STRUCTURE AND SYLLABI
OF
COLLABORATIVE
MASTER OF TECHNOLOGY (M.TECH)
IN
MECHATRONICS

PROPOSED BY
SCHOOL OF MECHATRONICS AND ROBOTICS
IN COLLABORATION WITH THREE CSIR LABORATORIES
[CMERI (DURGAPUR), CEERI (PILANI) AND CSIO (CHANDIGARH)]

2020-2021

INDIAN INSTITUTE OF ENGINEERING SCIENCE AND TECHNOLOGY, SHIBPUR

Master of Technology in Mechatronics- 2 year, 4 semester Course Structure

First Semester

Sl. No	Paper	Credit	Note
1	Paper-I (Dep. Core)	3	1. Paper – I, II and III are **compulsory subjects** for the particular specialization and are mentioned in Table A. 2. Paper – IV is **departmental elective** subject, to be selected from the Table B. 3. Paper – V is an **open elective**, to be selected from subjects offered by other departments / schools / centers (subject to availability). Table-C summarizes the subjects offered by School of Mechatronics and Robotics, which can be opted by students from other departments / schools / centers. 4. Lab – I, II, III are typically related to Paper – I, II and III mentioned in Table D.
2	Paper-II (Dep. Core)	3	
3	Paper-III (Dep. Core)	3	
4	Paper-IV (Dep. Elec.)	3	
5	Paper-V (Open Elec.)	3	
	Theory Subtotal	**15**	
6	Lab – I	2	
7	Lab – II	2	
8	Lab – III	2	
	Practical Subtotal	**6**	
	Total Credit	**21**	

Specialization: ***Mechatronics***

Table A: Departmental Core Papers for the specialization (Paper – I, II, III)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5101	Mechatronics System Design	3	0	0	3	3	100
2	MC5102	Embedded System Application	3	0	0	3	3	100
3	MC5103	Advanced Control Systems	3	0	0	3	3	100

Table B: Departmental Elective Papers for the specialization (Paper – IV)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5121	Fundamentals of Electronics Engineering*	3	0	0	3	3	100
2	MC5122	Fundamentals of Mechanical Engineering#	3	0	0	3	3	100

* Fundamental of Electronics Engineering (MC5121) is for the students having Mechanical, Mechatronics, Production, Automobile, Manufacturing and Aeronautical background.

Fundamental of Mechanical Engineering (MC5122) is for the students having Electrical, Electronics, Telecommunication, Instrumentation and Control background.

Open Elective Papers for the specialization (Paper – V)

Students studying M. Tech. in Mechatronics will opt a subject offered by other departments / schools / centers in the First Semester as Open Elective. The Open Elective Subject offered by School of Mechatronics and Robotics, given in Table – C, can be opted by students from other departments / schools / centers.

Table C: Open Elective Papers for other specialization

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5161	Product Design and Development	3	0	0	3	3	100

Table D: Departmental Labs for the specialization (Lab – I, II, III)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5171	Mechatronics Laboratory	0	0	3	3	2	100
2	MC5172	Automation and Robotics Lab	0	0	3	3	2	100
3	MC5173	Control Systems Lab	0	0	3	3	2	100

Second Semester

Sl. No	Paper	Credit	Note
1	Paper - VI (Dep. Core)	3	1. Paper – VI, VII and VIII are **Compulsory Subjects** for the particular specialization and are mentioned in Table F. 2. Paper – IX is **Departmental Elective** subject, to be selected from the Table G. 3. Paper – X is an **Open Elective**, to be selected from subjects offered by other departments / schools / centers (subject to availability). Table-H summarizes the subjects offered by School of Mechatronics and Robotics, which can be opted by students from other departments / schools / centers.
2	Paper - VII (Dep. Core)	4	
3	Paper - VIII (Dep. Core)	3	
4	Paper-IX (Dep. Elec.)	4	
5	Paper-X (Open Elec.)	3	
	Theory Subtotal	**17**	
6	M. Tech Project Part - I (Term Paper)	4	
7	Term Paper Seminar and Viva-voce	2	
	Practical Subtotal	**6**	
	Total Credit	**23**	

Specialization: **Mechatronics**

Table F: Departmental Core Papers for the specialization (Paper – VI, VII, VIII)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5201	Robotics	3	0	0	3	3	100
2	MC5202	Machine Learning in Mechatronics	3	1	0	4	4	100
3	MC5203	Signal Processing and Applications	3	0	0	3	3	100

Table G: Departmental Elective Papers for the specialization (Paper – IX)

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5221	CAD/CAM Automation and Prototype Development[§]	3	1	0	4	4	100
2	MC5222	Industrial Instrumentation and Prototype Development[¥]	3	1	0	4	4	100

[§] CAD/CAM Automation and Prototype Development (MC5221) is for the students having Electrical, Electronics, Telecommunication, Instrumentation and Control background.

[¥] Industrial Instrumentation and Prototype Development (MC5222) is for the students having Mechanical, Mechatronics, Production, Automobile, Manufacturing and Aeronautical background.

Open Elective Papers for the specialization (Paper – X)

Students studying M. Tech. in Mechatronics need to opt a subject offered by other departments / schools / centers in the Second Semester as Open Elective. The Open Elective Subject offered by School of Mechatronics and Robotics, given in Table – H, can be opted by students from other departments / schools / centers.

Table H: Open Elective Papers for other specialization

Sl. No	Subject code	Subject Name	Class Load/Week			Total load (h)	Credit	Marks
			L	T	P			
1	MC5261	Industry 4.0	3	0	0	3	3	100
2	MC5262	Artificial Intelligence for Robotics	3	0	0	3	3	100

Table I: M.Tech Project Part-I

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	MC5291	M. Tech. Project Part - I (Term Paper)	8	4	200
2	MC5292	Term Paper Seminar and Viva-voce		2	100

Third Semester

Sl. No	Paper	Credit	Note
1	M. Tech. Thesis Part - II (Progress Report)	12	For M. Tech Thesis Part - II (Progress Report), the student will submit the details of work done for the M. tech Thesis during the third semester, and findings (if any). Submission will be followed by a seminar and viva-voce.
2	Progress Report Seminar and Viva-voce	6	
	Total Credit	**18**	

M. Tech Project Part - II

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	MC6191	M. Tech. Thesis Part - II(Progress Report)	24	12	300
2	MC6192	Progress Report Seminar and Viva-voce		6	100

Fourth Semester

Sl. No	Paper	Credit	Note
1	M. Tech. Final Thesis	22	For M. Tech Final thesis, the student will compile the entire work done for the M. Tech Project, along with the findings, in the form of a Thesis and submit at the end of the semester. Thesis submission will be followed by a Thesis seminar and viva-voce.
2	Thesis Seminar and Viva-voce	8	
	Total Credit	**30**	

M. Tech Project Part – III

Sl. No	Subject code	Subject Name	Total load (h)	Credit	Marks
1	MC6291	M. Tech. Final Thesis	30	22	400
2	MC6292	Thesis Seminar and Viva-voce		8	200

Total Credit: 21 + 23 + 18 + 30 = 92

Program Educational Objectives (PEO)

1.Apply engineering knowledge, critical thinking and problem solving skills with multidisciplinary Engineering expertise.

2.Work or pursue higher education in multicultural, multilingual and multinational environment for lifelong learning

3.Develop innovative and sustainable products in engineering-related fields for societal improvement

Program Outcomes (PO)

1.An ability to independently carry out research /investigation and development work to solve practical problems

2.An ability to write and present a substantial technical report/document

3.An ability to demonstrate a degree of mastery over the area as per the specialization of the program.

4.An ability to engage in life-long learning.

5.An ability to plan and execute projects

Detail Syllabus for Master of Technology in Mechatronics - 2 year, 4 semester Course

MC5101: MECHATRONICS SYSTEM DESIGN

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: The primary objective of mechatronics is to integrate the mechanical systems with electrical, electronics and computer systems and to provide a multidisciplinary approach to product development and manufacturing system design.

Sl No.	Course Outline	No. of Classes
1.	**Overview of Mechatronics :** Introduction to Mechatronics system, Mechatronics in manufacturing, Comparison between Traditional and Mechatronics approach.	03
2.	**Mathematical Modeling of Physical Systems :** Modeling of Mechanical, Electrical, Electromechanical, Thermal, Hydraulic and Pneumatic systems. system modelling with structured analysis, Modelling paradigms for Mechatronic System, Block Diagrams, Mathematical Models, Systems of Differential-algebraic Equations, Response Analysis.	14
3.	**Simulation Techniques**: Solution of model equations and their interpretation, zeroth, first and second order system, time response parameters, transfer function and frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis, design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment.	13
4	**Selection of Transducers :** Transducers for Mechatronic Systems and their Characteristics, Different types of Sensors, Actuators: a comparative study, Selection criterion.	04
5.	**Case Studies**: Automatic Rain sensing/wiper activation system, drowsy-driver sensing system, Washing Machine, Copier.	05
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Explain the primary elements involved in mechatronics systems, Working principles and application of sensors and actuators.
2. Formulate and simulate model of a mechatronics system

Text Books:

1. Bolton, William. *Mechatronics: electronic control systems in mechanical and electrical engineering*. Pearson Education, 2003.
2. Fuller, James L. *Robotics*. Prentice Hall PTR, 1998.

Reference Books:

1. Schuler, Charles A., and William L. McNamee.*Industrial electronics and robotics*. McGraw-Hill, 1986.
2. Karnopp, Dean C., Donald L. Margolis, and Ronald C. Rosenberg. *System dynamics: modeling, simulation, and control of mechatronic systems*. John Wiley and Sons, 2012.
3. Bishop, Robert H. *The Mechatronics Handbook-2 Volume Set*. CRC press, 2002.

MC5102: EMBEDDED SYSTEM APPLICATIONS

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To impart knowledge about Microcontrollers, advanced embedded processor. To know the fundamentals about Embedded system and real time task scheduling.

Sl No.	Course Outline	No. of Classes
1.	**Introduction:** Introduction to embedded systems and basic computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations.	02
2.	**Microcontroller:** Introduction to 8051 Microcontroller and its families, Microcontroller Architecture, Programming model, Timer and Counters, Memory Interfacing, Addressing modes, Instruction sets, Assembly and C programming for Microcontroller.	05
3.	**Peripheral Interfacing and Communication:** Programmable Peripheral Interfacing, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing. SPI and I2C Controllers. LCD Controller, Interfacing of drivers for DC, Servo and Stepper Motor.	06
4.	**Advanced Embedded Processor:** Overview of embedded computing platforms; ARM Processor, FPGA's and SoC's	09
5.	**Real Time Operating System:** Introduction to Real-time systems and Real- time Scheduling, OS tasks, different types of scheduling algorithm, Semaphore, Message Queues, Mail Boxes and pipes, Timer Functions, Events, Memory Management Interrupt.	05
6.	**Sensors:** Fundamentals of Analog and digital sensor: Encoders, Hall sensors, gyroscopes; Capacitance transducers, piezoelectric sensors, Inductive Sensor (LVDT, RVDT), ultrasound transducers, tactile sensor, Bio-Sensors: ECG, EMG, EEG, Smart Gloves, speed sensor.	06
7.	**Actuators:** Hydraulic and Pneumatic actuators: Basic structure of Electro pneumatic and Electrohydraulic systems and controls. Electrical actuators: Stepper motors, Servo motors, brushless dc motors, Relay, Drive circuits for speed and position control (H-Bridge, Chopper, PWM etc).	06
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to
1. Learn the programming concept, peripheral interface for embedded processors.
2. Implement the knowledge of processing concept for designing the real time signal acquisition.

Text Books:

1. Vahid, Frank, and Tony Givargis. *Embedded system design: a unified hardware/software introduction*. John Wiley and Sons, Inc., 2001.
2. Kamal, Raj. *Embedded systems: architecture, programming and design*. Tata McGraw-Hill Education, 2011.
3. Liu, J. W.S. *Real-Time Systems.* Pearson Education, 2000.
4. Patranabis, D. *Sensors and Tranducers*. PHI Learning Pvt. Ltd., 2003.
5. Doebelin, Ernest O. *Measurement Systems-Application and Design*. McGraw-Hill, 2007.

6. Murty, D. V. S. *Transducers and Instrumentation*. PHI Learning Pvt. Ltd., 2010.

Reference Books:

1. Gajski, Daniel D., Frank Vahid, Sanjiv Narayan, and Jie Gong. *Specification and design of embedded systems*. Prentice-Hall, Inc., 1994.
2. Heath, Steve. *Embedded systems design*. Elsevier, 2002.
3. Marwedel, Peter. *Embedded system design*. Vol. 1. New York: Springer, 2006.
4. Berger, Arnold S. *Embedded systems design: an introduction to processes, tools, and techniques*. CRC Press, 2001.
5. Catsoulis, John. *Designing Embedded Hardware*. O'Reilly Media, Inc., 2005.
6. Ganssle, Jack. *The art of designing embedded systems*. Newnes, 2008.
7. Patterson, David A., and John L. Hennessy. *Computer organization and design MIPS edition the hardware/software interface*. Newnes, 2013

MC5103: ADVANCED CONTROL SYSTEMS

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: This course develops expertise in analysis and synthesis of controllers based on classical, modern and advanced controller design techniques for mechatronic systems.

Sl No.	Course Outline	No. of Classes
1.	**Introduction to Control System:** Role of control system in Mechatronics, Role of Modeling in Mechatronics Design, Open loop vs feedback control, continuous vs discrete time control, Analog vs digital control. Signals and Systems. Transfer Functions and Laplace transforms, state space representation.	04
2.	**Control System Design:** Time domain and frequency domain analysis; Root Locus Method; Stability - absolute and relative; Industrial motion control – PID controllers, controller tuning; State Space Design.	06
3.	**Digital Control:** Discrete time mathematics, z-transforms, sampling rates, zero and first order hold, time delays, computer control implementation concepts, discrete-domain state space realization.	05
4.	**Optimal Control:** State Observers; Kalman Filters as State Observers; Dynamic System LQ optimization – LQR design.	05
5.	**Robust Control:** Types of uncertainty; Sensitivity and complementary sensitivity; Small gain theorem; H_2 and H_∞ control.	05
6.	**Adaptive Control:** Basic adaptive control schemes, Self-Tuning Regulators, Model reference adaptive control, Adaptive pole placement techniques.	03
7.	**Intelligent Control:** Expert systems, fuzzy logic, artificial neural networks, evolutionary computing and hybrid systems, Reinforcement learning.	06
8.	**Design:** Case Studies on different Control Design Techniques; Future Trends	05
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Analyse nonlinear systems by phase-plane method, describing function method and lyapunov method

2. Derive discrete-time mathematical models in both time domain and z-domain.
3. Design optimal, robust and intelligent controllers

Text Books:

1. Ogata, Katsuhiko. *Modern control engineering*. Upper Saddle River, NJ: Prentice Hall, 2009.
2. Ogata, Katsuhiko. *Discrete-time control systems*. Englewood Cliffs, NJ: Prentice Hall, 1995.
3. Anderson, Brian DO, and John B. Moore. *Optimal control: linear quadratic methods*. Courier Corporation, 2007.
4. Glad, Torkel, and Lennart Ljung. *Control theory*. CRC press, 2014.
5. Karl J. Astrom, and Bjorn Wittenmark. *Adaptive Control.* Addison-Wesley, 1995.
6. T. Nanayakkara, F. Sahin, and M. Jamshidi. *Intelligent Control Systems with an Introduction to Systems of Systems*, CRC Press, 2008.

MC5121: FUNDAMENTALS OF ELECTRONICS ENGINEERING

(Bridge Course for the students having Mechanical, Mechatronics, Production, Automobile, Manufacturing and Aeronautical background)

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To provide basic knowledge on Electrical and Electronic circuits, Semiconductors, Amplifiers for the students coming from Mechanical engineering Background.

Sl No.	Course Outline	No. of Classes
1.	**Electric Circuits and Components:** Introduction, Basic Electrical Elements – Resistor, Capacitor, Inductor, Kirchhoff's Laws – Series Resistance Circuit, Parallel Resistance Circuit, Voltage and Current Sources and Meters, Thevenin and Norton Equivalent Circuits, Alternating Current Circuit Analysis, Power in Electrical Circuits, Transformer, Impedance Matching, Grounding and Electrical Interference, Electrical Safety	07
2.	**Semiconductor Electronics:** Review Semiconductors devices: Junction Diode – Zener Diode, Voltage Regulators, Optoelectronics Diodes, Analysis of Diode Circuit, Three terminal devices – BJT, JFET, MOSFET, Transistor as an amplifier, Four terminal devices, SCR, DIAC, Triac – Photo devices:- Photodiode, Photo transistor, Photo SCR, LED, LCD, Opto-isolator and Photo Coupled Pairs. Basics of OpAmp.	07
3.	**Introduction to Computing:** Number system, Logic gates, Boolean algebra, Combinational Logic circuits, Sequential Logic circuits – Flip flops (RS, JK, T, D), Register, Counters, Shift registers, Decoder, Encoder, MUX, DMUX, Memories – RAM, ROM, PROM, EPROM, EEPROM	06
4.	**Programmable Logic Controllers:** Construction, Types, Configuring I/O modules, Profibus and Fieldbus communication, Programming and Applications	05
5.	**Basic Programming Language:** Introduction to C and Python. Programming and application	10
6.	**Recent Trends:** Introduction to MEMS, NEMS, IoT Devices, basics of Wireless Sensor Networks, Case Studies and Future Trends.	04
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Know the working principle, and characteristics of the various electronics components.
2. Solve the complex problem of electrical and electronics circuit networks.
3. Design and develop the suitable electronic circuit for processing the sensor output and drive the actuator.

Text Books:

1. Nashelsky, Louis, and Robert L. Boylestad. *Electronic devices and circuit theory*. Prentice/Hall International, 1978.
2. Floyd, Thomas L. *Digital Fundamentals, 10/e*. Pearson Education India, 2011.
3. Floyd, Thomas L. *Electronic devices: conventional current version*. Pearson, 2012.
4. Malvino, Albert, and David Bates. *Electronic principles*. McGraw-Hill, Inc., 2006.

MC5122: FUNDAMENTALS OF MECHANICAL ENGINEERING

(Bridge Course for the students having Electrical, Electronics, Telecommunication, Instrumentation and Control background)

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To Provide Basic knowledge on Mechanical systems, Shaft, Gear-train, Coupling and Modelling and Dynamic analysis of electric Machines for students coming from Electrical/ Electronics/ Computer science Background.

Sl No.	Course Outline	No. of Classes
1.	**Basic Mechanical Engineering :** Review of basic engineering mechanics; Stress-strain under different types of loading; Stress and strain, elastic constants, Poisson's ratio; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine.	07
2.	**Modelling and Dynamic Analysis of Machine Components:** Design for static and dynamic loading; Failure theories; Lumped parameter modeling; Distributed parameter modeling of rod and beam like members; Response under dynamic loading.	04
3.	**Hydraulic and Pneumatic System:** Fluid power systems and components – constructional features, operating principles and characteristics.	04
4.	**Power and Motion Transmission Elements:** Shaft; Gear-train; Coupling; Belt; CAM; Screw-Nut; Bearings; Springs.	06
5.	**Overview of Manufacturing Processes:** Conventional methods of machining; CNC Machining; Additive Manufacturing	04
6.	**Kinematics and Dynamics:** Mechanisms**;** Computer-Aided Analysis of Mechanisms;Position and Displacement; Velocity; Acceleration; Static Force Analysis; Dynamic Force Analysis; Machine Vibration.	06
7.	**Engineering Design Software:** Basics of CAD software (AutoCAD/ Solidworks/etc.)	03

8.	**Smart Materials:** Materials for both actuation and sensing: Piezoelectric Materials, Magnetostrictive Materials, Materials for actuation: Shape Memory alloys, Magnetic shape memory material, Electro/Magneto rheological fluids; Design of shape memory actuator, selection of materials, Smart actuation and control, Applications of SMA, Electro-active polymers (EAPs): Ionic polymer metal composites (IPMC), Conductive polymers, Carbon nanotubes, Dielectric elastomers, Design and control issues for EAP actuators, Applications of EAP for biomimetic, tactile display and medical devices.	05
Total		**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Identify and quantify forces in a static framework
2. Analyze and select appropriate actuator
3. Analyze mechanisms for motion transformation
4. Select appropriate machining processes
5. Formulate equations of motion for mechanisms

Text Books:

1. Archer, Robert R., Stephen H. Crandall, Norman C. Dahl, Thomas J. Lardner, and M. Srinivasan Sivakumar, eds. *An introduction to Mechanics of Solids*. Tata McGraw-Hill Education, 2012.
2. Shigley, Joseph Edward. *Theory of machines*. Allied Publishers, 1995.
3. Shigley, Joseph Edward, and Charles R. Mischke. Mechanical Engineering Design. McGraw-Hill, 2005.
4. Ernst, Walter. Oil hydraulic power and its industrial applications. McGraw-Hill, 1949.
5. Esposito, Anthony. Fluid power with applications. Upper Saddle River: Prentice-Hall International, 2000.

MC5161: PRODUCT DESIGN AND DEVELOPMENT

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: The course aims at providing the basic concepts of product design, product features and its architecture with a focus on the front end processes. At the end of this course the student is expected to have an understanding of the overview of all the product development processes and knowledge of concept generation and selection tools.

Sl No.	Course Outline	No. of Classes
1.	**Introduction:** Need for developing products – Strategic importance of Product development – integration of customer, designer, material supplier and process planner, Competitor and customer – Behavior analysis. Understanding customer – prompting customer understanding – involve customer in development and managing requirements – Organization – process management and improvement – Plan and establish product specifications.	05
2.	**Concept Generation And Selection:** Task – Structured approaches – clarification – search – externally and internally – explore systematically – reflect on the solutions and processes – concept selection – methodology – benefits.	05
3.	**Product Architecture:** Implications – Product change – variety – component standardization – product performance – manufacturability – product development management – establishing the architecture – creation – clustering – geometric layout development – fundamental and incidental interactions – related system level design issues – secondary systems – architecture of the chunks – creating detailed interface specifications.	08

4.	**Industrial Design:** Integrate process design – Managing costs – Robust design – Integrating CAE, CAD, CAM tools – Simulating product performance and manufacturing processes electronically – Need for industrial design – impact – design process – investigation of for industrial design – impact – design process – investigation of customer needs – conceptualization – refinement – management of the industrial design process – technology driven products – user – driven products – assessing the quality of industrial design.	10
5.	**Design For Manufacturing And Product Development:** Definition – Estimation of Manufacturing cost – reducing the component costs and assembly costs – Minimize system complexity – Prototype basics – principles of prototyping – planning for prototypes – Economic Analysis – Understanding and representing tasks – baseline project planning – accelerating the project – project execution.	09
6.	**Advanced Manufacturing Techniques:** 3D Scanning and 3D Printing, Recent Trends in Micro Manufacturing	02
	Total	**39**

Course Learning Outcomes (CLOs): The student will be able to
1. Apply the principles of product design to modify existing engineering systems or to develop new artifacts.
2. Design a system taking into consideration the concepts of ease of production, maintenance, handling, installation etc.
3. Translate the concepts of economics in design, optimization of design and human factors approach to product design.

Text Books:

1. Eppinger, Steven, and Karl Ulrich. *Product design and development*. McGraw-Hill Higher Education, 2015.
2. Pugh, Stuart. *Total design: integrated methods for successful product engineering*. Addison-Wesley, 1991.

MC5171: MECHATRONICS LABORATORY

L-T-P: 0-0-3 **Full Marks: 100 [Credit – 02]**

Course Objectives: To get accustomed with working of mechatronics systems and hands on experience on Mechatronics system design.

Sl No.	Following Experiments will be performed	No. of Classes
1.	Mechanism development and robot kits	06
2.	Micro-controller for motion control and path planning of BOE-BOT, HEX-CRAWLER, ROBOT, Stair Climbing Vehicle	06
3.	Performance analysis of mechatronics system using Visual Nastran 4D software with MATLAb interface, 20Sim, AMESim software	09
4.	Hands on training on LabVIEW	06
5.	Introduction to Virtual Reality environment: programming language, interfacing Haptic devices.	03
6.	Study and demonstrate the working principle of the following sensors: Capacitive sensor, Strain Gauge, Inductive Sensor	03
7.	Design and development of signal conditioning circuit to synthesis the output of sensors signal and Microcontroller based data acquisition.	03

8.	Measurement of physical parameters (i.e. speed, position, touch etc.) by making of sensor prototype	03
Total		**39**

MC5172: AUTOMATION AND ROBOTICS LABORATORY

L-T-P: 0-0-3 **Full Marks: 100 [Credit – 02]**

Course objectives: To be familiarize with different sensors and signal conditioning circuit. Hands on experience on LabVIEW and PLC

Sl No.	Following Experiments will be performed	No. of Classes
1.	Hardware configuration and Programming of PLC	03
2.	Testing and validation of PLC programming related to motion control	03
3.	Study on PLC controlled Pneumatic, Hydraulic and Electric actuator.	03
4.	Interfacing of sensors with PLC and LabVIEW based HMI platform	03
5.	Study and demonstration of Automation based system	06
6.	Hands on working and training on following robotics related hardware and test-beds: 6 D.O.F. articulated robots.	03
7.	Wheeled Mobile and Legged Mobile Robot equipped with actuators and different sensors	03
8.	Robot modeling and simulation using Workspace software	06
9.	Testing and validation of developed algorithms related to navigation, guidance, obstacle avoidance and control.	06
10.	Path planning and programming for mobile robots using Webots software	03
Total		**39**

MC5173: CONTROL SYSTEMS LAB

L-T-P: 0-0-3 **Full Marks: 100 [Credit – 02]**

Course Objectives: To get the flavour of real-life control problems and have hands on experience on modeling and control of mechatronic systems.

Sl No.	Following Experiments will be performed	No. of Classes
1.	Step, ramp and Impulse response of first order and second order systems.	03
2.	Time domain analysis for second order systems and identification of damping.	03
3.	Stability analysis of linear systems using Routh-Hurwitz method and Root Locus.	03
4.	Frequency response analysis using Bode Plot and Polar Plot.	03
5.	Design of PID Controller for first order and second order systems	06
6.	Design of Controller for speed control of DC Motor System, Flexible Beam Structure.	06
7.	Design of PID Based controller for Twin Rotor Multi Input Multi Output System	03
8.	Design of Controller for stabilization of Rotary Inverted Pendulum.	03
9.	Temperature control of a Heat Chamber, disturbance study	03
10.	Servo Control of electric drive and pneumatic drive	06
Total		**39**

MC5201: ROBOTICS

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To introduce the modelling, simulation, and control of spatial multi-degree-of-freedom robotic manipulators. In particular, the student will study the kinematics and dynamics of robotic manipulators. Additionally, student will get awareness about the trajectory planning and control of robotic arm.

Sl No.	Course Outline	No. of Classes
1.	**Introduction:** History of the development of robots, basic components of robotic systems, Anatomy and structural design of robot, manipulation, arm geometry, Drives and control (hardware) for motions, End effectors and grippers.	02
2.	**Kinematics:** Translation, orientation of rigid bodies, Representation of links and joints, workspace, velocities, manipulator jacobian, singularities of robots and mechanisms, Kinematics for serial and parallel manipulators, election of coordinate frames, Homogeneous transformation, DH parameters, Direct and Inverse kinematics: Two link planner, PUMA 560, Stanford arm, SCARA and Stewart Platform.	09
3.	**Dynamics of Robots**: Introduction to robot dynamics, Forward and inverse dynamics of robot manipulators, Rigid link Recursive Acceleration, Lagrange-Euler Dynamic formulation.	08
4.	**Trajectory Planning and Control:** Path planning, trajectory planning, Joint space trajectory planning, Cartesian space trajectory, planning, Continuous trajectory recording (Trajectory following), position, velocity and force control.	06
5.	**Mobile Robotics:** Wheeled mobile robots, bipeds, swarm robotics, Military mobile robots, Underwater robots, Surveillance robots, Nano robots.	04
6.	**SLAM (Simultaneous Localization and Mapping):** Localization, Planning, Segmented Ste, Fun with Parameters, SLAM, Graph SLAM, Implementing Constraints, Adding Landmarks, Matrix Modification, Untouched Fields, Landmark Position, Confident Measurements, Implementing SLAM.	06
7.	**Virtual Reality and Haptics:** Virtual reality concepts, virtual world and real world, Interface to virtual world (inputs and outputs), Types of interaction, Applications, Definition of Haptics, Importance of Touch, Tactile Proprioception, Tactual Stereo genesis, Kinesthetic Interfaces, Tactile Interfaces, Human Haptics, Overview of existing applications.	04
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Identify and formulate the desired robotic design specifications for a particular application
2. Design and simulate the forward and inverse kinematic model
3. Develop and analyze the trajectory planning
4. Model robot dynamics for a given serial robotic manipulator
5. Apply the joint- and Cartesian-based schemes to control the manipulators in different applications.
6. Analyze mobile robot in virtual and real environment

Text Books:

1. Fu, King Sun, Ralph Gonzalez, and CS George Lee. *Robotics: Control Sensing. Vis*. Tata McGraw-Hill Education, 1987.
2. Craig, John J. *Introduction to robotics: mechanics and control, 3/E*. Pearson Education India, 2009.

Reference Books:

1. Spong, Mark W., and Mathukumalli Vidyasagar. *Robot dynamics and control*. John Wiley and Sons, 2008.
2. Lewis, Frank L., D. M. Dawson, and Chaouki T. Abdallah. *Control of robot manipulators*. Prentice Hall PTR, 1993.
3. Crane III, Carl D., and Joseph Duffy. *Kinematic analysis of robot manipulators*. Cambridge University Press, 2008.
4. Pham, Duc Truong, and Wilfred B. Heginbotham. *Robot grippers*. IFS (Publications) Ltd, UK, 1986.
5. Koren, Yoram. *Robotics for engineers*. McGraw-Hill, 1985.
6. Ranky, Paul G., Chung You Ho, and Paul G. Ranky. *Robot modelling: control and applications with software*. IFS (Publications), 1985.

MC5202: MACHINE LEARNING IN MECHATRONICS

L-T-P: 3-1-0 **Full Marks: 100 [Credit – 04]**

Course Objectives: To provide an overview on recent developments in machine learing, which covers Fuzzy, Neuro, Probabilistic Reasoning and Evolutionary Computation that has been applied in mechatronics.

Sl No.	Course Outline	No. of Classes
1.	**Introduction to Machine Learning:** Preliminary of statistical methods, different machine learning techniques, Estimation diagnosis, computational advantages	04
2.	**Introduction to Estimation:** Brief of probability and Statistics, Gaussian Intro Variance Comparison, Maximize Gaussian, Measurement and Motion, Parameter Update, New Mean Variance, Gaussian Motion, Kalman Filter Code, Kalman Prediction, Kalman Filter Design, Kalman Matrices, Detection theory.	06
3.	**Optimization:** Basic concepts of Constrained Optimization, Cost function; Feasible Solution Set; KKT method; Convex Optimization, Linear programming; LMI and BMI.	06
4.	**Fuzzy Set Theory and Fuzzy Logic System:** Basic concepts in Fuzzy Set theory, Operations of Fuzzy sets, Fuzzy relational equations, Fuzzy inference, Fuzzification, Defuzzification, Decision making logic, Membership functions, Rule base.	06
5.	**Introduction to ANN:** Fundamentals of Neural networks, Neural network architectures, Learning methods, multilayer perceptrons, Back propagation algorithm and its variants, Different types of learning.	06

6.	**Genetic Algorithms:** Introduction to genetic algorithms, initialization, selection, mutation and termination, classification of genetic programming.	06
7.	**Implementation in Mechatronics Systems:** control and learning, navigation, vision, multimedia, and several robotics implementation such as inverted pendulum, autonomous vehicles, and ping-pong robot.	05
Total		**39**

Course Learning Outcomes (CLOs): The students will be able to
1. Implement fuzzy controllers for control and classification.
2. Use ANN for classification, control and optimization problem.
3. Obtain the optimum solution using evolutionary approach.
4. Integration of neuro and fuzzy system.
5. Formulate hybrid intelligent algorithms for mechatronics application.
6. Implementation of the machine learning techniques on the prototype developed by the students

Text Books:

1. Hirota, Kaoru, and Toshio Fukuda, eds. *Soft computing in mechatronics*. Vol. 32. Springer Science and Business Media, 1999.
2. Goldberg, David E. *Genetic algorithms.* Pearson Education India, 2006.
3. Rao, Singiresu S. Engineering optimization: theory and practice. John Wiley & Sons, 2019.
4. Haykin, Simon. Neural Networks and Learning Machines, 3/E. Pearson Education India, 2010.
5. Ross, Timothy J. Fuzzy logic with engineering applications. Vol. 2. New York: Wiley, 2004.
6. Jang, J-S Roger, Sun, C-T, Mizutani, Eiji. *Neuro-fuzzy and Soft Computing: A Computati Approach to Learning and Machine Intelligence.* Prentice Hall, 1997.
7. Rajasekaran, Sanguthevar, and GA Vijayalakshmi Pai. *Neural networks, fuzzy logic and ge algorithm: synthesis and applications*. PHI Learning Pvt. Ltd., 2003.

MC5203: SIGNAL PROCESSING AND APPLICATIONS

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To introduce different analog and digital signal processing techniques. Application to bio signal processing and Image signal processing. In particular, the student will study different signal conditioning techniques.

Sl No.	Course Outline	No. of Classes
1.	**Introduction:** Elements of Analog and Digital Signal Processing system, continuous time signals, discrete time signals, sampling of analog signals, sampling theorem, quantization, coding, digital vs discrete time signals, advantages of digital processing over analog processing.	02

2.	**Signals and Systems :** Classification, analysis of linear systems, response of LTI systems to arbitrary inputs, convolution, causal systems, stability, finite duration and infinite duration impulse response, recursive and non-recursive systems, description by differential/difference equations, structures for realization.	02
3.	**Analog Signal Processing:** Continuous time filters; Single amplifier and multiple amplifier structures and filter parameter sensitivities. Cascade filter. Sampled data filter; Mixed signal circuits; Noise and Interference signals and their reduction; Logarithmic and exponential amplifiers; Voltage controlled oscillator, Phase locked loop.	06
4.	**Digital Signal Processing:** Frequency domain sampling, properties of DFT, Linear filtering methods based on the DFT, frequency analysis using DFT, FFT algorithms**;** Design of digital filters; Characteristics of filters, FIR filters, IIR filters from analog filters, DSP processors.	09
5.	**Statistical Signal Processing:** Statistical modelling of signals; Spectral factorization; AR, MA and ARMA models; Estimating signal from a mixture; MMSE estimation; Weiner filtering; Least Squares filtering.	06
6.	**Image Processing:** Fundamentals of Digital Image, Filtering technique; binary and grey-scale images; Image segmentation; Thresholding; Edge detection; Region growing and region splitting; Feature extraction, Pattern recognition, Image Transforms, Wavelet Transform, JPEG Image Compression, Image Formats, Thermal Image processing.	07
7.	**Application in Biomedical Signal Processing and Condition Monitoring of Machines:** Speech Signals: The source-filter model of speech production, spectrographic analysis of speech; Clinical applications of Electrocardiogram (ECG) signals; Medical imaging techniques like ultrasound, X-ray, CT, MRI, PET, and SPECT; magnetic resonance imaging (MRI). Monitoring and measurement of vibration; Machine Condition Monitoring and Diagnosis.	07
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to

1. Identify the signals and systems
2. Apply the principles of Fourier transform analysis to describe the frequency characteristics of discrete-time signals and systems
3. Apply the principles of signal analysis to filtering including analog, digital, and biomedical signals. learn the fundamentals of digital image processing techniques.

Text Books:

1. Proakis, John G., and Dimitris G. Manolakis. *Digital signal processing.* PHI Publication: New Delhi, India, 2004.
2. Johnson, Johnny R. *Introduction to Digital Signal Processing.* Prentice Hall, 1989.
3. Mitra, Sanjit Kumar, and Yonghong Kuo. *Digital signal processing: a computer-based approach*. McGraw-Hill, 2006.
4. Oppenheim, Alan V., and Schafer, Ronald W. *Discrete-time signal processing*. Pearson Education, 2014.
5. Rabiner, Lawrence, and Ronald Schafer. *Theory and applications of digital speech processing*. Prentice Hall Press, 2010.

6. Franco, Sergio. *Design with operational amplifiers and analog integrated circuits*. McGraw-Hill, 2002.
7. Davies, E. Roy. *Machine vision: theory, algorithms, practicalities*. Elsevier, 2004.

MC5221: CAD/CAM AUTOMATION AND PROTOTYPE DEVELOPMENT

(Elective Paper for the students having Electrical, Electronics, Telecommunication, Instrumentation and Control background)

L-T-P: 3-1-0 **Full Marks: 100 [Credit – 04]**

Course Objectives: To learn the concepts of automation systems in manufacturing sector. To familiarize the basics of CAD/CAM and FE tool in Dynamic problems addition to intelligent machining operations.

Sl No.	Course Outline	No. of Classes
1.	**Introduction** to Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Computer Integrated Manufacturing (CIM), product cycle and automation in CAD/CAM, Need of CAD/CAM.	07
2.	**Modelling:** Introduction to transformation, plane and space curves, solid modeling, surface modeling, FEM, FEA, Structure analysis, motion analysis.	07
3.	**Process Planning**: Basic concepts of process planning, computer aided process planning (CAPP), Retrieval or vaiant and generative approach of CAPP, Implementation consideration of CAPP.	05
4.	**Numerical Control of Machine Tools**: Principles of Numerical control (NC), Computer Numerical control (CNC), Direct Numerical control (DNC), comparison between conventional and CNC systems, Classification of CNC system, NC coordinate system, positional control, system devices; drives, ball screws, transducers, feedback devices, counting devices, signal converters, interpolators, adaptive control system.	09
5.	**NC Part Programming**: Concept, format, codes, preparatory and miscellaneous coded, manual part programming, APT programming, macros, fixed cycles.	04
6.	**Prototype Development:** Design and develop a prototype using existing laboratory facilities. Detailed guideline may be found in Annexure-I.	07
Total		**39**

Course Learning Outcomes (CLOs): The students will be able to
1. Apply the concepts of machining for CNC milling and turning equipment
2. Create and validate NC part program data
3. Produce an industrial component by interpreting 3D part model/ part drawings
4. Create and demonstrate the technical documentation for design
5. Design and develop a prototype

Text Books:

1. Groover, Mikell, and E. W. J. R. Zimmers. *CAD/CAM: computer-aided design and manufacturing*. Pearson Education, 1983.

2. Groover, Mikell P. *Automation, production systems, and computer-integrated manufacturing*. Prentice Hall Press, 2007.
3. Radhakrishnan, Pezhingattil, S. Subramanyan, and V. Raju. *CAD/CAM/CIM*. New Age International, 2008.
4. Rao, Posinasetti Nageswara. *CAD/CAM: principles and applications*. Tata McGraw-Hill Education, 2004.
5. Chang, Tien-Chien, and Richard A. Wysk. *Computer-aided manufacturing*. Prentice Hall PTR, 1997.

MC5222: INDUSTRIAL INSTRUMENTATION AND PROTOTYPE DEVELOPMENT

(Elective Paper for the students having Mechanical, Mechatronics, Production, Automobile, Manufacturing and Aeronautical background)

L-T-P: 3-1-0 **Full Marks: 100 [Credit – 04]**

Course Objectives: To provide basic knowledge of measurement, different sensor and relevant signal conditioning circuit. In addition, basics of SCADA, LABVIEW, HMI and Instrumentation systems will be discussed.

Sl No.	Course Outline	No. of Classes
1.	**Measurement Systems:** Performance terms, static and dynamic characteristics, system transfer function, system accuracy, sources of error, different measuring instruments.	02
2.	**Signal Conditioning:** Need for Signal Conditioning, DC and AC Signal conditioning, Filter and Isolation Circuits, Amplifiers, instrumentation amplifiers, Signal Transmitting Circuits, multiplexers, Fundamentals of Data Acquisition System	08
3.	**Display Devices:** construction and interfacing of LED Matrix display, LCD display, recorders, data loggers.	04
4.	**Instrumentation System:** Measurement of pressure, temperature, Flow, liquid level, Gas chromatography,	08
5.	**Virtual Instrumentation:** Introduction to VI, Identification of LabVIEW tools, VI Programming, HMI Basics, Types, Applications of Human Machine Interface, HMI Processing, Interaction styles and general design interaction.	07
6.	**Practical Instrumentation Systems and Their Applications:** Agro-based; Biomedical and prosthetic; Strategic and defense related ; Disaster mitigation; Opto-electronic , Concept of SCADA. Case Studies and Future Trend	03
7.	**Prototype Development:** Design and develop a prototype using existing laboratory facilities. Detailed guideline may be found in Annexure-I.	07
	Total	**39**

Course Learning Outcomes (CLOs): The students will be able to
1. Acquire knowledge of Instrumentation system including sensor and actuators.
2. Analyze and design different type of programs based on PLC and VI tools.
3. Design and develop the signal conditioning circuit for data acquisition system.
4. Design and develop a prototype

Text Books:

1. Patranabis, D. *Principles of industrial instrumentation*. Tata McGraw-Hill Publishing, 1976.
2. Liptak, Bela G. *Instrument Engineers' Handbook, Volume One: Process Measurement and Analysis*. CRC press, 2003.
3. Liptak, Bela G. *Instrument Engineers' Handbook, Volume Two: Process Control and Optimization*. CRC press, 2018.

Reference Books:

1. Considine, Douglas M., and Glenn D. Considine. *Standard handbook of industrial automation*. Springer Science and Business Media, 2012.
2. Doebelin, Ernest O. *Measurement Systems-Application and Design*. McGraw-Hill, 2007.
3. Barua, Alok. *Fundamentals of Industrial Instrumentation*. Wiley, 2013.
4. Anand, M. M. S. *Electronic Instruments and Instrumentation Technology*. PHI Learning Pvt. Ltd., 2004.
5. Alavala, Chennakesava R. *Principles of Industrial Instrumentation and Control Systems*. Cengage Learning Services, 2009.

MC5261: INDUSTRY 4.0

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: This course provides students with an introduction to Industry 4.0, its building blocks, its applications and advantages compared to conventional production techniques. Learners get a deep insight into how intelligent processes, big data, artificial intelligence, IoT and IIoT can be used to build up the production of the future.

Sl No.	Course Outline	No. of Classes
1.	**Introduction to Industry 4.0 :** The Various Industrial Revolutions , Globalization and Emerging Issues, Digitization and the Networked Economy, Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today's Factory.	03
2.	**Basic Components of Industry 4.0 :** 2.1 Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services 2.2 *Digital Twins*: Basic concepts of Digital Twins , Benefits, impact and challenges , Features and Implementation of Digital Twins , Types of Digital Twins, Digital Twin use cases, Applications for digital twins in production (examples of existing or future applications in the field of manufacturing), 2.3 Big Data and Advanced Analysis, Value chains in manufacturing companies, Cyber-physical Systems, Customization of products, Cloud Computing / Cloud Manufacturing, Security issues within Industry 4.0 networks.	09
3.	**Supportive System and Technologies for Industry 4.0 :** Robotic Automation and Collaborative Robots , Mobile Computing, Cyber Security, Augmented Reality and Virtual Reality, Artificial Intelligence, Embedded device, Smart Sensor & Actuator, Machine Learning, Human Machine Interaction, Additive Manufacturing, Process Modeling and Simulation.	10
4.	**Introduction to IIoT:** Basic architecture of IIoT, IIoT Layers: sensing, processing and , communication; Data Analytics, Application of Cloud Computing in IIoT.	07

5.	**Applications of Industry 4.0:** Smart Manufacturing , Smart Devices and Products , Smart Logistics , Predictive Analytics, Smart workpiece, Smart workplace, Smart cities, Smart transportation, Industry 4.0 laboratories, Smart Connected System Design, Factories and Assembly Line, Food Industry, Inventory Management & Quality Control, Milk Processing and Packaging Industries, Smart Warehouse.	05
6.	**Case Studies:** Case studies include but not limited to, Stanley Black & Decker, Linz AG Transforming Public Transit in Austria Case Study, Aegean Motorway Converged Roadway Network Case Study, Alaska Department of Transportation Case Study, British Columbia Hydro Utility Case Study, City of Mississauga Connected City Case Study, California Shock Trauma Air Rescue (CALSTAR) Case Study, Austrian Autobahn Connected Roadways Case Study	05
Total		**39**
Course Learning Outcomes (CLOs): The students will be able to 1. Learn basic components of Industry 4.0 like IIoT, Cyber-physical system, Big-data analytics etc. 2. Design digital twin 3. Learn group activities through case studies		

Text Books:

1. *The Fourth Industrial Revolution* by Klaus Schwab, Crown Business, 2017.
2. *Industry 4.0: The Industrial Internet of Things* by Alasdair Gilchrist, Apress, 2016.

Reference Books:

1. *Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0* by Ibrahim Garbie, Springer, 2016.
2. *Handbook Of Industry 4.0 And Smart Systems* by Pascual D G, Taylor & Francis Ltd, 2020.
3. *Designing the Internet of Things* by A. McEwen and H. Cassimally, 1st edition, Wiley, 2013.
4. *Database Cloud Storage: The Essential Guide to Oracle Automatic Storage Management* by N. Vengurlekar and P. Bagal, 1st edition, McGraw-Hill Education, 2013..
5. *Industrial Automation: Hands on* by F. Lamb, 1st edition, McGraw-Hill Education, 2013.

MC5262: ARTIFICIAL INTELLIGENCE FOR ROBOTICS

L-T-P: 3-0-0 **Full Marks: 100 [Credit – 03]**

Course Objectives: To get an overview of the characteristics of AI systems with different searching techniques and algorithms. To study the concept of representing knowledge of ANN architecture, fuzzy logic and genetic algorithm.

Sl No.	Course Outline	No. of Classes
1.	**Introduction to Kalman Filter:** Brief of probability and Statistics, Gaussian Intro Variance Comparison, Maximize Gaussian, Measurement and Motion, Parameter Update, New Mean Variance, Gaussian Motion, Kalman Filter Code, Kalman Prediction, Kalman Filter Design, Kalman Matrices.	03
2.	**Introduction to Particle Filter:** Slate Space, Belief Modality, Particle Filters, Using Robot Class, Robot World, Robot Particles	03
3.	**Fuzzy Set Theory and Fuzzy Logic System:** Basic concepts in Fuzzy Set theory, Operations of Fuzzy sets, Fuzzy relational equations, Fuzzy inference, Fuzzification, Defuzzification, Decision making logic, Membership functions, Rule base.	05

4.	**Introduction to Artificial Neural Networks:** Fundamentals of Neural networks, Neural network architectures, Learning methods, multilayer perceptrons, Back propagation algorithm and its variants, Different types of learning.	06
5.	**SLAM (Simultaneous Localization and Mapping):** Localization, Planning, Segmented Ste, Fun with Parameters, SLAM, Graph SLAM, Implementing Constraints, Adding Landmarks, Matrix Modification, Untouched Fields, Landmark Position, Confident Measurements, Implementing SLAM.	08
6.	**Genetic Algorithms:** Introduction to genetic algorithms, initialization, selection, mutation and termination, classification of genetic programming.	05
7.	**Hybrid Techniques:** Neuro-fuzzy systems, genetic neuro systems, genetic fuzzy systems. Probabilistic techniques:Tree search, Monte-carlo techniques, Radial basis function, Gaussian, Probabilistic neural networks.	06
8.	**Industrial Applications of Intelligent Systems:** Application of fuzzy logic, Neural network and Genetic algorithm in Mechatronics application.	03
Total		**39**
Course Learning Outcomes (CLOs): The students will be able to 1. Learn the basics and applications of AI and categorize various problem domains, basic knowledge representation 2. Analyze basic concept of particle filter, fuzzy logic system and advanced mapping techniques		

Text Books:

1. Goldberg, David E. *Genetic algorithms*. Pearson Education India, 2006.
2. Singiresu S. Rao. *Engineering Optimization Theory and Practice*. Fourth Edition, John Wiley & Sons, Inc.
3. Simon Haykin. *Neural Networks and Learning Machines*. Third Edition, Pearson Prentice Hall.
4. Timothy J. Ross. *Fuzzy Logic with Engineering Applications*, Third Edition, Wiley.
5. J-S. R. Jang, Chuen-Tsai Sun, Eiji Mizutani. *Neuro-Fuzzy and Soft Computing*. Prentice Hall.
6. Rajasekaran, Sanguthevar, and GA Vijayalakshmi Pai. *Neural networks, fuzzy logic and genetic algorithm: synthesis and applications*. PHI Learning Pvt. Ltd., 2003.

MC5291: M. Tech Project Part - I (Term Paper)

L-T-P: 0-0-8 **Full Marks: 200 [Credit – 04]**

MC5292:Term Paper Seminar and Viva-voce

Full Marks: 100 [Credit – 02]

Remarks: At the end of second semester, every M. Tech. student shall submit a well formatted document, embodying her/his own work and written by her/him own language, in the form of a "Term Paper" report, duly endorsed by her/his supervisor, which may be related to her/his project. The student shall also deliver a seminar and appear in a viva-voce before a board-of-examiners to be constituted by the Departmental Postgraduate Committee (DPGC) concerned. The evaluation shall be based on the term-paper document and the seminar and viva-voce.

MC6191: M. Tech. Thesis Part - II (Progress Report)

L-T-P: 0-0-24 **Full Marks: 300 [Credit – 12]**

MC6192:Progress Report Seminar and Viva-voce

Full Marks: 100 [Credit – 06]

Remarks: At the end of third semester, every student shall submit a well formatted document, written by her/him in her/his own language, in the form of a "Progress Report" on the research work carried out so far by her/him on his dissertation/thesis topic. The progress-report shall be accepted for examination if and only if it is duly endorsed by her/his supervisor. The student shall also deliver a seminar and appear in a viva-voce before a board-of-examiners to be constitute by the Departmental Postgraduate Committee (DPGC) concerned. The evaluation shall be based on the progress-report and the seminar and viva-voce.

MC6291: M. Tech. Final Thesis

L-T-P: 0-0-30 **Full Marks: 400[Credit – 22]**

MC6292:Thesis Seminar and Viva-voce

Full Marks: 200 [Credit – 08]

Remarks: At the end of fourth semester every student shall submit a thesis, endorsed and approved by her/his supervisor, in a standard format approved by the Institute. After submission of the Thesis, the student shall be required to present the thesis before a duly constituted Board of Examiners of each specialization, as decided by the Departmental Postgraduate Committee (DPGC) concerned. For every student a separate Board of Examiners may be constituted; the Board may consist of one external expert, and the project supervisor(s).

Course Learning Outcomes (CLOs): The students will be able to

1. Identify a problem based on literature review of community /industry/ research.
2. Propose a methodology for solving the identified problem
3. Demonstrate project work with technical contribution.
4. Write technical report for the project work and present the same

Annexure-I: Guidelines for Prototype Development in Departmental Elective Subjects

MC5221: CAD/CAM AUTOMATION AND PROTOTYPE DEVELOPMENT

MC5222: INDUSTRIAL INSTRUMENTATION AND PROTOTYPE DEVELOPMENT

Objectives: The purpose of this exercise is to generate a knowledge-base among the students for development of mechatronics prototype, using theories studied and laboratories performed earlier. Here the students will have to design and develop a mechatronics system, using an integrated system design approach, from component level to assembly using various tools already available in the school and will submit a report. This will ensure development of knowledge regarding fabrication processes and assembly leading to manufacturing a prototype.

Guidelines: Typical projects may contain combinations of the following component types: transducers, analog front ends, micro-controllers and processors, FPGAs, digital signal processors, electrical interfaces, wired or wireless connectivity, printed circuit boards required for integration and test, and software/firmware modules needed to operate a designed system, mechanical component, 3D printed component, assembly components, mechanisms etc. This activity is a backdrop used to teach key aspects of the development process such as hardware-software codesign, documentation, realistic use of requirements, design partition, integration strategy, interface design, risk mitigation, and design strategies to accommodate available resources. Students will select a project concept and then create an implementation plan that will define the semester's activity. Students may work independently or in teams to define, develop, test, and document their projects. Students are encouraged to select topics based on their interests and learning objectives.

Typical prototype may be

1. Intelligent Mobile Robot (Wheeled/Hexapod)
2. Smart Orthotic / Prosthetic devices
3. X-Y plotter / Low cost 3D Printer
4. Automatic Vending Machine (using PLC/Arduino)
5. Bio-medical devices
6. Intelligent Gripper
7. Innovative Intelligent Product development
8. Precision motion control of mechanism
9. Vehicle model / Aero Model
10. Any other electro-mechanical intelligent innovative working model

Steps	Activity plans
1.	Select a prototype design idea from the existing facilities
2.	Design the mechatronic system implementing an integrated system design approach applying knowledge acquired in various theory / laboratory courses in the curriculum
3.	Analyze and optimize the design considering various requirements, such as reliability, fatigue loading, manufacturing, assembly, installation, maintenance, cost, design standards, industry standards etc.
4.	Use suitable manufacturing and fabrication processes for manufacturing the prototype
5.	Assemble the components after manufacturing. Analyze the working of the prototype
6.	Test the performance of the final product and modify / optimize the prototype, if required