2022-23

MECHANICAL ENGINEERING

MECHATRONICS

PREPARED BY
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Techno India NJR Institute of Technology

Course File

5ME3-01: MECHATRONIC SYSTEMS

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5ME3-01: MECHATRONIC SYSTEMS

Credit: 2 **Max. Marks: 100(IA: 20, ETE:80)**
2L+0T+0P **End Term Exam: 2 Hours**

SN	CONTENTS	Hours
1	Introduction: Objective, scope and outcome of the course.	1
2	Overview of Mechatronics: Historical perspective, Definition, Applications, Block diagram of Mechatronic system, Functions of Mechatronics Systems, Systems Engineering, Verification Vs Validation, Benefits of mechatronics in manufacturing.	2
	Electrical and Electronic Systems: Electrical circuits and Kirchhoff's laws, Network Theorems and AC circuit Analysis, Transformers, Analog Devices, Signal Conditioning, Digital Electronics, Data Acquisition systems.	3
3	Modeling, Analysis and Control of Physical Systems: Basics of System Modeling: LTI and LTV systems, Need for modeling, Types of modeling, Steps in modeling, Building blocks of models, Modelling of one and two degrees of freedom systems, Modeling of Electro-mechanical systems, Mechanical Systems, Fluid systems, Thermal systems; Dynamic Responses, System Transfer Functions, State Space Analysis and System Properties, Stability Analysis using Root Locus Method, Stability Analysis using Bode Plots, PID Controllers (with and without Time Delay)	5
4	Sensors and Actuators: Static characteristics of sensors and actuators, Position, Displacement and Proximity Sensors, Force and torque sensors, Pressure sensors, Flow sensors, Temperature sensors, Acceleration sensors, Level sensors, Light sensors, Smart material sensors, Micro and Nano sensors, Selection criteria for sensors, Actuators: Electrical Actuators (Solenoids, Relays, Diodes, Thyristors, Triacs, BJT, FET, DC motor, Servo motor, BLDC motor, AC motor, Stepper motors), Hydraulic and Pneumatic actuators, **Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.**	7
5	Microprocessors, Microcontrollers and Programmable Logic Controllers: Logic Concepts and Design, System Interfaces, Communication and Computer Networks, Fault Analysis in Mechatronic Systems, Synchronous and Asynchronous Sequential Systems, Architecture, **Microcontrollers.**	3
6	Programmable Logic Controllers (PLCs): Architecture, Number Systems Basics of PLC Programming, Logics, Timers and Counters, Application on real time industrial automation systems.	4
	Case Studies: Design of pick and place robot, Car engine management system, Automated manufacturing system, Automatic camera, Automatic parking system, Safety devices and systems.	3
	TOTAL	28

Course Overview:

The word mechatronics is composed of "mecha" from mechanism and the "tronics" from electronics. It is the synergistic integration of mechanical engineering, with electronics and intelligent computer control in the design and manufacturing of industrial products and processes. Mechatronics generally involves (i) implementing electronics control in a mechanical system (ii) enhancing existing mechanical design with intelligent control and (iii) replacing mechanical component with an electronic solution. This course will cover all aspects related with mechatronics such as sensors and transducers, actuators and mechanisms, signal conditioning, microprocessors and microcontrollers, modeling & system response and design and mechatronics.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Knowledge	Understand key elements of Mechatronics system, representation into block diagram
2	Comprehension	Understand & describe principles of sensors, its characteristics, interfacing with DAQ microcontroller
3	Application	Understand the concept of PLC system and code the ladder programming, and significance of PLC systems in industrial application
4	Application	Understand control actions such as Proportional, derivative and integral and study its significance in industrial applications
5	Application	Understand about PLC.

Prerequisites:

1. Students must have done a course on fundamentals of Mathematics - Calculus, differential equations, numerical methods.
2. Students must have done a course on fundamentals of C programming.
3. Students must have done a course on Basics of Electrical and electronics engineering.

Course Outcome Mapping with Program Outcome:

Mechatronics Year of study: 2021-22															
Course Outcome	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	2	0	0	0	0	0	3	2	1
CO2	3	2	2	2	2	1	0	0	0	0	0	0	3	2	1
CO3	2	2	2	2	1	0	0	0	0	0	0	0	2	2	1
C04	2	2	2	1	1	1	0	0	0	0	0	0	2	2	1
C05	2	2	2	1	1	1	0	0	0	0	0	0	2	2	1
Average	2.50	2.00	2.00	1.75	1.50	1.00	0.50	0.00	0.00	0.00	0.00	0.00	2.50	2.00	1.00

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	**INTRODUCTION**
2	**2**	**OVERVIEW OF MECHATRONICS:** Students will observe historical perspective, definitions and applications of mechatronics systems, Block diagram of Mechatronic system, Functions of Mechatronics Systems.
3	2	Students will understand systems engineering, Verification Vs Validation, Benefits of mechatronics in manufacturing
4	2	Students will able to understand electrical circuits and Kirchhoff's laws, Network Theorems and AC circuit Analysis.
5	2	Students will able to understand transformers, Analog Devices, Signal Conditioning.
6	2	Students will understand the basics of digital electronics, data acquisition systems.
7	**3**	**MODELING, ANALYSIS & CONTROLOF PHYSICAL SYSTEMS:** Students will understand the basics of system modeling: LTI and LTV systems, Need for modeling, Types of modeling
8	3	Students will able to understand the steps in modeling, Building blocks of models, Modelling of one and two degrees of freedom systems, Modeling of Electromechanical systems
9	3	Students will able to do modelling of Mechanical Systems, Fluid systems, Thermal systems.
10	3	Students will observe the dynamic responses, System Transfer Functions, State Space Analysis and System Properties.

11	3	Students will able to perform stability analysis using Root Locus Method, Stability Analysis using Bode Plots, PID Controllers (with and without Time Delay)
12	**4**	**SENSORS & ACTUATORS:** Students will understand the static characteristics of sensors and actuators, Position, Displacement and Proximity Sensors.
13	4	Students will able to identify force and torque sensors, Pressure sensors, Flow sensors.
14	4	Students will able to identify temperature sensors, Acceleration sensors, Level sensors, Light sensors, Smart material sensors.
15	4	Students will able to identify micro and nano sensors, Selection criteria for sensors.
16	4	Students will understand the basics of actuators: Electrical Actuators (Solenoids, Relays, Diodes, Thyristors, Triacs, BJT, FET.
17	4	Students will understand the basics of DC motor, Servo motor, BLDC motor, AC motor, Stepper motors),
18	4	Students will understand the basics of Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys
19	**5**	**MICROPROCESSORS, MICROCONTROLLERS AND PROGRAMMABLE LOGIC CONTROLLERS:** Students will understand Logic Concepts and Design, System Interfaces
20	5	Students will understand **c**ommunication and Computer Networks, Fault Analysis in Mechatronic Systems,
21	5	Students will understand Synchronous and Asynchronous Sequential Systems, Architecture, Microcontrollers.
22	**6**	**PROGRAMMABLE LOGIC CONTROLLERS (PLCS)**
23	6	Students will know the number Systems Basics of PLC Programming,
24	6	Students will know the Logics, Timers and Counters
25	6	Students will know the application on real time industrial automation systems.
26	6	Students will be able to design of pick and place robot
27	6	Students will be able to design Car engine management system, Automated manufacturing system.
28	6	Students will be able to locate and install automatic camera, Automatic parking system, Safety devices and systems.

Text Books

1. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering by W. Bolton
2. “Principles, Concepts and Applications – Mechatronics” by Nitaigour and Premchand Mahilik
3. “Introduction to Mechatronics and Measurement Systems” by David G Alciatore and Michel BiHistand

Assessment Methodology:

1. Assignments one from each unit.
2. Midterm subjective paper where they have to solve basic questions with numerical and derivations from each unit. (Twice during the semester)
3. Final paper at the end of the semester subjective.

Teaching and Learning resources:

MOOC Courses: https://nptel.ac.in/courses/112/107/112107298/

020831

5E1321

Roll No. _____ Total No. of Pages : 2

5E1321

B.Tech. V Semester (Main) Examination, Nov. - 2019
ESC Mechanical Engg.
5ME3-01 Mechatronic Systems
(Common For ME,AE)

Time : 2 Hours **Maximum Marks : 80**

Min. Passing Marks : 28

Instructions to Candidates:

*Attempt **all five** questions from **Part A**, **four** questions out of **six** questions from **Part B** and **two** questions out of **three** from **Part C**.*

(Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly). Units of quantities used/calculated must be stated clearly.

Part - A

(Answer should be given up to **25** words only)

All questions are **compulsory** **(5×2=10)**

1. Describe the key elements of the Mechatronics system.
2. Consider an Electrical resistance strain gauge with a resistance of 100Ω and a gauge factor of 2.0. What is the change in resistance of the gauge when it is subjected to a strain of 0.001?
3. During a temperature measurement using bimetallic strips, an aluminium rod of 12 m length at 28°C expands. Calculate the expansion when the temperature changes from 0°C to 120°C? Assume the thermal expansion coefficient for aluminium as 25×10^{-6}/°C.
4. Explain with diagram the working of PVDF tactile sensor.
5. Compare physical components of hydraulic and pneumatic system along with advantages and disadvantages?

Part - B

(Analytical/Problem solving questions)

Attempt any **four** questions **(4×10=40)**

1. Name and explain any two examples of sequential control systems.
2. Consider a parallel rectangular plate air - spaced capacitor of 30×20 cm^2 and the distance between the plates is 1.2 mm. If the relative permittivity for air is 1.006. Calculate the displacement sensitivity of the device by neglecting the displacement of the central plate. Assume permittivity of the plates as 8.854×10^{12} F/m.

3. Develop an op - amp circuit that can provide an output related to the input voltage by $V_0 = 5.5V_1 + 10V_2 + 4$.

4. A negative feed back closed - loop system was subjected to 10 V and the system has a forward gain of 2 and feedback gain of 0.5. Determine (a) the output voltage (b) the error voltage. It is given that G(s) = 2, H(s) = 0.5 and R(s) = 10V.

5. Explain the principle of the brushless D.C. permanent magnet motor.

6. Describe in detail with diagrams, various pressure sensors and temperature sensors.

Part - C

(Descriptive/Analytical/Problem Solving/Design Questions)

Attempt any **two** questions **(2×15=30)**

1. Derive the relationship between the height h_1,h_2 and time for the hydraulic system shown in Figure 1 given below. Neglect inertance.

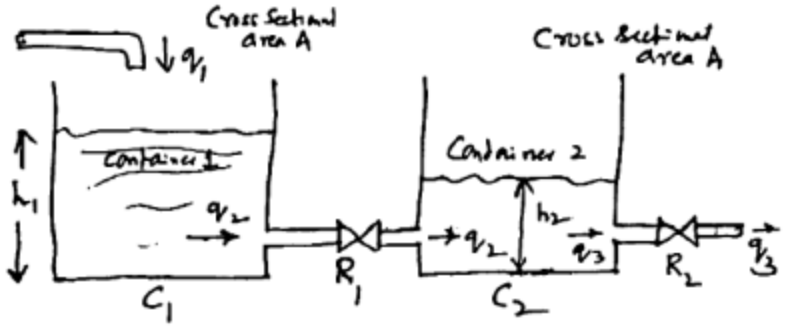

Figure 1

Explain the factors influence to design the Mechatronics system with one practical Example.

a) Explain for a microprocessor, the roles of **(4)**

i) Accumulator

ii) Status

iii) Memory address

iv) Program counter registers

b) Draw a block diagram of a basic micro controller and explain the function of each subsystem. **(6)**

c) What are various electrical Actuators Describe any four of them. **(5)**