Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IE**

Semester : **Sixth**

Course Title : **Mechatronics**

Course Code : **22643**

1. RATIONALE

Mechatronics is a rapidly developing interdisciplinary field of engineering, which comprises the development of various computers integrated electro-mechanical systems. It is an integration of mechanical engineering, electrical & electronics engineering, computer engineering, control and instrumentation engineering. This integration facilitates the production of complex engineering systems with a high level of performance, reliability at affordable price. Due to these aspects, industrial sector is rapidly adopting such integrated systems. To adopt such systems, industries are in need of the diploma engineers to install, operate and maintain these systems.

2. COMPETENCY

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

- **Install, Operate and Maintain various types of mechatronic systems.**

3. COURSE OUTCOMES (COs)

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

a) Install and Maintain the sensors and transducers of mechatronics systems.
b) Install and Maintain CNC Machine.
c) Install and Maintain pneumatic components in mechatronic systems.
d) Install and Maintain hydraulic components in mechatronic systems.
e) Install and Maintain different components of robotic systems.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

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

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

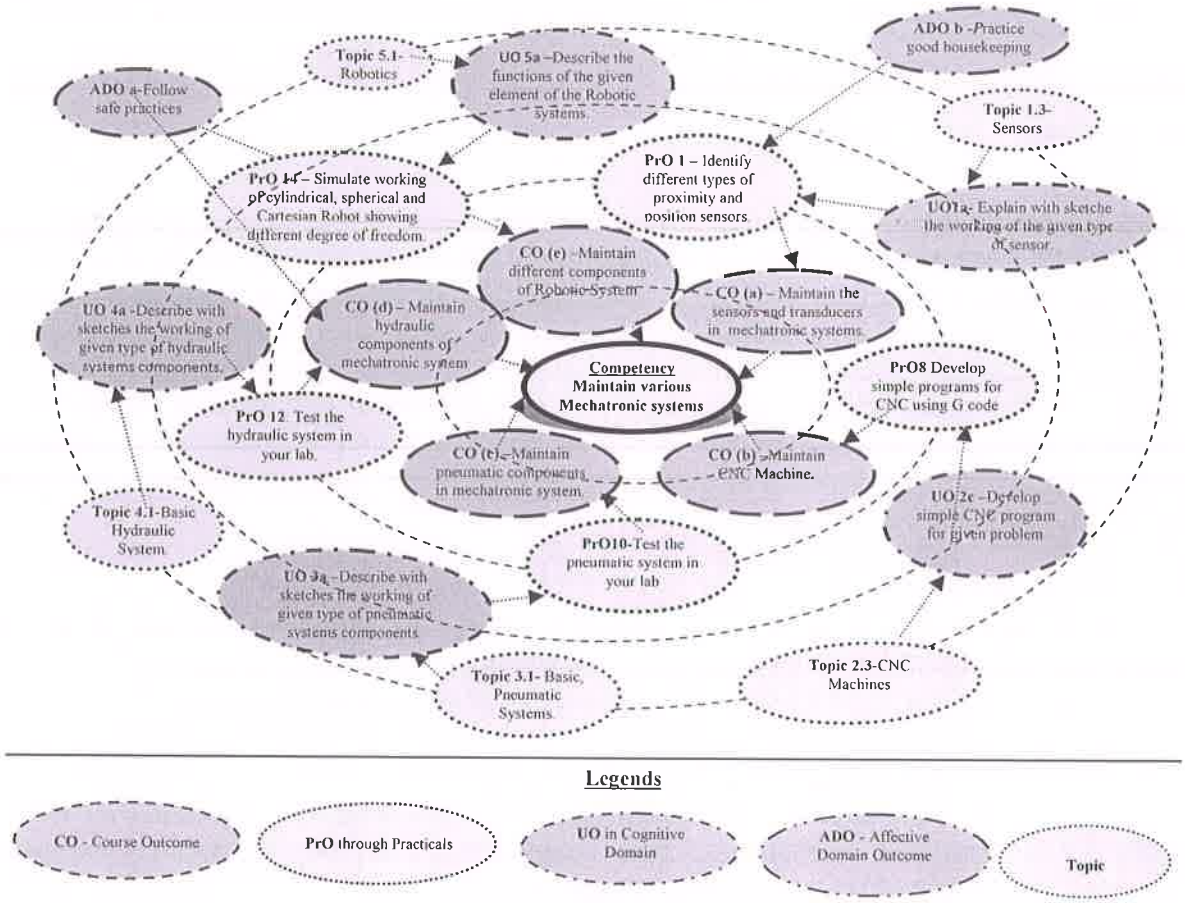

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

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

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify different types of proximity and position sensors.	I	02
2	Choose the appropriate sensors for the given applications.	I	02*
3	Use relevant transducer for velocity, motion, acceleration and torque sensors for the specified applications.	I	02
4	Measure the speed of the given motor using stroboscope sensor.	I	02*
5	Identify various components of translational mechanical system	II	02
6	Identify various components of rotational mechanical system	II	02
7	Identify various components of electrical system.	II	02*
8	Develop simple programs for CNC using G code and M code.(open source software)	II	02*
9	Troubleshoot pneumatic system of mechatronic systems.	III	02
10	Test the pneumatic system available in your Lab.	III	02*
11	Troubleshoot hydraulic system of mechatronic systems.	IV	02
12	Test the hydraulic system available in your Lab.	IV	02*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
13	Troubleshootdifferent mechanical actuators of mechatronic systems	IV	02
14	Simulate the working of cylindrical, spherical and Cartesian robot showing different degree of freedoms.	V	02
15	Simulate the working of pick and place robot. (Matlab / simulink software)	V	02*
16	Demonstrate the working of Automated Guide Vehicle (Virtual Lab / Demonstration in Industry/Videos).	V	02
17	Demonstrate the working ofAnti-lock Braking System (ABS)(Virtual Lab / Demonstration in Industry/Videos).	V	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	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		**100**

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

a) Follow safety practices.
b) Practice good housekeeping.
c) Practice energy conservation.
d) Work as a leader/a team member.
e) Follow ethical Practices.

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

- 'Valuing Level' in 1st year
- 'Organisation Level' in 2nd year

- 'Characterization Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTSREQUIRED

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

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Sensors, transducers and signal conditioners demonstration boards.	01, 02 ,03 and 04
2	Small physical models of different types of system (if not available use virtual labs or any other relevant sources).	05 to 07
3	CNC machine.	08
4	Pneumatic system component trainer kit.	09, 10
5	Hydraulic system component trainer kit.	11, 12, 13
6	Small robotics model/proto type/ (or virtual lab).	14, 15
7	AGV and ABS simulation (small physical model or virtual lab)	16, 17

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught 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 Sensors for Mechatronics system.	1a. Describe with sketches the function of the given type(s) of sensors and transducers. 1b. Compare the given types of sensorsbased on given criteria. 1c. Explain with sketches the working of the given type(s) of sensor. 1d. Justify the need for the signal conditioning circuits in the given mechatronics system. 1e. Describe the troubleshooting procedure for the specified problem of the given type of sensor or transducers.	1.1 **Mechatronics system architecture:** Sensors, signal conditioners, PLC/ Embedded controllers, pneumatic, hydraulic and electrical actuators. 1.2 **Introduction to Real Time Mechatronics System:** Block diagram & Functions: Real time mechatronics system(Flexible Manufacturing System: FMS), Computer Integrated Machines: CIM)) 1.3 **Sensors:** Construction, principle of operation and application) i. **Proximity and position Sensors:** Photo electric sensors, Hall Effect sensors, optical encoder, eddy current proximity sensor, inductive sensor, capacitive sensor. ii. **Velocity Sensors:** Electromagnetic transducers, Tacho generators iii. **Motion Sensors:** Stroboscope, pyro electric sensors. iv. **Acceleration sensors:** strain gauge accelerometer, piezoelectric accelerometer, LVDT accelerometer. v. **Pressure sensors:** load cells

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		vi. **Torque sensors :** Torque measurement using strain gauge, torque measurement using torsion bar (optical method, capacitive method, proximity sensor method, stroboscope method). **1.4 Signal conditioners:** Need of isolators, filters, amplifiers, fluid amplifiers, optical amplifiers and data converters in mechatronics systems.
Unit –II Basic Mechatronics systems.	2a. Describe with sketches the building blocks of the given system model. 2b. Built a model from given system component. 2c. Develop simple CNC programs for given problem. 2d. Describe with sketches general configuration of CNC systems.	2.1 **Basic System Models:** Introduction, mechanical system building blocks – Translational and Rotational system building up a mechanical system model ,Electrical system building blocks - building up a model for an electrical system. **2.2 System Models:** Introduction, rotational-translational systems, electro-mechanical systems – System components & function. (No mathematical modelling) **2.3 CNC Machines:** General configuration of CNC system, advantages of CNC, part programming of CNC machines, G codes and M codes, small application programs, CNC based drilling machine.
Unit-III Pneumatic System	3a. Explain the working of given type of pneumatic system components. 3b. Explain the working principle of given type(s) of pneumatic actuator. 3c. Identify the use of given type(s) of pneumatic component. 3d. Describe the procedure to maintain the given type(s) of pneumatic system component.	3.1 **Basic Pneumatic Systems:** Basic, Pneumatic system circuit, Air compressors, filters and regulators, air treatment, valves 3.2 **Actuators :**Principle of operation of linear actuators (single acting cylinder, double acting cylinder) rotary actuators(rotating vane, gear type) and direction control valves (poppet valve, spool valve) 3.3 **Pneumatic System:** Applications, Advantages and Limitations.
Unit-IV Hydraulic System	4a. Explain the working of given type of hydraulic system components. 4b. Explain the working principle of given type(s) of hydraulic actuator. 4c. Explain with sketches the working	4.1 **Basic Hydraulic systems:** primary components of hydraulic systems: Reservoir, hydraulic pumps, Hydraulic motor, filters and pressure regulation

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	of the given mechanical actuating system. 4d. Identify the use of given type(s) of Hydraulic system components. 4e. Describe the procedure to maintain the given type(s) of Hydraulic system components.	4.2 **Actuators :**Principle of operation of linear actuators (single acting cylinder, double acting cylinder) rotary actuators(rotating vane, rack and pinion type) 4.3 **Mechanical Motion Element:** cams, gear, belt , rack and pinion and bearings (principle of operation and application) 4.4 **Hydraulic System**: Applications, Advantages and Limitation
Unit – V Robotics and Mechatronics Applications	5a. Describe with sketches the functions of the given element of the Robotic systems. 5b. Explain with sketches the given degree of freedom for a robot. 5c. Explain with sketches the working of the given robotics application. 5d. Compare the given types of robot on the basis of degree of freedom, construction, end effectors used and applications. 5e. Describe the procedure to maintain the given robotic system for the specified application.	5.1 **Robotics:** Block diagram and function of each component (sensors, drive system, control system, end effectors), construction and degrees of freedom of cylindrical, spherical and Cartesian robots, applications of robot. 5.2 Microcontroller based antilock brake system. 5.3 Microcontroller based pick and place robot. 5.4 Microcontroller based car park barrier system. 5.5 AGV (Automated Guided Vehicle): Basic concept, block diagram, role of mechatronic in guided vehicle

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

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Sensors for Mechatronics system.	14	06	08	06	20
II	Basic Mechatronics systems.	06	02	04	04	10
III	Pneumatic System	10	04	06	04	14
IV	Hydraulic System	10	04	06	04	14
V	Robotics & Mechatronics Applications	08	04	04	04	12
Total		**48**	**20**	**28**	**22**	**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 manuals based on practical performed in laboratory.
b) Give seminar on relevant topic.
c) Library/Internet survey regarding different data books and manuals.
d) Prepare power point presentation on "Mechatronic Systems".
e) Undertake a market survey of different manufacturer of "Mechatronic Systems".

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-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 is given here. Similar micro-projects could be added by the concerned faculty:

a) Design a microcontroller based robotarm to pick and place ferrous material from one place to another place (zero to 180 degree).

b) Design a microcontroller based AVCS for speed control and mirror adjustment for car. (Use relevant speed measurement sensor for speed control and simple small dc motor for mirror adjustment)
c) Design a controller based ABS (Use of linear actuator).
d) Design a small model for hydraulic system.
e) Design a small model for pneumatic system.
f) Design a model to demonstrate the use of any one velocity sensor.
g) Demonstrate the use of any one motion sensor using simulation.
h) Demonstrate the use of any one pneumatic actuator using simulation.
i) Demonstrate the use of any one mechanical actuator using simulation.

Note: To implement above micro project actual physical model or simple computer simulation is expected.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Mechatronics - Integrated Mechanical electronic systems.	Ramachandran,K. P.; Vijayaraghavan,G. K.; Balasundaram, M.S.	Wiley-India, New Delhi First edition, 2008 ISBN: 978-81-265-1837-1
2	Mechatronics	Bolton,W.	Pearson Education, New Delhi, 2003,3rd Edition, ISBN: 0131216333
3	Mechatronics	Rajput, R. K.	S. Chand & Co. ltd. New Delhi,1st Edition,, ISBN: 81-219-2859-1
4	Mechatronics	Singh,M. D.; Joshi, J. G.	PHI Learning Private Limited, New Delhi,2006,ISBN: 8120329864

14. SOFTWARE/LEARNING WEBSITES

a) Automation studio (educational version).
b) Autosar (educational version)
c) Mechatronics -www.youtube.com /mechatronics
d) www.nptel.ac.in/downloads/112103174/
e) Basics of Mechatronics - https://www.youtube.com/watch?v=Ro_tFv1iH6g.
f) Simulation of Mechatronics systems -www.youtube.com/watch?v=DbGTwvyT_Co.
g) Understanding control system - www.youtube.com/watch?v=pVAY2zOy0vU.
h) AVCS – Cruise Control - https://www.youtube.com/watch?v=zq1RSDNRh3Q.
i) CNC machine - https://www.youtube.com/watch?v=-Qn-KCU4cWU
j) System variations - www.youtube.com/watch?v=G4OLOjY4MpQ.
k) ABS - www.youtube.com/watch?v=NCkwnm_lsPc.