Maharashtra State Board of Technical Education (MSBTE)

I – Scheme
IV – Semester Course Curriculum

Course Title: **Mechanical Engineering Measurements** (ME)
(Course Code: .....)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering	Fourth

1. RATIONALE

Measurement activities are given prime importance in industry. The art of measurement plays an important role in all branches of engineering. With advances in technology, measurement techniques have also taken rapid strides, with many types of instrumentation devices, innovations, refinements. The course aims at making a Mechanical Engineering diploma holder familiar with the principles of instrumentation, transducers and measurement of non electrical parameters like temperature, pressure, flow, speed, force, torque for engineering applications.

2. COMPETENCY

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

- **Use relevant analog and digital measuring devices in mechanical engineering related applications**.

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency**:**

a. Use relevant instrument for measuring displacement.
b. Use relevant instrument for measuring force and torque.
c. Use relevant pressure and temperature measuring instruments.
d. Use relevant instruments for measurement of flow.
e. Select relevant instruments for measurement of vibration and strain.
f. Select relevant instruments for speed and sound measurement.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	-	2	5	70	30*	25	25	150

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

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

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

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

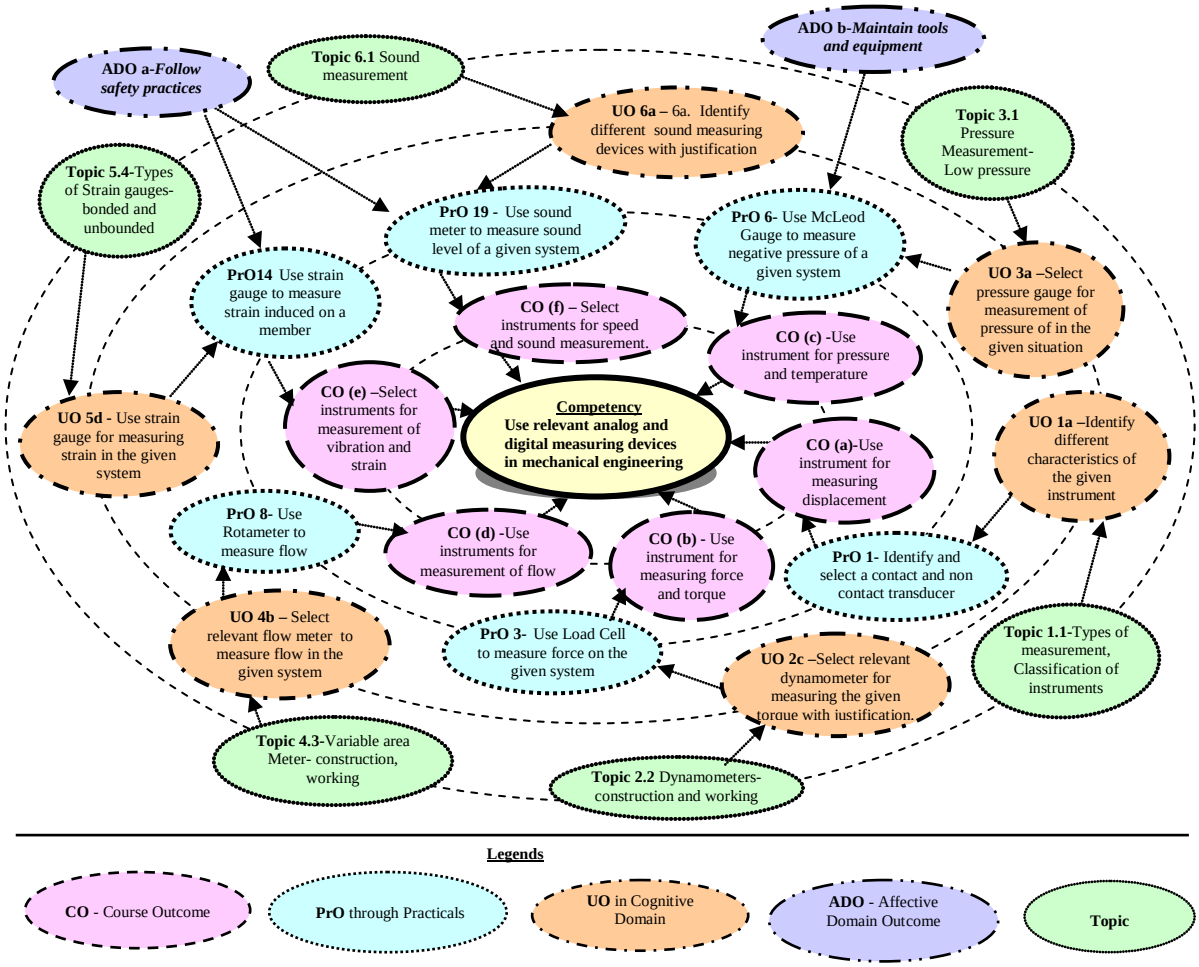

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify and select the contact and non-contact transducers.	I	02*
2	Use inductive transducer to measure displacement in given sample.	II	02
3	Use Load cell to measure force on the given system.	II	02*
4	Use Eddy Current Dynamometer to measure tangential force.	II	02*
5	Use Bourdon's Pressure gauge measure pressure in a given system.	III	02
6	Use McLeod Gauge to measure negative pressure of a given system.	III	02
7	Use liquid in glass Thermometer and Thermocouple to measure temperature.	III	02*
8	Use Rotameter to measure flow.	IV	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	Use Ultrasonic flow meter to measure flow of liquid.	IV	02
10	Use Stroboscope to measure speed of rotating shaft.	V	02*
11	Use Inductive Pick up to measure speed of rotating machine.	V	02
12	Use of FFT analyzer to measure vibrations of a given structure.	V	02*
13	Use of FFT analyzer to measure vibrations of a given machine.	V	02
14	Use strain gauge to measure strain induced on a member.	V	02*
15	Use Sling Psycrometer to measure air properties.	VI	02
16	Measure sound level of a given system using sound meter.	VI	02*
17	Use different speed measuring instruments to measure speed and compare the values.	VI	02
	Total		**34**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	10
2	Handling of measuring instruments carefully while performing the practical.	20
2	Setting and operation	30
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

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

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. 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	Inductive transducer- measurement range -0 to 100 mm -Sensor -inductive (non linear) solenoid type on board with micrometer, micrometer screw guage assembly for displacement, bridge balance type circuit Display 3.5 digit digital display	1
2	Load cell – force measurement range 5- 50 N -sensor-4 arm bridge with strain guage capacity-2 kg, 3.5 digital display	2
3	Eddy Current Dynamometer Power rating: 0.18 KW to 55 KW Max Speed: 4,000 RPM; Torque Indicator: Spring Balance OR Digital Indicator with Zero, Span, Calibration presets; Max Torque: 100 KgM (1000 Nm); Speed Sensor: 60-Tooth wheel with Magnetic Speed Pick up Sensor Torque Sensor: Spring Balance with Pulley and rope, Load cell or Rotary Torque Sensor; Cooling: Self Cooled or FAN Cooled, to avoid Water Cooling hassles.	3
4	Sensor - Bourdon tube C type with LVDT Display 3.5 digit display for pressure/ displacement	4
5	McLeod guage with arrangement for high pump	4
6	Sensor- type k (Cr- Al)thermocouple, sensor assembly and water bath with heating arrangement Display3.5digit digital display	5
7	Rotameter trainer - Sensor -standard glass rotameter, process tank with motor pump Display- float position on graduated scale	6
8	Ultrasonic flow meter: 100 PPM OF 100 Microns in Size Paticulate or Bubbles Required,Battery Operated,Non-Invasive Clamp-On Transducer,Large Character Display; User Selected Velocity Units ,Measures Fluid Velocities from (0.10 to 9.00 MPS),100:1 Turndown Ratio,Pipe Sizes from 6.3 mm	7
9	Stroboscope- Range upto 5000 RPM display – LED digital	8
10	Inductive pickup for speed measurement- Sensor – inductive , variable speed motor arrangement, 3.5 digital display	9
11	FFT analyzer: Specifications:Vibration Velocity: 0.1 – 200 mm/s True RMS,Acceleration: 0.1 – 200m/s² Peak,Displacement: 0.5 – 2000 μm Peak – Peak,Resolution: 0.1 mm/s,Accuracy: ± 2% + 0.1 mm/s,Frequency response: 10 – 1khz,Power: Rechargeable battery Pack with charger,Display: 2 x 16 line back light dot matrix LCD,Operating Temp. Range: 0 – 55ºC,Casing: ABS,Sealed Membrane key pad,Input Connectors: BNC Round,Size:200x100x40 mm	10
12	Strain gauge trainer (strain /force measurement)- Sensor-four arm bridge with strain gauge mounted on cantilever 2kg, Display 3.5digit digital display	11

S. No.	Equipment Name with Broad Specifications	PrO. No.
13	Sling Psycrometer: The Sling Psychrometer measures RH between 10 and 100% (for dry bulb temperatures between 30 and 100 °F) with an accuracy of ± 5%; Measurement Range :Dry/wet bulb temperature :25 to 120 °F or -5 to +50 °C (see ordering information); Relative humidity (RH) : 10 to 100%, for dry bulb temperature between 30 and 100 °F (-1 and 38 °C)	12
14	Sound meter: LCD backlight for clear reading. Wide measuring range: 30-130dB.Sound level measurement. in./Max./Lock current value. Hold the measurement data; Manual/auto shutoff. Equipped with sponge ball. Portable and easy to use suitable for sound quality control in factory, office, home, school and construction site.	13
15	Multi digital stratoscope cum tachometer for speed measurement- upto 5000 rpm	14

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added**.**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to Measurement	1a. Identify the specified characteristics of the given instrument in the figure. 1b. Identify the error in the given instrument based on the given data. 1c. Classify the transducers based on the given application. 1d. Describe with sketches, the working of he non-contact type transducer for the given situation.	1.1 Types of measurement, Classification of instruments, Static terms and characteristics- Range and Span, Accuracy and Precision, Reliability, Calibration, Hysteresis and Dead zone, Drift, Sensitivity, Threshold and Resolution, Repeatability and Reproducibility, Linearity. Dynamic characteristics- Speed of response, Fidelity and Dynamic errors, Overshoot. 1.2 Measurement of error- Classification of errors, environmental errors, signal transmission errors, observation errors, operational errors. 1.3 Classification of transducers, active and passive, contact non-contact, mechanical electrical, analog digital.
Unit-II Displacement, Force and Torque Measurement	2a. Select the displacement measuring sensor for measurement of displacement in the given situation with justification. 2b. Select the relevant force measuring sensors for measurement of pressure in the given situtation with	2.1 Specification, selection and application of displacement transducer. Capacitive transducer, Potentiometer, LVDT, RVDT. 2.2 Force Measurement System- characteristic of force measurement, creep curve for force transducer. 2.3 Force and Load Sensors- Types of Load cell, load cell applications,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification. 2c. Select the relevant dynamometer for measuring the given torque with justification. 2d. Describe with sketches the procedure for measurement of displacement, force and torque using the given device.	construction and working of Quartz force sensor, Force rings. 2.4 Torque Measurement- Inline and Reaction Torque measurement 2.5 Torque sensors- construction and working of Slip ring, Rotary Transformer, Infrared sensor, FM Transmitter. 2.6 Dynamometers – construction and working of Transmission dynamometer, absorption dynamometer, Eddy current Dynamometer.
Unit– III Pressure and Temperature Measurement	3a. Select the pressure gauge for measurement of pressure in the given situation with justification. 3b. Choose the relevant instruments to measure temperature of the given system with justification. 3c. Select the relevant pyrometer for given application with justification. 3d. Describe with sketches the procedure for measurement of temperature and pressure using the given device.	3.1 Pressure Measurement- Low pressure gauges- McLeod Gauge, Thermal conductivity gauge, Ionization gauge, Thermocouple vacuum gauge, Pirani gauge. High Pressure gauge-Diaphragm, Bellows, Bourdon tube, Electrical resistance type, Photoelectric pressure Transducers, piezoelectric type. 3.2 Non-electrical methods- Bimetal , Liquid in glass thermometer and Pressure thermometer. 3.3 Electrical methods- RTD, Platinum resistance thermometer, Thermistor, Thermoelectric methods - elements of thermocouple, Seebeck series, law of intermediate temperature, law of intermediate metals, thermo emf Measurement. 3.4 Pyrometers- Working and Principle of Radiation and Optical Pyrometer.
Unit– IV Flow Measurement	4a. Identify the flowmeter for the given situation with justification mentioning the salient features. 4b. Select the relevant flowmeter to measure flow in the given system with justification. 4c. Describe with sketches the procedure for measurement of flow using the given	4.1 Types of flow meter, Selection criteria for flow meter, classification 4.2 Flow meters- application and construction of Orifice , venture tube, segmental wedges ,pitot tube, Dall Tube. 4.3 Variable area Meter- construction, working and principle of Rota meter, anemometer. 4.4 Positive Displacement Flow meter- construction, advantages and

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	ultrasonic flowmeter.	disadvantages of Coriolis flow meter, Oscillating piston flow meter, Rotating vane flow meter. 4.5 Ultrasonic flow meter- application and construction of Doppler and Transit time ultrasonic flow meter.
Unit –V Vibration and Strain Measurement	5a. Select the relevant sensor for vibration measurement in the given situation with justification. 5b. Describe with sketches the use of FFT analyzer for measuring the vibration in the given situation. 5c. Identify the relevant strain gauges for measuring strain in the given situation with justification. 4d. Describe with sketches the procedure for measurement of strain in the given system using strain gauge.	5.1 Concept of natural frequency, free body diagram and spring mass system. 5.2 Vibration measurement element-principle and working of velocity pickup ,Accelerometer, Inductive Pick Up, Capacitive Pick Up , Stroboscope. 5.3 Introduction to FFT Analyzer, working and application. 5.4 Types of Strain gauges- bonded and unbounded, gauge factor, strain gauge selection criteria. 5.5 Methods of strain measurement-Axial, bending, Torsional. 5.6 Construction of foil, semiconductor and wire wound strain gauge.
Unit–VI Miscellaneous Measurement Sound, speed and humidity measurements	6a. Identify the relevant sound measuring device in the given situation with justification the mentioning the salient features. 6b. Describe with sketches the use speed measuring instrument in the given situation. 6c. Select the relevant instrument for measuring Humidity in the given situation with justification. 6d. Describe with sketches the procedure for measurement of Humidity using the given device.	6.1 Sound measurement, principle of Electro dynamic microphone and Carbon microphone. 6.2 Speed measurement –working and principle of Eddy current generation type tachometer, incremental and absolute type, Mechanical Tachometers, Revolution counter and timer, Slipping Clutch Tachometer, Electrical Tachometers, Contact less Electrical tachometer. 6.3 Humidity measurement –working and principle of Hair hygrometer, Sling psychomotor.

***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 Measurement	06	02	04	06	12
II	Force and Torque Measurement	10	02	04	06	12
III	Pressure and Temperature Measurement	08	02	04	06	12
IV	Flow Measurement	08	02	04	06	12
V	Vibration and Strain Measurement	08	02	04	04	10
VI	Miscellaneous Measurement	08	02	02	08	12
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 journal based on practical performed in measurement laboratory. Journal consist of drawing, observations , required measuring tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
   i. Measuring Tools and equipment in measurement laboratory.
   ii. Machineries in measurement laboratory
c. Undertake a market survey of local dealers for measuring equipments and prepare a report.
d. Visit to any Tool room and observe the working of inspection and testing department. also prepare a report consisting
   i. Different advanced Measuring Instruments
   ii. Different Measuring standards and Calibration process
   iii. Care and maintenance of measuring instruments observed.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

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

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

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Before starting practical, teacher should demonstrate the working of instrument.
g. Instructions to students regarding care and maintenance of measuring equipments.
h. Show video/animation films to explain functioning of various measuring Instruments
i. Teacher should ask the students to go through instruction and Technical manuals of instruments

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Predict and test the performance of sensors of various kinds, including strain gages, thermocouples, tachometers, displacement transducers, dynamometers, pressure gages and transducers.
b. Collect information of flow measuring devices.
c. Perfrom comparative study of different parameters of LVDT various contact sensors.
d. Perform comparative study of various non - contact sensors
e. Visit to automobile workshop and observe the various sensors used in car. also prepare report of the same i.e name ,use, location, function.
a. Visit the market and collect the sensor brochures with specifications of different manufactures.
b. Prepare a list of instruments used for vibration measurement and analysis.
c. Vist a power plant or manufacturing industry and identify situations where these sensors and instruments are used for predictive maintenance and condition monitoring.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechanical measurements and instrumentation	Rajput R.K.	S.K.Kataria and Sons, New Delhi, 2013, ISBN:978-93-5014-285-1
2	Mechanical Measurement and Control	Jalgaonkar R.V.	Everest Publishing House, New Delhi, 2010, ISBN-9788186314265.
3	Mechanical and Industrial Measurements	Jain R.K.	Khanna Publications, New Delhi, 2012, ISBN: 978-8174091912

S. No.	Title of Book	Author	Publication
4	Instrumentation Devices and Systems	Narang C.S.	Tata McGraw Hill Publications, New Delhi, 2012, ISBN: 978-0074633502
5	Instrumentation, Measurement and Analysis	Nakra B. C.; Chaudhary K.K.	Tata McGraw Hill Publications, 2010, New Delhi, ISBN:0070482969

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in/courses/112106138
b. https://cosmolearning.org/video-lectures/pyrometry-cont
c. https://www.youtube.com/watch?v=VpmZjIsV4C4
d. www.youtube.com/watch?v=qNlIZYAk9pI
e. https://www.youtube.com/watch?v=xcvNl1HHY9o
f. https://www.youtube.com/watch?v=DxdFiIDrFBc
g. https://www.youtube.com/watch?v=-_ZeUgVjajc
h. https://www.youtube.com/watch?v=iTjBPHtADA4
i. https://www.youtube.com/watch?v=I4h644S_64w
j. https://www.youtube.com/watch?v=XQT6RSNN9sA
k. https://www.youtube.com/watch?v=FgNAlKTTNtE
l. https://www.youtube.com/watch?v=sLZeR7RMGFA
m. https://www.youtube.com/watch?v=QGBRwXwxnuU
n. https://www.youtube.com/watch?v=jTbRMMgbnNU
o. https://www.youtube.com/watch?v=KeZ5CfPOlBc
p. https://www.youtube.com/watch?v=3hOVfbGSQ0c
q. https://www.youtube.com/watch?v=80sNyYPTXPA
r. https://www.youtube.com/watch?v=EWqThb9Z1jk
s. https://www.youtube.com/watch?v=j-u3IEgcTiQ
t. https://www.youtube.com/watch?v=CLEP5LQ-y0I

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

MSBTE Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1	Mr. S.S. Harip, Lecturer (Selection Grade)	Government Polytechnic, Ahmednagar	9890055381	sanjayharip@gmail.com
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3	Mr. N S Salunke. Lecturer (Selection grade)	Sou Venutai Chavan Polytechnic, Pune	9373544580	sniranjan@sinhagad.edu

NITTTR Bhopal Resource Persons

S. No.	Name and Designation	Department	Contact No.	Email
1	Dr. Sharad K. Pradhan, Associate Professor	Mechanical Engineering	09300802353	spradhan@nitttrbpl.ac.in

S. No.	Name and Designation	Department	Contact No.	Email
2	Dr. (Mrs.) Vandana Somkuwar, Associate Professor	Mechanical Engineering	07552660600	vsomkuwar@nittrbpl.ac.in

Maharashtra State Board of Technical Education (MSBTE)

'I' – Scheme
IV– Semester Course Curriculum

Course Title: **Fundamental of Mechatronics**
(Course Code: .....)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering	Forth

1. RATIONALE

Rapid development in Technology and competitive economy has led to development of new trends in manufacturing Industry such as CNC Machines, Automation, FMS etc. which consists of combination of mechanical, electrical and electronic systems which is referred as Mechatronics. Diploma engineer in professional life has to operate and maintain systems being developed in the area of Mechatronics. In view of this, it is important for him to understand fundamental facts, concepts, principles and application of Mechatronics systems which enables him to work as technician to adopt an interdisciplinary approach of engineering while working on shop floor/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 mechatronics equipment for different applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency**:**

a. Identify different instruments, sensor, actuators, microprocessor, software and mechanical components in mechatronics based systems.
b. Use sensor for different mechatronics applications.
c. Use transducers for different mechatronics based applications.
d. Use actuator for various mechatronics based applications.
e. Programme PLC for various applications.
f. Use microprocessor and microcontroller for various mechatronics based applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
1#	-	2	3	-	-	25*	25~[1]	50

(#): *No theory Exam**;*** ***(*):(~[1])****: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*

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

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

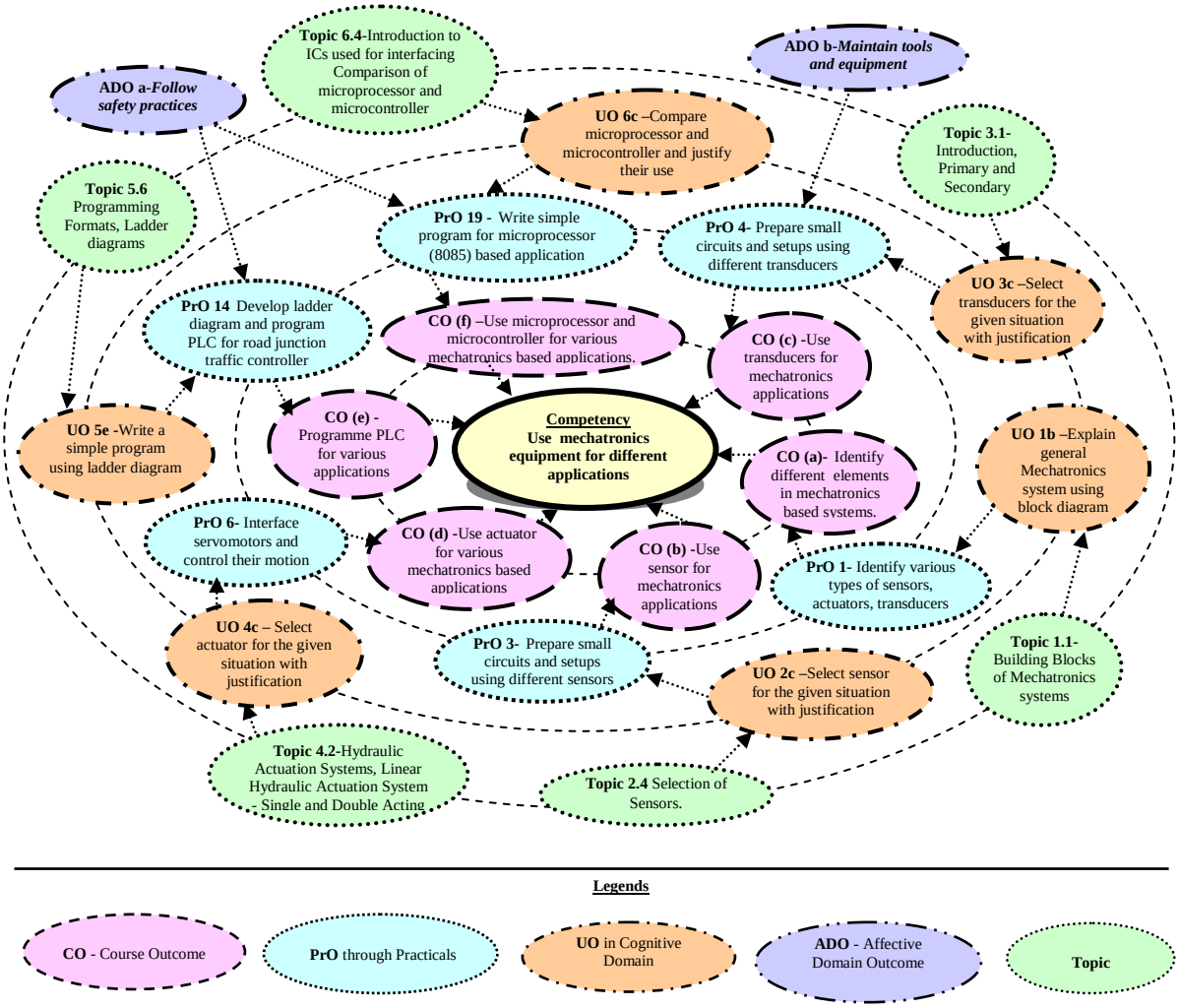

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify various types of sensors, actuators, transducers, PLC and microprocessors used in mechatronics systems with their specifications.	I	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
2	Select sensors, actuators, transducers, PLC and microprocessors used in mechatronics systems.	II, III, IV, V	02*
3	Prepare small circuits and setups using different sensors with PLC and microprocessors used in mechatronics systems.	II, VI	02*
4	Prepare small circuits and setups using different transducers with PLC and microprocessors used in mechatronics systems.	III, VI	02*
5	Prepare small circuits and setups using different actuators with PLC and microprocessors used in mechatronics systems.	IV, VI	02*
6	Interface servomotors of different ratings for given situations and control their motion.	IV	02
7	Use open and closed loop controls to interface servomotors.	IV	02
8	Interface stepper of different ratings for given situations and control their motion.	IV	02*
9	Use simulation software to design hydraulic and pneumatic circuits with component sizing.	IV	02*
10	Build Electro-Hydrulic circuits to interface to PLC using given simulation software.	IV,V	02*
11	Build Electro-pneumatic circuits using given simulation software.	II, III, IV	02
12	Build Hydraulic circuits using given simulation software.	II, III, IV	02
13	Develop ladder diagram and program PLC for simulation of a pedestrian traffic controller.	II, III, IV, V	02*
14	Develop ladder diagram and program PLC for simulation of four road junction traffic controller using given software	II, III, IV, V	02*
15	Develop ladder diagram and program PLC for simulation of Lift / elevator control	II, III, IV, V	02
16	Develop ladder diagram and program PLC for simulation of Washing machine control	II, III, IV, V	02*
17	Develop ladder diagram and program PLC for simulation of Tank level control using given software	II, III, IV, V	02
18	Develop ladder diagram and program PLC for simulation of Soft drink vending machine control	II, III, IV, V	02
19	Write simple program for microprocessor (8085) based application.	VI	02*
	Total		**38**

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S.No.	Performance Indicators	Weightage in %
a.	Preparation of experimental set up	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
- '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	latest educational network versions of 20 Sim/Hydrasim software	1 to 19
2	Basic Pneumatic Trainer Kit with manual and electrical controls/ PLC Control	1 to 19
3	Electro-pneumatic Trainer kit	1 to 19
4	PLC Trainer Kits	1 to 19
5	Basic Hydraulic Trainer Kit	1 to 19
6	Hydraulics, Pneumatics & PLC Systems Simulation Software /Automation Studio	1 to 19
7	8051 - Microcontroller kit with stepper motor and drive circuit sets.	1 to 19
8	LAB VIEW software with Sensors to measure Pressure, Flow rate, direction, speed, velocity and force.	1 to 19
9	Real Time Temperature Controller	1 to 19
10	PID Controller and DC Motor Speed controller	1 to 19
11	Servo controller using Open/Closed loop control system	1 to 19

S. No.	Equipment Name with Broad Specifications	PrO. No.
12	Pneumatic Power circuit system	1 to 19
13	Stepper Motor and 8051Microprocesser kit	1 to 19

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 Basic Mechatronics System	1a. Compare traditional and Mechatronics system with given examples and block diagram. 1b. Explain given Mechatronics system. 1c. Calculate active power, reactive power, apparent power and power factor of the given A.C series circuit to draw the vector diagram. 1d. Identify different instruments, sensor, actuators, microprocessor techniques, software and mechanical components in the given mechatronics based system figure with justification.	1.1 Introduction, Need and Scope 1.2 Traditional V/s Mechatronics Approach, 1.3 Block diagram representation of General Mechatronics system showing various components with suitable example, 1.4 Control System - Open and Closed Loop Systems, Basic Elements of closed loop system, 1.5 Building Blocks of Mechatronics - Electronics, Instrumentation, Sensor, Actuators, Microprocessor techniques, Software, Mechanical Components.
Unit– II Sensors	2a. Explain with sketches the working of the given sensor with sketch and block diagrams. 2b. Write specifications and features of the given sensor. 2c. Select the relevant sensor for the given situation with justification. 2d. Describe with sketches the procedure for testing and installation of the given sensor.	2.1 Introduction, Need of Sensors, 2.2 Contact and Non - Contact Type of Sensors, Classification. 2.3 Working and Application of- Potentiometer Sensors, Strain Gauge Elements, Capacitive Elements, Eddy Current, Proximity Sensors, Inductive Proximity Sensors, Light Sensors, Pressure Sensors, Pneumatic Sensors, Pyroelectrical Sensors, Piezoelectric Sensors. 2.4 Selection of Sensors. 2.5 Testing and installation of sensors.
Unit-III Transducers	3a. Explain with sketches the working of the given transducers. 3b. Write specifications and features of the given transducers.	3.1 Introduction, Primary and Secondary Transducers, Working of Primary and Secondary Transducers,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	3c. Select relevant transducers for the given situation with justification.	3.2 Mechanical Device as Primary detectors, Electrical Transducers, Active and Passive Transducers, Analog and Digital Transducers.
Unit –IV Actuators	4a. Explain with sketches the working of the given Hydraulic actuator with sketch and block diagrams. 4b. Write specifications and features of the given hydraulic, mechanical and electrical actuator. 4c. Select the relevant actuator for the given situation with justification.	4.1 Classification of Actuators, Need and Scope, 4.2 Hydraulic Actuation Systems, Linear Hydraulic Actuation System - Single and Double Acting, Rotary Hydraulic Actuation Systems - Gear Motors, Vane Motors, Piston Motors, Pneumatic Actuation System, Linear Pneumatic Actuation Systems - Single and Double Acting, Rotary Pneumatic Actuation Systems - Gear Motors and Vane Motors, 4.3 Mechanical Actuation Systems - Harmonic Drives, 4.4 Electrical Actuation Systems - Electrical Systems Viz. Switching Devices, solenoid type Devices, Drive Systems, Mechanical Switches Viz. Debouncing, Keypads, Electro-Mechanical and Solid State Relays, Stepper Motors. 4.5 Design and sizing actuator parameters and their impact on system
Unit-V Programmable Logic Controller	5a. Explain with sketches the working of the given PLC with sketch and block diagrams. 5b. Write specifications and features of the given PLC and power supply. 5c. Select relevant PLC and power supply for the given situation with justification. 5d. Describe with sketches the procedure for installation, troubleshooting and maintenance of the given PLC. 5e. Write a simple program using ladder diagram.	5.1 Basic PLC functions, PLC block diagram, Difference between relay panel and PLC, merits and demerits 5.2 Power supply, input/output modules (analog, digital) concepts of sink/source, set/reset, latch/unlatch, 5.3 Installation, troubleshooting and maintenance. 5.4 Selection of a PLC 5.5 Programming equipment; Programming Formats, Ladder diagrams and sequence listing,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		PLC auxiliary commands and functions, Online, offline, stop/run modes of operations uploading/downloading between PLC and PC.
Unit-VI Micro Processor and Popular Mechatronics Systems	6a. Explain with sketches the working of the microprocessor with sketches and block diagrams. 6b. Justify the use of D/A converters and A/D converters in the given application. 6c. Justify the use microprocessor/ microcontroller for the given situation 6d. Explain with sketches the working of mechatronics devices in the given appliance with sketches and block diagrams.	6.1 Introduction, Architecture-Pin Configuration, Instruction set, 6.2 Interfacing input and output devices, Interfacing D/A converters and A/D converters, 6.3 Applications-Temperature control-Stepper motor control-Traffic light controller, 6.4 ICs used for interfacing Comparison of microprocessor and microcontroller 6.5 Application of Mechatronics systems in Washing Machines, Desk Jet Printer, CNC Trainers, Pick and Place Robot, Automatic camera.

***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

- Not applicable -

10. SUGGESTED STUDENT ACTIVITIES

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

a. Visit any nearby industry and prepare a list of mechatronics devices available with specifications.
b. Do internet survey to create small mechatronics circuits.
c. Prepare power point presentation or animation for understanding working of different sensors, actuators, PLC and transducers.
d. Simulate different mechatronic systems using LabView/ hydraulic and pneumatic software.

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 mechatronics based systems and applications.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various pneumatic, hydraulic and mechatronic systems.
i. Use open source simulation software to model Pneumatic, Electro-Pneumatic and hydraulic circuits and ladder diagrams.

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. Design and testing of Mechatronics circuits using component sizing to control
   i. Velocity
   ii. direction
   iii. force and loading of single and double acting actuators
b. Design, Simulation and analysis of Practical Industry based Fluid Power and PLC applications such as:
   i. Mobile Hydraulics system Forklift / Dumper Truck / Excavators, Drilling Machine
   ii. PID Feedback circuits for Hydraulics. (Motion Control, Power Car Steering, Aircraft Steering)
   iii. PLC controlled Cylinder Sequencing Circuits
   iv. PLC Timer / Counter Controlled Cylinder Sequencing Circuits
   v. PLC controlled Bottle Filling Plant.
c. Perform speed control of AC and DC drives.
d. Dissemble a digital weighing machine and understand how weight is measured.
e. Dissemble a digital thermometer and try to understand how temperature is measured.
f. Prepare a report on use of Mechatronics elements in washing machine, lift, microwave oven, ATM etc.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechatronics	Bolton W.	Addison Wesley Longman Ltd., U.S.A. 1999, ISBN 9780582357051
2	Mechatronics	H.M.T.	McGraw Hill Education, New Delhi, 2000, ISBN ata McGraw-Hill Education, 2000 ISBN 9780074636435
3	Mechatronics Electronics in Production and Process	Dawson, D.A., Burd N.C., Loader A.J.	Chapman-Hall, 1993, Taylor & Francis, ISBN 9780748757428
4	Introduction to mechatronics and Measuring Systems	Histand Michael B. Alciatore David G.	McGraw-Hill, New Delhi, 2003 ISBN 9780072402414
5	Mechanical Measurements and Instrumentation	Sawhney Puneet, Sawhney A.K.	Dhanpat Rai and Sons, 2013, New Delhi

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.cesim.com/simulations
b. https://www.famictech.com/edu/videos-educational.html
c. www.scilab.org/scilab
d. www.automationstudio.com
e. www.ni.com/multisim
f. www.youtube.com /electric circuits
g. www.dreamtechpress.com /ebooks
h. www.nptelvideos.in/electrical engineering/ circuit theory
i. www.learnerstv.com/free-engineering
j. www.orcad.com/resources/orcad-downloads

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

MSBTE Resource Persons

S.No.	Name	Institute	Contact No.	Email
1	Mr. A.P. Patil	Bharti Vidhyapeeth's Jawaharlal Nehru Institute of Technology Pune	9890273838	patil.arun27@gmail.com
2	Mr. Sunil Chore	India Soft Technology Pvt. Ltd. Pune	9860897222	sunil.chore@indiasoft.com

NITTTR Bhopal Resource Person

S.No.	Name	Department	Contact No.	Email
1	Dr. Sharad K. Pradhan Associate Professor	Mechanical Engineering	9300802353	spradhan@nitttrbpl.ac.in

Maharashtra State Board of Technical Education (MSBTE)

I – Scheme
IV – Semester Course Curriculum

Course Title: **Fluid Mechanics and Machinery**
(Course Code: .....)

Diploma programme in which this course is offered	Semester in which offered
Mechanical Engineering	Fourth

1. RATIONALE

Knowledge of fluid properties, fluid flow and fluid machinery is essential in all fields of engineering. Hydraulic machines have important role in water supply, irrigation, power generation and also in most of the engineering segments. This course is intended to develop the skills to estimate loss in pipes, efficiency of hydraulic machines like turbine, pumps etc., head on a pump and select a pump for a particular application, diagonose and rectify the faults in pumps and turbines, replace pressure gauges and other accessories on hydrauic machines turbines, and apply their knowledge in hydraulics to select appropriate devices like pressure gauges, valves, flow devices, pipes etc for different field applications.

2. COMPETENCY

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

- **Maintain hydraulic machines applying principles of fluid mechanics.**

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 Manometers and Bourden gauge to measure pressure.
b. Use flow meters to measure the rate of flow.
c. Maintain flow through pipes.
d. Maintain the jet impact on various types of vanes for optimum efficiency.
e. Maintain hydraulic turbines.
f. Maintain hydraulic pumps.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
4	-	2	6	70	30*	25	25	150

(*): *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.

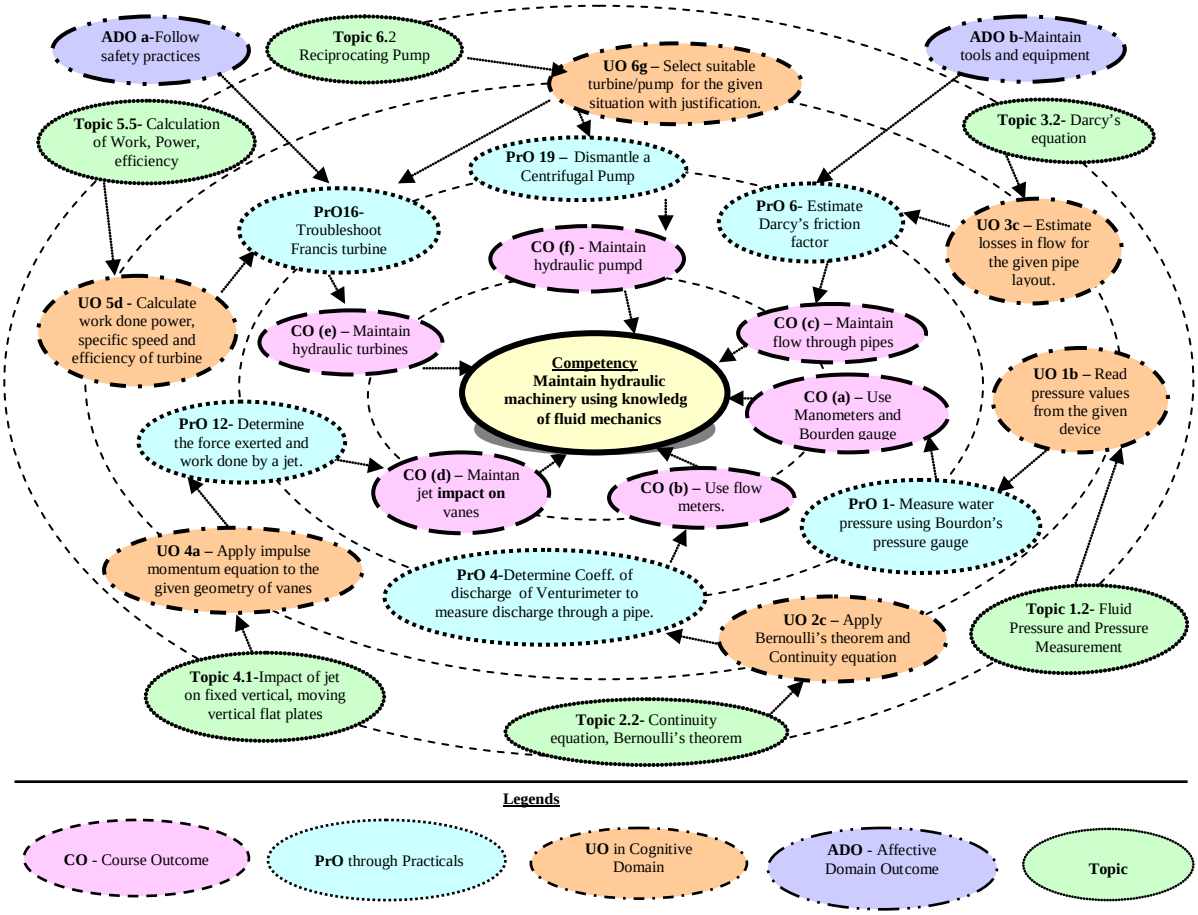

Figure 1 - Course Map

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	**a.** Use Bourdon's pressure gauge and U-tube Manometer to measure water pressure. **b.** Measure discharge of water using measuring tank and stop watch.	I	02*
2	Calibrate Bourdon's pressure gauge using Dead weight pressure gauge to measure pressure.	I	02
3	Measure total energy available at different sections of a pipe layout.	II	02*
4	Use Venturimeter to measure discharge through a pipe.	II	02*
5	Use Sharp edged circular orifice to measure discharge through a pipe Determine coefficient of Discharge, Coefficient of Contraction and Coefficient of Velocity of.	II	02
6	Estimate Darcy's friction factor 'f' in pipes of three different	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	diameters for four different discharges.		
7	Determine frictional losses in sudden expansion and sudden contraction in pipe.	III	02
8	Determine frictional losses in gradual expansion and gradual contraction in pipe.	III	02
9	Determine frictional losses at entrance and exit of pipe.	III	02*
10	Determine frictional losses in bend in pipe.	III	02
11	Determine frictional losses in elbow in pipe.	III	02
12	Determine the force exerted and work done by a jet on flat plate (or any other Vane, if possible)	IV	02*
13	Dismantle and assemble a Pelton Turbine.	V	02
14	Use Pelton wheel test rig to determine overall efficiency of Pelton wheel.	V	02
15	Dismantle and assemble a Francis turbine model.	V	02
16	Determine overall efficiency of Francis turbine using the test rig.	V	02
17	Dismantle and assemble a Kaplan turbine model.		
18	Determine overall efficiency of Kaplan turbine using the test rig.	V	02
19	Dismantle a Centrifugal pump.	VI	02*
20	Assemble a Centrifugal pump.	VI	02*
21	Determine overall efficiency of Centrifugal Pump and plot its operating characteristics using Centrifugal pump test rig.	VI	02*
22	Dismantle a Reciprocating pump	VI	02*
23	Assemble a Reciprocating pump	VI	02*
24	Determine overall efficiency of Reciprocating pump using Reciprocating pump test rig.	VI	02*
25	Determine percent slip of Reciprocating pump.	VI	02
	Total		**50**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		**100**

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

a. Follow safety and ethical practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Update yourself about the latest advancements happening in the field of fluid mechanics and machinery.

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	Bernoulli's theorem Apparatus.	1,3
2	Dead weight pressure gauge calibrater.	2
3	Flow measuring devices (Venturimeter/ orifice meter) Apparatus.	4
4	Hydraulic coefficient test rig.	5
5	Determination of major losses /minor losses in pipe fittings Apparatus.	6 to 11
6	Impact of jet test rig	12
7	Pelton wheel test rig.	13, 14
8	Francis turbine test rig	15
9	Turbine turbine test rig	16
10	Centrifugal pump test rig.	19 t0 21
11	Reciprocating pumps test rig.	22 to 25

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 Properties of Fluid and Fluid	1a. Convert the pressure values from the chart of the given device and into the specified units.	1.1 Properties of Fluids: Density, Specific gravity, Specific volume, Specific Weight, Dynamic viscosity, Kinematic viscosity, Surface tension,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Pressure	1b. Choose the relevant pressure measuring device for the given situation with justification. 1c. Select the relevant pressure measuring devices for the given application with justification. 1d. Calculate fluid pressure, total pressure and centre of pressure on the given immersed body in the specified liquid and the given position. 1e. Describe with sketches the procedure to troubleshoot the given pressure measuring device.	Capillarity, Vapour, Pressure, Compressibility 1.2 Fluid Pressure and Pressure Measurement: Fluid pressure, Pressure head, Pressure intensity, Concept of absolute vacuum, gauge pressure, atmospheric pressure, absolute pressure; Simple and differential manometers, Bourden pressure gauge; Total pressure, center of pressure on- regular surface immersed in given liquid in horizontal, vertical and inclined Positions.
Unit-II Fluid Flow	2a. Compare the types of fluid flow based on the given characteristic properties. 2b. Choose the relevant discharge measuring device for the given situation with justification. 2c. Apply Bernoulli's theorem and Continuity equation to the given discharge measuring device and data. 2d. Choose the relevant discharge measuring device for the given application with justification. 2e. Describe with sketches the procedure to calculate discharge using the given flow meter. 2f. Describe with sketches the procedure to troubleshoot the given flow measuring device	2.1 Types of fluid flows-Laminar, turbulent, steady, unsteady, uniform, non uniform, rotational, irrotational, one, two and three dimensional flow. 2.2 Continuity equation, Bernoulli's theorem. 2.3 Venturimeter – Construction, principle of working, coefficient of discharge, Derivation for discharge through venturimeter 2.4 Orifice meter – Construction, Principle of working, hydraulic coefficients. Derivation for discharge through Orifice meter 2.5 Pitot tube – Construction, Principle of Working
Unit– III Flow through Pipes	3a. Use laws of fluid friction for the given Laminar and turbulent flow. 3b. Use Darcy's equation and Chezy's equation for the given frictional losses. 3c. Estimate losses in flow for the given pipe layout. 3d. Calculate power transmitted and transmission efficiency for the given pipe layout and data.	3.1 Laws of fluid friction for Laminar and turbulent flow; Darcy's equation and Chezy's equation for frictional losses. 3.2 Minor losses in pipe fittings and valves; Hydraulic gradient line and total energy line. 3.3 Hydraulic power transmission through pipe 3.4 Water hammer phenomenon in pipes, causes and remedial measures.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– IV Impact of Jet	4a. Apply impulse momentum equation to the given geometry of vanes and find equation for force and work done. 4b. Calculate force exerted by a jet, work done and efficiency for the given vane and data. 4c. Interpret with sketches the velocity diagram for the given curved vane with special reference to turbines. 4d. Interpret with sketches the velocity diagram for the given curved vane with special reference centrifugal pumps.	4.1 Impact of jet on fixed vertical, moving vertical flat plates. 4.2 Impact of jet on curved vanes with special reference to turbines and Pumps.
Unit –V Hydraulic Turbines	5a. Select the relevant hydraulic turbine fo the given application with justification. 5b. Calculate work done, power, specific speed and efficiency of the given turbine and data. 5c. Describe with sketches the functioning of the given types of Draft tubes. 5d. Interpret with sketches the characteristic curves of the given turbine. 5e. Describe with sketches the procedure to troubleshoot the given type of hydraulic turbine.	5.1 Layout and features of hydroelectric power plant, surge tanks and its need. 5.2 Classification of hydraulic turbines and their applications. 5.3 Construction and working principle of Pelton wheel, Francis and Kaplan turbine. 5.4 Draft tubes – types and construction, Concept of cavitation in turbines. 5.5 Calculation of Work done, Power, efficiency of turbine.
Unit –VI Pumps	6a. Select the relevant hydraulic pumps fo the given application with justification. 6b. Calculate work required and efficiency of the given centrifugal pump ad data. 6c. Interpret with sketches the characteristic curves of the given pump. 6d. Calculate slip, efficiencies, and power required to drive the given reciprocating pump and data. 6e. Select the suitable pump for the given situation with	6.1 Centrifugal Pumps: Construction, principle of working, priming methods and Cavitation; Types of casings and impellers; Static head Manometric head, Work done, Manometric efficiency, Overall efficiency. Numericals based on above parameters, NPSH, Performance Characteristics of Centrifugal pumps and its trouble shooting, Construction, working and applications of multistage pumps. Working principle and applications of Submersible pumps and Jet pump. 6.2 Reciprocating Pump: Construction,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification. 6f. Describe with sketches the procedure to troubleshoot the given type of hydraulic pump.	working principle and applications of single and double acting reciprocating pumps; Slip, Negative slip, Cavitation and separation. Use of Air Vessels; Indicator diagram with effect of acceleration head and frictional head; Pump selection criteria- head, discharge

***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	Properties of Fluid and Fluid Pressure	12	02	02	04	08
II	Fluid Flow	10	02	04	06	12
III	Flow through Pipes	10	02	04	06	12
IV	Impact of Jet	06	00	04	04	08
V	Hydraulic Turbines	12	02	04	08	14
VI	Pumps	14	04	04	08	16
Total		**64**	**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 journals based on practical performed in laboratory.
b. Follow the safety precautions.
c. Use various mechanical measuring instruments and equipments related to fluid mechanics and machinery.
d. Read and use specifications of the hydraulic machines and equipments.
e. Library / Internet survey of hydraulics and hudraulic machines
f. Prepare power point presentation or animation for understanding constructional details and working of different hydraulic machines.
g. Visit nearby shops to identify different PVC and GI pipe fittings. Collect manufacturing catalogues related to the same.

h. Visit nearby shops to identify different pumps. Collect manufacturing catalogues related to the same and compare their salient features.
i. Prepare a list of commercially available software related to computational Fluid dynamics (CFD).

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Correlate subtopics with actual domestic and industrial fluidic systems.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various fluid machinery and pipe line.
i. Use open source simulation software.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Prepare a pipe layout water suppy of your lab from supply reservoir and calculate the loss of head.
b. Prepare a chart of showing all the pressure and flow measuring devices.
c. Prepare a demonstration model of hydroelectric power plant.
d. Calculate running cost of your house hold pump and verify the electricity bill.
e. Gather information of hydroelectric power plants in Maharashtra, India and world.
f. Visit a hydroelectric power plant and write report.
g. Make a video to explain the Hydraulic power generation which could be understood by common man.

h. Select a pump for a coolant recirculation in lathe machine, Bore well pumps, pump at service station, pump used in water coolers, pump in purified water filter system with justification.
i. Download catalogue of pump manufacturer like kirloskar, cri,texmo,etc and compare their parameters.
j. Dissemble and assemble centrifugal pump for fault finding, troubleshooting and to identify wornout parts.
k. Prepare display chart of types of pipes on the basis of mareial, size and applications.
l. Study pressure gauges used by road side tyre worrks, blood pressure measurement by doctors,, pressure gauges mounted on turbine test rig.
m. Visit to nearby pump manufacturing unit
n. Conduct market survey of pump suppliers and prepare report on technical specifications, area of applications, cost, material of different parts and maintenance procedure.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Hydraulics and Fluid Mechanics including Hydraulic Machines	Modi P.N. Seth S. M	Standard Book House New Delhi, 2013, ISBN 978818940126
2	Fluid Mechanics and Hydraulic m/c	Bansal R. K.	Laxmi Publication Pvt. Ltd., New Delhi, 2013, ISBN 9788131808153
3	A text book of Fluid Mechanics and Hydraulic Machines	Rajput R. K.	S. Chand and Company Pvt. Ltd. New Delhi, 2000, ISBN 9789385401374
4	Fluid Mechanics and Hydraulic Machines: problems and solution	Subramanya K.	McGraw-Hill Co. Ltd. New Delhi 2011, ISBN 9780070699809
5	Fluid Mechanics and Machinery	Ojha, Berndtsson, Chnadramouli	Oxford University Press, New Delhi 2000, ISBN 9780195699630
6	Introduction to Fluid Mechanics and Fluid Machines	Som S. K. , Biswas G.	Tata McGraw-Hill Co. Ltd. New Delhi 2005, ISBN 9780070667624
7	A Textbook of Hydraulics, Fluid Mechanics and Hydraulic Mechanics	Khurmi R. S.	S. Chand and Co. Ltd. New Delhi 2015, ISBN-13: 9788121901628
8	Hydraulic, fluid mechanics and fluid machines	Ramamrutham S.	Dhanpat Rai and Sons New Delhi 2011, ASIN: 8187433809
9	Fluid Mechanics	Streeter Victor, Benjamin Wylie E., Bedford K.W.	McGraw Hill Education; New Delhi, 2017,ISBN 978-0070701403
10	Hydraulic Machines	Jagdish lal	Metropolitan; 2008, ISBN-13: 9788120004221

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.nptel.ac.in/courses
b. www.learnerstv.com www.ni.com/multisim

c. https://www.youtube.com/watch?v=e6a2q9k2JCA
d. https://www.youtube.com/watch?v=5TTnFccqJEE
e. https://www.youtube.com/watch?v=3Gq3tR3fkM0
f. https://www.youtube.com/watch?v=UNBWI6MV_lY
g. https://www.youtube.com/watch?v=ljMVt7T4HQM
h. https://www.youtube.com/watch?v=wnOQMk7pKak
i. https://www.youtube.com/watch?v=IcJOkRZPNMI
j. https://www.youtube.com/watch?v=w7n0srAzm8g
k. https://www.youtube.com/watch?v=f9LY0-WP9Go
l. https://www.youtube.com/watch?v=tXLI-IeAynI
m. https://www.youtube.com/watch?v=qbyL--6q7_4
n. https://www.youtube.com/watch?v=3BCiFeykRzo
o. https://www.youtube.com/watch?v=0p03UTgpnDU
p. https://www.youtube.com/watch?v=BaEHVpKc-1Q
q. https://www.youtube.com/watch?v=oQqMrtc6kJQ

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

MSBTE Resource Persons

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NITTTR Bhopal Resource Person

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Maharashtra State Board of Technical Education (MSBTE)

'I' – Scheme
IV– Semester Course Curriculum

Course Title: **Manufacturing Processes**
(Course Code: …….)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering	Fourth

1. RATIONALE

Diploma engineers require the knowledge of core principles of manufacturing processes to design, analyze and manufacture industrial equipments, transport systems, aircrafts, robots and others. This subject intends to help the students in performing various operations on Lathe, Drilling machine, Shaper, Slotter, Welding and Foundry shop. It gives insight of how the raw material gets converted into finished products using various manufacturing processes an parameters.

2. COMPETENCY

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

- **Produce components using conventional manufacturing processes.**

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. Produce jobs using lathe and drilling machines.
b. Produce jobs using shaping and slotting operations.
c. Prepare product using different casting processes.
d. Prepare product using different forming processes.
e. Use joining process to produce jobs.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	-	2	5	70	30*	25	25	150

(*): *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.

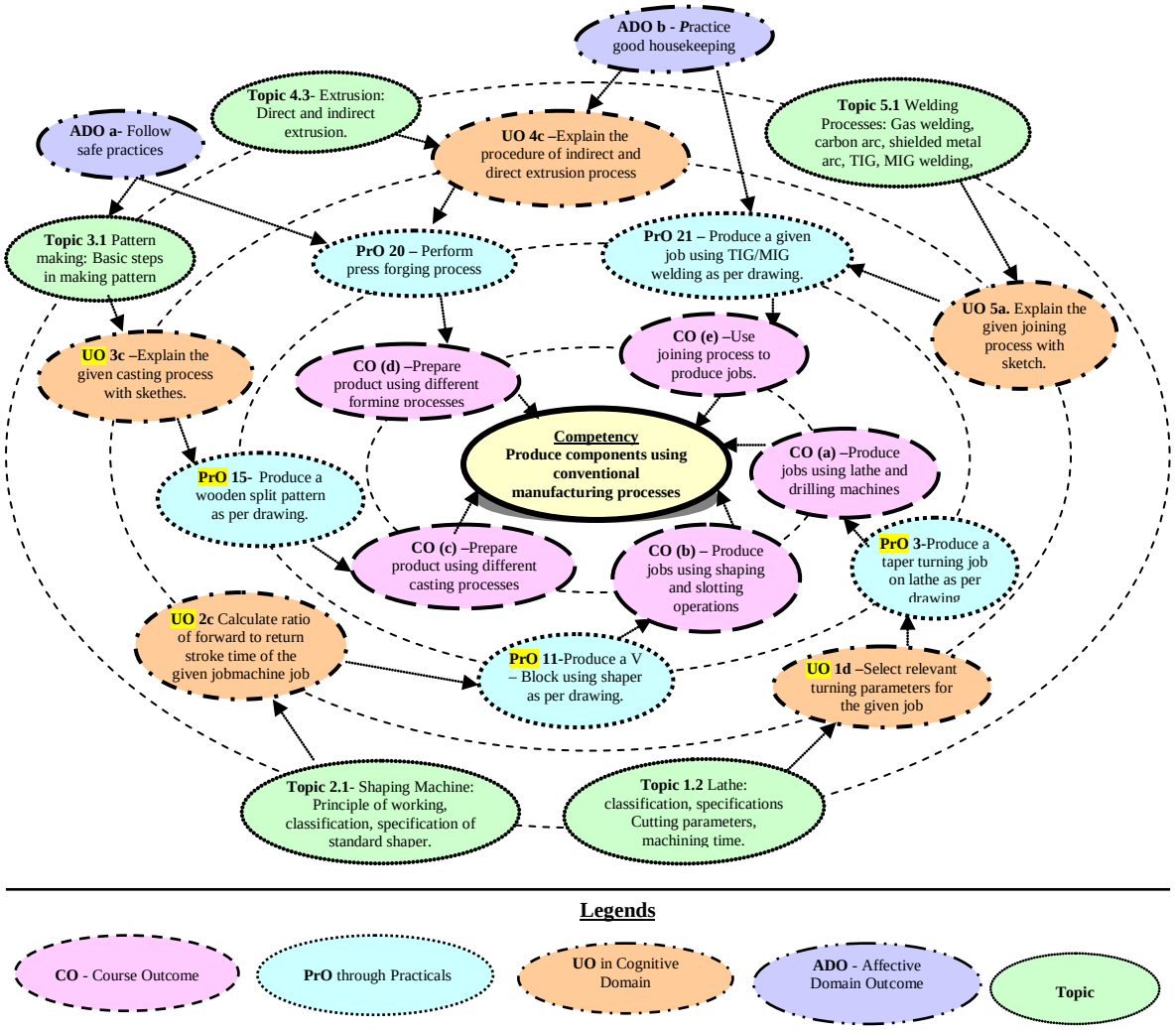

Figure 1 - Course Map

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:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Produce a plain turning job on lathe as per given drawing.	I	02*
2.	Produce a step turning job on lathe as per given drawing.	I	02
3.	Produce a taper turning job on lathe as per given drawing.	I	02
4.	Produce a turning job on lathe with knurling and chamfering operation as per given drawing	I	02*
5.	Produce an eccentric turning job on lathe as per given drawing	I	02
6.	Produce turning job on lathe with threading operation as per given	I	02*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	drawing		
7.	Produce turning job on lathe with drilling and boring operations as per given drawing.	I	02*
8.	Use radial drilling machine to produce job with drilling, reaming, tapping and countersinking operation as per given drawing.	I	02*
9.	Produce drilling job on radial drilling machine with boring and spot facing operation as per given drawing.	I	02
10.	Use radial drilling machine to produce job with counterboring and counter-sunk operation as per given drawing.	I	02
11.	Produce a V – Block using shaper as per given drawing.	II	02*
12.	Adjust stroke length of quick return mechanism of shaping machine. Record time required for various stroke lengths.	II	02
13.	Produce a job with keyway on slotter as per given drawing.	II	02
14.	Produce a wooden solid pattern as per given drawing.	III	02
15.	Produce a wooden split pattern as per given drawing.	III	02
16.	Produce a mould by using solid pattern/split pattern as per drawing.	III	02*
17.	Produce a simple Job/product with the help of Hand Plastic molding machine as per given drawing.	III	02
18.	Perform cold rolling of non ferrous metal and study its effect on various properties.	IV	02*
19.	Perform direct or indirect extrusion process on extruder/extrusion machine.	IV	02
20.	Perform press forging process	IV	02
21.	Produce a given job using TIG/MIG welding as per drawing.	V	02
22.	Perform soldering / brazing operation on the given job.	V	02*
	Total		**44**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
a.	Preparation of Job drawing, selection of material, tool and estimation of cutting parameters.	20
b.	Setup of machine, tool and Job	15
c.	Actual machining operation	20
d.	Inspection of Job using measuring instrument.	15
e.	Answer to questions on operations	10
f.	Submission of job and workshop diary in time.	10
g.	Safety precautions and good housekeeping	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 safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/or a team member.
d. Maintain tools and equipment in good working condition.
e. Handle the machine and tools with care.

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	Center Lathe Machine (Length between centers : 2000 mm)	1 to 7
2	Radial drilling machine (Drill diameter : upto 40 mm)	8 to10
3	Shaping/Slotting machine (Maximum stroke length : upto 150 mm)	11to13
4	Pattern making, moulding and casting shop with necessary equipments.	14 to16
5	Plastic Hand Moulding Machine	17
6	Rolling mill made for Laboratory work	18
7	Hardness Tester with standard specification of Rockwell Hardness	18
8	Metallurgical Microscope ideal for examining Large and Single Side polished Metal samples	18
9	Extruder and extrusion dies	19
10	Feed system mechanism.	19
11	Forging press	20
12	Dies and punches for press forging.	20
13	Reheating furnace	20
14	TIG/MIG welding set up with suitable specification	21
15	Soldering machine	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 Fundamentals of Machining and Machining Operations	1a. Identify different machining operations to be performed for the given job with justification. 1b. Explain with sketches the procedure of performing the given lathe machine operation on a job. 1c. Explain with sketches the procedure of performing the given Drilling machine operation on a job. 1d. Select the relevant turning and drilling process parameters for the given job with justification. 1e. Explain with sketches to measure cutting speed, feed, and depth of cut for the given job in turning and drilling operations.	1.1 **Machining Process:** Mechanics of Chip formation, Single point cutting Tool and its geometry. Methods of Machining, Types of Chips, Principal elements of Metal Machining. 1.2 **Lathe:** classification, specifications of center lathe; Basic parts of center lathe and their functions; Lathe accessories: chucks (three jaw, four jaw, and magnetic chuck), mandrels, rests, face plates, centers, and angle plates; Lathe operations like facing, plain turning, taper turning, thread cutting, chamfering, grooving, knurling. Cutting tool nomenclature and tool signature. Cutting parameters – speed, feed, depth of cut and machining time. 1.3 **Drill Machine**: Classification, specifications of radial drilling machine. Basic parts of radial drilling machine, sensitive drilling and their functions. Drilling machine operations like drilling, reaming, boring, counter sinking, counter boring, spot facing. Cutting parameters - speed, feed, depth of cut and machining time.
Unit –II Shaping/ Slotting Machines.	2a. Explain with sketches the working of shaping and slotting machines with sketches. 2b. Select the relevant cutting speed, feed, depth of cut for the given job with justification. 2c. Calculate ratio of forward to return stroke time of the given shaping machine job. 2d. Explain with sketches the procedure to produce keyway by the given machine as per the given sketch.	2.1 **Shaping Machine**: Principle of working, classification, specification of standard shaper. Basic parts of standard shaping machine and their functions. Quick return mechanism. Different shaping operations. 2.2 **Slotting Machine**: Principle of working, classification, specification. Basic parts of Slotting machine and their functions.
Unit – III Casting Processes and Plastic	3a. Design a simple pattern for the given job. 3b. Design a simple mould for the given the job.	3.1 **Pattern making:** Basic steps in making pattern, types, materials and allowances. 3.2 Color coding of patterns

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Moulding :	3c. Explain with sketches the given casting process. 3d. Select the relevant furnace for the given raw material with justification. 3e. Select the relevant plastic moulding process for the given situation with justification.	3.3 **Moulding**: Types of moulding sands, properties of sand, moulding methods, cores and core prints. Elements of gating system. Bench and floor moulding methods. 3.4 **Casting:** Safety practices / precautions in foundry shop. Furnaces, construction and working of cupola furnace, electric arc furnace. Centrifugal casting- Method and applications. Casting defects - Causes and remedies. 3.5 **Plastic**: Types of plastics; Plastic processing like Calendering and vacuum forming. 3.6 **Plastic moulding methods**: Compression moulding, Injection moulding, Blow moulding and Extrusion. Applications of plastic moulding methods.
Unit– IV Forming Processes	4a. Select the relevant forming process for the given component with justification. 4b. Identify with sketches the point of differences between forging, rolling and extrusion process with justification. 4c. Explain with sketches the given extrusion process as per the given situation.	4.1 **Drop forging**: Introduction to forging. Upset forging, press forging, open die and closed die forging operations. 4.2 **Rolling**: Principle of rolling, hot and cold rolling. Types and applications of rolling mill. 4.3 **Extrusion**: Direct and indirect extrusion. Advantages, disadvantages, applications of extrusion processes.
Unit–V Joining Processes	5a. Explain with sketches the given joining process. 5b. Select the relevant joining process for the given job with justification. 5c. Select the relevant soldering/ brazing process for the given job with justification. 5d. Identify types of the welding defects in the given component figure with justification. 5e. Select the relevant fillers as per the job with justification.	5.1 **Welding Processes:** Gas welding, carbon arc welding, shielded metal arc welding, TIG welding, MIG welding, plasma arc welding, resistance welding types - spot, seam and projection. Electron beam welding, laser beam welding, welding defects. 5.2 **Introduction to soldering and brazing** Process, fillers, heating methods and applications.

***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	Fundamental of machining and Machining Operations	12	04	04	08	16
II	Shaping/Slotting Machines.	08	02	04	06	12
III	Casting Processes and plastic moulding	12	04	06	08	18
IV	Forming Processes	10	02	06	08	16
V	Joining Processes	06	02	02	04	08
Total		**48**	**14**	**22**	**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. Visit a Foundry shop and observe the Centrifugal/Investment/Die Casting process and identify the different defects on the surface of component.
b. Visit a plastic molding industry and collect information on types of molding machines, its specification and observe various activities performed in a molding process.
c. Visit an industry where the operation like drop forging, rolling and extrusion are carried out. Collect information on types these machines, their specification and observe various activities performed and characteristics of output product.
d. Visit a Industry/workshop to observe the process like seam, spot, TIG and MIG welding. Collect information on these machines, their specification and observe these processes critically to get information regarding various accessories (electrodes, current rating etc.) used in these processes.
e. Collect information of recent advancement in manufacturing processes, machines/tools/equipment and their specifications/manufacturer and application in the industries.
f. Collect information of various forming processes used in industries. Observe shape of input and output products and suggest suitable operation for various jobs.

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 the different components of the machine to the students thoroughly before they start doing the practice.
g. Demonstrate trouble shooting practice to the students.
h. Encourage students to refer different technical websites, videos of manufacturing processes to have deeper understanding of the subject.

12. SUGGESTED MICROPROJECT:

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

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

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

a) Prepare a cast product of different mechanical engineering drawing models with wax material.
b) Prepare various types of welding joints (with metal components). Display them on wall board.
c) Fabricate types of keys like sunk key, woodruff key, spline etc.
d) Prepare various types of patterns/ core/ core box etc with suitable material.
e) Prepare a model of Quick-Return Mechanism using wood material**.**
f) Prepare model Pulley and Belt drive system used in the lathe.
g) Prepare Model of Direct Extrusion process.
h) Prepare Hammer forging working Model.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Manufacturing Engineering Handbook	Hwaiyu Geng	McGraw Hill,New York, 2000, ISBN:9780071398251
2	Workshop Technology, Volume- I and II	Raghuvanshi B.S.	Dhanpat Rai Publications, New Delhi, 2009, ISBN 10:0470534915

3	Production Technology (Manufacturing Processes)	Sharma P.C.	S. Chand and Company, 2013, New Delhi, ISBN:9788721911146
4	Text book of Production Technology	Khanna O.P.	Dhanpat Rai Publications, New Delhi, 2010, ISBN :9788189928322
5	A text book of Foundry Technolgy	Khanna O.P.	Dhanpat Rai Publications, New Delhi, 2010, ISBN :9788189928346
6	Elements of workshop Technology-Volume I and Volume II	Chaudhary Hajra S.K.	Media Promoters and Publishers Ltd., Mumbai, 2005; ISBN : 9788185099156
7	Workshop Technology Volume- I and II	Bawa H.S.	McGraw-Hill Education, New Delhi, 2011, ISBN : 13:EBK0009651
8	Workshop Technology Part- I and II	Chapman W.	Taylor and Francis, New Delhi, 1995, ISBN:13:9780415503020
9	Materials and Processing in Manufacturing	Black J.T. Kosher Ronald A.	Wiley India Pvt.Ltd., New Delhi 1999, ISBN:9788126540464

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a) http://nptel.ac.in
b) www.basicmechanicalengineering.com/lathe-machine-operations-basic-turning-
c) www.mechengg.net/2016/0peration-performed-on-shaping-machine.html
d) www.protolabs.com/injection-molding/plastic-injection-molding/
e) www.thelibraryofmanufacturing.com /forming_basics.html
f) www.themetalcasting.com/casting-process.html

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION (MSBTE)

I - Scheme
II - Semester Course Curriculum

Course Title: **Computer Aided Drafting** (2nd Sem AE, PS, 4th Sem ME)
(Course Code: .....)

Diploma programme in which this course is offered	Semester in which offered
Automobile Engineering, Plastics Engineering	Second
Mechanical Engineering	Fourth

1. RATIONALE

The market driven economy demands frequent changes in product design to suit the customer needs. With the introduction of computers the task of incorporating frequent changes as per requirement is becoming simpler. Moreover, the technology driven competitive environment in today's market is compelling design/consulting engineering firms and manufacturing companies to seek CAD conversion of their existing paper based engineering documents. The focus of this course is to provide the student with hands-on experience in drafting and editing of an iindustrial production drawing using one of the commercial Computer Aided Drafting software with particular emphasis on the application of CAD software.

2. COMPETENCY

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

- **Prepare digital drawings using computer aided drafting 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. Use file management techniques in a CAD software.
b. Draw complex 2D geometric figures using a CAD software.
c. Modify complex 2D geometric figures using a CAD software
d. Use software to dimension and write text on existing 2D geometric entities.
e. Use software to plot existing drawing with desired plot parameters.
f. Create Isometric drawings using a CAD software
g. Use layers and blocks to create digital drawings using relevant softwares.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
-	-	2	2	-	-	25**	25~[1]	50

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

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

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

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

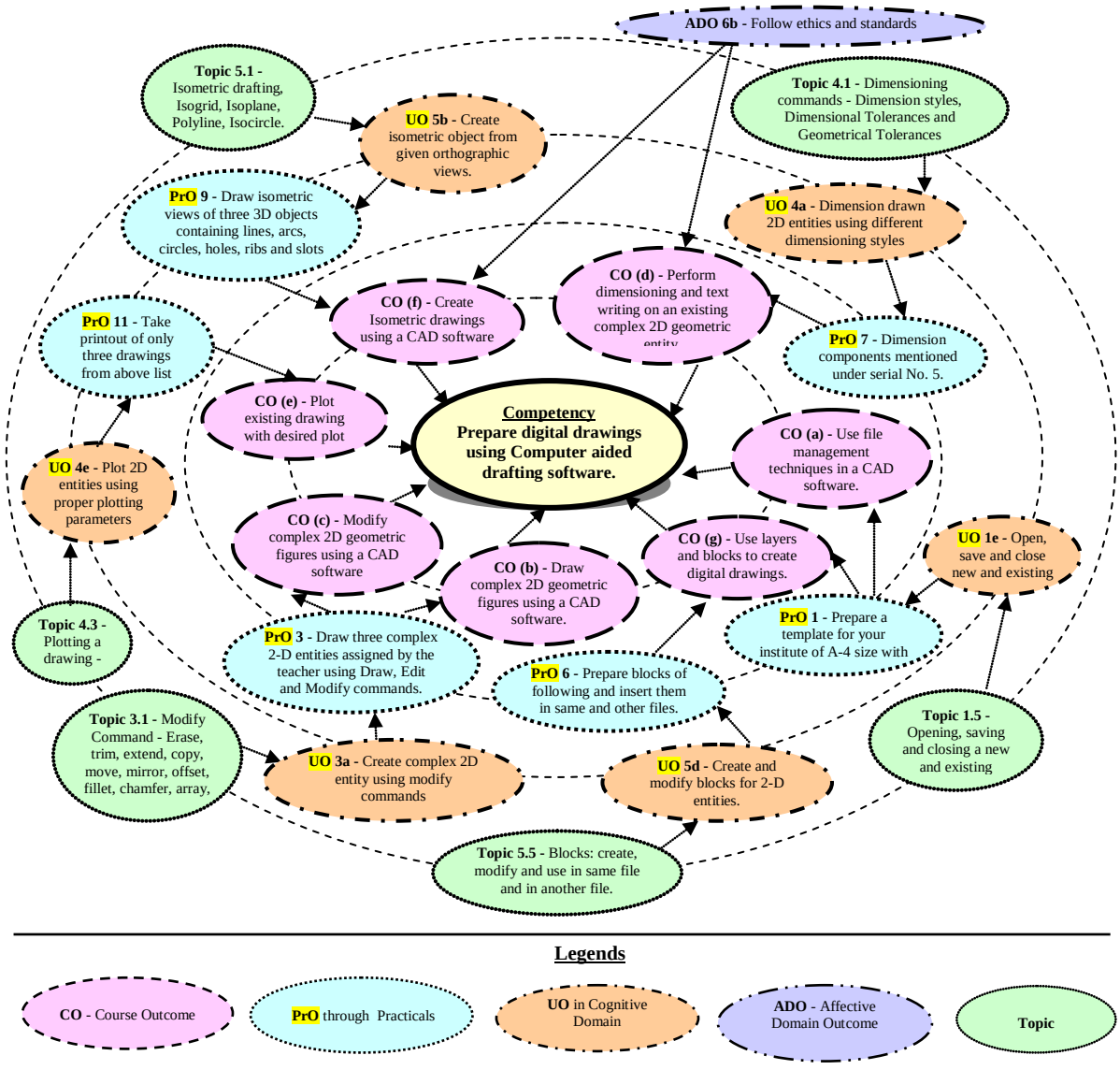

Figure 1 - Course Map

6. SUGGESTED PRACTICALS / EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1.	Prepare a template for your institute of A-4 size with title block and institute logo.	All	02
2.	Use the software to draw one simple 2-D entities using Draw commands individually. Part I	II	02*
3.	Use the software to draw another simple 2-D entities using Draw commands individually. Part II	II	02
4.	Use the software to draw another simple 2-D entities using Draw commands individually. Part III	II	02
5.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part I	II, III	02*
6.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part II	II, III	02
7.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part III	II, III	02
8.	Use the software to draw four complex 2-D entities assigned by the teacher using Draw, Edit and Modify commands. Part IV	II, III	02
9.	Use the software to draw to estimate Area, Perimeter, and Centroid for the given 2D entities like Circle, Pentagon, Trapezium, hexagon and 2D entity with arcs and spline curves using 'Enquiry' and 'List' commands.	II	02
10.	Use the software to draw Epicycloid and Hypocycloid curves using pitch circle as directing circle of a cycloidal gear and an appropriate size smaller circle as generating circle. Part I	II	02
11.	Use the software to draw Epicycloid and Hypocycloid curves using pitch circle as directing circle of a cycloidal gear and an appropriate size smaller circle as generating circle. Part II	II	02
12.	Use the software to create Hexagonal nut and Bolt (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
13.	Use the software to create Front view and side view of V-Groove Pulley (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
14.	Use the software to create Spherical and Flat headed Rivet (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
15.	Use the software to create Front view of 2-Wheeler Piston (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
16.	Use the software to create Front view of typical Open Ended Spanner (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
17.	Use the software to create Front view of Connecting Rod (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02*
18.	Use the software to create Front view of Poppet valve (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
19.	Use the software to create Front view of Deep groove ball bearing (similar objects can be taken up) using Computer Aided Drafting approach.	II, III	02
20.	Use the software to prepare blocks of Hexagonal nut and bolt and insert them in same and other files (similar objects can be taken up). Part I	V	02*
21.	Use the software to prepare blocks of Ball bearing and insert it in same and other files (similar objects can be taken up). Part II	V	02
22.	Use the software to prepare blocks of Chain sprocket and insert it in same and other files (similar objects can be taken up). Part III	V	02
23.	Use the software to dimension all above components mentioned under serial No.12-19. Also insert relevant text in the drawing. Part I	IV	02
24.	Use the software to draw sectional view of piston of a two-wheeler. Main drawing of Piston in one layer, hatching in another layer and dimensioning and text in third layer. Part I	IV,V	02
25.	Hatch above drawing using layer facility and write dimensions and text using on another layer. Part II	IV,V	02
26.	Use the software to draw isometric views of three 3D objects containing lines, arcs, circles, holes, ribs and slots. Part I	V	02*
27.	Use the software to draw isometric views of three 3D objects containing lines, arcs, circles, holes, ribs and slots. Part II	V	02
28.	Use the software to draw isometric views of three 3D objects containing lines, arcs, circles, holes, ribs and slots. Part III	V	02
29.	Draw three Isometric drawings from given Isometric views and dimension it. Part I	V	02
30.	Draw three Isometric drawings from given Isometric views and dimension it. Part II	V	02
31.	Draw three Isometric drawings from given Isometric views and dimension it. Part III	V	02
32.	Take printout of only three drawings from above list using template developed in S.No. 01	IV	02
	Total		**64**

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	Developing/ using Institute Template	20
2	Selecting relevant set up parameters	05
3	Creating given drawing using relevant Commands.	40
4	Dimensioning the given drawing and writing text using blocks and layers effectively.	15
5	Answer to sample questions	10
6	Submission of digital drawing file/plot in time	10
Total		**100**

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

a. Follow safe practices to operate CAD workstations.
b. Practice energy conservation.
c. Follow ethics and standards.

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 administrators.

S. No.	Equipment/Instruments/Other resources name with Broad Specifications	PrO. No.
1	Networked Licensed latest version of Computer Aided Drafting software	All
2	CAD workstation with latest configurations for each student.	All
3	Plotter/Printer with latest versions.	All
4	LCD projector and Screen/ Interactive board	All

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics is to 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 Fundamentals of CAD Drawing Setup	1a. Explain use of computer in drafting and designing. 1b. Use the AutoCAD workspace and interface. 1c. Work with the User Coordinate System and World Coordinate System. 1d. Apply different object selection methods in a given situation 1e. Open, save and close new and given drawings/ templates	1.1 Fundamentals of Computer Aided Drafting (CAD) and its applications, Various Softwares for Computer Aided Drafting. 1.2 Co-ordinate System- Cartesian and Polar Absolute, Relative mode, UCS,WCS. 1.3 CAD initial setting commands- Snap, grid, Ortho, Osnap, Limits, Units, Ltscale, Object tracking. 1.4 Object Selection methods- picking, window, crossing, fence, last and previous. 1.5 Opening, saving and closing a new and existing drawing/template
Unit– II Draw, Enquiry, Zoom and Formatting Commands	2a. Use viewing commands. 2b. Apply formatting commands 2c. Draw simple 2D entities using given draw commands 2d. Determine coordinates, distance, area, length, centroid of the given 2D entity	2.1 Zoom Commands – all, previous, out, in, extent, Realtime, dynamic, window, pan. 2.2 Formatting commands - Layers, block, linetype, lineweight, color. 2.3 Draw Command - Line, arc, circle, rectangle, polygon, ellipse, spline, block, hatch 2.4 Enquiry commands – distance, area.
Unit– III Edit and Modify Commands	3a. Create given complex 2D entity using modify commands 3b. Use grip command to manipulate given 2D entity	3.1 Modify Command - Erase, trim, extend, copy, move, mirror, offset, fillet, chamfer, array, rotate, scale, lengthen, stretch, measure, break, divide, explode, align. 3.2 Grips editing- Move, Copy, Stretch.
Unit– IV Dimensioning, Text and Plot Commands	4a. Dimension given 2D entities using different dimensioning styles 4b. Apply Geometric and dimension tolerance symbols on the given entity. 4c. Write text on given 2D entity. 1f. Create user defined dimension and text styles for a given situation 4d. Plot given 2D entities using proper plotting parameters.	4.1 Dimensioning commands - Dimension styles, Dimensional Tolerances and Geometrical Tolerances, Modify dimension style. 4.2 Text commands - dtext, mtext command. 4.3 Plotting a drawing - paper space, model space, creating table, plot commands.
Unit– V Isometric	5a. Draw isometric entities. 5b. Create isometric object from	5.1 Isometric drafting, Isogrid, Isoplane, Polyline, Isocircle.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Drawings, Layers, and Blocks	given orthographic views. 5c. Use Layers for 2D drawings. 5d. Create and modify blocks for given 2D entities. 5e. Use blocks in same and in another given file.	5.2 Dimensioning Isometric drawings. 5.3 Text writing on Isometric drawing. 5.4 Layer, Layer properties and applications. 5.5 Blocks: create, modify and use in same file and in another file.

***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 SPECIFICATION TABLE FOR QUESTION PAPER (INTERNAL) DESIGN

Unit No.	Unit Title	Practice Hours	Distribution of Practical Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of CAD Drawing Setup	02	-	02	02	04
II	Draw, Enquiry, Zoom and Formatting Commands	06	01	-	04	05
III	Edit and Modify Commands	06	01	-	04	05
IV	Dimensioning, Text and Plot Commands	06	01	-	04	05
V	Isometric Drawings, Layers, and Blocks	12	01	01	04	06
Total		**32**	**04**	**03**	**18**	**25**

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. Maintain a separate folder on Computer workstation allotted, in which all above mentioned practicals should be saved and will be submitted/ mailed as a part of term work.
b. Collect at least one 2D drawing like Production drawings, Layouts from nearby workshops/industries/builders/contractors and develop them using computer aided drafting approach.
c. Explain at least one problem for drafting to all batch colleagues. Teacher will assign the problem to be explained by student.

d. Assess at least one 2D drawing of other students (A group of 5-6 students may be identified by teacher) and note down the mistakes committed by the group. Selected students will also guide other students for correcting mistakes, if any.

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. Bring real objects in the classroom for demonstration purpose.
g. Demonstrate use of various commands of CAD using LCD projector/ interactive board, during hands on sessions.
h. Show videos and animations to explain use of layers, blocks and other relevant commands.
i. Demonstrate use of hardware like plotter.

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 Transmission**: Each batch will identify fasteners, couplings, joints used in plastic machines and using CAD software prepare drawings. The figures should be labeled and dimensioned using software.
b. **2D Machinery components**: Each batch will identify machinery components used in plastic machines and using CAD software prepare drawings. The figures should be labeled and dimensioned using software.
c. **3D Transmission**: Each batch will identify fasteners, couplings, joints used in plastic machines and using CAD software prepare isometric drawings. The figures should be labeled and dimensioned using software.

d. **3D Machinery components**: Each batch will identify machinery components used in plastic machines and using CAD software prepare isometric drawings. The figures should be labeled and dimensioned using software.
e. **Digital Drawings:** Each batch will identify manual drawings of machinery components used in plastic machines and using CAD software create digital drawings using relevant software.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Drawing Practice for Schools and Colleges IS: SP-46	Bureau of Indian Standards	BIS, GOI, Third Reprint, October 1998, ISBN: 81-7061-091-2
2.	Engineering Drawing	Bhatt, N.D.	Charotar Publishing House, Anand, Gujarat, 2010, ISBN:978-93-80358-17-8
3.	Machine Drawing	Bhatt, N.D.; Panchal, V. M.	Charotar Publishing House, Anand, Gujarat, 2010, ISBN:978-93-80358-11-6
4.	Engineering Graphics with AutoCAD	Kulkarni D. M.; Rastogi A. P.; Sarkar A. K.	PHI Learning, New Delhi (2010), ISBN: 978-8120337831
5.	Essentials of Engineering Drawing and Graphics using AutoCAD	Jeyapoovan T.	Vikas Publishing House Pvt. Ltd, Noida, 2011, ISBN: 978-8125953005
6.	AutoCAD User Guide	Autodesk	Autodesk Press, USA, 2015
7.	AutoCAD 2016 for Engineers and Designers	Sham Tickoo	Dreamtech Press; Galgotia Publication New Delhi, Twenty Second edition, 2015, ISBN-13: 978-9351199113

14. SOFTWARE/LEARNING WEBSITES

a. http://www.mycadsite.com/tutorials/
b. http://tutorial45.com/learn-autocad-basics-in-21-days/
c. https://www.lynda.com/AutoCAD-training-tutorials/160-0.html
d. http://www.investintech.com/resources/blog/archives/5947-free-online-autocad-tutorials-courses.html
e. http://www.cad-training-course.com/
f. http://au.autodesk.com/au-online/overview
g. https://www.youtube.com/watch?v=yruPUj_61bw
h. https://www.youtube.com/watch?v=xquI8gcdwbs
i. https://www.youtube.com/watch?v=JTOP6TV4Mvw
j. https://www.youtube.com/watch?v=x7X25Xpa07o
k. https://www.youtube.com/watch?v=Si93Y36tUmY
l. https://www.youtube.com/watch?v=D8dPWKihkEo

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

S. No.	Name and Designation	Institute	Contact No.	Email

S. No.	Name and Designation	Institute	Contact No.	Email
1	Prof. Sunil Gandhi	Pimpri-Chinchwad Polytechnic, Pune	9552665472	sun1gandhi@yahoo.co.in
2	Prof. Krantiveer Pawar	Government Polytechnic, Awasari	9422550460	krantipawar@yahoo.com
3.	Prof. Pradeep Gavade	Government Polytechnic, Dhule	9860472743	gavadepradip2007@rediffmail.com

Faculty Resource Persons from NITTTR Bhopal

S.No.	Name and Designation	Department	Contact No.	Email
1	Dr. Sharad K. Pradhan	Mechanical Engineering	9300802353	spradhan@nitttrbpl.ac.in

Maharashtra State Board of Technical Education (MSBTE)

I – Scheme

IV – Semester Course Curriculum

Course Title: **Environmental Pollution and Energy Conservation** (ME, PT)
(Course Code: .....)

Diploma Programme in which this course is offered	Semester in which offered
Mechanical Engineering, Production Technolgy	Fourth

1. RATIONALE

Diploma mechanical engineers are dealing with various environmental aspects in terms of solid and liquid waste. They also have to deal with different environmental changes in relation to protection of environment as well as instruments in different industries. Diploma mechanical engineers are also involved in dispensing process of various nonfunctional and damaged part of instruments and mechanical devices. To take care of all these issues they need to be informed about the pollution related to water, air and soil. This course is designed to equip the diploma engineer with necessary skills related to the environmental pollution and energy conservation for effective performance of the job role.

2. COMPETENCY

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

- **Implement energy conservation and pollution reduction techniques for sustainable environment in mechanical engineering related industries.**

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 the sources in mechanical engineering domain responsible for global warming and ozone depletion.
b. Minimise air and water pollution control related to mechanical devices/processes/ products.
c. Use the relevant renewable energy technologies.
d. Use land fill and incineration methods for treatment of industrial solid waste.
e. Apply ISO14000 norms in the mechanical engineering related industries.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	-	2	5	70	30*	25	25	150

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

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

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

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

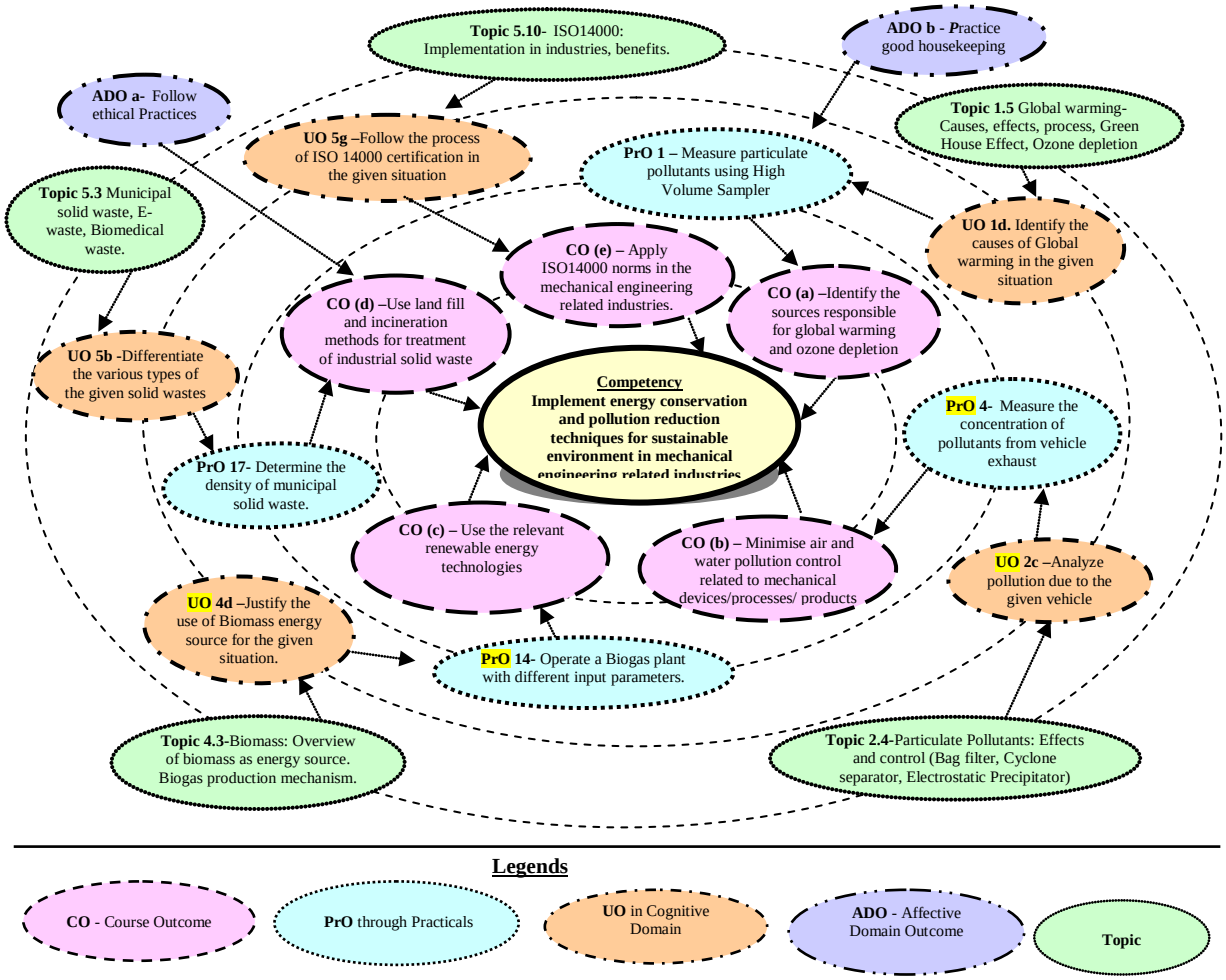

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use High Volume Sampler to measure particulate pollutants.	I	02*
2	Use Orsat apparatus to determine the composition of flue gases	I	02
3	Use Zeldal apparatus to determine the composition of air	II	02*
4	Measure the concentration of pollutants from vehicle exhaust.	II	02
5	Determine the chloride content in waste water.	II	02*
6	Determine the total solids in waste water.	II	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
7	Determine biological oxygen demand of waste water.	II	02
8	Determine the Chemical oxygen demand of waste water.	II	02*
9	Determine the dissolved oxygen in waste water.	II	02
10	Determine the turbidity of waste water using turbidity meter.	II	02
11	Determine the Sulphate content in waste water	II	02*
12	Determine the neutralization point for charcoal treatment of acidic waste water.	II	02
13	Use acid base titration to determine the strength of alkaline material in waste water.	II	02
14	Determine the fuel content in the given sample of biomass.	III	02
15	Assemble a small biogas plant to generate electric power	IV	02*
16	Dismantle the biogas plant.	IV	02
17	Assemble the solar PV plant to produce electric power.	IV	02*
18	Dismantle the solar PV plant.	IV	02
19	Assemble a horizontal axis small wind turbine to produce electric power	IV	02*
20	Dismantle a horizontal axis small wind turbine.	IV	02
21	Assemble a vertical axis small wind turbine to produce electric power	IV	02*
22	Dismantle a vertical axis small wind turbine.	IV	02
23	Assemble a micro hydro power plant to produce electric power	IV	02*
24	Dismantle a micro hydro power plant.	IV	02
25	Determine the density of municipal solid waste.	V	02*
26	Determine the density of hazardous waste.	V	02
	Total		**52**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		**100**

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

a. Follow safety practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. 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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	For laboratory purpose High volume sampler Motor: 0.6 HP, Power: 6.25amp, 750W, Flow set point: 40SFCM, Mass flow control accuracy: +/- 2.5% deviation(24 Hrs), Power source: 110 V 1 Phase, 60 HZ ,Weight: 61kg ,	01
2	Orsat Apparatus: Three absorption pipette, Two compartment type, 100ml gas burette with outer jacket, manifold with stopcocks and aspirator bottle for the analysis of CO, O_2, CO_2 particularly in fuel and furnace gas. Wooden cabinet with sliding doors.	02
3	B.O.D. incubator: Chamber Volume: 285lit, Cu. Ft-10, Internal size: CMS-57X57 X 88, External size: CMS 70X85X166, Shelves-2: Range :+5^{o}C to 60^{o}C	07
4	C.O.D. digester: Multifunction dry bath fitting, Temperature control from ambient +5^{o}C to 150^{o}C with +1^{o}C accuracy	08
5	Zeldal Apparatus	03
6	DO meter : Temperature range: -5^{o}C to 55^{o}C, Resolution: 0.1^{o}C , Accuracy: +/-0.3^{o}C, Range: 0 to 500%	09
7	PUC Kit Component Range Resolution CO 0-15% 0.01% CO2 0-19.9% 0.1% HC 0-20000ppm 1 ppm O2 0-25% 0.01% NOx 0-5000ppm 1 ppm Power Supply 12V DC, 230VAC, Single Phase, 50-60Hz Power: 25W	04
8	Turbidity Meter: Range: 0-10000NTU, Principle: Nephelometric, Ratio:	11

S. No.	Equipment Name with Broad Specifications	PrO. No.
	Full time ON or OFF, Accuracy +/- 2% of reading + 0.01NTU, Resolution: 0.0001NTU; Response time <6sec, sample size: 30ml, light source :IR, temperature: 0^{o}C to 50^{o}C, Air purge: External dryer supply	
9	1 to 3 kW biogas plant with relevant auxiliaries	15,16
10	1 to 3 kW solar PV plant with solar tracking arrangement	17,18
11	1 to 5 kW horizontal axis small wind turbine with towers	19.20
12	0.5 to1 kW vertical axis wind turbine with towers	21,22
13	1 to 3 kW micro hydro power plant with relevant auxiliaries	23,24
14	Weighing Balance: Accuracy 0.1mg to 500gm	All
15	Stop Watch	
16	Desicator	07
17	Oven: Max Temperature 1000 ^{o}C, minimum Temperature +30 ^{o}C, Volume 28 to 128 Litres.	06
18	Reflux Condenser: 500ml flask with condenser assembly	08
19	Filter Paper	06
20	Heater	06, 07
21	Galssware: Burrete, Pippette, Conical Flask, Beaker, Measuring Cylinder, Specific gravity Bottle etc.	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 (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Ecosystem	1a. Identify the components of the given Biotic and Abiotic system. 1b. Differentiate the given Aquatic and Terrestrial ecosystem. 1c. Identify the chemical cycles in the given Ecosystem with justification 1d. Identify the causes of Global warming in the given situation with justification.	1.1 Structure of ecosystem, Biotic and Abiotic components 1.2 Food chain and food web 1.3 Aquatic(Lentic and Lotic) and terrestrial ecosystem 1.4 Carbon, Nitrogen, Sulphur, Phosphorus cycle. 1.5 Global warming-Causes, effects, process, Green House Effect, Ozone depletion
Unit– II Air and, Noise Pollution	2a. Identify the components of air pollutants in the given sample of air with justification. 2b. Use relevant separator for the given air pollution control situation. 2c. Analyze pollution due to the given vehicle. 2d. Identify the factors related to the given machinery	2.1 Definition of pollution and pollutant. 2.2 Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler 2.3 Air Pollutants: Types 2.4 Particulate Pollutants: Effects and control (Bag filter, Cyclone separator, Electrostatic Precipitator) 2.5 Gaseous Pollution Control: Absorber, Catalytic Converter, 2.6 Effects of air pollution due to

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	responsible for air pollution with justification. 2e. Identify sources of noise pollution in the given situation with justification. 2f. Identify sources of water pollution in the given situation with justification.	Refrigerants, I.C., Boiler) 2.7 Noise pollution: sources of pollution , measurement of pollution level, Effects of Noise pollution 2.8 Noise pollution (Regulation and Control) Rules,2000
Unit– III Renewable Energy Technologies	3a. Identify the type of clean energy for the given situation with justification. 3b. Explain working and construction of the given solar energy device with sketches. 3c. Justify the use of wind energy in the given situation. 3d. Justify the use of Biomass energy source in the given situation. 3e. Justify the use of a micro hydro power plant in the given situation. 3f. Explain with sketches the working and construction of the given type of biomass power plant.	3.1 Solar Map of India, Solar PV System: Construction, Components, Working; Applications: Street light, solar lantern and others 3.2 Wind Map of India, Small Wind Turbines: status and future prospects of wind energy. Wind energy in India. Environmental benefits and limitations of wind as energy source. 3.3 Biomass: Overview of biomass as energy source. Thermal characteristics of biomass as fuel. Anaerobic digestion. Biogas production mechanism. Utilization and storage of Biogas. 3.4 Micro hydro power plant: Construction and working. 3.5 Ocean energy: Tidal power, wave power, Ocean Thermal Energy Conversion (OTEC) 3.6 Geothermal energy.
Unit- IV Water and Soil Pollution	4a. Identify the pollutants in given waste water sample with justification. 4b. Calculate BOD and COD of the given waste water sample. 4c. Apply activated sludge treatment in the given house hold waste water. 4d. Use relevant method for treatment of the given waste water sample. 4e. Identify causes of soil pollution for the given situation with justification.	4.1 Sources of water pollution, Types of water pollutants, Characteristics of water pollutants: Turbidity, pH, total suspended solids, total solids 4.2 BOD and COD: Definition, calculation 4.3 Waste Water Treatment: Primary methods: sedimentation, froth floatation, Secondary methods: Activated sludge treatment, Trickling filter, Bioreactor, Tertiary Method: Membrane separation technology, RO(reverse osmosis). 4.4 Causes, Effects and Preventive measures of Soil Pollution: Causes- Excessive use of Fertilizers,

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		Pesticides and Insecticides, Irrigation, E-Waste.
Unit-V Solid Waste and Environmental Management	5a. Identify the sources of solid waste in the given situation. 5b. Differentiate the various types of the given solid wastes. 5c. Apply the principle of 3R in the given situation. 5d. Apply the scientific method of sanitary landfill in the given situation. 5e. Apply the air and water pollution control act in the given industry. 5f. Explain the role of different pollution control boards. 5g. Apply various pollution control act for the given fabrication/manufacturing/service industry. 5h. Follow the process of ISO 14000 certification in the given situation.	5.1 Solid waste generation 5.2 Sources and characteristics of : 5.3 Municipal solid waste, E- waste, Biomedical waste. 5.4 Metallic wastes and Non-Metallic wastes (lubricants, plastics, rubber) from industries. 5.5 Collection and disposal: MSW(3R, principles, energy recovery, sanitary landfill), Hazardous waste 5.6 Air quality act2004, air pollution control act 1981 and water pollution and control act1996. 5.7 Structure and role of Central and state pollution control board. 5.8 Concept of Carbon Credit, Carbon Footprint. 5.9 Environmental management in fabrication industry. 5.10 ISO14000: Implementation in industries, benefits.

***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	Ecosystem	10	04	02	02	08
II	Air and Water Pollution Control	11	06	06	06	18
III	Renewable Energy Technologies	12	06	08	08	22
IV	Water and Soil Pollution	10	04	04	06	14
V	Solid Waste and Environmental Management	05	02	04	02	08
Total		**48**	**22**	**24**	**24**	**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. Plant trees (5 to 6) in your nearby locality/Polytechnic campus and prepare report about its growth and survival after two months.
b. Organize seminar on air pollutants of relevant MIDC area/vehicle
c. Organize poster exhibition about global warming and ozone depletion.
d. Visit a nearest water purification/effluent treatment plant.

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 real pollution situation related to mechanical engineering domain.
g. Use proper equivalent analogy to explain different concepts.
h. Use Flash/Animations to explain various topics.

12. SUGGESTED MICRO-PROJECTS

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

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

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

a. Prepare a list of materials: solid/liquid/gas related to mechanical engineering devices, processes, products which are responsible for any type of pollution and collect information on how to dispose of them as per norms to minimize the pollution.

b. **Collection of Data from Internet:** Collect everyday information on percentage of carbon dioxide and hydrocarbons in any four metro cities for two month
c. **Visit of Municipal Effluent Treatment Plant:** Visit municipal effluent treatment plant and prepare report on solid waste, dissolved waste.
d. **Visit of Municipal Water Treatment Plant:** Visit municipal water treatment plant and prepare report on various stages of water treatment.
e. **Visit of Wind Energy/Solar Energy Power plants:** Collect the information on its functioning and the amount of energy generated per day, per month, per year.
f. **Visit of Micro-hydro Power plants:** Collect the information on its functioning and the amount of energy generated per day, per month, per year.
g. **Solid Waste Management:** Identify and list the industries using the solid waste as raw material.
h. **ISO Implementation:** List and categorize the industries certified with ISO 14000 in India.
i. **Preparation of chart**: Prepare the chart of solid waste management showing effects on environment.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Environmental Engineering Science	Nazaroff, William Cohen, Lisa	Wiley, New york, 2000, ISBN 10: 0471144940
2	Air Pollution	Rao, M. N. Rao, H.V.N.	Mc-Graw Hill Publication, New Delhi, 1988, ISBN: 0-07-451871-8
3	Wind Power Technology	Earnest, Joshua	PHI Learning, New Delhi, 2015, ISBN:978-81-203-5166-0
4	Solar Energy	Solanki, Chetan Singh	PHI Learning, New Delhi, 2016, ISBN:978-81-203-5111-0
5	Waste Water Treatment for Pollution Control and Reuse	Arceivala, Soli Asolekar, Shyam	Mc-Graw Hill Education New Delhi, 2007, ISBN:978-07-062099-5
6	Waste Water Engineering	Metcalf and Eddy	Mc-Graw Hill, New York, 2013, ISBN: 077441206
7	Industrial Solid Waste	Patvardhan, A.D.	TERI Press, New Delhi, 2013 ISBN:978-81-7993-502-6
8	Environmental Pollution Control and Engineering	Rao, C. S.	New Age International Publication, 2007, ISBN: 81-224-1835-X

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. www.eco-prayer.org
b. http://mnre.gov.in/schemes/grid-connected/solar-thermal-2/
c. http://mnre.gov.in/file-manager/grid-wind/guideline-wind.pdf
d. http://mnre.gov.in/schemes/grid-connected/solar/
e. http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/
f. http://mnre.gov.in/schemes/grid-connected/biomass-gasification/
g. http://mnre.gov.in/schemes/grid-connected/biogas/
h. http://mnre.gov.in/schemes/new-technologies/biofuels/
i. http://mnre.gov.in/schemes/grid-connected/small-hydro/
j. http://mnre.gov.in/schemes/new-technologies/geothermal/

k. http://mnre.gov.in/schemes/new-technologies/tidal-energy/
l. http://mnre.gov.in/schemes/new-technologies/hydrogen-energy/
m. www.teriin.org
n. www.mnre.gov.in
o. www.cpcp.nic.in
p. www.cpcp.gov.in
q. www.indiaenvironmentportal.org.in
r. www.whatis.techtarget.com
s. www.sustainabledevelopment.un.org
t. www.conserve-energy-future.com

15. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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