Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Fourth**

Course Title : **Fundamental of Mechatronics**

Course Code : **22048**

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:

- **Operate and manipulate mechatronics systems as per requirements.**

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			Credit (L+T+P)	Examination Scheme													
				Theory							Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
2	-	2	4	--	--	--	--	--	--	--	25#	10	25~	10	50	20	

*(~): For the **practical only courses,** the PA has two components under practical marks i.e. the assessment of practicals (seen in section 6) has a weightage of 60% (i.e. 15 marks) and*

micro-project assessment (seen in section 12) has a weightage of 40% (i.e. 10 marks). This is designed to facilitate attainment of COs holistically, as there is no theory ESE.

Legends: **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment, @ Internal Assessment, # External Assessment, *# On Line Examination, ^ Computer Based Assessment.

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

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

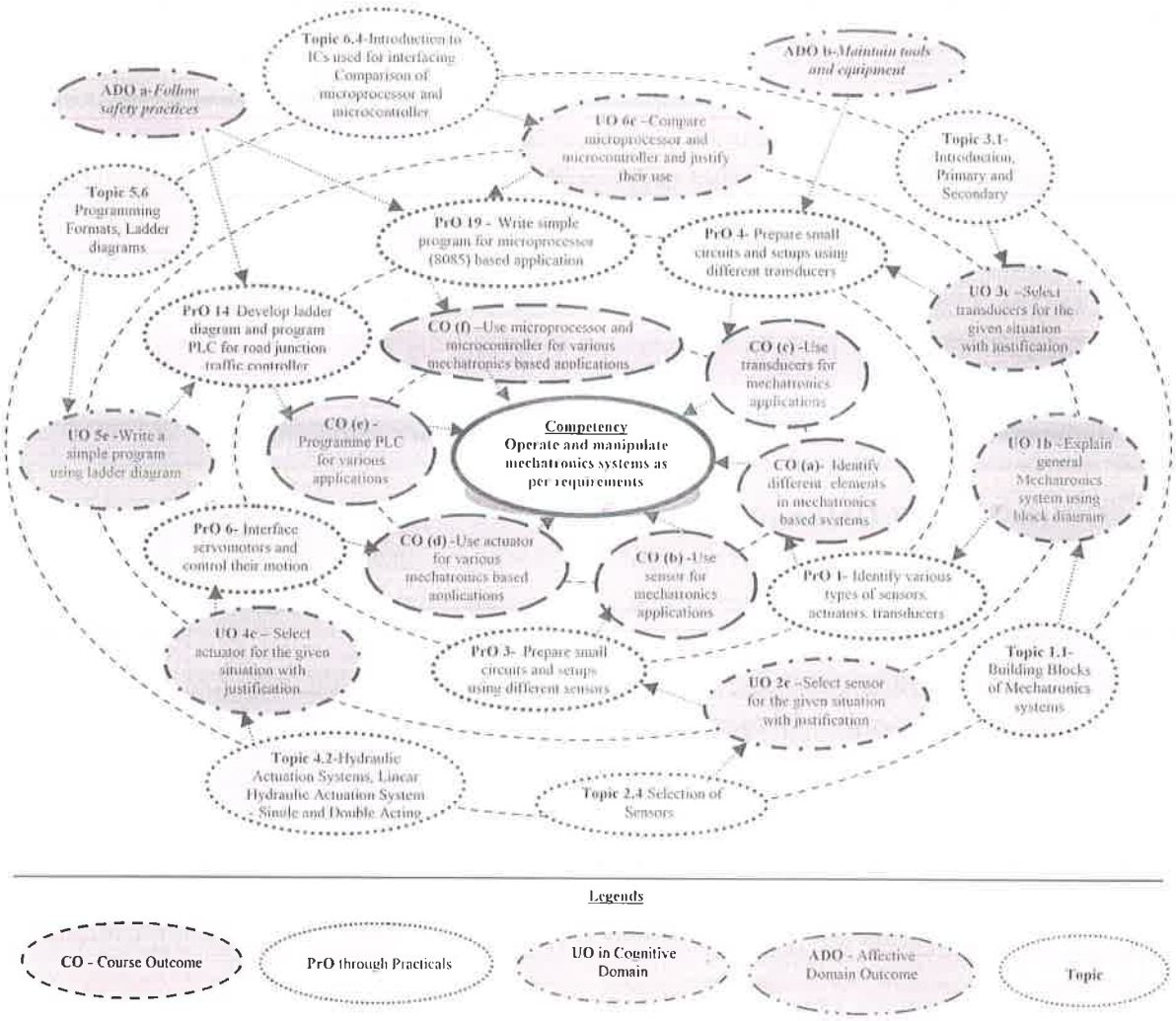

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Select sensors, actuators, transducers, PLC and Microcontrollers for given application with justification.	II, III, IV, V,VI	02*
2	Prepare small circuits using different sensors Proximity Sensor –NPN.NO.PNP, Limit Switch, Opto sensors, Pressure sensors, Motor-24V DC, interfacing facility with PLC used in Mechatronics systems	II, III,IV,V	02*
3	Verify the functions of Logic Gates for the given Ladder Diagram by using PLC	III, IV,V	02*
4	Prepare small circuits using different transducers like linear and rotary transducers with PLC	IV,V	02
5	Develop ladder diagram and program PLC for Timers and Counters	III,IV,V	02*
6	Prepare small circuits for door open and close application using different actuators with PLC.	III,IV,V	02
7	Develop ladder diagram and program PLC for Temperature control.	III,IV,V	02*
8	Build Electro-pneumatic circuits for given application.	III,IV, V	02*
9	Develop ladder diagram and program PLC for simulation of a pedestrian traffic controller.	III, IV, V	02*
10	Develop ladder diagram and program PLC for Lift / elevator control	III, IV, V	02*
11	Develop ladder diagram and program PLC for Washing machine control	III, IV, V	02
12	Develop ladder diagram and program PLC for Tank level control	III, IV, V	02
13	Develop ladder diagram and program PLC for Soft drink vending machine control	III, IV, V	02
14	Write a program for 8051 microcontroller for speed control of stepper motor.	IV,VI	02*
15	Develop a program for 8051 microcontroller for relay interfacing.	III,IV,VI	02
			30

Note

i. *A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12or 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	PLC Trainer Kit with 12 DI.12 DO.2AI and 2AO with ladder and SCADA	3,4,6,12,13
2	Basic Pneumatic Trainer Kit with manual and electrical controls/ PLC Control	3,4
3	Electro-pneumatic Trainer kit	10,
4	Basic Hydraulic Trainer Kit	11
5	Hydraulics and Pneumatics Systems Simulation Software	12,13
6	BLDC, stepper motor and drive circuit sets.	5
7	AC servo and VFD trainer kit	5,
8	Real Time Temperature Controller	2,3
9	PID Controller and DC Motor Speed controller	17,18
10	Servo controller using Open/Closed loop control system	7,8
11	Pneumatic Power circuit system	
12	Real Time Temperature Controller	17

S. No.	Equipment Name with Broad Specifications	PrO. No.
13	SCADA software (2000 points) with Siemens TIA portal free software educational bundle or equivalent Free Software	1,2,6
14	Pneumatic Power circuit system for Door close and open application, stamping application and raw material rejection system	6,9

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I Basic Mechatronics System	1a. Compare with block diagram the features of the traditional and Mechatronics system for the given example 1b. Describe the basic elements of the given closed loop system. 1c. Identify sensor, actuators, microprocessor techniques, software and mechanical components in the given diagram of the mechatronics based system 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,
Unit-II Transducers	2a. Classify the transducers. 2b. Select the relevant transducers for the given situation with justification	2.1 Introduction, Primary and Secondary Transducers, Working of Primary and Secondary Transducers, 2.2 Mechanical Device as Primary detectors, Electrical Transducers, Active and Passive Transducers, Analog and Digital Transducers.
Unit– III Sensors	3a. Classify the Sensors. 3b. Explain the working of the given sensor and Write specifications, features of the sensors. 3c. Select the relevant sensor for the given situation with	3.1 Introduction, Need of Sensors, Contact and Non - Contact Type of Sensors, Classification. 3.2 Working and Application of- Potentiometer Sensors, Strain Gauge Elements, Capacitive Elements, Eddy Current, Proximity Sensors, Inductive

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	justification.	Proximity Sensors, Light Sensors, Pressure Sensors, Pneumatic Sensors, Pyro electrical Sensors, Piezoelectric Sensors. 3.3 Selection of Sensors
Unit –IV Actuators	4a. Explain with sketches the working of the given Hydraulic actuator with sketch and block diagrams. 4b. Prepare the specifications and features of the given hydraulic, mechanical and electrical actuator. 4c. Select the relevant actuator for the given situation with justification.	4.1 Introduction and Classification of Actuators, Need and Scope. 4.2 Hydraulic Actuation Systems, Linear Hydraulic Actuation System - Single and Double Acting, Pneumatic Actuation Systems - Gear Motors and Vane Motors, 4.3 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. 4.4 Selection of Actuaators
Unit-V Programmable Logic Controller	5a. Explain with sketches the working of the given PLC. 5b. Write specifications and features of the given PLC and power supply. 5c. Select the relevant PLC and power supply for the given situation with justification. 5d. Write a simple program using ladder diagram for the given situation.	5.1 Introduction, definition, Basic PLC functions, PLC block diagram, Difference between relay panel and PLC, 5.2 Power supply, input/output modules (analog, digital) concepts of sink/source, set/reset, latch/unlatch, 5.3 Selection of a PLC, Programming equipment, 5.4 Programming Formats, Ladder diagrams and sequence listing, PLC auxiliary commands and functions,
Unit-VI Microcontroller and Applications of Mechatronics Systems	6a. Explain 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. Explain with sketches the working of the mechatronics devices in the given	6.1 Comparison of microprocessor and microcontroller 6.2 Introduction, Architecture-Pin Configuration of 8051 Microcontroller 6.3 Introduction to interfacing of D/A converters and A/D converters with 8051 microcontroller. 6.4Applications-Temperature control-Stepper motor control 6.4 Application of Mechatronics systems in

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	appliance.	Washing Machines,

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

10. SUGGESTED STUDENT ACTIVITIES

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

a. 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 fluid power circuits to control
   i. Velocity
   ii. direction and
   iii. force of single and double acting actuators
b. Perform speed control of AC and DC drives.
c. Dissemble a digital weighing machine and understand how weight is measured.
d. Dissemble a digital thermometer and try to understand how temperature is measured.
e. 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: 0074636435
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