV	02*
17	Implement traffic light control using ladder diagram.	IV	02*
18	Implement automated elevator control using ladder diagram	IV	02
19	Implement car parking system using ladder diagram	IV	02
20	Implement tank level control using ladder diagram	IV	02*
21	Implement conveyor system using ladder diagram.	IV	02*
22	Develop ladder program for rotating stepper motor in forward direction and reverse direction at constant speed.	IV	02*
23	Implement car washing system using ladder diagram.	IV	02
24	Implement object sorting (Metallic & Nonmetallic) system using ladder diagram	IV	02*
25	Develop a ladder program for ON/OFF control of DC motor in forward and reverse directions	IV	02*
26	Develop ladder program for temperature control using any temperature sensor with heater on off.	IV	02*
27	Develop ladder program for bottle filling application.	IV	02*
28	Implement automatic color mixing plant/machine using PLC.	IV	02
29	Write ladder program for robotic arm control using PLC.	IV	02*
30	Study different SCADA software and system in the market and select the suitable SCADA software for given application.	V	02*
31	Use various functions of SCADA simulation editor. Write the steps to develop simple object.	V	02*
32	Develop a SCADA mimic screen/diagram for START/STOP logic system to turn ON/OFF light after pressing start-stop switch.	V	02*
33	Observe alarm annunciation using SCADA.	V	02
34	Control liquid level in Tank by using SCADA.	V	02*
35	Control speed of DC motor using SCADA.	V	02
36	Observe reporting & trending in SCADA System for temperature control using any temperature sensor.	V	02*
	Total		**72**

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 needs 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:*
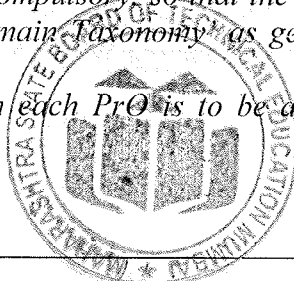
Sr. No.	Performance Indicators	Weightage in %
a.	Arrangement of available equipment or model	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	Submission of report in time	10
Total		**100**

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. 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/ 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	PLC Trainer kit	01, 06, 16-19
2	Conveyer bet (24 V DC operated) Kit	21,27,28
3	Water level Tank Kit	20,28
4	Stepper Motor PLC Interfacing Kit	22,29
5	Proximity Sensor (Indicative & Capacitive)	18,19,21,24,27,28,29
6	12 V DC motor	18,21,25,27,29
7	12 V & 24 V DC Power SMPS	01-29
8	SCADA Software	30-36
9	PLC Programming Software	06-29
10	Miscellaneous (Siren, Solenoid Valve, Lamp, Indicators, Connecting Wires, Multi-meter)	01-29

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.
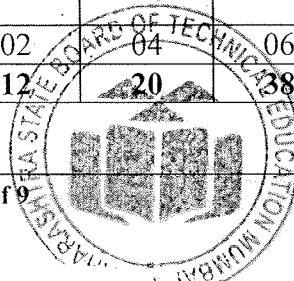
Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I **Introduction** **to Industrial** **Automation**	1a. Explain need of automation 1b. Identify various elements of automation. 1c. Sketch block diagram of an automated system. 1d. Write types of automation. 1e. Identify given symbol. 1f. Develop Power & control circuit for specific application. 1g. List advantages of Programmable logic over Hardwired relay logic.	1.1 Introduction to automation. Evolution of industrial automation, its need & importance. 1.2 Automation Hierarchy (Field level, Control level, Supervisory level, Production Control level and Enterprise Level) 1.3 Analog control, Digital control-supervisory control & Direct digital Control (DDC) 1.4 Types of Automation - Fixed, Flexible, Programmable, Integrated. 1.5 Different symbol used in industrial control circuit. 1.6 Concept of Power Circuit & Control Circuit- DOL starter, Star Delta Starter 1.7 The need of PLC over Hardwired relay logic, benefits and limitations of PLC in Industrial Automation
Unit– II **PLC** **Fundamentals**	2a. Draw block diagram of PLC. 2b. Explain functions of different parts of PLC. 2c. Describe the given module of PLC. 2d. Select Input / Output device to be interfaced with according to industry/ manufacture standard. 2e. Identify type of given PLC. 2f. State application areas of PLC. 2g. Explain with sketches the redundancy concept for the given PLC.	2.1 Block diagram of PLC 2.2 Function of different parts of PLC Power supply, Memory, CPU, I/O modules, specialized I/O modules 2.3 Discrete I/O Module of PLC, Block diagram & Specification 2.4 Analog I/O Module of PLC, Block diagram & Specification 2.5 Concept of Sinking & sourcing, its connections with PLC. 2.6 Overview of Commonly used IO devices for PLC according to industry standards 2.7 Redundancy in PLC, PLC Types, Size & its Application, Selection of PLC
Unit-III **Basics of PLC** **Programming**	3a. Describe elements of different programming languages used to program PLC. 3b. Explain processor scan cycle. 3c. Specify proper I/O addressing format of the given PLC. 3d. Explain use of different PLC programming instructions to write a simple program for performing a given operation.	3.1 PLC Programming languages 3.2 Program SCAN cycle. 3.3 I/O Addressing of PLC. 3.4 PLC Programming Instructions: Relay Type Instruction; Timer Instruction: ON Delay, OFF delay, Retentive; Counter Instruction: UP, DOWN, High Speed; Internal Relay Instruction; Logical and Comparison Instruction; Arithmetic Instructions; Data Movement Instructions 3.5 Programming Examine If Open, Examine If Closed Instruction

	3e. Explain PLC, PC interfacing Process 3f. List DO's & Dont's for PLC installation	3.6 PLC & PC Interfacing, DO's and Dont's for PLC Installation
Unit –IV **PLC & IO** **Interfacing &** **Ladder** **Programming**	4a. Develop ladder diagrams for simple application. 4b. Describe a PLC Ladder program for the given Industrial Application. 4c. Describe method for troubleshooting the given PLC ladder diagram.	4.1 Basics of Ladder programming. 4.2 Ladder Diagram for seal in circuit. 4.3 Simple programming-based examples using ladder logic language based on relay, timer, counter, logical, arithmetic, comparison and data handling instructions. 4.4 PLC Based applications: Motor sequence control, Traffic Light Control, Elevator Control, Car Parking, Tank Level Control, Conveyor System, Stepper Motor Control, Reaction/ Reactor Control.
Unit-V **Introduction** **to SCADA**	5a. Explain benefits of SCADA system 5b. List different Communication Protocol used for SCADA 5c. Explain the interfacing of PLC & SCADA System. 5d. List steps for creating simple SCADA Screen. 5e. Identify specified components of DSC System.	5.1 Introduction to SCADA, Benefits of SCADA, Various editors of SCADA 5.2 Data Communication Protocol- Data Highway DH-485, RS -232, Control Net, Device Net, Ethernet, MODBUS, Fieldbus, ProFibus-DP, 5.3 Interfacing SCADA system with PLC: Typical connection diagram, Object linking and embedding for Process Control (OPC) 5.4 Steps for creating SCADA screen for simple object 5.5 SCADA architecture: Monolithic, distributed and networked. 5.6 Use of HMI, Concept of DCS 5.7 Applications of SCADA: Water Reservoir SCADA System, SCADA Water treatment facility, Electrical generating plant SCADA System, Traffic Light Control

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 Industrial Automation	08	02	04	06	12
II	PLC Fundamentals	10	02	04	08	14
III	Basics of PLC Programming	10	02	04	08	14
IV	PLC & IO Interfacing & Ladder Programming	12	04	04	10	18
V	Introduction to SCADA	08	02	04	06	12
	Total	**48**	**12**	**20**	**38**	**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.*
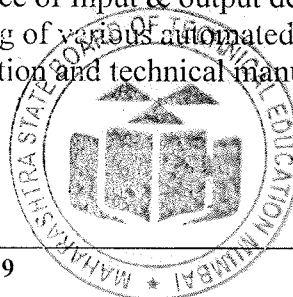
10.   SUGGESTED STUDENT ACTIVITIES

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 PLC laboratory. Journal consists of Wiring diagram, Interfacing Diagram, observations, required equipment's, date of performance with teacher signature.

b. Download the Information Brochures or Datasheets:
    i.   Different types of PLC
    ii.   Different types of SCADA System
    iii.   Sensors & Actuators

c. Visit to any Nearby Manufacturing or Process Industry and prepare a report consisting of
    i.   Various advanced systems
    ii.   Various standards
    iii. Maintenance of components of Automated system.

d. Refer operating manuals of the PLC's of reputed manufacturers.

e. Prepare the safety precautions, DO's and Dont's while working with PLC.

f. Prepare the list of available PLC I/O devices in the market.

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. Students can participate in online PLC / automation forums.

g. Correlate subtopics with automated system and equipment's.

h. Use proper equivalent analogy to explain different concepts.

i. Use Flash/Animations to explain various components, operation and maintenance of automated system.

j. Before starting practical, teacher should demonstrate the working of Automated system.

k. Instructions to students regarding care and maintenance of Input & output devices.

l. Show video/animation films to explain the functioning of various automated systems.

m. Teacher should ask the students to go through instruction and technical manuals

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

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

a. Prepare report and presentation of various manufacturers of PLC available market for displaying its features using data sheets.
b. Prepare report and presentation of various input /output modules of PLC available in market for displaying its features using data sheets.
c. Draw and verify the ladder diagram for washing machine by using PLC and prepare report.
d. Implement programming of Oil and Water separation process in PLC using Ladder Diagram programming language.
e. Write program to measure the scan cycle of a PLC using Ladder Diagram programming language using simulation software and prepare a report on it.
f. Write PLC program to store data of various process sequentially and prepare report on it.
g. Write PLC program to measure time taken by an event and prepare report on it.
h. Prepare PLC based system to control the street light as per the intensity of natural light.
i. Prepare PLC based system to control drip irrigation.
j. Prepare PLC and SCADA based system to open or close the railway gate automatically.
k. Implement versatile automation system for home that can automate any three home appliances.
l. Prepare PLC and SCADA based system for bottle filling.
m. Prepare report and presentation of various SCADA software available in the market for displaying its features.
n. Troubleshoot faulty kit / equipment's available in the automation laboratory.
o. Visit automation industry using PLC/SCADA/DCS/HMI system and prepare detailed report on it.

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Process Control Instrumentation Technology, Eighth Edition	Curtis D. Johnson	Pearson New international Edition ISBN 13: 978-1-292-02601-5
2	Introduction to Programmable Logic Controller	Gary Dunning	Cengage Learning India Pvt Ltd. ISBN-13: 978-81-375-0302-7
3	Programmable Logic Controller	John W. Webb Ronald A. Reis	PHP Learning Pvt. Ltd ISBN: 978-81-203-2308-7

4	Programmable Logic Controller Programming & Application	Jhon R. Hackworth Frederick D. Hackworth	Pearson, ISBN: 978-81-775-8771-5
5	Control of Machines	K. Bhattacharya, Brinjinder Singh	New Age International Publishers ISBN-978-81-224-1818-7
6	Programmable Logic Controller	Frank D. Petruzella	Mc Graw Hill Education India ISBN: 978-0-07-106738-6
7	Industrial Automation with SCADA concept, communication, security	K S Manoj	Notion press eISBN-978-1-68466-829-8

14. SOFTWARE/LEARNING WEBSITES

a. https://nptel.ac.in/courses/108/105/108105062
b. https://www.inductiveautomation.com/resources/article/what-is-scada
c. https://www.youtube.com/watch?v=ygd7JICvYYo
d. https://www.youtube.com/watch?v=PbAGl_mv5XI
e. https://www.youtube.com/watch?v=QvdUnFzTcnY
f. https://www.youtube.com/watch?v=5ZiIA-kMV8M
g. https://www.youtube.com/watch?v=B3YVpgs9RY4
h. https://www.youtube.com/watch?v=nlFM1q9QPJw
i. https://www.youtube.com/watch?v=xvVCSYt_YsQ
j. https://www.youtube.com/watch?v=wgomvDixJw0
k. https://www.youtube.com/watch?v=txi2p5_OjKU
l. https://www.youtube.com/watch?v=YxF9QgRAx8A
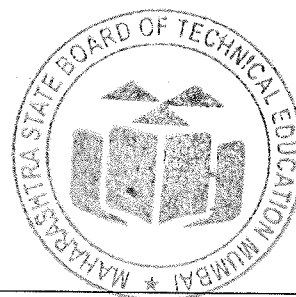
Program Name	: Diploma in Mechatronics
Program Code	: MK
Semester	: Fifth
Course Title	: Automotive Mechatronics
Course Code	: 22586

1. RATIONALE

Automobile is one of the key sectors for overall development of world and it is an essential part of our modern life. Automotive sector provides largest opportunities for diploma engineers. Now days new features and technology get develop in this sector in very short period of time. Mechatronics engineers should have an overall knowledge of various systems of automobile. This course provides knowledge of various systems of automobile and application of various electrical and electronic components to this system. Mechatronics system improves the performance and safety of vehicle as well as human beings. Human safety and comfort have priority while designing new vehicle so this course covers various safety features and control systems. Overall knowledge of course will be helpful to students getting employed in Automobile sectors. Students would also acquaint them with the latest technological advances taking place in Automobile sector.

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 automotive Mechatronics 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. Identify various automobile systems with functions and location.
- b. Select automotive sensors and actuators.
- c. Diagnose different faults in advanced automobile warning systems.
- d. Maintain automotive control systems.
- e. Use diagnostic tools and instruments.

4.   TEACHING AND EXAMINATION SCHEME

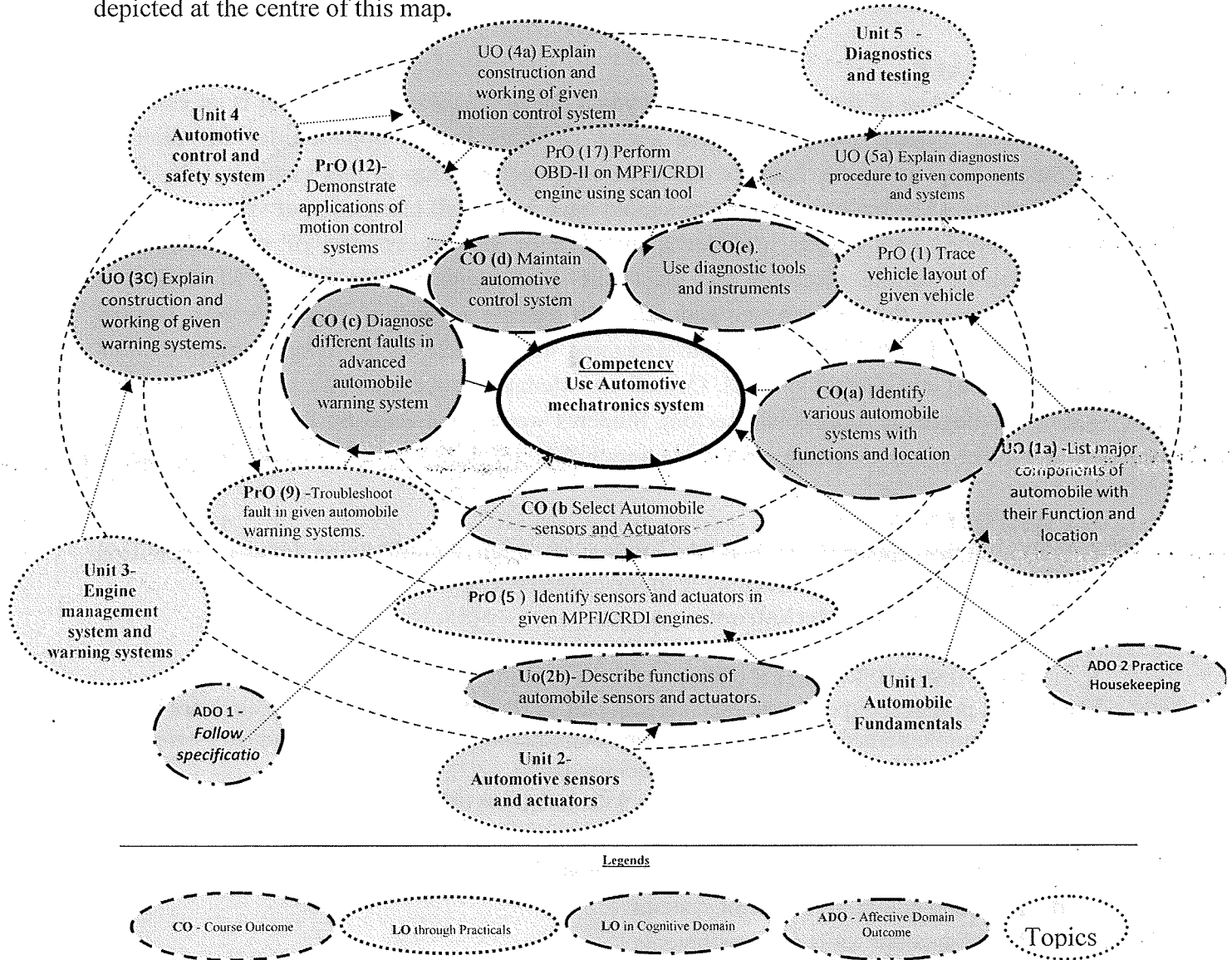| Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

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 Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
1.	Trace vehicle layout of given vehicle	I	02*
2.	Identify parts in 4-stroke engine (Petrol/Diesel)	I	02
3.	Use different hand tools and measuring devices.	I	02*
4.	Compare specifications and features of control systems of any modern Automobile with reference to any system such as TDI and CRDI system used in a vehicle.		02

5.	Identify sensors and actuators in the given MPFI/CRDI engine.	II	02
6.	Diagnose (waveform, resistance and voltage output) oxygen sensor and throttle position sensor using oscilloscope.	II	02*
7.	Diagnose (waveform, resistance and voltage output) Engine Temperature sensor and manifold absolute pressure sensor using oscilloscope.	II	02
8.	Use scan tools for fault diagnosis in Engine management system (EMS).	III	02*
9.	Troubleshoot fault in given automobile warning systems. (any four)	III	02*
10.	Perform flash code analysis of malfunction Brake actuator warning system on vehicle dashboard.	III	02
11.	Diagnose ABS system using trouble codes.	IV	02
12.	Demonstrate applications of motion control system like cruise control system EPS, TCS, IEC etc. in vehicle	IV	02*
13.	Perform diagnostic trouble codes for air bag system.	IV	02*
14.	Perform diagnostic trouble codes for park assist system.	IV	02
15.	Identify safety devices used in a given vehicle.	IV	02*
16.	Perform on Board Diagnosis OBD-II on the CRDI engine using Scan tool.	V	02*
17.	Perform on Board Diagnosis OBD-II on the MPFI/CRDI engine using Scan tool.	V	02
18.	Test injection waveform using oscilloscope.	V	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 needs 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.	Arrangement of available equipment / test rig or model	20
b.	Setting and operation	20
c.	Safety measures	10
d.	Observations and Recording	10
e.	Interpretation of result and Conclusion	20
f.	Answer to sample questions	10
g.	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. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
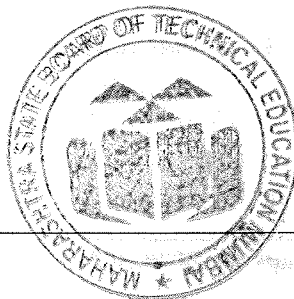f. Follow ethical Practices.

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/ 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.	General purpose tools (spanner, ring spanner and socket)-6mm to 32mm	All
2.	Special purpose tools (piston ring expander, piston ring compressor, valve lifter, spark plug remover, torque wrench), torque wrench range -10 Nm to 200 Nm	All
3.	Four-wheeler vehicle make of TATA, Mahindra or alike in good running condition. OR Cut section working model of four-wheeler transmission system showing all the parts	All
4.	**Multiport fuel injection system** with sensors, actuators and electronic control module, exhaust gas circulation valve and Positive crankcase ventilation valve make reputed manufacturers power 25 KW@ 5000 RPM to 50 KW @ 5000 RPM: Cubic capacity 1000 CC to 2000 CC	04,05,06,07
5.	**Scan tool:** Make reputed manufacturers: On Board Diagnosis (OBD), II Generation scan tool, controlled Network area enabled, color display, operating temperature:0 to 50°C, Internal storage: 4AAA Batteries, External Power :7 to 18 Volts; generic tools; accessories: extended cable, OBD II cable; relevant optional accessories.	06,07,09, 10,13,15
6.	**Automotive Diagnostic Oscilloscope**; Type PC Based or hand-held analog channel: 8; Bandwidth :1000 KHz; Input impedance resistance: 1 MΩ; Input sensitivity :10mV/div to 5 V/div	04,05
7.	**Digital Multimeter: Make: Reputed manufacturers** Measure Voltage and Current AC and DC, Resistance, Capacitance, diodes, continuity, frequency, Min-Max functions: LCD Display,0 to 50°C operation, Temperature, DC voltage-2mV to 1000V alternating current, current: 2 Ma TO 20 A DC, Diode Test, Continuity Test-Audible buzzer, resistance: 200 Ω to 200 MΩ;	8,15,16,17,4,5,9

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
Automobile
Fundamentals
	1a. List major components of automobile with their location and function.
	1b. Draw block diagram of general vehicle layout.
	1c. Explain working of given power train control system with block diagram.
	1d. Interpret given vehicle layout for functional relationship of suspension, steering, cooling and lubrication system.
	1e. State Necessity, Functions and location of given automobile system.
		1.1 Automobile: Definition, Need of Automobile, Classification of Automobiles,
		1.2 Major components of Automobile with their function and location.
		1.3 Power train control system: Electronic control system used in MPFI/GDI and CRDI System.
		1.4 Block diagram of general vehicle layout.
		1.5 Necessity, Functions and locations of following automobile systems.
		  a. Transmission system, steering system.
		  b. Suspension system.
		  c. Cooling and lubrication system
		  d. Fuel injection and Ignition system.
		  e. Starting and charging system.

Unit - II **Automotive** **Sensors and** **Actuators**	2a. List variables sensed in engine control. 2b. Describe functions of automobile sensor (s) and actuator (s). 2c. Explain with sketches working and output signals of given automotive sensor(s) 2d. Explain given automotive actuators. 2e. Describe procedure for maintaining given automotive sensors and actuators.	2.1 Automotive control system applications of sensors and actuators. 2.2 Variables to be sensed. 2.3 Sensors in Automotive: Air flow rate sensors, Engine speed sensor, Engine crankshaft angular position sensor, Timing sensor, Throttle angle sensor, Pressure sensor, Temperature sensor, Exhaust gas oxygen sensor, Knock sensor, Engine torque sensor. 2.4 Actuators: Automobile Engine control Actuators, Exhaust gas recirculation actuators. 2.5 Variable valve timing.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit-III **Engine** **Management** **System and** **Warning** **Systems**	3.a Describe Electronic engine management system. 3.b State importance of warning systems. 3.c Explain concept of Electronic engine control system 3.d Explain construction and working of given warning system.	3.1 Electronic Engine Management system. -Introduction to Electronic Diesel Control (EDC) unit 3.2 Concepts of an Electronic Engine control system: Inputs to controller, Outputs from controller. 3.3 Warning systems: Brake actuators warning system, oil pressure warning system, and engine over heat warning system, air pressure warning system, and speed warning system.
Unit - IV **Automotive** **Control and** **Safety Systems**	4.a Explain construction and working of given motion control system. 4.b Justify "motion control system improves safety and comfort level". 4.c Explain necessity of given motion control system. 4.d State importance of Automobile safety system. 4.e Explain given safety system.	4.1 Automotive motion control systems: Cruise control system, Antilock Braking system (ABS), Electronic suspension systems, Electronic power steering system, Traction control system, Stability control, Integrated Engine control. 4.2 Automobile Safety systems: Air bags, Seat belt, park assist system, collapsible steering column, door lock system. 4.3 Global positioning satellite (GPS). 4.4 Pedestrian protection and night vision with pedestrian detection.
Unit-V **Diagnostics** **and Testing**	5.a Explain diagnostics procedure to given component and system. 5.b Explain OBD II Procedure. 5.c State procedure for standalone diagnosis of given component. 5.d . Describe six step approach in testing given automotive component with flow chart. 5.e List diagnostics fault codes with meaning. 5.f Select type of measuring instrument for testing.	5.1 Electronic control system diagnostics 5.2 Service Bay Diagnostics tool 5.3 Onboard Diagnostic (OBD II) Procedure of MPFI/CRDI system. 5.4 Standalone diagnosis: Sensors and actuators. 5.5 Six step approach for component testing. 5.6 Diagnostic Fault codes 5.7 Measuring Instruments: Digital multi-meters, Oscilloscope, scan tool, Frequency meters.

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.
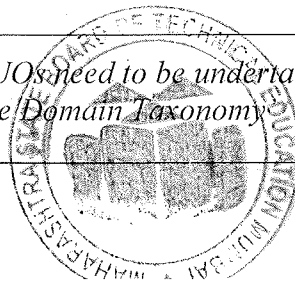
9.   SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Automobile Fundamentals	10	04	04	06	14
II	Automotive Sensors and Actuators	10	02	04	08	14
III	Engine Management System and Warning systems	06	02	04	06	12
IV	Automotive Control and Safety Systems	12	02	06	08	16
V	Diagnostics and Testing	10	02	06	06	14
	Total	48	12	24	34	70

Legends: R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)
Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.

10.   SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Observe videos to operate various testing equipment's. Prepare a list of appropriate equipment considering its range/applications.
b. Collect videos relevant to MPFI, CRDI, GDI, control and operation.
c. Collect specifications and features of control system of any modern automobile with reference to any system such as MPFI or GDI and prepare report of the same.
d. Collect specifications and features of control system of any modern automobile with reference to any system such as MPFI or GDI and prepare report of the same.
e. Collect specifications and features of control system of vehicle, such as: ABS, Electronic suspension systems, Electronic power steering system and prepare report for the same
f. Collect specifications and features of control system of vehicle, such as: Traction control system, Stability control, Integrated Engine control and prepare report for the same.
g. Visit a modern service station for observing automobile electronics and computer-controlled systems and prepare a report on the same.
h. Prepare power point presentation or animation for understanding different components/ aggregates and systems.
i. Observe videos relevant to practical task. Prepare a list of appropriate tool/ equipment Considering its range/ application. For following applications, tools should be listed:
  i.   Diagnostic tools for MPFI engine
  ii. Diagnostic tools for CRDI engine

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 various automobile system.

g. Use proper equivalent analogy to explain different concepts.

h. Use Power point presentation, models and animations to explain various components, operation and maintenance of automobile systems.

i. Before starting practical, teacher should explain theory related to it in briefly.

j. Instructions to students regarding care and maintenance of measuring equipment's and tools.

k. Show video/animation films to explain functioning of components and systems.

l. Teacher should ask the students to go through instruction and technical manuals

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

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

a. Choose a modern engine. Search information on any one system from website. Prepare a report for the same.

b. Case study based on Visit an automobile garage to study a faulty system of an engine.

c. Diagnose system of an engine using scan tool/ Multimeter. Prepare a report for the same.

d. Identify a modern technology used in an engine. Collect relevant information on the technology and its features. Compare the same with older/ modern technologies adopted in other vehicles. Refer internet/ reference books/ manufacturer published literature for the same. Prepare a report.

e. Prepare a detail report on diagnosis of MPFI engine: following steps to be followed:
    i. Student should visit the shops/ garage for survey.
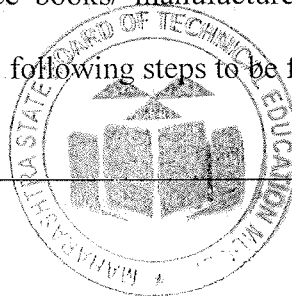
ii. List out steps of diagnosis.

iii.Diagnose a system of an engine using scan tool/multimeter/oscilloscope.

iv. Prepare a report

f. Prepare a detail report on diagnosis of MPFI engine: following steps to be followed:

i. Student should visit the shops/ garage for survey.

ii. List out steps of diagnosis.

iii.Diagnose a system of an engine using scan tool/multimeter/oscilloscope.

iv. Prepare a report

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Automobile Engineering Vol-I & II	Dr. Kirpal Singh	Standard Publishers Distributors, New Delhi, 2011, ISBN:978-81-8014-171-3
2	Understanding Automotive Electronics	William B. Ribben	Butterworth-Heinemann, UK, 2017, ISBN 13:978-0128104347
3	Automotive Electrical and Electronics	A K BABU	Khanna Book Publishing Co. Ltd, New Delhi, 2016,ISBN:978-93-82609-69-8
4	Automotive Electronics Handbook	Ronald K. Jurgen	McGraw-Hill Inc.
5	Automotive Handbook	Bosch, Robert	Bentley Publishes, UK, 2014, ISBN:13:978978-1119975564
6	Advanced Automotive Fault Diagnosis.	Denton, Tom	Routledge, New York, 2012, ISBN:978-0415725767

14.   SOFTWARE/LEARNING WEBSITES

1. www.Learnengineering.org
2. www.araiindia.com
3. www. saeindia.org.in
4. https://www.youtube.com/channel/UCYcARi6zsqrcC0M90gdve5A- Automobile Basics
5. https://www.youtube.com/watch?v=jAqC0qxIiL8 for MPFI system
6. https://www.youtube.com/watch?v=KzF8ieiJ9UY for CRDI system
7. https://www.youtube.com/watch?v=M9dZUOr6n4g for camshaft and crankshaft sensor testing
8. https://www.youtube.com/watch?v= 8q6qZQJQEIU for automotive sensors and actuators
9. https://www.youtube.com/watch?v=RR8LsMBwL2I for Scan tool video
10. https://www.youtube.com/watch?v=NUvWnOd5lFw for Common Rail Diesel Injector Working and Common Failure Points
11. https://www.youtube.com/watch?v=jKtBSFoAYlg- for cruise control system
12. https://www.youtube.com/watch?v=oMDqgcm4ZjU - Park assist system
13. https://www.youtube.com/watch?v=lnK00rtWf68 for Throttle Position sensor cleaning
14. https://www.youtube.com/watch?v=98DXe3uKwfc - Antilock Braking system
15. https://www.youtube.com/watch?v=CYufBm5Bek8 - working of Air bag
16. https://www.youtube.com/watch?v=JIa0nsrQXI0 to read car fault codes and to clear them
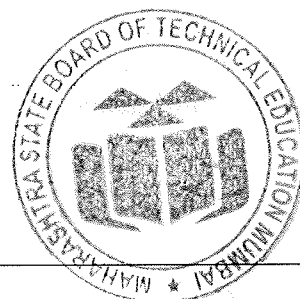
Program Name	: Diploma in Mechatronics
Program Code	: MK
Semester	: Fifth
Course Title	: Industrial Robotics
Course Code	: 22587

1.   RATIONALE

Industrial robots are widely used in many manufacturing industries. They can assist manufacturing to make it more competitive and efficient. The most obvious impact of industrial robots is that they eliminate many dirty, repetitive, and dangerous tasks with hazardous materials and in challenging environments. The purpose of Industrial Robotics course is to respond the demands of manufacturing industries and to meet 21st century workforce needs. It is therefore need of the time for students to learn industrial Robotics principles to work in industry. This course therefore attempts to build required skills of this field in diploma students.

2.   COMPETENCY

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

- **Operate industrial robots.**

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 basic components used in robots.
   b.   Select sensors for different robotic applications
   c.   Program robots for basic applications.
   d.   Maintain robot for basic applications.
   e.   List future Robot technologies.

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Paper Hrs.	Theory						Practical					
					ESE		PA		Total		ESE		PA		Total	
L	T	P			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; # - External 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 Exercises (PrOs) (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
1	Recognize different basic robotic components and its working for given system.	I	02*
2	Interface various robot end effectors for given system.	I	02*
3	Interface various sensors in given robotics systems.	II	02
4	Simulate different motion commands for given systems.	III	02*
5	Simulate different end effector commands for given systems.	III	02
6	Write program for specific path movement of robot.	III	02
7	Write program for pick and place activity.	III	02*

8	Write program for palletizing the object.	III	02
9	Write program for inspection. (Bolt, Bearing etc.)	III	02
10	Write program for spot welding operation.	III	02
11	Write program for painting operation.	III	02
12	Perform maintenance of given robotic system as per standard procedure.	IV	02*
13	Case study on robotic systems used in automobile industry.	IV	02*
14	Interface PLC and prepare ladder diagram for any simple application.	V	02*
15	Case Study on any one future applications of robot (e.g. Military operations, Fire-fighting operations, under sea operations, Space operations, Industry 4.0 etc.)	V	02*
16	Case study on COBOTS for given application.	V	02
	Total		**32**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical needs 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.	Preparation of experimental set up	10
b.	Handling of instruments carefully while performing the practical.	20
c.	Setting up, operation and checking output	20
d.	Safety measures	05
e.	Observations	15
f.	Interpretation of result and conclusion	20
g.	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. Demonstrate working as a leader/a team member.
    e. Follow ethical Practices.

The ADOs are not specific to any one PrO but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

    • 'Valuing Level' in 1st year
    • 'Organizing Level' in 2nd year
    • 'Characterizing 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	Programmable Robot trainer kit with standalone servo controller as well as compatible PLC interface with following features: 1) Minimum 3 linkages 2) Minimum 4 degree of freedom 3) Different Mechanical end effectors 4) Various Sensors 5) Compatible Robot vision system for inspection.	4, 5, 6, 7
2	Robot off line simulation software	8
3	Computers with internet connectivity (Minimum Core i5 Processor, 8 Gb RAM, 500 GB HDD)	9
4	Standard Tool kit (Mechanical & Electrical) for robot maintenance	10

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 **Basic Components of Robotics Systems**	1a. Define robotics. 1b. Identify components used in robots. 1c. Explain different robot configurations. 1d. State different robot specifications. 1e. List basic robot motions. 1f. List different joints used in robotic systems. 1g. Explain different robots end effectors. 1h. List different considerations in gripper selection.	1.1 Introduction, Definition, need, brief history, Laws of Robot. 1.2 **Robot configurations-** Polar (Spherical), Cylindrical, Cartesian coordinate, Jointed arm (Articuted), SCARA (Selective Compliance Assembly Robot Arm). 1.3 **Basic elements of Robot system (Robot Anatomy): -** Base, Manipulator arm, End Effectors, Sensors and transducers, Actuators and Drives, Control systems 1.4 **Robot specification: -** Work envelope, Load carrying capacity, Speed of movement, Accuracy, Repeatability, Special resolution 1.5 **Basic Robot motions: -** Vertical motions, Radial motions, Rotational motions, Pitch motions, Roll motions, Yaw motions 1.6 **Types mechanical joints used in Robotics system: -** Linear Joint, Orthogonal joint, Rotational Joint, Twisting Joint, Revolving Joint 1.7 **Robots End Effectors: -** Types of End Effectors, Mechanical Grippers, Tools as End Effectors, Other Type of Grippers (Vacuum, Magnetic, Adhesive, Hooks, Scoops etc.)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		1.8 Robot-End Effecter Interface 1.9 Considerations in Gripper Selections.
Unit– II Robotic Sensors and Vision	2a. Explain different robotic sensors. 2b. List uses of sensors in Robotics. 2c. List desirable features of sensors in robotics. 2d. Explain robot vision system. 2e. List industrial applications of vision controlled robotic system.	2.1 **Robotic Sensors**-Introduction to Sensors. 2.2 **Types of Sensors in Robotics** - Tactile Sensors-Touch sensors, Force sensors, Force sensing wrist, Joint sensing, Tactile array sensors, Proximity and Range Sensors, Miscellaneous Sensors and Sensor-based Systems, Uses of Sensors in Robotics 2.3 Desirable features of sensors in Robotics. 2.4 **Robot Vision-** Introduction, **The Sensing and Digitizing Function-** Imaging devices, Lighting techniques, Analog to Digital signal conversions (Sampling, Encoding, Image storage) **Image Processing and Analysis-** Image Data reduction, Segmentation, Thresholding, Region growing, Edge detection, Feature extraction, Object Recognition 2.5 Industrial application of vision controlled Robotic system
Unit-III Introduction to Robot Languages & Programming	3a. List different robot languages. 3b. Explain Textual robot language. 3c. List various generations of programming languages. 3d. Explain Robot language structure. 3e. List different commands in robot programming. 3f. Explain different robot programming methods. 3g. State capabilities and limitations of lead through programming method. 3h. Write simple programs to perform simple operations. 3i. State capabilities and limitations of lead through programming method.	3.1 **Introduction to Robot Languages: -** The Textual Robot Languages, Generations of Robot Programming Languages, Robot Language Structure, Constant, Variables and other Data Objects, Motion Commands, End Effecter and Sensor Commands, Computations and Operations, Program Control and Sub-routines, Communications and Data Processing, Monitor Mode Commands. 3.2 **Introduction to Robot Programming:** Methods of Programming a Robot, Lead through Programming Methods, Robot Programme as a Path in Space, Motion Interpolation, WAIT, SIGNAL and DELAY Commands, Branching, Capabilities and Limitations of Lead through Methods 3.3 Introduction to Teach Pendant. 3.4 Simple Program for Pick and place activity. 3.5 Simple Program to Palletize the object. 3.6 Simple Program for Inspection (Bolt, Bearing etc.)

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit –IV **Robot** **Applications &** **Maintenance**	4a. Explain use of robot in material handling 4b. Explain use of robot in any processing operations. 4c. Explain use of robots in automated assemblies. 4d. Explain use of robots in inspections. 4e. Explain procedure of Robot maintenance. 4f. Explain procedure to test and troubleshoot robots 4g. List different common troubles and remedies in robot operation 4h. List different safety rules in robot handling.	**Robot Applications: -** 4.1 **Robots in Material Handling-** Pick and place Robot, Robots in palletizing and related operations 4.2 **Robots in processing operations-** Spot Welding, Continuous Arc Welding, Spray Coating, Die-casting, Plastic molding, Forging operation 4.3 Robots in automated assemblies 4.4 Robots in automated inspections 4.5 **Robot maintenance:** Need and types of maintenance. 4.6 Common troubles and remedies in robot operation. 4.7 General safety norms, aspects and precautions in robot handling. 4.8 Introduction on interlocking of robot.
Unit –V **Robot** **Technology of** **the Future**	5a. Explain robot intelligence. 5b. Explain advance sensor capabilities. 5c. Explain Telepresence and related technologies. 5d. Explain different advanced mechanical design features. 5e. Explain system integration and network. 5f. Explain future use of robots in various application like military operations, fire-fighting operations, space operations etc.	5.1 Introduction, Robot intelligence, Advanced sensor capabilities (3D Vision), Telepresence and related technologies, Mechanical design features (Direct Drive robot, Multiple arm coordinate robot), Mobility, locomotion and navigation, Universal hand, System integration and network 5.2 Future applications of Robots: - Military operations, Fire-fighting operations, under sea operations, Space operations, Industry 4.0 etc.

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	Basic Components of Robotics Systems	12	04	06	06	16
II	Robotic Sensors and Vision	08	02	04	06	12
III	Introduction to Robot Languages & Programming	14	02	06	10	18
IV	Robot Applications & Maintenance	08	02	04	08	14
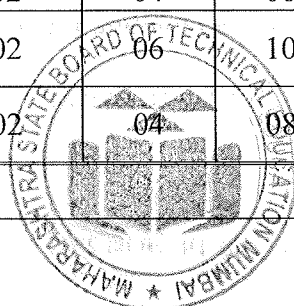
Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	Robot Technology of the Future	06	02	04	04	10
	Total	48	12	24	34	70

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. Journal consists of drawing, observations, required equipment's, date of performance with teacher signature.
    b. Undertake micro projects.
    c. List various Robot controlling parameters and its effect on the performance of Robots.
    d. List different types of Robots and their application.
    e. Download free Robot motion simulation software and check program on it.
    f. Visit Industries having robots and prepare specification list, understand operational and maintenance practices.
    g. Case Study on various robot manufacturing companies and gripper manufacturing companies.
    h. Download videos of robotic applications.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

    a. Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
    b. *'L' in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
    c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
    d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
    e. Guide student(s) in undertaking micro-projects.
    f. Use Flash/Animations to explain the working of different Robots Sensors and Actuators devices.
    g. Use free Robot simulation software to check program on it.
    h. Arrange the visit to any automated manufacturing/Automobile industry to understand various robot configurations and applications.
    i. Prepare a chart to show the Fundamentals of robots
    j. Prepare a chart to show the Robotic system
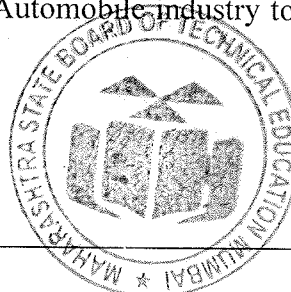
12.   SUGGESTED MICRO-PROJECTS

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

a. Visit Industries having robots and prepare detail report on operational and maintenance practices.
b. Simulate various robot programs on free robot simulation software.
c. Develop robot programs for performing the various industrial operations.
d. Case study on robotics systems used in automobile/manufacturing industry.
e. Case study on future robot technologies.
f. Case study on various future applications of robotic systems.

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Industrial Robotics	Mikell P. Grover, Mitchell Weiss, Roger N. Nagel & Nicholas G. Odrey	TATA McGraw-hill education India Pvt. Ltd. New Delhi, 2010, ISBN:978-0-07-026509-7
2	A Textbook on Industrial Robotics	Ganesh S. Hegde	University Science Press, New Delhi, 2009, ISBN: C-16689/08/12
3	Introduction to Industrial Robotics	Ramchandran Nagarajan	Pearson Education India, New Delhi, 2016, ISBN:978-93-325-4480-2
4	Robotics and Industrial Automation	R. K. Rajput	S. Chand Limited, 2008 ISBN:- 9788121929974
5	Robotics and Control	R. K. Mittal & I J Nagrath	TATA McGraw-hill education India Pvt. Ltd. New Delhi, 2010, ISBN:0-07-048293-4
6	Fundamentals of Robot Technology	D. J. Todd	British library Cataloguing in Publication Data, ISBN-13: 978-94-011-6770-3

14.   SOFTWARE/LEARNING WEBSITES

a. https://www.youtube.com/watch?v=fH4VwTgfyrQ
b. https://www.youtube.com/watch?v=s-yne8xTNM0&pbjreload=101
c. https://www.youtube.com/watch?v=QAby_ilhoDQ
d. https://www.youtube.com/watch?v=P7fi4hP_y80
e. https://www.youtube.com/watch?v=rbki4HR41-4
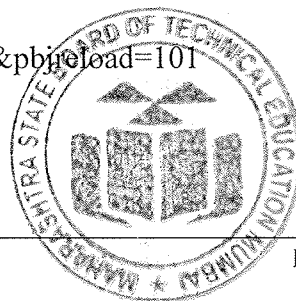
f. https://www.youtube.com/watch?v=pa5_tudyAF8
g. https://www.youtube.com/watch?v=ybS_Zi-4qfg
h. https://www.youtube.com/watch?v=69RtLBImXiU
i. https://www.youtube.com/watch?v=qFKn_8FiJCA
j. https://www.youtube.com/watch?v=6lAz2IGCIqQ

MK5I
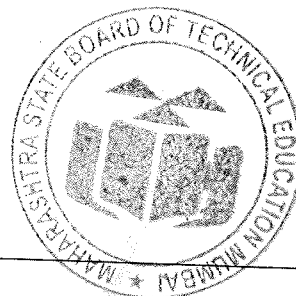
Program Name	: Diploma in Mechatronics
Program Code	: MK
Semester	: Fifth
Course Title	: Internet of Things (Elective)
Course Code	: 22588

1.   RATIONALE

The Internet of Things (IoT) is a course about the new paradigm of objects interacting with people, with information systems, and with other objects. The focus will be more on the possibilities offered by the different technologies, and on the creative thinking techniques to find innovative applications of combinations of such technologies in real- life scenarios. Some presentations will also be scheduled in which people from industry will make presentations about selected topics related to the IoT.

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 knowledge of technology for creative thinking and real-life problems 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 basic blocks of IoT systems.
- b.   Use hardware and IoT components.
- c.   Integrate IoT hardware and components
- d.   Demonstrate different platforms and their interfacing.
- e.   Design applications of IoT.
- f.   Apply ethics in IoT.

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
					Theory						Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

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.
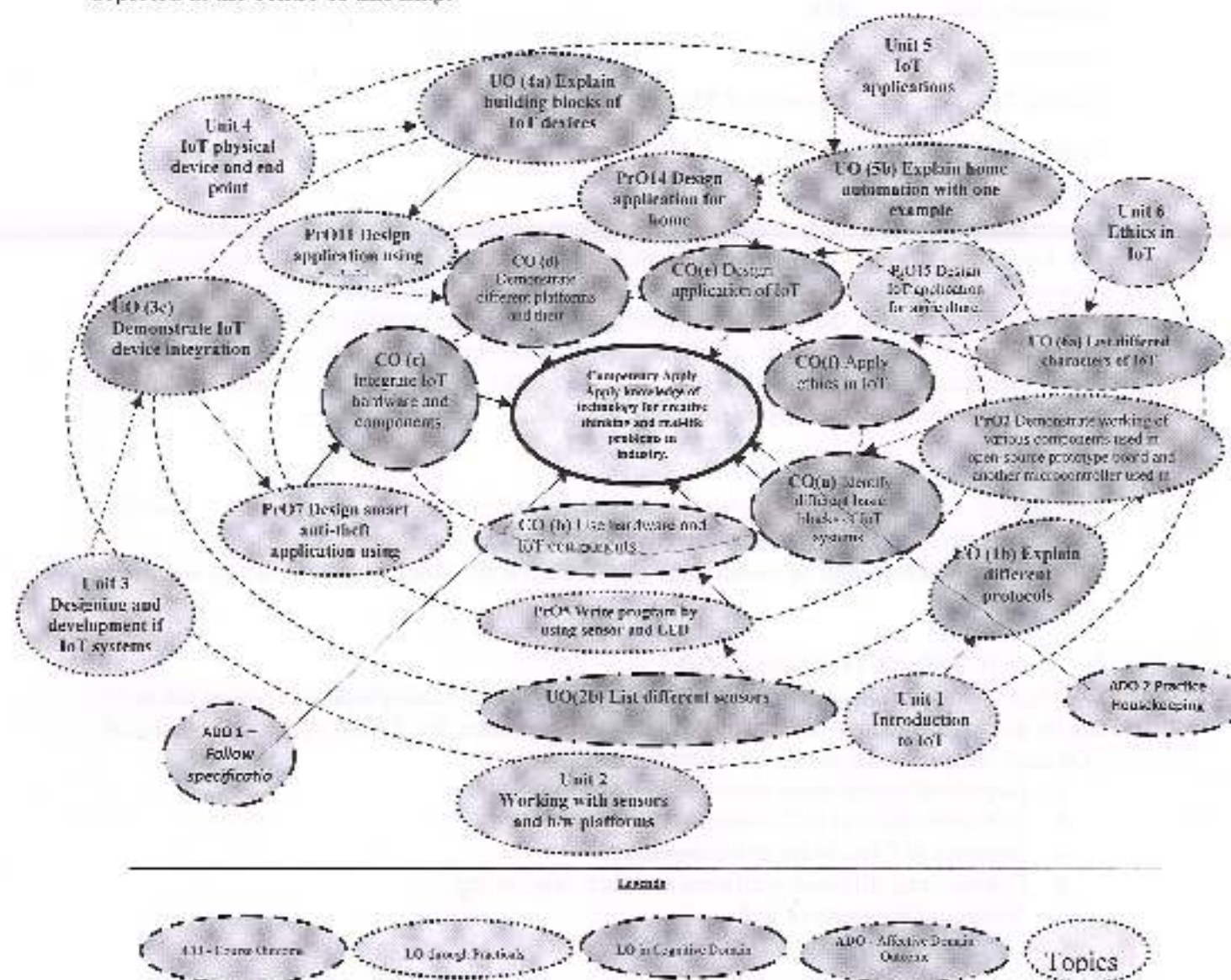

Figure 1 - Course Map

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 Exercises (Learning Outcomes in Psychomotor Domain)	Unit No.	Approx. Hrs. required
1	Observe operations of USB cables, Wires, Power Supply Units, Transistors, Breadboards, Relay, Multimeter, Tester, Soldering Kit, Wire cutter, Hot glue gun and other components required for designing of IoT available in your lab.	1	02*
2	Demonstrate working of various components used in open-source prototype board and another microcontroller used in your lab.	1	02*
3	Identify different types of sensors and their working, input output pins available in Lab.		02
4	Observe response of microcontroller by connecting different sensors on breadboard with any microcontroller available in your	II	02

	lab.		
5	Write program by using sensor and LED	II	02*
6	Interface different shields (like Ethernet and Wi-Fi networking, Bluetooth, GSM cellular networking, motor control, RFID, audio, SD Card memory, GPS, sensors, color LCD screens, and more), with controller for obtaining performance of particular shield and breakouts.	III	02*
7	Design smart anti-theft application using microcontroller and shields or breakouts.	III	02
8	Design Home security alarm system application using microcontroller and shields or breakouts	III	02
9	Design application using different types protocols used in IoT communication.	III	02*
10	Compare different IoT platforms Raspberry-Pi, Arduino, Intel Galileo, Tibbo project systems available in market	III	02*
11	Design application using Arduino or Raspberry-Pi for 4 Digit 7 segment LED display (PART-I)	IV	02
12	Design application using Arduino or Raspberry-Pi for 4 Digit 7 segment LED display (PART-II)	IV	02
13	Design application using Arduino or Raspberry-Pi for Smart street light system.	IV	02
14	Design any one application using Raspberry–Pi to control operation of stepper motor.	V	02*
15	Design application for home automation.	V, VI	02*
16	Design IoT application for agriculture.	V, 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 needs 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.	Experimental setup with proper interfacing	20
b.	Program development	25
c.	Program debugging	15
d.	Observations and verifications of output	20
e.	Answer to sample questions	10
f.	Timely submission	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. 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/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will assure in uniformity in conduct of practical's, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	USB cables, wires, power supply units, transistors, breadboards, relay, Multimeter, Tester, Soldering Kit, wire cutter, Hot glue gun.	All
2	Sensors: Temperature, Light, Ultra-Sonic, Humidity, Water Detector, PIR sensor, Pressure Sensor, IR sensor, Touch Sensor, Color Sensor, Humidity Sensor, Tilt Sensor, Flow and Level Sensor, Smoke, Gas and Alcohol Sensor	3,4,5.
3	Shields: Ethernet and Wi-Fi networking, Bluetooth, GSM cellular networking, motor control, RFID, Audio, SD Card memory, GPS, sensors, color LCD screens.	6,7
4	Any Open-Source Prototype Board Available in Market	2,9,10,11,12,13

8.   UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit–1 Introduction to Internet of Things (IoT)	1a. List characteristics of IoT 1b. Explain logical designing 1c. Compare different technologies used in IoT 1d. Explain different IoT enabling technologies. 1e. Explain different deployment levels.	1.1 Introduction to IoT 1.2 IoT characteristics 1.3 Physical design of IoT: Things in IoT, IoT Protocols 1.4 Logical design of IoT: IoT Fundamental blocks, IoT Communication Model, IoT 1.5 Communication API's 1.6 IoT Enabling Technologies: Wireless Sensor Networks, Cloud Computing, Big Data Analytics, Communication Protocols, Embedded Systems 1.7 IoT Levels and Deployment templates – IoT Level-1, IoT Level-2, IoT Level-3, IoT Level-4, IoT Level-5, IoT Level-6
Unit–II Working with Sensors and Hardware Platforms	2a. Define sensor 2b. List different sensors 2c. Describe different input and out pins 2d. Interpret magnet relays	2.1 Sensors and its different parameters sensed by sensor: Temperature, Light, Ultrasonic, Humidity, Water detector, PIR sensor, Pressure Sensor, IR sensor, Touch Sensor, Color Sensor, Humidity Sensor, Tilt

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	and switches 2e. Demonstrate different types of middleware	Sensor, Flow and Level Sensor, Smoke, Gas and Alcohol Sensor. 2.2 Input and out pins of sensors, magnet relays and switches 2.3 **Middleware:** M2M: RFID, WSN, SCADA.
Unit-III Designing and Development of IoT Systems	3a. Explain design methodology for IoT 3b. Explain IoT level specification for Home automation 3c. Demonstrate IoT device integration 3d. State procedure for deploying IoT application. 3e. Apply logical designing for different applications. 3f. Explain different protocols for IoT	3.1 **IoT Design Methodology:** Purpose and requirement specification, Process specification, Domain model specification, Information model specification, Service specification, IoT level specification, Device and component integration, Functional view specification, Operational view specification, Device and component integration, application development. 3.2 Logical Designing using programming language. 3.3 Interface with Hardware 3.5 Other hardware devices 3.6. Protocols
Unit –IV IoT Physical Device and End Point	4a. Explain building blocks of IoT devices 4b. Demonstrate different IoT physical devices. 4c. Explain cloud base IoT platforms 4d. Explain interfacing of any one hardware with sensors.	4.1 IoT device: Building Blocks of an IoT device. 4.2 Physical Devices: Arduino, Raspberry Pi, Intel Galileo, Tibbo project systems. 4.3 Cloud base IoT platforms and other open-source platforms. 4.4 Configuration of hardware platform. 4.5 Interfacing of Arduino, Raspberry Pi.
Unit-V IoT Applications	5a. List types of home automation 5b. Explain home automation with one example. 5c. Demonstrate agriculture automation with diagram. 5d. Construct physical IoT device designing for health application	5.1 Nuclear Home automation 5.2 Environment 5.3 Retail 5.4 Logistics 5.5 Agriculture 5.6 Health
Unit-VI Ethics in IoT	6a. List different characters of Internet of things 6b. Explain privacy v/s IoT 6c. State Disrupting Control and Crowdsourcing from IoT 6d. Explain ideal ethics for IoT	6.1 Characterizing the Internet of Things 6.2 Privacy 6.3 **Control:** Disrupting Control, Crowdsourcing 6.4 **Environment:** Physical Things, Electronics, Internet Services 6.5 **Solutions:** The IoT as part of solution, Cautious Optimism, The open IoT definition

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	Unit Title	Teaching	Distribution of Theory Marks

No.		Hours	R Level	U Level	A Level	Total Marks
I	Introduction to Internet of Things (IoT)	06	02	04	04	10
II	Working with sensors and hardware platforms	06	02	04	04	10
III	Designing and development of IoT systems	10	02	04	08	14
IV	IoT Physical Device and end point	12	02	04	08	14
V	IoT applications	10	02	04	08	14
VI	Ethics in IoT	04	02	02	04	08
	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. Prepare report on different protocols used for communication in IoT
 b. Prepare report of open-source hardware used in IoT by collecting different datasheets.
 c. Prepare presentation role of IoT in mechatronics industry.
 d. Collect information from internet, magazines and journals about IoT based applications in the field of mechatronics.
 e. Conduct an internet survey on different open-source development boards used in IoT available in market.

11.   SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

 a. Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
 b. '*L*' *in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
 c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
 d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
 e. Guide student(s) in undertaking micro-projects.
 f. Use flash/animation to explain various concepts.
 g. Encourage students to use mobile apps related to the course.
 h. Encourage students to refer educational websites related to course to further enhance the concepts learnt.
 i. Continuously monitor the students' performance and provide constructive feedback.

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

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

a. Build machine light controller circuit.
b. Build circuit to blink LEDs in different patterns.
c. Build quiz buzzer system.
d. Build system using LCD for displaying name of your institute in rolling fashion.
e. Build open-source hardware-based product counter.
f. Build obstacle detector using open-source prototype board.
g. Build countdown timer using LED 7-segment display.
h. Build automatic door opening/closing system.
i. Build open-source prototype board-based temperature display system using any temperature sensor.
j. Build distance measurement circuit using ultrasonic sensor.
k. Build open-source prototype board-based obstacle detector using IR sensor.
l. Build motion sensor circuit using open-source based board and PIR sensor.
m. Prepare report on features of advanced microprocessors.

13.   SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Internet of things – A hand on approach	Arshdeep Bahga and Vijay Medisetti,	University Pres ISBN 9788173719547
2	Designing the Internet of things	Adrin McEwen & Hakim Cassimality	Wiley India ISBN: 9788126556861
3	The internet of things in the cloud	Honobo Zhou	CRC press ISBN: 978-1-4398-9302-9
4	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry	Cisco Press, ISBN-10: 1-58714-456-5

14.   SOFTWARE/LEARNING WEBSITES

a) https://iot.intersog.com/blog/iot-platforms-overview-arduino-raspberry-pi-intel-galileo-and-others/
b) https://www.guru99.com/iot-tutorials.html
c) https://www.ardunio.cc/en/tutorials/
d) https://www.iotforall.com/
e) https://nevonprojects.com/iot-projects/

Program Name	: Diploma in Mechatronics
Program Code	: ME/ MK
Semester	: Fifth
Course Title	: Computer Integrated Manufacturing (Elective)
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												
				Paper Hrs.	Theory						Practical					
L	T	P			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 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 Mechatronics**
Program Code	: **MK**
Semester	: **Fifth**
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.
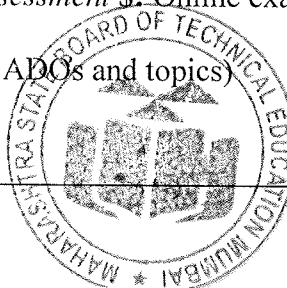- e.   Prepare plans to manage the enterprise effectively.

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

($):Online Examination; (~):PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e.15 marks) and micro-project assessment (seen in section 12) and the remaining has a weightage 40% (i.e.10 marks) will be 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 $: Online examination.

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.
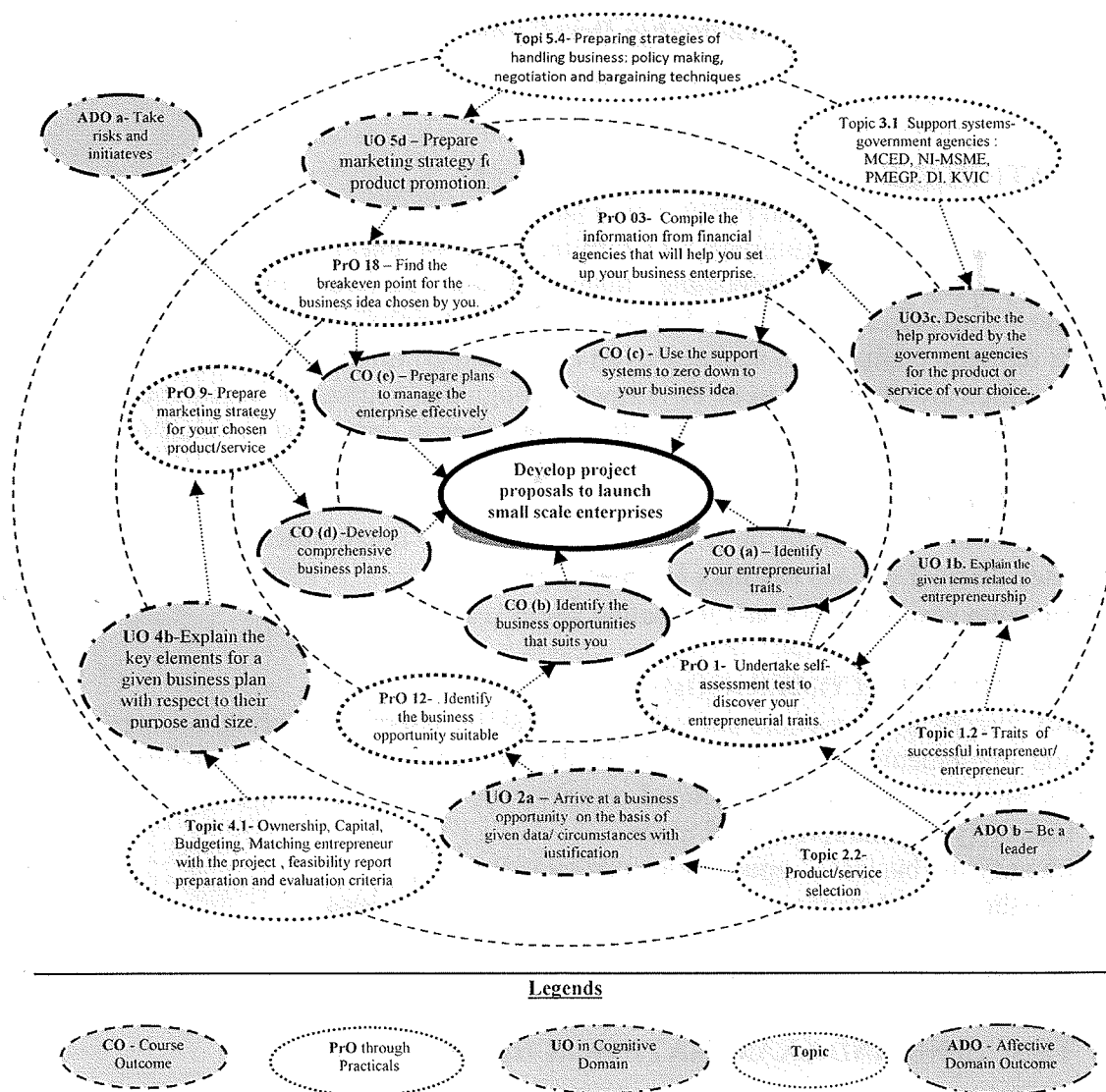

Figure 1 - Course Map

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 enrepreneure indicating milestone achievements.	I	02*
2	Undertake SWOT analysis to arrive at your business idea of a product/service.	I	02
3	Generate business ideas(product/service) for intrapreneurial and	II	02*

| S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	entrepreneurial opportunities through brainstorming.		
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
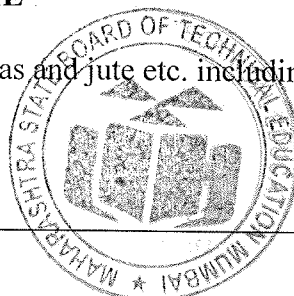
3. Bandage cloth
4. Basket cane (Procurement can also be made from State Forest Corpn. and State Handicrafts Corporation)
5. Bath tubs of plastic
6. Battery Charger
7. Belt leather and straps
8. Bolts and Nuts
9. Boot Polish
10. Brooms
11. Domestic Brushes of different types
12. Buckets of all types 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
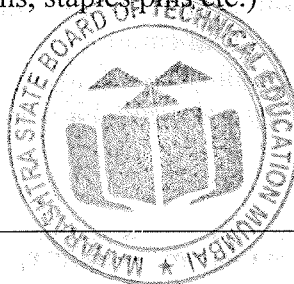
49. Spectacle frames
50. Steel Chair
51. Umbrellas
52. Utensils all types

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
6	Answer the sample questions	10
7	Submission of report in time	10
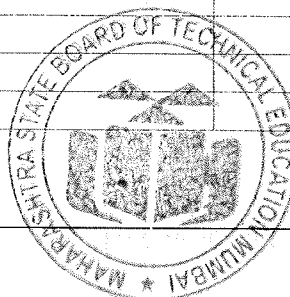
S. No.	Performance Indicators		Weightage in %
	Total		100

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.
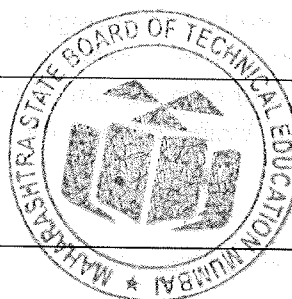
S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Seminar Hall equipped with conference table,chairs and multimedia facilities	All
2	Modern desktop Computer with internet connection.	All

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 1c. Describe the salient features of the resources required for starting the specified enterprise.	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 global market. 1.4 Intrapreneur and entrepreneur

| Unit	Unit Outcomes (In cognitive domain)	Topics and Sub-topics
	1d. Identify the characteristics for a given type of enterprise.	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 business enterprise, stating the assumptions made.	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
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.
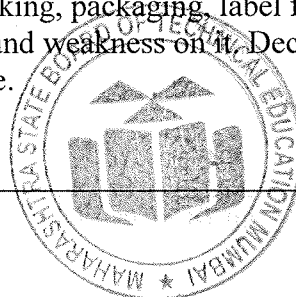
i.   Choose any advertisement and analyse its good and bad points.
j.   Decide any product and analyse its good and bad features.
k.   Select any product and prepare its cost sheet.
l.   Choose any product and study its supply chain.
m.   Arrange brainstorming sessions for improvement of any product.
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.
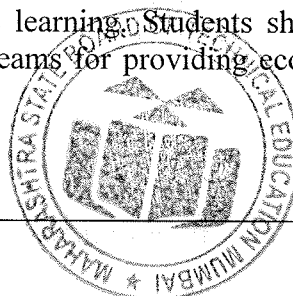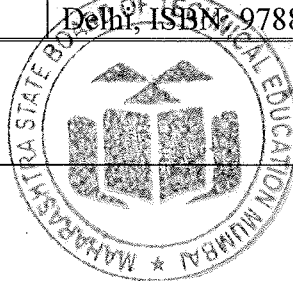
h. Business simulations should be used to enhance behavioural traits of successful intrapreneurs and entrepreneurs amongst students. Emphasis should be on creating entrepreneurial society rather than only setting up of enterprise.

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.

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, 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
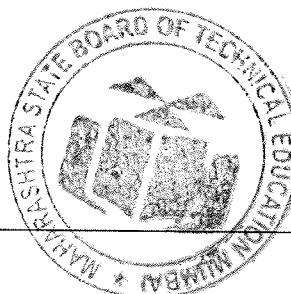
Program Name	:	Diploma in Mechanical Engineering/Plastic Engineering / Mechatronics
Program Code	:	ME / PS / MK
Semester	:	Fifth
Course Title	:	Solid Modelling and Additive Manufacturing
Course Code	:	**22053**

1.   RATIONALE

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

2.   COMPETENCY

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

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

3.   COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:
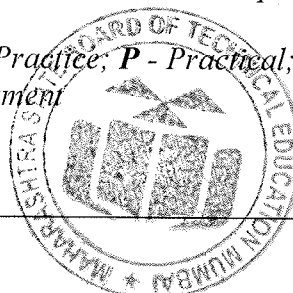
- a.   Prepare 2D Drawing using sketcher workbench of any parametric CAD software.
- b.   Generate 3D Solid models from 2D sketch using Part workbench of any parametric CAD software.
- c.   Prepare assembly of part models using Assembly workbench of any parametric CAD software.
- d.   Generate orthographic views of 3D solid models/assemblies using drafting workbench of any parametric CAD software.
- e.   Plot a drawing for given part model/assembly.
- f.   Print components using 3D Printer/Rapid prototyping machine.

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Paper Hrs.	Theory						Practical					
					ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
-	-	4	4	--	--	--	--	--	--	--	50#	20	50~	20	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 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

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

5.   COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.
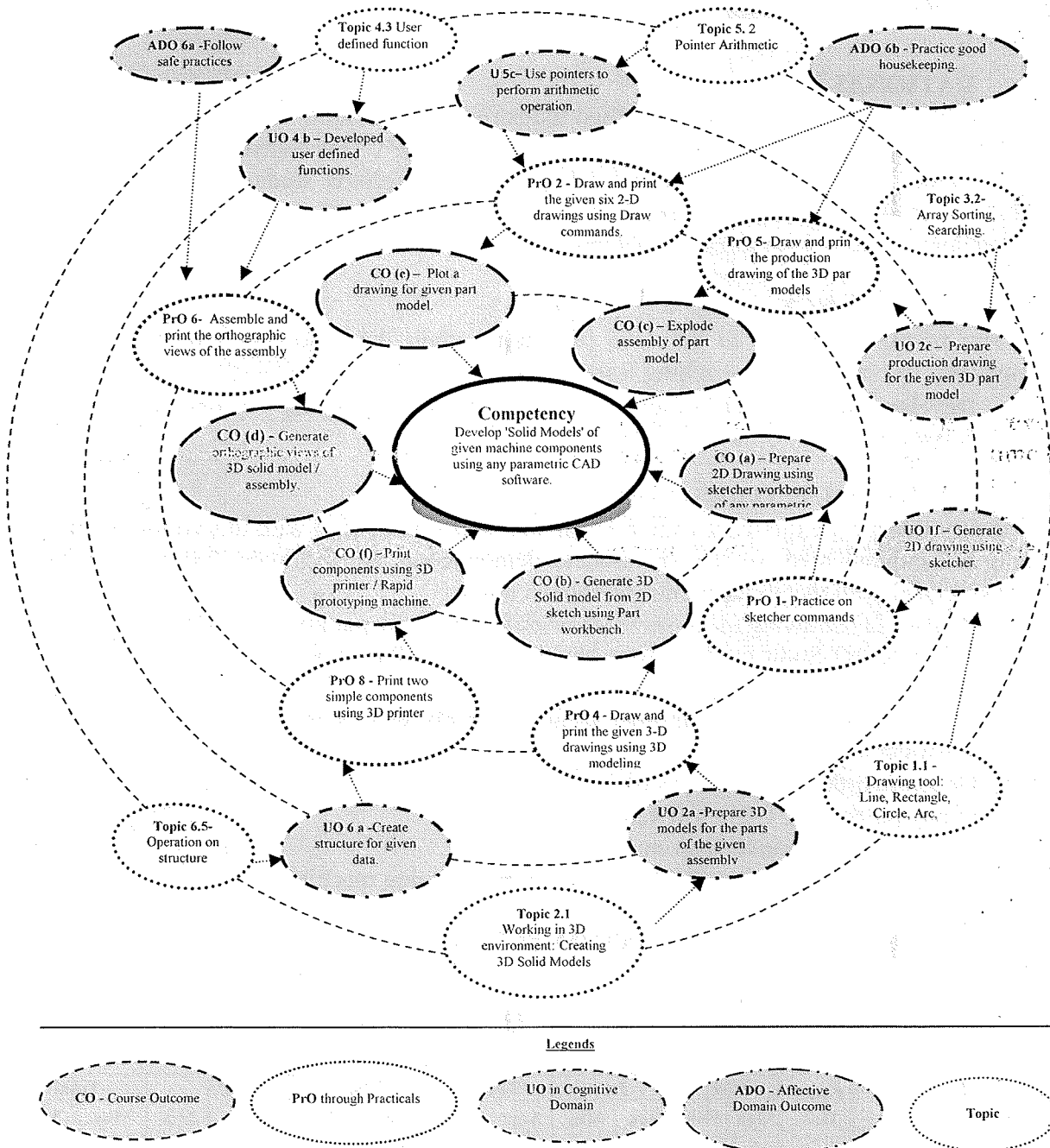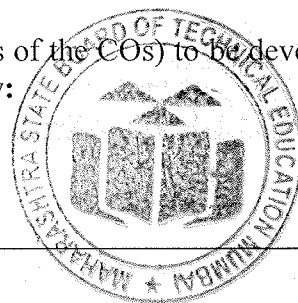

Figure 1 - Course Map

6.   SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare drawing template consisting of Name plate boundary lines and projection symbol.	I	02
2.	Draw and print two simple 2D geometries using sketcher commands	I, V	02*
3.	Draw and print two complex 2D geometries using sketcher commands	I, V	02
4.	Draw and print the given two simple 3-D drawings using 3D modeling commands	II, V	02*
5.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem-I)	II, V	02
6.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
7.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
8.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -I continued)	II, V	02
9.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - I)	III, IV, V	02
10.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem – I continued)	III, IV, V	02
11.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts.(Problem - II)	II, V	02
12.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
13.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem - II continued)	II, V	02
14.	Draw and print the production drawing of the 3D part models of individual components of Bench vice / Drill Jig / Screw Jack / Tool Post / any assembly consisting of at least five parts. (Problem -- II continued)	II, V	02
15.	Assemble and print the orthographic views of the assembly, bill of materials of Bench vice / Drill Jig / Screw Jack / Tool Post / any	III, IV,	02

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

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 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	Use of proper commands	40
2	Completion of drawing with minimum size of model tree	20
3	Generation and printing of drawing views, tables, etc. and their arrangement on different sheet sizes.	20
4	Able to answer oral questions.	10
5	Completion of work in time.	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

    a. Follow safety practices.
    b. Practice good housekeeping.
    c. Practice energy conservation.
    d. Handle solid modeling software carefully.
    e. Plan for creation of solid model.
    f. Demonstrate working as a leader / a team member.
    g. Maintain software tools and equipment.
    h. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

    • 'Valuing Level' in 1st year
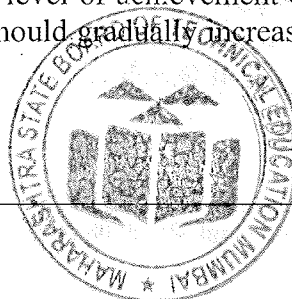
- 'Organising Level' in 2nd year and
- 'Characterising Level' in 3rd year.

7.   MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	Expt. Sr. No.
1	Hardware: Personal computer, (i3/ i5 or higher), RAM minimum 4 GB, A3 / A4 size printer / plotter. Display-wide Screen preferably.	For all Experiments
2	Operating system: Windows XP/Windows 7/ Windows 8/Windows 10 or higher.	
3	Software: Any parametric solid modeling software.	
4	3D printer / Rapid prototyping Machine.	17, 18

8.   UNDERPINNING THEORY COMPONENTS

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

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

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

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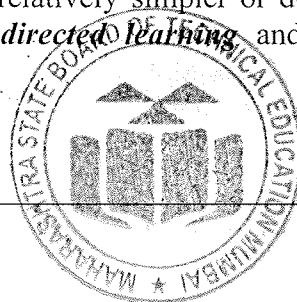
10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related *co-curricular* activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

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

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

    a. Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
    b. *'L' in item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
    c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the

development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.

e. Guide student(s) in undertaking micro-projects.

f. Correlate subtopics with actual design and additive manufacturing.

g. Use proper equivalent analogy to explain different concepts.

h. Use Flash/Animations to explain 3D printing and Rapid prototyping manufacturing methods.

12.   SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three.*

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work-diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than *16 (sixteen) student engagement hours* during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. **2D drawing**: Each student will collect one or two drawings from the nearby industry/workshop and prepare a 2D drawing from it.

b. **3D model**: Each student will identify a small assembly from the institute workshop/laboratory. Measure the dimensions of each part and prepare sketches. Using sketches prepared 3D model of parts and assembly. Plot the assembly and detail drawings. (eg. Bench vice, Machine vice, Tool post, Couplings, Joints, Bearings etc.)

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

13.   SUGGESTED LEARNING RESOURCES

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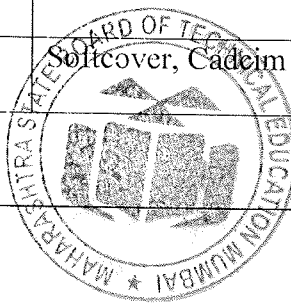
S. No.	Title of Book	Author	Publication
5	NX 4 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
6	Solid Edge V19 for Designers	Sham Tickoo, Deepak Maini	Softcover, Cadcim Technologies
7			

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