ANNA UNIVERSITY: : CHENNAI 600 025

UNIVERSITY DEPARTMENTS

M.E. MECHATRONICS (FT)

REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

VISION

To develop educational avenues for the students to emerge as disciplined researchers, technocrats and entrepreneurs making transformative impact on establishing a world class society in the domain of Production Engineering and Automation.

MISSION

1. To impart students with knowledge on modern manufacturing and automated systems by incorporating critical thinking, leadership qualities, communication with interpersonal skills.
2. To create a conducive environment for exchange of multidisciplinary ideas towards research, creativity, innovation and entrepreneurship to meet the societal needs with optimal solutions.
3. To follow the values of integrity and honesty through curricular, co-curricular and extracurricular activities.

Attested

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REGULATIONS – 2023

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

I. Secure gainful employment in industry, academia and research avenues by showcasing their competence and adaptability.

II. Outshine in scientific, managerial, and entrepreneurial roles, applying a versatile and multidisciplinary approach with capacity to address complex challenges.

III. Graduates will possess the skills and knowledge to excel as technocrats, specializing in the design, development, and analysis of mechatronic systems to provide sustainable solutions for industrial and societal issues.

IV. Graduates will embody ethical responsibility, committing to lifelong learning and exhibit effective communication as individual professional and collaborative team member.

PROGRAMME OUTCOMES (POs):

PO	Programme Outcome
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	Students should be able to demonstrate a degree of mastery in the area of mechatronics.
4	Graduates will have a solid understanding of key concepts, methodologies, core components, and contemporary tools and techniques essential for unified mechatronics systems with intelligence.
5	Students will develop, analyze and optimize the solution for diverse engineering challenges using a mechatronics-based approach.
6	Graduates will be capable of constructing real-time or virtual mechatronic systems with considerations for industrial standards, environmental impact, ethical principles, and socio-economic factors.

PEO & PO Mapping

PEO	PO					
	1	**2**	**3**	**4**	**5**	**6**
I.	2	2	1	1	1	1
II.	2	2	2	2	2	2
III.	3	2	3	3	3	2
IV.	2	2	1	1	1	2

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PROGRAMME ARTICULATION MATRIX

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Concepts in Electronics Engineering	1.4	1.4	1	1	1.4	1
		Concepts of Mechanisms and Design	1.6	1.4	1.6	1.2	1.8	2
		Sensors and Data Acquisition System	1.4	1.2	1.2	1.4	1	1
		Control System Design	1.8	1.8	1.6	1.8	2.2	1
		Drives and Actuators	1.4	1.6	2	1.4	1.2	2
		Research Methodology and IPR	3	3	2	-	-	-
		Professional Elective – I	-	-	-	-	-	-
		Control Systems Design Laboratory	2	2.5	1.6	1.6	2.5	1.6
		Computer Aided Modelling- Mini Project	1.3	3	-	1	1.6	3
	SEMESTER II	Mechatronics System Design	1	1	2	3	2	3
		Industrial Robotics	1	1	2	2	1.4	1.4
		Industrial Automation	1.6	1	1.6	2	1.4	1.4
		Embedded Systems	1.2	1	1	1.5	1	1.2
		Professional Elective – II	-	-	-	-	-	-
		Professional Elective – III	-	-	-	-	-	-
		Robot Simulation, Programming and Inspection Laboratory	1	3	3	3	2	2
		Mechatronics System Design – Mini Project	1	3	1.3	3	2.3	3
YEAR II	SEMESTER III	Professional Elective – IV	-	-	-	-	-	-
		Professional Elective - V	-	-	-	-	-	-
		Project Work - I	3	3	3	3	3	3
		Internship	2.3	3	2.6	2.6	2	3
	SEMESTER IV	Project Work - II	3	3	3	3	3	3

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M.E. MECHATRONICS (FT)

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CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABI FOR SEMESTER I TO IV

SEMESTER - I

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MR3151	Concepts in Electronics Engineering*	FC	2	0	2	4	3
	MR3101	Concepts of Mechanisms and Design*	FC					
2.	MR3152	Sensors and Data Acquisition System	PCC	3	0	4	7	5
3.	MR3102	Control System Design	PCC	3	0	0	3	3
4.	MR3103	Drives and Actuators	PCC	3	0	4	7	5
5.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
6.		Professional Elective – I	PEC	3	0	0	3	3
PRACTICAL								
7.	MR3111	Control Systems Design Laboratory	PCC	0	0	3	3	1.5
8.	MR3112	Computer Aided Modelling-Mini Project#	EEC	0	0	3	3	1.5
			TOTAL	**16**	**1**	**16**	**33**	**25**

Note: 1. * - is bridge course for circuit and non-circuit stream of students. Students with multi-disciplinary background (i.e, Mechatronics, Robotics and Automation may opt anyone of this based on the undergraduate curriculum exposure).

2. # - Mini project internal evaluation

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SEMESTER-II

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MR3201	Mechatronics System Design	PCC	3	0	0	3	3
2.	MR3251	Industrial Robotics	PCC	3	0	0	3	3
3.	MR3202	Industrial Automation	PCC	3	0	4	7	5
4.	MR3203	Embedded Systems	PCC	3	0	4	7	5
5.		Professional Elective – II	PEC	3	0	0	3	3
6.		Professional Elective – III	PEC	3	0	0	3	3
PRACTICAL								
7.	MR3211	Robot Simulation, Programming and Inspection Laboratory	PCC	0	0	3	3	1.5
8.	MR3212	Mechatronics System Design – Mini Project#	EEC	0	0	3	3	1.5
			TOTAL	**18**	**0**	**14**	**32**	**25**

Note: 1# - Mini project internal evaluation

SEMESTER-III

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective –IV	PEC	3	0	0	3	3
2.		Professional Elective– V	PEC	3	0	0	3	3
PRACTICAL								
3.	MR3311	Project Work– I	EEC	0	0	12	12	6
4.	MR3312	Internship	EEC	0	0	2	2	1
			TOTAL	**6**	**0**	**14**	**20**	**13**

SEMESTER-IV

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1	MR3411	Project Work– II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL CREDITS -25+25+13+12= 75 CREDITS

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FOUNDATION COURSES (FC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3151	Concepts in Electronics Engineering	FC	2	0	2	4	3
	MR3101	Concepts of Mechanisms and Design	FC	2	0	2		

RESEARCH METHODOLOGY COURSE (RMC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3112	Computer Aided Modelling- Mini Project	EEC	0	0	3	3	1.5
2.	MR3212	Mechatronics System Design – Mini Project	EEC	0	0	3	3	1.5
3.	MR3311	Project Work– I	EEC	0	0	12	12	6
4.	MR3312	Internship	EEC	0	0	2	2	1
5.	MR3411	Project Work– II	EEC	0	0	24	24	12

PROGRAM CORE COURSES (PCC)

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3152	Sensors and Data Acquisition System	PCC	3	0	4	7	5
2.	MR3102	Control System Design	PCC	3	0	0	3	3
3.	MR3103	Drives and Actuators	PCC	3	0	4	7	5
4.	MR3111	Control Systems Design Laboratory	PCC	0	0	3	3	1.5
5.	MR3201	Mechatronics System Design	PCC	3	0	0	3	3
6.	MR3251	Industrial Robotics	PCC	3	0	0	3	3
7.	MR3202	Industrial Automation	PCC	3	0	4	7	5
8.	MR3203	Embedded Systems	PCC	3	0	4	7	5
9.	MR3211	Robot Simulation, Programming and Inspection Laboratory	PCC	0	0	3	3	1.5
			TOTAL	**21**	**0**	**22**	**43**	**32**

MINI PROJECTS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3112	Computer Aided Modelling- Mini Project	PCC	0	0	3	3	1.5
2.	MR3212	Mechatronics System Design – Mini Project	PCC	0	0	3	3	1.5
			TOTAL	**0**	**0**	**6**	**6**	**3**

PROFESSIONAL ELECTIVE COURSES (PEC)

(ALL COURSES COMMON TO PROFESSIONAL ELECTIVE I- V)

ROBOTICS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3051	Multi-Body Dynamics and Control	PEC	3	0	0	3	3
2.	MR3002	Mobile Robotics	PEC	3	0	0	3	3
3	MR3003	Robot Operating Systems	PEC	3	0	0	3	3
4.	MR3004	Humanoid Robotics	PEC	3	0	0	3	3
5.	MR3005	Multi Agent Robotics	PEC	3	0	0	3	3

MOBILITY SYSTEMS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3006	Automobile Engineering	PEC	3	0	0	3	3
2.	AM3351	Electric and Hybrid Vehicles	PEC	3	0	0	3	3
3	MR3007	Vetronics	PEC	3	0	0	3	3
4.	MR3008	Smart Mobility and Intelligent Vehicles	PEC	3	0	0	3	3
5.	MR3009	Advanced Driver Assistance Systems	PEC	3	0	0	3	3

INTELLIGENCE SYSTEMS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3010	Programming in Python	PEC	3	0	0	3	3
2.	MR3011	Machine Vision and Computer Vision	PEC	3	0	0	3	3
3	MR3012	Machine Learning and Deep Learning	PEC	3	0	0	3	3
4.	MR3013	Haptics and Mixed Reality	PEC	3	0	0	3	3
5.	MR3014	Applied Signal Processing	PEC	3	0	0	3	3

EMBEDDED SYSTEMS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3001	Single Board Computers and Programming	PEC	3	0	0	3	3
2.	MR3015	Communication Protocols	PEC	3	0	0	3	3
3	MR3016	FPGA for Embedded Systems	PEC	3	0	0	3	3
4.	MR3017	GPU Computing	PEC	3	0	0	3	3

INDUSTRIAL AUTOMATION

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3018	Industrial Internet of Things	PEC	3	0	0	3	3
2.	MR3019	Human Machine Interface	PEC	3	0	0	3	3
3	MR3020	Advanced Control Systems	PEC	3	0	0	3	3
4.	MR3021	Motion Control Technology	PEC	3	0	0	3	3
5.	MR3052	Digital Twin and Industry 5.0	PEC	3	0	0	3	3

MECHATRONICS SYSTEMS

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3022	Mechatronics in Manufacturing Systems	PEC	3	0	0	3	3
2.	MR3023	Medical Mechatronic Systems	PEC	3	0	0	3	3
3	MR3024	Bio-mechatronics	PEC	3	0	0	3	3
4.	MR3053	Drone Technologies	PEC	3	0	0	3	3
5.	MR3025	Marine Robotics	PEC	3	0	0	3	3

MANUFACTURING TECHNOLOGY

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3026	Micro and Nano systems	PEC	3	0	0	3	3
2.	MR3027	Modelling and Finite Element Analysis of Electromechanical Systems	PEC	3	0	0	3	3
3	MN3051	Concepts In Product Development	PEC	3	0	0	3	3
4.	MR3028	CNC Technology	PEC	3	0	0	3	3
5.	MR3029	Computer Aided Inspection	PEC	3	0	0	3	3

INDUSTRIAL MANAGEMENT

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MR3030	Design of Experiments	PEC	3	0	0	3	3
2.	IL3152	Operations Management	PEC	3	0	0	3	3
3	MR3031	Terotechnology	PEC	3	0	0	3	3
4.	QE3251	Lean Six Sigma	PEC	3	0	0	3	3
5.	IL3251	Supply Chain Systems and Management	PEC	3	0	0	3	3

SI. NO.	M.E MECHATRONICS (FULL TIME)					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	**FC**	03	00	00	00	03
2.	**PCC**	14.5	17.5	00	00	32
3.	**PEC**	03	06	06	00	15
4.	**MC**	03	00	00	00	03
5.	**EEC**	1.5	1.5	07	12	22
	TOTAL CREDITS	**25**	**25**	**13**	**12**	**75**

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MR3151	CONCEPTS IN ELECTRONICS ENGINEERING	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

1.	To recall the functionality of fundamental electronic components.
2.	To understand the functions of operational amplifier and its applications.
3.	To review and use the logic gates for various digital circuit development.
4.	To understand the functions and uses in measurement.
5.	To learn the power management on various electronic units.

UNIT I **ELECTRONIC COMPONENTS AND DEVICES** **6**

Resistors, Capacitors, Inductors, Transformers – Types and Properties - PN Junction Diodes, Zener Diodes, Transistors, Thyristors – Types - Operating Mechanism -Characteristics and Applications. LED Construction and Working – Applications, Types of Displays and its Construction – Applications.

UNIT II **OPERATIONAL AMPLIFIERS AND APPLICATIONS** **6**

Operational Amplifiers – Principles, Specifications, Characteristics and Applications - Arithmetic Operations, Integrator, Differentiator, Comparator, Schmitt Trigger, Instrumentation Amplifier, Active Filters, Linear Rectifiers, Waveform Generators, Sample and Hold Circuits, D/A Converters, Feedback and Power Amplifiers, Sine Wave Oscillators.

UNIT III **DIGITAL ELECTRONICS** **6**

Number Systems – Logic Gates – Boolean Algebra – Simplification of Boolean Functions – Study of Combinational Logic Circuits - Full Adder, Code Converters, Multiplexers, Decoders, Study of Sequential Logic Circuits - Flip-Flops, Counters, Shift Registers – Memory - Types - Solid State Memory – A/D Converters.

UNIT IV **MEASURING INSTRUMENTS** **6**

Regulated Power Supply - Rectifiers and Filters – Switching Power Supplies - Thermal Considerations. Measurement of Voltage, Current, Frequency and Power Using Multi Meters, Oscilloscopes, Recorders, Data Loggers, Signal Sources, Counters, Analyzers and Printers.

UNIT V **POWER MANAGEMENT** **6**

Energy Estimation – Power Estimation and Optimization of Electrical and Electronics Elements, Integrated System - Sensors, Data Acquisition System - Drives, Switching Devices, Actuators and Controllers - Batteries - Types, Specification - Power Conversion Methods.

TOTAL **30 PERIODS**

LIST OF EXPERIMENTS:

1. Study of Digital Storage oscilloscope.
2. Experimentation with CRO.
3. Design of DC power supplies
4. Design of Inverting Amplifier and Non-Inverting Amplifiers
5. Design of Instrumentation amplifier.
6. Design of analog filters.
7. Design of combinational circuits and sequential circuits.
8. Design of A/D converters and D/A converters.
9. RC Servo motor driver circuit.
10. Design of stepper motor driver circuit

(Any 7 Experiments)

30 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State the fundamentals of electronic, circuits and measurement instruments.
CO2	Recognize the components, circuits and measurement instruments operation.
CO3	Design and develop the circuits using electronics components and measure using instruments.
CO4	Analyse the circuit by measuring parameters using measurement instruments.
CO5	Create circuit to perform the signal conditioning, power management and logic operations

REFERENCES:

1. Millman and Halkias, “Electronic Devices and Circuits”, McGraw Higher Ed., 2015.
2. Jacob Millman, “Microelectronics Digital and Analog Circuits and Systems”, McGraw-Hill, 2014.
3. HelfrickA.D and Cooper.W. D. “Modern Electronic Instrumentation and Measurements Techniques”, Prentice Hall, 2016.
4. Roy Choudhury, “Linear Integrated Circuits”, New Age, 2018
5. Malvino & Leach, “Digital Principles and Application”, Tata McGraw-Hill Education, 2002.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	1	1	1
2	1	1	1	1	1	1
3	1	2	1	1	2	1
4	2	1	1	1	2	1
5	2	2	1	1	1	1
Avg	**1.4**	**1.4**	**1**	**1**	**1.4**	**1**

MR3101	CONCEPTS OF MECHANISMS AND DESIGN	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

1.	To understand the functionality of basic mechanisms and to determine the position, velocity, and acceleration profiles of these mechanisms.
2.	To recognize the effect of friction in joints and to know the various types of mechanical power transmission using belt drives and cams.
3.	To understand the behaviors of the vibration in various machines.
4.	To design machine components.
5.	To design transmission elements.

UNIT I	**MECHANISMS**	**6**

Definition – Machine And Structure – Kinematic Link, Pair and Chain – Classification of Kinematic Pairs – Constraint & Motion - Degrees of Freedom – Inversion of Mechanisms along with their Practical Applications. Introduction to Kinematic Analysis and Synthesis of Simple Mechanisms – Determination of Velocity and Acceleration of Simple Mechanisms.

UNIT II	**FRICTION AND CAMS**	**6**

Types of Friction – Friction in Screw and Nut – Screw Jack- Belt (Flat And V) Drives. Cam-Terminology-Different Types of Cams and Followers – Cam Design for Different Follower Motion Curves, Graphical Construction of Cam Profiles for Different Types of Follower

UNIT III	**VIBRATIONS**	**6**

Basic Terminology Related to Vibrations, Free and Forced Vibrations Without and With Damping– Force Transmitted to Supports – Vibration Isolation – Vibration Absorption – Critical Speed of Shafts- Torsional Vibration of Shafts – Single and Multi-Rotor Systems – Geared Shafts.

UNIT IV	**DESIGN OF MACHINE COMPONENTS**	**6**

Design of Closed Coiled Helical Spring - Design of Couplings – Design of Shaft

UNIT V	**DESIGN OF TRANSMISSION ELEMENTS**	**6**

Design of Gears - Selection and Specification - Design of Journal Bearings – Selection and Specification of Anti-Friction Bearings – Roller Bearings – Ball Screw - Chain Drive.

TOTAL	**30 PERIODS**

LIST OF EXPERIMENTS:

1. Law of Polygon of Forces Apparatus
2. Parallel Force System Apparatus
3. Rolling Friction Apparatus
4. Square Threaded Screw Jack
5. Bell Crank Lever
6. Equilibrium Forces Apparatus
7. Sliding Friction Apparatus
8. Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double Rocker, Oscillating cylinder Mechanisms.
9. Single degree of freedom Spring Mass System – Determination of natural Frequency and verification of Laws of springs – Damping coefficient determination.

(Any 7 Experiments)

30 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Reproduce the fundamental of mechanism in machinery development
CO2	Describe the working and usage of mechanism and mechanical parts in a system development
CO3	Design and develop the various mechanisms and mechanical parts for a system
CO4	Analyze by determining the mechanical parameters to the mechanical components and Mechanisms
CO5	Evaluate the mechanical component and mechanism by graphical representation and by doing experiments.

REFERENCES

1. Bansal R.K, “Theory of Machines”, Laxmi Publications (P) ltd., New Delhi. 2016.
2. Malhotra.D.R. and Gupta.H.C. “The Theory of Machines” Satya Prakasam, Tech. India Publications, 2000.
3. R.S.Khurmi and Gupta, “Theory of Machines” Eurasia Publishing House Pvt Ltd. 2020.
4. Joseph Edward Shigley, Charles R. Mischke, “Mechanical Engineering Design”, Mcgraw Hill International Edition, 2011.
5. V B Bhandari, “Design of Machine Elements” 5th edition, McGraw Hill, 2020.
6. T.V. Sundarajamoorthy and N. Shanmugam, “Machine Design”, Anuradha Publication, 2018.
7. Design Data: Data Book of Engineers by PSG College-Kalaikathir Achchagam – Coimbatore, 2020

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	1	1	2	2
2	1	1	2	1	2	2
3	1	2	2	2	1	2
4	2	1	1	1	2	2
5	2	2	2	1	2	2
Avg	**1.6**	**1.4**	**1.6**	**1.2**	**1.8**	**2**

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MR3152	SENSORS AND DATA ACQUISITION SYSTEM	L	T	P	C
		3	0	4	5

COURSE OBJECTIVES:

1.	To learn the various types of sensors, transducers, sensor output signal types, calibration techniques, formulation of system equation and its characteristics.
2.	To understand basic working principle, construction, Application and characteristics of displacement, speed and ranging sensors.
3.	To understand and analyze the working principle, construction, application and characteristics of force, magnetic and heading sensors.
4.	To learn and analyze the working principle, construction, application and characteristics of optical, pressure, temperature and other sensors.
5.	To familiarize students with different signal conditioning circuits design and data acquisition system.

UNIT I SENSOR CLASSIFICATION, CHARACTERISTICS AND SIGNAL TYPES **9**

Basics of Measurement – Classification of Errors – Error Analysis – Static and Dynamic Characteristics of Transducers – Performance Measures of Sensors – Classification of Sensors – Sensor Calibration Techniques – Sensor Outputs - Signal Types - Analog and Digital Signals, PWM and PPM.

UNIT II DISPLACEMENT, PROXIMITY AND RANGING SENSORS FORCE, MAGNETIC AND HEADING SENSORS **9**

Displacement Sensors – Brush Encoders - Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer – Range Sensors - Ultrasonic Ranging - Reflective Beacons - Laser Range Sensor (LIDAR) – GPS - RF Beacons

UNIT III FORCE, MAGNETIC AND HEADING SENSORS **9**

Strain Gage – Types, Working, Advantage, Limitation, and Applications: Load Measurement – Force and Torque Measurement - Magnetic Sensors – Types, Principle, Advantage, Limitation, and Applications - Magneto Resistive – Hall Effect, Eddy Current Sensor - Heading Sensors – Compass, Gyroscope and Inclinometers

UNIT IV OPTICAL, PRESSURE, TEMPERATURE AND OTHER SENSORS **9**

Photo Conductive Cell, Photo Voltaic, Photo Resistive, LDR – Fiber Optic Sensors – Pressure – Diaphragm – Bellows - Piezoelectric - Piezo-resistive - Acoustic, Temperature – IC, Thermistor, RTD, Thermocouple – Non-Contact Sensor - Chemical Sensors - MEMS Sensors - Smart Sensors.

UNIT V DATA ACQUISITION SYSTEM **9**

Need for Signal Conditioning – Resistive, Inductive and Capacitive Bridges for Measurement - DC and AC Signal Conditioning – Analog and Digital Data Acquisition Systems-ADC-DAC-Data Sampling-Parameters Measured using DAQ- DAQ Cards and Modules- DAQ Software.

45 PERIODS

LIST OF EXPERIMENTS:

1. Experiments Using Strain Gauge Sensor: Load Measurement, Torque
2. Determine the characteristics of Pressure Sensor.
3. Displacement Measurement using Inductive type-LVDT and Magnetic type - Hall Effect Sensor.
4. Determine the Characteristics of Various Temperature Sensors.
5. Determine the Characteristics of Various Light Detectors (Optical Sensors).
6. Distance Measurement using Ultrasonic and Laser Sensor.
7. Determine angular velocity using gyroscope.
8. Experiment on accelerometer to determine amplitude and frequency of Vibration.
9. Speed and Position Measurement Using Encoders.
10. Experiment on acquisition of analog signal using DAQ.
11. Experiment on acquisition of digital signal using DAQ.
12. Design and realize circuit to convert change in resistance, inductance and capacitance to voltage.

60 PERIODS

	TOTAL	**105 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State the principles of various sensor, sensor characteristics, signal types, calibration methods.
CO2	Determine the transfer function and empirical relation of sensors through sensor response study
CO3	Describe the operation of sensors, circuits and data acquisition system
CO4	Analyze and select the suitable sensor for the given applications.
CO5	Select and design suitable signal conditioning circuit for data acquisition.

REFERENCES

1. Ernest O. Doeblin, “Measurement system, Application and Design”, Tata McGraw Hill Publishing Company Ltd., 2004.
2. Jacob Fraden, “Handbook of Modern Sensors, Physics, Design and Applications”, Springer, 2016.
3. John P. Bentley., “Principle of Measurement systems”, Pearson Prentice Hall, 2008.
4. Patranabis D., “Sensor and Actuators”, Prentice Hall of India (Pvt) Ltd., 2005.
5. Renganathan S., “Transducer Engineering”, Allied Publishers (P) Ltd., 2003

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	-	1	-	1
2	1	1	1	2	1	1
3	1	1	1	1	1	1
4	2	2	2	1	2	1
5	2	1	2	2	1	1
Avg	**1.4**	**1.2**	**1.2**	**1.4**	**1**	**1**

MR3102	CONTROL SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To represent and simplify the mathematical models for various types of physical systems.
2.	To recognize the time domain specifications and to analyze of various types of system and its characteristics in time domain.
3.	To know the frequency domain specifications and to analyze of various types of system and its characteristics in frequency domain methods.
4.	To design compensator and controller using time and frequency domain.
5.	To evaluate, analyze and design a control system of servomotors for motion control.

UNIT I SYSTEM REPRESENTATION AND MODELLING **9**

Introduction and Need for Control Systems with Examples – Open loop and Closed loop Systems – Transfer Function Model – System Representation - Mathematical Modelling of Mechanical, Electrical, Thermal, Fluid Transportation, and Fluid Powered Systems – Block Diagram Reduction – Signal Flow Graph.

UNIT II TIME DOMAIN ANALYSIS **9**

Feedback Systems – Block Diagram - Inputs Signals and its Models - Time Domain Response of First & Second Order Systems – Time Domain Specifications - Steady State Errors and Error Constants – Routh Hurwitz Criterion – Root Locus – Root Locus Approach for Control System Design. Impulse Responses of Various Types of System and its Stability.

UNIT III FREQUENCY DOMAIN ANALYSIS **9**

Performance Measures in Frequency Domain - Bode Plot – Polar Plot – Nyquist Stability Criterion – Stability Analysis – Experimental Determination of Transfer Functions – Control System Design using Frequency Domain Analysis.

UNIT IV DESIGN OF COMPENSATORS AND CONTROLLERS **9**

Lead, Lag, Lag-Lead Compensation in Time Domain and Frequency Domain. Introduction - Characteristics of Analog ON-OFF, P, PI, PD and PID Controllers – Implementation Issues of PID Controller – Tuning of Controllers - Practical PID Control –Two DOF PID Controllers-Bumpless Control Transfer Between Manual and PID Control - Anti-Windup Control Using a PID Controller

UNIT V MOTION CONTROL **9**

Analysis of Servo Motor System Using Root Locus and Bode Plot - Stability Analysis – Implementation of P, PI, PD and PID Controllers for Servo Motor and Analysis-Motion Control System and its Design Challenges– Overview of Nonlinear Models (inverted pendulum) – control.

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Describe the terminologies, definitions and performance measures of control system.
CO2	Identify the parameters of mathematical modelling of a system method in time and frequency analysis.
CO3	Design the signal flow graph, block diagram, transfer function, state space models, stability analysis methods, compensators and control methods.
CO4	Evaluate the system modelling as well as system stability.
CO5	Suggest the modelling and analytical methods, control technique and controller for the given applications

Attested

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REFERENCES

1. Nise Norman S., “Control Systems Engineering”, John Wiley & Sons Inc., 2020.
2. Asif Sabanovic and Kouhei Oshnishi, “Motion Control Systems” Willey, 2011.
3. William.S Levine, “Control System Fundamentals”, CRC Press, 2019.
4. Farid Golnaraghi, Benjamin C. Kuo, “Automatic Control Systems”, Willey, 2017.
5. Nagrath.I.J and Gopal, “Control System Engineering”, New Age international (P) Ltd., 2010.
6. Ogata.K, “Modern Controls Engineering”, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	2	2	1	1	1	1
2	1	2	2	2	1	1
3	2	2	1	2	3	1
4	2	1	2	2	3	1
5	2	2	2	2	3	1
Avg	**1.8**	**1.8**	**1.6**	**1.8**	**2.2**	**1**

Attested

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MR3103	DRIVES AND ACTUATORS	L	T	P	C
		3	0	4	5

COURSE OBJECTIVES:

1.	To recognize the standard symbols and to understand the functions of basic fluid power generation and actuation elements.
2.	To realize the functions of fluid regulation and control elements and its typical uses in fluid power circuit and to acquire the practice on assembling the various types of pneumatic circuits.
3.	To familiar and exercise the design procedure of various types of pneumatic and hydraulic fluid power circuits and to provide a training to create the various types of hydraulic circuits.
4.	To understand the typical functions and selections of various types electrical actuators and to provide the hands-on training to the use of various electrical motors for automatic control.
5.	To apprehend the utilities of mechanical and power electronic drives for various functional requirements of actuators and control valves.

UNIT I	**FLUID POWER SYSTEM GENERATION AND ACTUATORS**	**9**

Need For Automation, Classification of Drives - Hydraulic, Pneumatic and Electric – Comparison – ISO Symbols for their Elements, Selection Criteria. Generating Elements- Hydraulic Pumps and Motor Gears, Vane, Piston Pumps – Motors - Selection and Specification - Drive Characteristics – Utilizing Elements - Linear Actuator – Types, Mounting Details, Cushioning – Power Packs – Accumulators

UNIT II	**CONTROL AND REGULATING ELEMENTS**	**9**

Control and Regulating Elements — Direction, Flow and Pressure Control Valves -Methods of Actuation, Types, Sizing of Ports. Spool Valves - Operating Characteristics -Electro Hydraulic Servo Valves - Types - Characteristics and Performance

UNIT III	**CIRCUIT DESIGN FOR HYDRAULIC AND PNEUMATICS**	**9**

Typical Design Methods – Sequencing Circuits Design - Combinational Logic Circuit Design - Cascade Method – KV Mapping - Electrical Control of Pneumatic and Hydraulic Circuits - Use of Relays, Timers, Counters, Programmable Logic Control of Hydraulics - Pneumatics Circuits - PLC Ladder Programming

UNIT IV	**ELECTRICAL ACTUATORS**	**9**

DC Motors – Construction, Working Principle, Classification, Characteristics, Applications – Single Phase and Three Phase AC Motors – Construction, Working Principle, Classification, Characteristics and Applications, Special Electrical Motors - Servomotors - Stepper Motors, Principle, Classification, Construction and Working - BLDC Motor and its Operating Modes - Piezo Electric Actuators – Linear Electrical Actuators - Hybrid Actuators

UNIT V	**ELECTRICAL DRIVE CIRCUITS**	**9**

Drives for Motion Control - DC Motors - Speed, Torque, Direction and Position Control - H-Bridge under PWM Mode**.** Control of AC Motor Drives – VFD Drives – Energy Saving AC Drives - AC Servo Drives - Speed, Breaking, Direction, Position and Torque Control – Stepper Motor Drive Circuits for Speed and Position Control - Drives for BLDC Motor - Selection of Drives – Protection and Switchgears.

45 PERIODS

LIST OF EXPERIMENTS:

FLUID POWER DRIVES

1. Experimental Verification of Speed Control Circuits in Pneumatic and Hydraulic Trainer.
2. Experimental Verification of Single and Double Acting Cylinder Circuits Using Different Directional Control Values.
3. Experimental Verification of Electro-Pneumatic Circuits.
4. Experimental Verification of Pneumatic Sequencing Circuits.
5. Experimental Verification of Logic, Meter-in and Meter-out Pneumatic Circuits.
6. Experimental Verification of Electro Pneumatic Sequencing Circuits.
7. Control of PLC Based Electro Pneumatic Sequencing Circuits.
8. Control of PLC Based Electro Hydraulic Sequencing Circuits

Any 5 experiments

ELECTRICAL DRIVES

1. Control the Position, Speed and Direction of DC Servo Motors
2. Control the Position, Speed and Direction of AC Servo Motors
3. Control the Position, Speed and Direction Stepper Motor.
4. Control the Position, Speed and Direction Control of Linear mechanical drive with DC Servo/ stepper Motor.

	60 PERIODS
TOTAL	**105 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State the operation of pneumatic, hydraulic and electrical actuators and its circuit components.
CO2	Describe the working of pneumatic, hydraulic and electrical actuators and its circuit components in a circuit.
CO3	Design the circuit using pneumatic, hydraulic and electrical actuators to perform sequential operation.
CO4	Select appropriate pneumatic, hydraulic and electrical actuators, and corresponding drives to perform automation for a given application.
CO5	Develop and analyze the circuit of pneumatic, hydraulic and electrical actuators for a required application.

REFERENCES

1. Austin Hughes, “Electric Motors and Drives Fundamentals, Types and Applications”, Fourth Edition, Elsevier, 2019
2. Singh.M.D, Khanchandani.K.B, “Power Electronics”, Second Edition, McGraw-Hill, 2008.
3. Antony Esposito, “Fluid Power Systems and Control”, Prentice-Hall, 2013.
4. Gopal K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publications, 2002.
5. Peter Rohner, “Fluid Power Logic Circuit Design”, the Macmillan Press Ltd., London, 1979.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	1	2
2	2	1	2	1	1	2
3	1	2	2	2	2	2
4	2	2	2	2	1	2
5	1	2	2	1	1	2
Avg	**1.4**	**1.6**	**2**	**1.4**	**1.2**	**2**

Attested

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RM3151 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	1	0	3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.

5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

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MR3111	CONTROL SYSTEMS DESIGN LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1.	To familiarize the Modelling of system and control.
2.	To design controller using time and frequency domain.
3.	To evaluate, analyze and design a control system of servomotors for motion control.

LIST OF EXPERIMENTS

1.	Mathematical Modelling and Simulation of a Physical Systems.
2.	Simulation and Reduction of Cascade and Parallel, and Closed Loop Sub-System.
3.	Plot the pole-zero configuration in s-plane for the given Transfer Function.
4.	Simulation and Analysis of First and Second Order System Equations in Time and frequency Domain
5.	Simulation and Analysis of Root-Locus and Bode Plot.
6.	Simulation and Implementation of PID Controller Combinations for First and Second Order Systems.
7.	Simulation of Motor velocity, position and torque control.
8.	Realization of control in ball balancing system using PID controller
9.	Realization of control in quad rotor setup using PID controller
10.	Realization of control in inverted pendulum using PID controller

TOTAL | **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recognize the fundamentals of control system parameters.
CO2	Modelling and Analysis of control system and motion parameters.
CO3	Evaluate and analyse the performance of control system and motion parameters.

COs	POs					
	1	2	3	4	5	6
1	1	1	1	1	-	1
2	2	2	2	2	2	2
3	3	2	2	2	3	2
Avg	2	2.5	1.67	1.67	2.5	1.67

Attested

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MR3112	COMPUTER AIDED MODELLING - MINI PROJECT	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1.	To understand the method/Concepts in Design and the use of software.
2.	To design and assembly involved in various automated systems.
3.	To demonstrate the computer-based modelling in the software for selected application

MINI PROJECT

(EVALUATION - INTERNAL EXAMINATION SIMILAR TO MINI PROJECTS ONLY)

Students has to practice the following modelling task for the first 20 Periods duration

1. 2D modeling and 3D modeling of Bearing, and Couplings.
2. 2D modeling and 3D modeling of Gears and Ball screw.
3. 2D modeling and 3D modeling of Sheet metal components.
4. 2D modeling and 3D modeling of Jigs, fixtures and die.
5. Modeling and simulation of mechanism of 4 Bar chain
6. Modeling and simulation of mechanism of Slider crank,
7. Modeling and simulation of mechanism of Ball and screw and Rack and pinion.
8. Modeling and simulation of mechanism of Belt and chain drives.

After completion, Students has to do the Modelling, Assembly and simulation of the any of the following projects for the remaining 25Periods.

1. 3D Modeling and assembly of serial manipulators – Gantry/ Articulated/ SCARA/Delta/ Drone
2. 3D Modeling and assembly of Automotive subsystems.

Finally, student has to present project along with report.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Design and draw 2D and 3D models for part design and model developments for the selected project.
CO2	Assemble the parts and simulate motion functionality of the model virtually.
CO3	Demonstrate the knowledge of computer aided modeling in multibody system development.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	3	-	-	1	3
2	1	3	-	1	2	3
3	2	3	-	1	2	3
Avg	**1.3**	**3**	**-**	**1**	**1.67**	**3**

MR3201	MECHATRONICS SYSTEM DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To enlist the various elements required to design and integrate the mechatronic systems.
2.	To acquire the Modelling skill to capture the system dynamics of hybrid systems.
3.	To familiar the system identification techniques and to practice the design and assembly of mechatronics system and fine tuning the design and control for real time system development in software environment.
4.	To apply the optimization procedure for the appropriate selection of mechatronic system elements and process parameter optimization.
5.	To understand, apply, analyze and evaluate the functions of systems models for integrating the virtual elements of mechatronics.

UNIT I	ELEMENTS OF MECHATRONICS	9

Comparison of Conventional System vs. Mechatronic System – Identification of Mechatronic System Requirements in Real World Problems - Mechatronics System Overview – Key Elements – Identification of Key Elements in Various Systems - Application Overview – Mechatronics System Design Process - Recent Advancements in Mechatronics System for Modern Automation.

UNIT II	SYSTEM MODELLING	9

Need for Modelling – Systems Overview – Representation of Systems in State Space – Analogue Approach – Parametric and Non-Parametric Modelling - Bond Graph Approach for Modelling of Electrical, Mechanical, Thermal, Fluid and Hybrid Systems

UNIT III	SYSTEM IDENTIFICATION	9

System Identification – White, Grey and Black Box Modelling - Overview – Types -Linear Regression- Least Square Method, Statistical Analysis of LS method, Possibilities and limitations with empirical modeling -Parameter Estimation-Algorithm - Simulation Fundamentals – Simulation Life Cycle – Hardware-In-Loop Simulation (HIL) - Controller Prototyping –Software's for Simulation and Integration

UNIT IV	SIMULATION AND DESIGN OPTIMIZATION	9

Optimization – Problem Formulation - Constraints – Overview of Linear and Nonlinear Programming Techniques – Advanced Optimization Techniques – Genetic algorithm - Particle Swarm Optimization

UNIT V	CASE STUDIES ON MODELING OF MECHATRONIC SYSTEMS	9

Modelling of Manufacturing Systems, Transportation System, Industrial Manipulator, Light Motor Vehicle, Aerial Vehicle, Underwater Vehicle - Modelling and Simulation of Automotive subsystems – Overview Modelling and Simulation Software – Toolboxes

TOTAL	45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State various elements of mechanical, electrical, thermal and fluid system and the parameters to model the system.
CO2	Describe the parameter selection and different types of system modelling, identification and optimization.
CO3	Develop the model, identify and optimize by selecting the input and output variables of a system.
CO4	Design and analyze the developed model numerically and by simulation.
CO5	Integrate and analyze the mechatronics system virtually and able to fine tune the system design and control algorithms in the software-in-loops before real time development.

Attested

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REFERENCES

1. Bradley, D. Dawson, N.C.Burd and A.J. Loader, “Mechatronics: Electronics in Product and Process”, Chapman and Hall, London, 1999.
2. Bolton, “Mechatronics – Electronic Control Systems in Mechanical and Electrical Engineering”, Addison Wesley Longman Ltd.6th edition, 2013.
3. Brian Morriss, “Automated Manufacturing Systems – Actuators Controls, Sensors and Robotics”, McGraw Hill International Edition, 2000.
4. Devadas Shetty, Richard A.Kolkm, “Mechatronics System Design”, PWS Publishing Company, 2009.
5. Ogata.K, “Modern Controls Engineering”, Prentice Hall of India Pvt. Ltd.5thediton, 2009.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	3	2	3
2	1	1	2	3	2	3
3	1	1	2	3	2	3
4	1	1	2	3	2	3
5	1	1	2	3	2	3
Avg	**1**	**1**	**2**	**3**	**2**	**3**

Attested

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MR3251	INDUSTRIAL ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To know the basic terminologies, classification, configurations and components of serial manipulator.
2.	To understand the mechanical design and robot arm kinematics
3.	To learn and understand the various linear control techniques on manipulators
4.	To learn and understand the various non-linear control techniques on manipulators
5.	To learn the robot programming and demonstrate the robot in various applications

UNIT I **INTRODUCTION TO SERIAL MANIPULATORS** **9**

Types of Industrial Robots, Definitions – Classifications Based on Work Envelope – Generations Configurations and Control Loops - Coordinate Systems – Need for Robot – Basic Parts and Functions – Specifications – Robotic Sensor - Position and Proximity's Sensing – Tactile Sensing – Sensing Joint Forces.

UNIT II **MECHANICAL DESIGN OF ROBOT SYSTEM** **9**

Robot Motion – Linkages and Joints – Mechanism – Method for Location and Orientation of Objects - Kinematics of Robot Motion – Direct and Indirect Kinematics Homogeneous Transformations – D-H Transformation – Drive Systems – End Effectors – Types, Selection, Classification and Design of Grippers – Gripper Force Analysis.

UNIT III **ROBOT DYNAMICS AND TRAJECTORY PLANNING** **9**

Trajectory planning – joint space, Cartesian space description and trajectory planning – third order, fifth order - Polynomial trajectory planning-control overview, Dynamic equations-control - Types of Programming – Teach Pendant Programming –Robotic Cell Layouts – Inter Locks-control overview

UNIT IV **MOBILE ROBOTICS** **9**

Wheeled Robot and Legged Robot – Architecture - Configurations and Stability - Design Space and Mobility Issues - Teleportation and Control – Localization – Navigation – AGV – AMR

UNIT V **APPLICATIONS OF ROBOTS** **9**

Architecture and working - Manufacturing Industries - Material Handling, Assembly, Inspection. Surgical robot – Haptics technology– Space vehicle and unmanned aerial vehicle – Underwater- ROV, AUV – Robot in Nuclear industry – Humanoid Robots – special type of robots

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State about fundamental concepts of manipulators and mobile robots.
CO2	Describe the robot types, robot elements, numerical computation methods and the applications
CO3	Solve the robot kinematics, dynamics, trajectory and path planning problems.
CO4	Analyze robot kinematics, dynamics, trajectory and path planning problems.
CO5	Create robot architecture, kinematic and dynamic solutions, program the robot for the given application in the environment.

REFERENCES

1. Saeed B. Niku, “Introduction to Robotics: Analysis, Control, Applications”, 3rd edition, John Wiley & sons, Inc., 2019.
2. John J. Craig, "Introduction to Robotics – Mechanics and control”, 3rd edition, Pearson Higher Education 2014.
3. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987.
4. Groover,M.P., Weis,M., Nagel,R.N. and Odrey,N.G., “Industrial Robotics Technology, Programming and Applications”, Mc Graw-Hill, Int., 2012.
5. Klafter,R.D., Chmielewski, T.A. and Negin,M., “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 1988.
6. Kevin M Lych and frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, First Edition, 2017.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	2	1	1
2	1	1	2	2	1	1
3	1	1	2	2	2	1
4	1	1	2	2	2	2
5	1	1	2	2	1	2
Avg	**1**	**1**	**2**	**2**	**1.4**	**1.4**

Attested

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MR3202	INDUSTRIAL AUTOMATION	L	T	P	C
		3	0	4	5

COURSE OBJECTIVES:

1.	To understand the importance of automation in industry and various industrial standard sensors and process parameters to control the production process.
2.	To learn PLC hardware, and practice the PLC programming and simulation in real systems.
3.	To get knowledge on industrial standard data communication protocols, SCADA, centralized and decentralized control.
4.	To get introduced to factory layout, Total Integrated Automation on factory and Industry 4.0.
5.	To get exposure on building automation using sensors, controllers and actuators

UNIT I INDUSTRIAL INSTRUMENTATION AND CONTROL **9**

Introduction and Need for Automation - Instrumentation System for Measurement of Process Parameters – Overview on Flow, Level, Pressure, Temperature, Speed, Current and Voltage Measurements – Proximity and Vision Based Inspection Systems – Process Control Systems – Continuous and Batch Process – Feedback Control System Overview.

UNIT II PROGRAMMABLE LOGIC CONTROLLER **9**

Fundamentals of Programmable Logic Controller - Functions of PLCs - Features of PLC - Selection of PLC - Architecture – Basics of PLC Programming - Logic Ladder Diagrams – Communication in PLC – Programming Timers and Counters – Data Handling - PLC modules - Advanced PLC.

UNIT III DATA COMMUNICATION AND SUPERVISORY CONTROL SYSTEMS **9**

Industrial Data Communications - Fiber Optics – Modbus – HART – DeviceNet – Profibus – Fieldbus – Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – Man-Machine Interfaces - Total Integrated Automation (TIA)

UNIT IV FACTORY AUTOMATION **9**

Factory Layout - Tools and Software Based Factory Modelling -Case Study on Automated Manufacturing Units, Assembly Unit, Inspection Systems and PLC Based Automated Systems - Introduction to Factory Automation Monitoring Software- Building Automation System-Software

UNIT V SMART TECHNOLOGIES FOR INDUSTRIAL 4.0 **9**

Industry 4.0-Challenges in Industry 4.0 - Big Data-Characteristics of Big Data - Artificial Intelligence - Machine to Machine Technologies - IoT-Digitization - Digital Twin

45 PERIODS

LIST OF EXPERIMENTS:

1. Experiments on Ladder Logic Program for Various Logic Gates AND, OR, NOT, NOR, NAND, EX-OR and EX-NOR.
2. Implement Various Mathematical Functions in PLC Using Ladder Diagram Programming Language.
3. Develop Ladder Diagram Programming to set Timer and Counter in PLC.
4. Develop PLC Program to Control Traffic Light.
5. Develop PLC Program to Maintain the Pressure and Level in a Bottle Filling System.
6. Develop Ladder Diagram Program in PLC for Material Filling and Material Handling
7. Develop Ladder Diagram Program in PLC for Object Shorting, Orientation Check and Material Property Check.
8. Develop the Ladder Diagram Program in PLC for Material Handling and Conveyor Control
9. Develop the Ladder Diagram Program in PLC for Feeding, Pick and Place Operation.
10. Experiments on Sensor and Actuator Interfacing and PLC to PLC Communication.

60 PERIODS

TOTAL **105 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State the need of identifying the control parameters, sensors, controllers, communication and role of advanced technologies in automating the industry.
CO2	Describe the operation of sensors, instrumentation, Logic controller, communication protocol, factory setup and smart technologies.
CO3	Design and simulate system layout develop logic program
CO4	Implement the selected sensor, protocol and logic in controller to automate an application.
CO5	Create industry model and simulate by varying the parameters to do analysis on statistical and management data of the plant.

REFERENCES

1. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, 2016.
2. Lucas, M.P., “Distributed Control System”, Van Nastrand Reinhold Company, 1986.
3. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design, Installation and Troubleshooting”, Newnes Publication - Elsevier, 2004.
4. Patranabis. D, “Principles of Industrial Instrumentation”, Tata McGraw-Hill Publishing Ltd.2nd edition, 2016.
5. Shengwei Wang, “Intelligent Buildings and Building Automation”, Routledge Publishers, 2009.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	2	1	2
2	1	1	1	2	1	2
3	2	1	2	2	2	1
4	2	1	2	2	2	1
5	2	1	2	2	1	1
Avg	**1.6**	**1**	**1.6**	**2**	**1.4**	**1.4**

MR3203	EMBEDDED SYSTEMS	L	T	P	C
		3	0	4	5

COURSE OBJECTIVES:

1.	To familiarize the architecture and fundamental units of microcontroller.
2.	To know the microcontroller programming methodology and to acquire the interfacing skills and data exchange methods using various communication protocols.
3.	To design the interface circuit and programming of I/O devices, sensors and actuators.
4.	To understand ARM processor architecture and its functions to meet out the computational and interface needs of growing mechatronic systems.
5.	To acquaint the knowledge of real time embedded operating system for advanced system developments.

UNIT I MICROCONTROLLER **9**

Fundamentals Functions of ALU - Microprocessor - Microcontrollers – CISC and RISC – Types Microcontroller - 8051 Family - Architecture - Features and Specifications - Memory Organization - Instruction Sets – Addressing Modes.

UNIT II PROGRAMMING AND COMMUNICATION **9**

Fundamentals of Assembly Language Programming – Instruction to Assembler – Compiler and IDE - C Programming for 8051 Microcontroller – Basic Arithmetic and Logical Programming - Timer and Counter - Interrupts – Interfacing and Programming of Serial Communication, I^2C, SPI and CAN of 8051 Microcontroller – Bluetooth and WI-FI interfacing of 8051 Microcontroller.

UNIT III PERIPHERAL INTERFACING **9**

I/O Programming – Interfacing of Memory, Key Board and Displays – Alphanumeric and Graphic, RTC, interfacing of ADC and DAC, Sensors - Relays - Solenoid Valve and Heater - Stepper Motors, DC Motors - PWM Programming – Closed Loop Control Programming of Servomotor – Overview of Advanced Microcontrollers.

UNIT IV ARM 7 PROCESSOR **9**

Introduction ARM 7 Processor - Internal Architecture – Modes of Operations – Register Set – Instruction Sets – ARM Thumb - Thumb State Registers – Pipelining – basic programming of ARM 7 - Applications

UNIT V REAL TIME MODELS, LANGUAGES AND OPERATING SYSTEMS **9**

Models and Languages – State Machine and State Tables in Embedded Design – High Level Language Descriptions – Real Time Kernel - OS Tasks - Task Scheduling - Kernel Services – Real Time Embedded Operating Systems - Real Time Programming Languages - GPIO Programming – Comparative Overview of C and Python for Embedded Systems.

TOTAL 45 PERIODS

LIST OF EXPERIMENTS:

1. Assembly Language Programming and Simulation of 8051.
   a) Data Transfer b) Arithmetic Instructions c) Counters d) Boolean and logical Instructions e) Code Conversion
2. Alphanumeric and Graphic LCD Interfacing using 8051 Microcontroller.
3. Input switches and keyboard interfacing of 8051.
4. Sensor Interfacing with ADC to 8051 and DAC &RTC Interfacing with 8051.
5. Timer, Counter and Interrupt Program Application for 8051.
6. Step Motor (Unipolar & Bipolar Motor) and PWM Servo Motor Control to Interfacing with 8051.
7. I2C Programming of 8051.
8. Interfacing and Programming of Bluetooth and Wi-Fi with 8051
9. Interfacing and Programming of Sensor with Real Time Embedded Operating Systems.
10. Interfacing and Programming of Camera with Real Time Embedded Operating Systems.
11. Interfacing and Programming of Actuator with Real Time Embedded Operating Systems.
12. Interfacing and Programming of Serial Communication with Real Time Embedded Operating Systems.
13. GPIO Programming of Real Time Embedded Operating Systems.

	60 PERIODS
TOTAL	**105 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Define the fundamentals of Microcontroller, Processor and Single board computers
CO2	Recognize the architecture, functions and features of Microcontroller, Processor and SBC
CO3	Develop the skills in programming and communication with 8051 Microcontrollers, Processor and SBC
CO4	Apply the skills in interfacing with 8051 microcontroller, Processor and SBC to develop a system to a simulation model.
CO5	Create software to realize in controller to perform the task.

REFERENCES

1. Ball S.R., “Embedded Microprocessor Systems – Real World Design”, Prentice Hall, 2006
2. Frank Vahid and Tony Givagis, “Embedded System Design”, 2011, Wiley.
3. James W. Stewart, “The 8051 Microcontroller Hardware, Software and Interfacing”, Regents Prentice Hall, 2003.
4. John B. Peatman, “Design with Microcontrollers”, McGraw Hill International, USA, 2005.
5. Kenneth J. Aylala, “The 8051 Microcontroller, the Architecture and Programming Applications”, 2003
6. Muhammad Ali Mazidi and Janice Gillispic Mazdi, “The 8051 Microcontroller and Embedded Systems”, Pearson Education, 2006.
7. Gay, W.W. (2014). The Raspberry Pi. In: Raspberry Pi Hardware Reference. A press, Berkeley, CA.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	1	-	2
2	1	1	1	1	1	2
3	1	1	1	2	1	-
4	1	1	1	2	1	1
5	2	1	1	-	1	1
Avg	**1.2**	**1**	**1**	**1.5**	**1**	**1.2**

MR3211	ROBOT SIMULATION, PROGRAMMING AND INSPECTION LABORATORY	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1.	To Model, Simulate and verify the forward and inverse kinematics of serial manipulators for trajectory generation and to attain the exposure on robot programming.
2.	To realize the integrated operation of mechatronics system thorough CNC Programming methods for part manufacturing.
3.	To observe, practice and analyze the function of automated quality inspection and classifications system for dimensional and non-dimensional features

LIST OF EXPERIMENTS

SIMULATION AND PROGRAMMING OF ROBOTS

1.	Simulation of Forward and Inverse Kinematics of Planar Manipulators.
2.	Simulation of Forward and Inverse Kinematics of Spatial Manipulators.
3.	Trajectory Planning of Planer Manipulators.
4.	Trajectory Planning of Spatial Manipulators.
5.	Programming of Serial Manipulators. ● Articulated Robot. ● Cartesian Robot. ● SCARA

PROGRAMMING OF CNC MACHINES

1.	NC Programming on CNC Routers, Vertical Machining Centre and Turning Centre
2.	Programming in EDM and Water Jet Cutting.
3.	Programming in Rapid Prototyping.

AUTOMATED MEASUREMENT AND INSPECTION

1.	Conveyor Based Object Sorting using Sensors.
2.	Conveyor with Vision Based Object Classification.
3.	Vision Based Measurements of Various Profiles.
4.	Automated Measurement using CMM Simple Profiles.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recognize the fundamentals of Kinematics, CNC Programming and Automation Systems.
CO2	Develop model, create program and perform the simulation, machining and measurement operation.
CO3	Analyse output and identify optimum parameter/machining process/measurement technique for given application.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	3	3	3	2	2
2	1	3	3	3	2	2
3	1	3	3	3	2	2
Avg	**1**	**3**	**3**	**3**	**2**	**2**

MR3212	MECHATRONICS SYSTEM DESIGN - MINI PROJECT	L	T	P	C
		0	0	3	1.5

COURSE OBJECTIVES:

1.	To learn fundamentals related to system modelling.
2.	To learn selection of appropriate control parameters to perform simulation.
3.	To learn software to perform simulation of the developed model.

MINI PROJECT

EVALUATION - INTERNAL EXAMINATION SIMILAR TO MINI PROJECTS ONLY

Students have to model, simulate and analyze the following topics (not limited to).

- 6 DOF Serial Manipulators with virtual sensors and actuators
- Parallel Manipulator
- Aerial Robot
- Mobile Robot
- Vehicle and its Automotive Sub System.

Finally, student has to present the project along with a report.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Develop the physical model and control parameters of the system.
CO2	Analyse the model by considering different variables.
CO3	Apply the real system parameters to analyse the developed model in the software.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	3	1	3	2	3
2	1	3	1	3	3	3
3	1	3	2	3	2	3
Avg	**1**	**3**	**1.33**	**3**	**2.33**	**3**

MR3311	PROJECT WORK - I	L	T	P	C
		0	0	12	6

COURSE OBJECTIVES:

1.	To enable students to select and define a problem/need for analysis in the field of mechatronics and its interdisciplinary area based on the complexity of the problem.
2.	To review and analyse literature/ data of selected problem for study and propose objective and scope of dissertation work.
3.	To develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the proposed field of dissertation work.

EVALUATION:

1.	A project topic may be selected based on the literature survey and the creative ideas of the students themselves in consultation with their project supervisor. The topic should be so chosen that it will improve and develop skills in design, modelling, simulation, developing algorithms, fabrication and integration of system elements for automation and research. Literature survey and a part of the project work be carried out in dissertation-I.
2.	The progress of the project is evaluated based on a minimum of three reviews and a review committee may be constituted by the Head of the Department.
3.	The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.
4.	A project report for dissertation-I is to be submitted at the end.
5.	Project work evaluation is based on the Regulations of the Credit system for the Post graduate programmes of Anna University

TOTAL	**180 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Apply the knowledge gained from theoretical and practical courses, and the problem identified through the literature survey.
CO2	Design, model and experiment/develop optimal solution for problem being investigated.
CO3	Analysis and interpretate the system and its performance, data, and synthesis of the information to provide valid conclusions and submit report.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	3	3	3	3	3	3
2	3	3	3	3	3	3
3	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**

Attested

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MR3312	INTERNSHIP	L	T	P	C
		0	0	2	1

COURSE OBJECTIVES:

1.	To assess defined problems in the industry and to provide the feasible solutions based on the skills of the graduate through internship
2.	To assess and acquire the training by observing and analyzing the functioning of various machineries and its elements in the industrial training.
3.	To acquire certified training on various design and automation systems and their technologies offered by state / central approved institution.

INTERNSHIPS

To assess defined problems in the industry for at least two weeks and to provide the feasible solutions based on the skills of the graduate through internship

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recognize the problem in the existing system.
CO2	Give feasible solutions to the industrial problem using a systematic approach and implement the learned technologies on the platform.
CO3	Enable students to communicate technical information in form of oral presentation and technical report in form of dissertation

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	2	3	3	2	2	3
2	2	3	2	3	2	3
3	3	3	3	3	2	3
Avg	**2.33**	**3**	**2.67**	**2.67**	**2**	**3**

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MR3411	PROJECT WORK - II	L	T	P	C
		0	0	24	12

COURSE OBJECTIVES:

1.	To define a problem/need for development and analysis in the field of mechatronics and its interdisciplinary area and it may be a continuation of dissertation -I or newly formulated problem for dissertation - I.
2.	To comprehensively review and analyse literature/ data to develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the field of problem.
3.	To design, model, simulate, develop algorithms, fabricate, integrate and system elements for automating the system for sustainable development and economical consideration.

EVALUATION:

1.	The progress of the project is evaluated based on a minimum of three reviews.
2.	The review committee may be constituted by the Head of the Department.
3.	A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.
4.	Project work evaluation is based on the Regulations of the Credit system for Post graduate programmes of Anna University.

TOTAL	360 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Apply the knowledge gained from the theoretical and practical courses in identifying and solving problems.
CO2	Analyse and interpret system and its performance, data, and synthesize of the factual information's to arrive at valid conclusions
CO3	Enable students to communicate technical information in form of oral presentation and technical report in form of dissertation

COs	POs					
	1	2	3	4	5	6
1	3	3	3	3	3	3
2	3	3	3	3	3	3
3	3	3	3	3	3	3
Avg	3	3	3	3	3	3

MR3051	MULTI-BODY DYNAMICS AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the importance of dynamics in analyzing the behavior of mechanical systems.
2.	To develop proficiency in using computational methods for dynamic analysis of multibody systems.
3.	To apply stability analysis techniques to assess the stability of nonlinear systems.
4.	To characterize the behavior of nonlinear systems using phase plane analysis and describing function.
5.	To design control strategies to achieve desired performance in nonlinear mechanical systems.

UNIT I	INTRODUCTION TO DYNAMICS	9

Importance of Multibody Dynamics - Particle Mechanics - Rigid Body Mechanics - Deformable Bodies - Constrained Motion- -Kinematics - Rotation - Translation - Velocity- Acceleration Equations – Mechanics of Deformable Bodies - Floating Frame Reference Formulation – Inertia - Generalized Forces - Equation of Motions - Multi Body Systems - Sub Systems - Friction and Spring Nonlinear Model - Nonlinear Dynamic Equations Formulation

UNIT II	COMPUTATIONAL METHODS FOR DYNAMIC ANALYSIS	9

Jacobian Matrix - Newton-Raphson Method - Nonlinear Kinematic Constrain Equation – System Mass Matrix - External and Elastic Forces - Acceleration Vector – Lagrangean Multiplier - Langrage's Equation – Kinetic Energy – Hamilton Equation - Hamilton vector Field- Euler - Langrage Equation- Generalized Reaction Forces – State Vector and Equation Formulation.

UNIT III	NONLINEAR SYSTEMS AND CONCEPTS	9

Linear Time Varying and Linearization – Input and Output Stability - Lyapunov Stability Analysis – Asymptotic Stability - Popov's and Circle Criterion - Perturbed System – Chaos – Periodic Orbits- Index theory and Limit Cycle – Centre Manifold Theory- Normal Forms- Nonlinear analysis- Poincare Maps - Bifurcations – Maps - Vector Fields - Methods – Control System Design using Lyapunov's Direct Method.

UNIT IV	SYSTEM CHARACTERIZATION	9

Stability, Controllability, Observability - Phase Plane Analysis - Phase Portrait - Limit Cycle - Describing Function - Assumption – Limit Cycles.

UNIT V	CONTROL OF NONLINEAR MECHANICAL SYSTEMS	9

Double Inverted Pendulum – Nonlinear Machineries – Robots - Suspension System - Aircraft.

TOTAL	45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Describe the fundamental concepts and principles of dynamics in mechanical systems.
CO2	Apply computational methods for analyzing and solving dynamic problems in multibody systems.
CO3	Analyze and evaluate the stability and behavior of nonlinear systems using mathematical techniques.
CO4	Characterize and assess the properties of mechanical systems, such as stability, controllability, and observability.
CO5	Design and implement control strategies to achieve desired performance in nonlinear mechanical systems.

REFERENCES

1. Ahmed A. Shabana, "Dynamics of Multibody Systems", Cambridge University Press, fifth edition, 2020.
2. Brian L. Stevens, Frank L. Lewis, "Aircraft Control and Simulation", Wiley India Pvt Ltd, third Edition, 2016.
3. Hasan Khalil, "Nonlinear Systems and Control", Prentice Hall, 2018.
4. Mahmut Reyhanoglu, "Dynamics and Control of a Class of Under Actuated Mechanical Systems", IEEE Transactions on Automatic Control, 44(9), 2013.
5. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamics System and Chaos", Springer-Verlag, Fouth Edition, 2018.
6. Wei Zhong and Helmut Rock, "Energy and Passivity Based Control of the Double Inverted Pendulum on a Cart", IEEE, 2019.

COs	POs					
	1	2	3	4	5	6
1	1	1	2	1	-	-
2	2	1	2	1	3	-
3	2	1	1	1	3	-
4	1	1	2	1	1	-
5	2	1	1	1	2	-
Avg	**1.6**	**1**	**1.6**	**1**	**1.8**	**-**

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MR3002	MOBILE ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To know the fundamental concepts and principles of mobile robotics.
2.	Gain proficiency in programming and implementing mobile robot systems using ROS.
3.	Develop skills in sensor integration, perception, and localization for mobile robots.
4.	Learn planning and navigation techniques for mobile robot autonomy.
5.	Apply knowledge and skills to design and build functional mobile robot prototypes.

UNIT I	**INTRODUCTION TO MOBILE ROBOTICS**	**9**

Introduction – Locomotion of the Robots – Key Issues on Locomotion – Legged Mobile Roots – Configurations and Stability – Wheeled Mobile Robots – Design Space and Mobility Issues – Unmanned Aerial and Underwater Vehicles – Teleportation and Control.

UNIT II	**KINEMATICS**	**9**

Kinematic Models – Representation of Robot – Forward Kinematics – Wheel and Robot Constraints – Degree of Mobility and Steerability – Maneuverability – Workspace – Degrees of Freedom – Path and Trajectory Considerations – Motion Controls - Holonomic Robots – Open Loop and Feedback Motion Control – Humanoid Robot - Kinematics Overview

UNIT III	**PERCEPTION**	**9**

Sensor for Mobile Robots – Classification and Performance Characterization – Wheel/Motor Sensors – Heading Sensors - Ground-Based Beacons - Active Ranging - Motion/Speed Sensors – Vision Based Sensors – Uncertainty - Statistical Representation - Error Propagation - Feature Extraction Based on Range Data (Laser, Ultrasonic, Vision-Based Ranging) - Visual Appearance based Feature Extraction.

UNIT IV	**LOCALIZATION**	**9**

The Challenge of Localization - Sensor Noise and Aliasing - Effector Noise – Localization Based Navigation Versus Programmed Solutions - Belief Representation – Single - Hypothesis Belief And Multiple-Hypothesis Belief - Map Representation - Continuous Representations - Decomposition Strategies - Current Challenges In Map Representation - Probabilistic Map-Based Localization - Markov Localization - Kalman Filter Localization - Landmark-Based Navigation - Globally Unique Localization - Positioning Beacon Systems - Route-Based Localization - Autonomous Map Building - Stochastic Map Technique - Other Mapping Techniques.

UNIT V	**PLANNING, NAVIGATION AND COLLABORATIVE ROBOTS**	**9**

Introduction - Competences for Navigation: Planning and Reacting - Path Planning - Obstacle Avoidance - Navigation Architectures - Modularity for Code Reuse and Sharing - Control Localization - Techniques for Decomposition - Case Studies – Collaborative Robots – Swarm Robots.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall the key issues, configurations, and types of mobile robots, as well as kinematic models and sensor classifications.
CO2	Understand the concepts of locomotion, perception, localization, and planning/navigation in mobile robotics.
CO3	Apply kinematic models, sensor data processing techniques, and localization methods to analyze and solve mobile robot problems.
CO4	Analyze and evaluate different approaches for perception, localization, and planning/navigation in mobile robotics.
CO5	Design and develop solutions for mobile robot locomotion, perception, localization, and planning/navigation using appropriate techniques and algorithms.

REFERENCES

1. Dragomir N. Nenchev, Atsushi Konno, Teppei T sujita, “Humanoid Robots: Modelling and Control”, Butterworth-Heinemann, 2018
2. Mohanta Jagadish Chandra, “Introduction to Mobile Robots Navigation”, LAP Lambert Academic Publishing, 2015.
3. Peter Corke, “Robotics, Vision and Control”,Springer, Third Edition, 2023.
4. Roland Siegwart and Illah R.Nourbakish, “Introduction to Autonomous Mobile Robots” MIT Press, Cambridge, 2016.
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6. Xiao Qi Chen, Y.Q. Chen and J.G. Chase, “Mobile Robots - State of the Art in Land, Sea, Air, and Collaborative Missions”, Intec Press, 2022.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	1	1	1
2	1	1	1	2	1	1
3	1	1	1	2	2	1
4	2	1	1	2	2	2
5	2	1	2	2	2	2
Avg	**1.4**	**1**	**1.2**	**1.8**	**1.6**	**1.4**

Attested

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MR3003	ROBOT OPERATING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To develop proficiency in programming and utilizing the ROS framework for robot applications.
2.	To gain hands-on experience in creating and modeling robots using CAD tools and URDF.
3.	To acquire skills in simulating and controlling robots in Gazebo and V-REP.
4.	To understand mapping, navigation, and motion planning techniques using ROS MoveIt.
5.	To apply theoretical knowledge to design and implement advanced robotic behaviors and interactions.

UNIT I	**ROS ESSENTIALS**	**9**

Introduction to ROS- Advantages and Disadvantages of ROS - ROS Framework- ROS package C++, Python – ROS computation Graph – nodes, Messages, topics, services, bags, ROS Master- ROS Community- Basic programming and Syntax overview in C++ and Python – start with ROS programming - Creating Environment - Services-Actions and Nodes- Simple Interaction with the Simulation environment

UNIT II	**BUILD YOUR OWN ROBOT ENVIRONMENT**	**9**

CAD Tools for Robot Modelling – ROS Packages for robot modelling – Unified Robot Description Format and Tags- Kinematics and Dynamics Library – Create URDF Model - Robot Modelling using Unified Robot Description Format (URDF) -ROS parameter server and adding real-world object representations to the simulation environment _ Create Robot description using 7 DOF: joint number, name, type and angle limits – Xacro – Rviz – viewing of 7 DOF arm – creation of wheeled robot

UNIT III	**SIMULATION ROBOTS IN ROS WITH GAZEBO**	**9**

Robot simulation - Gazebo –create simulation model at Gazebo- Adding colors, textures, transmission tags, 3D vision sensor to Gazebo- Moving robot joints using ROS controllers- ROS controller interacts with Gazebo, interfacing state controller, simulation of moving the robot joints – simulation of differential wheeled robot in Gazebo.

UNIT IV	**ROS WITH VREP**	**9**

V-REP is a multi-platform robotic simulator - Simulating the robotic arm using V-REP - Adding the ROS interface to V-REP joint - Simulating a differential wheeled robot, adding a laser sensor, 3D vision sensor

UNIT V	**MAPPING, NAVIGATION AND MOTION PLANNING ROS WITH MOVEIT**	**9**

Move it Instattion - Generating the Self-Collision matrix, virtual joints, planning groups, robot poses, robot end effector - MoveIt Architecture Diagram - Trajectory from RViz GUI executing in Gazebo - Planning scene overview diagram- Collision Checking **-** Motion Planning, Pick and Place Behaviors using Industrial Robots with ROS Moveit – ROS with MATLAB - ROS with Industrial

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall advantages/disadvantages of ROS, understand ROS framework, and basic programming syntax.
CO2	Explain ROS computation graph, URDF modeling, and kinematics/dynamics library.
CO3	Apply ROS programming to create an environment, build robot models, and interact with simulation.
CO4	Analyze integration of ROS with simulation platforms, evaluate mapping/navigation/motion planning techniques.
CO5	Synthesize knowledge of ROS, CAD tools, and simulation platforms to design and implement complex robot behaviors.

REFERENCES

1. Lentin Joseph, Jonathan Cacace, “Mastering ROS for Robotics Programming”, Second Edition, Packt Publishing, 2018
2. Lentin Joseph, Aleena Johny, “Robot Operating System (ROS) for Absolute Beginners Robotics Programming Made Easy”, Second Edition, Apress, 2022.
3. Lentin Joseph, “ROS Robotics Projects”, Packt publishing, Second ediiton, 2019.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	2	1	2
2	1	1	2	2	1	2
3	2	1	2	1	1	2
4	2	1	2	2	2	2
5	3	1	2	3	3	3
Avg	**1.8**	**1**	**2**	**2**	**1.6**	**2.2**

Attested

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MR3004	HUMANOID ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To apply research and investigative techniques to solve practical problems in mechatronics.
2.	To demonstrate effective technical communication skills through technical report writing and presentations.
3.	To develop a comprehensive understanding of key concepts, methods, and core elements of mechatronics.
4.	To utilize modern tools and techniques to design intelligent mechatronic systems.
5.	To analyze and optimize engineering solutions using a mechatronics-based approach.

UNIT I	**INTRODUCTION**	**9**

Historical development of Humanoids, Human Likeness of a Humanoid Robot, Trade-Offs in Humanoid Robot Design, Human-Friendly Humanoid Robot Design, characteristics of humanoid robots.

UNIT II	**KINEMATICS**	**9**

Kinematic structure, forward and inverse kinematic problems, differential kinematics, Twist, Spatial Velocity, and Spatial Transform, Inverse Differential Kinematic Relations. Differential kinematics at singular configurations- Gait Analysis

UNIT III	**ZMP AND DYNAMICS**	**9**

ZMP Overview,2D Analysis,3D Analysis, Measurement of ZMP, General Discussion- ZMP of Each Foot, ZMP for Both Feet Contact, Dynamics of Humanoid Robots, Humanoid Robot Motion and Ground Reaction Force, Momentum, Angular Momentum, Angular Momentum and Inertia Tensor of Rigid Body, Calculation of Robot's Center of Mass, Link Speed and Angular Velocity, Calculation of Robot's Momentum and Angular Momentum

UNIT IV	**BIPED WALKING**	**9**

Two-Dimensional Walking Pattern Generation, Two-Dimensional Inverted Pendulum, Behavior of Linear Inverted Pendulum, Orbital Energy, Support Leg Exchange, Planning a Simple Biped Gait, Extension to a Walk on Uneven Terrain.

UNIT V	**WALKING PATTERN GENERATION**	**9**

ZMP Based Walking Pattern Generation, Cart-Table Model, Off-Line Walking Pattern Generation, Stabilizer, Principles of Stabilizing Control, Stabilizing Control of Honda Humanoid Robot, Advanced Stabilizers

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Describe the historical development, characteristics, and design trade-offs of humanoid robots.
CO2	Interpret and summarize the concepts of kinematics, ZMP, and dynamics in humanoid robot systems.
CO3	Apply kinematic principles to solve forward and inverse kinematic problems and generate walking patterns for humanoid robots.
CO4	Analyze the dynamics of humanoid robots, including motion, ground reaction forces, momentum, and stability during bipedal locomotion.
CO5	Design and develop advanced stabilizing control strategies for humanoid robots to enhance their stability and performance during walking

REFERENCES

1. Goswami, P. Vadakkepat (Eds.), "Humanoid Robotics: A Reference", Springer, Netherlands, Dordrecht, 2020.
2. J K. Harada, E. Yoshida, K. Yokoi (Eds.), "Motion Planning for Humanoid Robots", Springer, London, 2010.
3. Lorenzo Sciavicco and Bruno Siciliano, "Modelling and Control of Robot Manipulators", second edition, Springer, 2000.

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4. Jean-Claude Latombe, "Robot Motion Planning", Kluwer Academy Publishers, 2004.
5. Dragomir N. Nenchev, Atsushi Konno, “Humanoid Robots Modeling and Control”, Butterworth Heinemann, 2019
6. Shuuji K, Hirohisa H, Kensuke H, Kazuhito, Springer-Verlag GmbH“Introduction to Humanoid Robotics”, Springer, London, 2022.
7. J. Craig, "Introduction to Robotics: Mechanics and Control", Fourth Edition, Pearson, 2022

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	1	1	1
2	1	1	1	1	2	2
3	1	1	1	1	1	1
4	1	1	1	1	2	2
5	1	1	1	2	2	2
Avg	**1**	**1**	**1**	**1.2**	**1.6**	**1.6**

MR3005	MULTI AGENT ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand principles of collaborative and swarm robotics.
2.	To explore modular robot design and kinematics.
3.	To study naturally inspired collaboration and decision-making in robotics.
4.	To analyze reconfigurable robot control mechanisms.
5.	To apply knowledge to design and optimize robotic systems.

UNIT I **INTRODUCTION TO COBOTICS** **9**

Collaborative Robotics- Properties - Introduction to Modern Mobile Robots: Swarm Robots, Cooperative and Collaborative Robots, Mobile Robot Manipulators-Current Challenges

UNIT II **SWARM ROBOTICS** **9**

Introduction, mapping, kinematics and trajectory error compensation, state transitions, collective decision making and methodologies, swarm robot scenarios-aggregation, clustering dispersion, pattern formation, sorting, flocking and collective motion, shepherding, heterogeneous swarms, Error Detection and Security.

UNIT III **MODULAR ROBOTICS** **9**

Module Designs - Modular Robot Representation -Modular Serial Robot Kinematics - Kinematic Calibration for Modular Serial Robots- Modular Serial Robot Dynamics - Modular Parallel Robot Kinematics

UNIT IV **NATURALLY INSPIRED COLLABORATION** **9**

Collective Decision-Making. Group Decision Making in Animals, Collective Motion as Decision Process, Models for Collective Decision-Making Processes, Urn Models, Voter Model, Majority Rule, Hegselmann and Krause, Kuramoto Model, Axelrod Model, Ising Model, Fiber Bundle Model, Sznajd Model, Bass Diffusion Model, Sociophysics and Contrarians**.**

UNIT V **RECONFIGURABLE ROBOTS** **9**

V-Shaped Formation Control for Robotic Swarms Constrained by Field of View – formation of reconfigurable virtual linkage - Reconfigurable Formation Control of Multi-Agents - Self-Assembly Modular Robot Platform Based on Sambot - Swarm Dynamics Emerging from Asymmetry.

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall the properties and challenges associated with collaborative robotics, swarm robotics, modular robotics, and naturally inspired collaboration.
CO2	Understand the concepts and principles of swarm robotics, modular robotics, and naturally inspired collaboration in robotic systems.
CO3	Apply the knowledge of swarm robotics to analyze and design collective decision-making methodologies and scenarios for swarm robot applications.
CO4	Analyze the kinematics, dynamics, and configuration options of modular robotics systems for various applications.
CO5	Evaluate the control mechanisms and emerging swarm dynamics of reconfigurable robots, considering their formation control and self-assembly capabilities.

REFERENCES

1. Guilin Yang, I-Ming Chen, “Modular Robots: Theory and Practice”, Springer, 2022.
2. GiandomenicoSpezzano, “Swarm Robotics”, Applied Sciences, MDPI, 2019.
3. Heiko Hamann, “Collective Decision-Making in Swarm Robotics: A Formal Approach”, Springer, 2019.

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COs	POs					
	1	2	3	4	5	6
1	1	1	2	1	-	1
2	1	1	2	2	1	1
3	1	1	2	2	2	1
4	1	1	2	2	3	2
5	1	1	2	3	3	2
Avg	1	1	2	2	2.25	1.4

Attested

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MR3006	AUTOMOBILE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the construction and layout of different types of automobile vehicles, including chassis, frame, and body structures.
2.	To explain the principles of vehicle aerodynamics and the various resistances and moments involved in vehicle motion.
3.	To analyze the components, functions, and materials used in internal combustion engines (IC engines) and the concept of variable valve timing (VVT).
4.	To evaluate and compare electronically controlled fuel injection systems for gasoline and diesel engines, including common rail direct injection and unit injector systems.
5.	To examine the transmission systems in vehicles, including manual and automatic gearboxes, clutch types, and torque converters.

UNIT I	**VEHICLE STRUCTURE AND ENGINES**	**9**

Types of automobiles vehicle construction and different layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines – components-functions and materials, variable valve timing (VVT).

UNIT II	**ENGINE AUXILIARY SYSTEMS**	**9**

Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three-way catalytic converter system, Emission norms (Euro and BS).

UNIT III	**TRANSMISSION SYSTEMS**	**9**

Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Overdrive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints, Differential and rear axle, Hotchkiss Drive and Torque Tube Drive.

UNIT IV	**STEERING, BRAKES AND SUSPENSION SYSTEMS**	**9**

Steering geometry and types of steering gear box-Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control.

UNIT V	**ALTERNATIVE ENERGY SOURCES**	**9**

Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels - Electric and Hybrid Vehicles, Fuel Cell Note: Practical Training in dismantling and assembling of Engine parts and Transmission Systems should be given to the students.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall the different types of steering gearboxes, suspension systems, and braking systems used in automobiles.
CO2	Understand the principles of vehicle aerodynamics and their impact on vehicle performance and efficiency.
CO3	Apply the knowledge of engine auxiliary systems to analyze and diagnose engine performance issues and propose appropriate solutions.
CO4	Analyze the functioning and performance of alternative energy sources in automobiles, such as natural gas, biofuels, and electric/hybrid systems.
CO5	Evaluate the impact of different transmission systems on vehicle performance, including their efficiency, gear shifting mechanisms, and power transfer capabilities.

REFERENCES

1. Jain K.K. and Asthana. R.B, “Automobile Engineering” Tata McGraw Hill Publishers, New Delhi, 2002.
2. Kirpal Singh, “Automobile Engineering”, Vol 1 & 2, Seventh Edition, Standard Publishers, New Delhi, 13th Edition 2014.
3. Ganesan V. “Internal Combustion Engines”, Third Edition, Tata McGraw-Hill, 2015.
4. Heinz Heisler, “Advanced Engine Technology,” SAE International Publications USA, 1998.
5. Joseph Heitner, “Automotive Mechanics,” Second Edition, East-West Press, 1999.
6. Martin W, Stockel and Martin T Stockle , “Automotive Mechanics Fundamentals,” The Good heart - Will Cox Company Inc, USA ,1978.
7. Newton, Steeds and Garet, “Motor Vehicles”, Butterworth Publishers,1989.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	-	-	1
2	1	1	1	-	-	1
3	2	1	1	-	-	1
4	2	1	1	-	-	1
5	1	1	1	-	-	1
Avg	**1.4**	**1**	**1**	**-**	**-**	**1**

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AM3351	ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	General aspects of Electric and Hybrid Vehicles (EHV), including architectures, modeling, sizing, sub-system design and hybrid vehicle control.
2.	Understand about vehicle dynamics,
3.	Design the required energy storage devices,
4.	Select the suitable electric propulsion systems and
5.	Understand of hybrid electric vehicles.

UNIT I	NEED FOR ALTERNATIVE SYSTEM	9

Need for hybrid and electric vehicles – main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Comparative study of diesel, petrol, hybrid and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles. Case study on specification of electric and hybrid vehicles.

UNIT II	DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES	9

Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refueling Systems

UNIT III	ENERGY STORAGE DEVICES AND SOURCES	9

Battery Parameters- - Different types of batteries. Battery Chemistry, Battery Modelling, Battery Management System, Thermal Management system. Ultra-capacitors. Fuel Cell, Characteristics- Fuel cell types- Electrolytic reactions of fuel cell. Cell Chemistry.

UNIT IV	MOTORS AND CONTROLLERS	9

Types of Motors, Characteristic of DC motors, AC single phase and 3-phase motor, PM motors, switched reluctance motors, Motor Drives and speed controllers, Torque Vectoring, Regenerative Braking. Rectifiers, Inverters, DC/DC converters.

UNIT V	SUBSYTEMS OF HYBRID AND ELECTRIC VEHICLES	9

Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid and Electric Vehicle- Economy of hybrid Vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1	Understand need and working of different configurations of hybrid and electric vehicles
CO2	Design and develop basic systems of electric vehicles and hybrid electric vehicles.
CO3	Choose proper energy storage systems for EV applications
CO4	Choose a suitable drive system for developing an electric and hybrid vehicle depending on resources
CO5	Understand basic operation of power-split device and control Strategies for hybrid and electric vehicle.

TEXT BOOKS:

1. James Larminie and John Lowry, “Electric Vehicle Technology Explained “John Wiley & Sons,2003
2. Iqbal Husain, “Electric and Hybrid Vehicles-Design Fundamentals”, CRC Press,2003
3. Mehrdad Ehsani, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles”, CRC Press,2005

REFERENCES:

1. Ron Hodkinson, “Light Weight Electric/ Hybrid Vehicle Design”, Butterworth Heinemann Publication,2005
2. Lino Guzzella, “Vehicle Propulsion System” Springer Publications,2005

COs	POs						PSOs		
	1	2	3	4	5	6	1	2	3
1	3	3	3	3	3	3	3	3	2
2	3	3	3	3	3	3	3	3	2
3	3	3	3	3	3	3	3	3	2
4	3	3	3	3	3	3	3	3	2
5	3	3	3	3	3	3	3	3	2
AVG	3	3	3	3	3	3	3	3	2

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MR3007	VETRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To introduce the architecture, sub-systems of car and engines types and its functions of automobile.
2.	To familiar the elements and functions of manual and automatic transmission, suspension and steering systems
3.	To understand functions of safety and diagnostic system and to familiar the role of ECU, communication protocols and modern automotive.
4.	To understand integration of various subsystem in aerial vehicles.
5.	To appreciate the integration of various subsystems in aerial vehicles.

UNIT I INTRODUCTION TO AUTOMOTIVE AND ENGINE CONTROL **9**

Need for Automobile - Architecture of Automobile – Car, Types of Sub-System in Car and its Integration, Chassis, Classification Engine – Types – Modern Engines – Advanced GDI, Turbo-charged Engines - Components of Electronic Engine Management – Engine Control Functions - Modes, Fuel Delivery Systems - MPFI, CRDI - Ignition Systems, Diagnostics.

UNIT II TRANSMISSION, SUSPENSION, STEERING SYSTEMS **9**

Transmissions Systems – Sub Systems, Manual, Automatic - Suspension – Suspension Modelling, Conventional, Semi Active and Active - Steering Systems – Manual and Automatic - Brake Systems - ABS - Stability - Emission Control Management – Hybrid Power Plants - Autonomous Cruise Control.

UNIT III SAFETY SYSTEMS AND ECU **9**

Safety Systems - Airbag - Automatic Door and Mirror - Parking Assist Systems - Blind Spot Avoidance – Telematics, Automatic Navigation - Dashboard - Diagnostics Systems – OBD - Communication Protocols - Cloud Connected Car – Level 4, Level 5 Automation - Autonomous Car.

UNIT IV AIRCRAFT MECHATRONICS **9**

Fundamentals - Components of an Airplane and their Functions - Motions of a Plane - Inertial Navigation – Sensors - Gyroscope- Principles, Gyro Equations, Rate Gyros - Rate Integration and Free Gyro, Vertical and Directional Gyros, Laser Gyroscopes, Accelerometers. Direct Reading Compass, Types of Actuation Systems-Linear and Non-Linear Actuation System, Modelling of Actuation Systems, Servo-Loop Analysis Actuator Design - Testing Methodologies, Performance Testing Equipment's for Sensors and Actuation Systems. Measurement and Control of Pressure, Temperature Fuel Quantity, RPM, Torque, Engine Vibration and Power. Electrical Power Requirement for Military and Civil Standards. Satellite Navigation - GPS -System Description -Basic Principles -Position and Velocity Determination

UNIT V MARINE MECHATRONIC SYSTEMS **9**

Basics of Marine Engineering – Architecture of Ships, Submarines – Types - Variable Buoyancy Systems - AUV - ROV - Propulsion Systems - Thrusters - Rudders – Marine Electrical – Power Generation - Lighting – Ventilation - Communication and Navigation-Stability and Control in Water.

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Describe the key components and integration of subsystems in automobiles, aircraft, and marine systems.
CO2	Apply principles of transmission, suspension, and steering systems to analyze and optimize vehicle performance and control.
CO3	Evaluate and assess safety systems and ECUs to ensure efficient and reliable operation in automotive applications.
CO4	Analyze and interpret the functioning of aircraft mechatronic systems for navigation, stability, and control.
CO5	Exhibit the understanding of automobiles, aircraft, and marine engineering principles and the application of mechatronics systems in vehicles.

REFERENCES

1. Jurgen R.K, “Automotive Electronics Handbook”, McGraw Hill, 1999.
2. Robert N Brady, “Automotive Computers and Digital Instrumentation”, Prentice Hall, 2000.
3. William B.Ribbens, “Understanding Automotive Electronics”, Butterworth, Heinemann Wobum, 2003.
4. D.A Taylor, “Introduction to Marine Engineering”, Elsevier, Butterworth Heinemann Publication, 2014.
5. Asgeir.J Sorensen, “Report: Marine Control System”, Norwegian University of Science and Technology, 2013.
6. D.A. Taylor, “Marine Control Practice”, Butterworth & Co (Publishers) Ltd., London, 1987.
7. Leslie Jackson, “Instrumentation and Control Systems”, Thomas Reed Publication Ltd., London, 2013.
8. Robert C. Nelson, “Flight Stability and Automatic Control”, McGraw-Hill, Inc, 1998.
9. Jane‘s,” Unmanned Aerial Vehicles and Targets”, 1999.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	2	1	2
2	3	1	2	2	1	2
3	3	1	2	2	1	2
4	2	1	2	2	2	2
5	2	1	2	2	1	2
Avg	**2.2**	**1**	**2**	**2**	**1.2**	**2**

MR3008	SMART MOBILITY AND INTELLIGENT VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the concept of automated, connected, and intelligent vehicles and their significance in the automotive industry.
2.	To gain knowledge about various sensor technologies used in smart mobility and their applications in vehicle systems.
3.	To explore the principles and theories behind connected autonomous vehicles and their control systems.
4.	To study wireless technology and networking concepts relevant to vehicle communication and autonomy.
5.	To examine the technology and applications of connected cars and autonomous vehicles, including the associated ethical, legal, technical, and security considerations.

UNIT I	**INTRODUCTION TO AUTOMATED, CONNECTED, AND INTELLIGENT VEHICLES**	**9**

Concept of Automotive Electronics, Electronics Overview, History & Evolution, Infotainment, Body, Chassis, and Powertrain Electronics, Introduction to Automated, Connected, and Intelligent Vehicles. Case studies: Automated, Connected, and Intelligent Vehicles

UNIT II	**SENSOR TECHNOLOGY FOR SMART MOBILITY**	**9**

Basics of Radar Technology and Systems, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera Technology, Night Vision Technology, Other Sensors, Use of Sensor Data Fusion, Integration of Sensor Data to On-Board Control Systems

UNIT III	**CONNECTED AUTONOMOUS VEHICLE**	**9**

Basic Control System Theory applied to Automobiles, Overview of the Operation of ECUs, Basic Cyber-Physical System Theory and Autonomous Vehicles, Role of Surroundings Sensing Systems and Autonomy, Role of Wireless Data Networks and Autonomy

UNIT IV	**VEHICLE WIRELESS TECHNOLOGY &NETWORKING**	**9**

Wireless System Block Diagram and Overview of Components, Transmission Systems – Modulation/Encoding, Receiver System Concepts– Demodulation/Decoding, Wireless Networking and Applications to Vehicle Autonomy, Basics of Computer Networking – the Internet of Things, Wireless Networking Fundamentals, Integration of Wireless Networking and On-Board Vehicle Networks

UNIT V	**CONNECTED CAR & AUTONOMOUS VEHICLE TECHNOLOGY**	**9**

Connectivity Fundamentals, Navigation and Other Applications, Vehicle-to-Vehicle Technology and Applications, Vehicle-to-Roadside and Vehicle-to-Infrastructure Applications, Autonomous Vehicles - Driverless Car Technology, Moral, Legal, Roadblock Issues, Technical Issues, Security Issues

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the key concepts and components of automated, connected, and intelligent vehicles.
CO2	Apply sensor technology to analyze and interpret data for smart mobility applications.
CO3	Evaluate and integrate sensor data to enhance the performance and autonomy of vehicles.
CO4	Design and implement wireless networking solutions for connected and autonomous vehicles.
CO5	Assess the challenges and ethical considerations associated with connected and autonomous vehicle technology.

REFERENCES

1. "Intelligent Transportation Systems and Connected and Automated Vehicles", 2016, Transportation Research Board
2. Radovan Miucic, "Connected Vehicles: Intelligent Transportation Systems", 2019, Springer
3. Tom Denton, "Automobile Electrical and Electronic systems, Roult edge", Taylor & Francis Group, 5th Edition, 2018.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	3	1	2
2	1	1	2	3	2	2
3	1	1	3	3	2	2
4	1	1	2	3	2	2
5	1	1	2	3	3	3
Avg	**1**	**1**	**2**	**3**	**2**	**2.2**

Attested

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MR3009	ADVANCED DRIVER ASSISTANCE SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To Understand automotive systems, components, and safety protocols.
2.	To Analyze and interpret data from various automotive sensors.
3.	To Integrate ADAS technology into vehicle electronics.
4.	To Evaluate and apply advanced driver assistance systems.
5.	To Design innovative automotive display and warning technologies.

UNIT I AUTOMOTIVE FUNDAMENTALS **9**

Power System-Running System-Comfort System– Engine Components – Drive train – suspension system, ABS, Steering System, ADAS standards, regulations, and safety protocols

UNIT II AUTOMOTIVE SENSORS **9**

Knock sensors, oxygen sensors, crankshaft angular position sensor, temperature sensor, speed sensor, Pressure sensor, Mass air flow sensor, Manifold Absolute Pressure Sensors, crash sensor, Coolant level sensors, Brake fluid level sensors – operation, types, characteristics, advantage and their applications. Radar, Ultrasonic Sonar Systems, Lidar Sensor Technology and Systems, Camera

UNIT III OVERVIEW OF DRIVER ASSISTANCE TECHNOLOGY **9**

Basics of Theory of Operation, Applications, Integration of ADAS Technology into Vehicle Electronics, System Examples, Role of Sensor Data Fusion. Vehicle Prognostics Technology

UNIT IV ADVANCED DRIVER ASSISTANCE SYSTEMS **9**

Advanced Driver Assistance Systems - Lane Departure (LDW), Active Cruise Control (ACC), Blind Spot Detection, Parking Assist, Autonomous Emergency Braking (AEB), Night Vision, Traffic Sign Recognition (TSR), Intelligent High beam Assistant (IHC), Tire Pressure Monitoring (TPMS), Front Collision Warning System (FCWS), Front Vehicle Departure Warning (FVDW), Adaptive Lighting, Driver Drowsiness Detection, Hill Decent Control, Rear Cross Traffic

UNIT V ADAS DISPLAY & IMPAIRED DRIVER TECHNOLOGY **9**

Center Console Technology, Gauge Cluster Technology, Heads-Up Display Technology, and Warning Technology – Driver Notification. Impaired Driver Technology -Driver Impairment Sensor Technology, Sensor Technology for Driver Impairment Detection, Transfer of Control Technology

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain automotive systems and components.
CO2	Apply sensor technology to analyze and interpret data for automotive applications.
CO3	Evaluate and integrate ADAS technology into vehicle electronics.
CO4	Design and implement advanced driver assistance systems.
CO5	Develop innovative automotive display and warning technologies.

REFERENCES

1. Tom Denton, “Automobile Electrical and Electronic systems, Roultedge”, Taylor & Francis Group, 5th Edition,2018.
2. William B Ribbens, “Understanding Automotive Electronic: An Engineering Perspective”, Elsevier Science,8th Edition,2017.
3. “Intelligent Transportation Systems and Connected and Automated Vehicles”, Transportation Research Board, 2016.
4. Radovan Miucic, “Connected Vehicles: Intelligent Transportation Systems”, Springer, 2019.

COs	POs					
	1	2	3	4	5	6
1	1	1	2	2	1	1
2	1	1	2	2	1	1
3	1	1	2	2	1	1
4	1	1	2	2	1	1
5	1	1	2	2	1	1
Avg	**1**	**1**	**2**	**2**	**1**	**1**

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MR3010	PROGRAMMING IN PYTHON	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand and apply fundamental problem-solving strategies and algorithms.
2.	To develop proficiency in a programming language and its syntax for problem-solving tasks.
3.	To analyze and evaluate different control flow structures and functions for efficient program execution.
4.	To demonstrate proficiency in working with various data types and manipulating data in programming.
5.	To apply advanced techniques and concepts to solve complex problems and develop efficient algorithms.

UNIT I	**PROBLEM SOLVING**	**9**

Fundamentals of Computing – Identification of Computational Problems -Algorithms, building blocks of algorithms (statements, state, control flow, functions), notation (pseudo code, flow chart, programming language), algorithmic problem solving, simple strategies for developing algorithms (iteration, recursion). Illustrative problems: find minimum in a list, insert a card in a list of sorted cards, guess an integer number in a range, Towers of Hanoi.

UNIT II	**DATA TYPES, EXPRESSIONS, STATEMENTS**	**9**

Python interpreter and interactive mode, debugging; values and types: int, float, Boolean, string, and list; variables, expressions, statements, tuple assignment, precedence of operators, comments; Illustrative programs: exchange the values of two variables, circulate the values of n variables, distance between two points.

UNIT III	**CONTROL FLOW, FUNCTIONS, STRINGS**	**9**

Conditionals: Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: state, while, for, break, continue, pass; Fruitful functions: return values, parameters, local and global scope, function composition, recursion; Strings: string slices, immutability, string functions and methods, string module; Lists as arrays. Illustrative programs: square root, gcd, exponentiation, sum an array of numbers, linear search, binary search.

UNIT IV	**LISTS, TUPLES, DICTIONARIES**	**9**

Lists: list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters; Tuples: tuple assignment, tuple as return value; Dictionaries: operations and methods; advanced list processing - list comprehension; Illustrative programs: simple sorting, histogram, Students marks statement, Retail bill preparation.

UNIT V	**FILES, MODULES, PACKAGES**	**9**

Files and exceptions: text files, reading and writing files, format operator; command line arguments, errors and exceptions, handling exceptions, modules, packages; Illustrative programs: Programming Exercise

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the key concepts and components of problem solving, including algorithms, computational problems, and strategies for developing algorithms.
CO2	Apply problem-solving techniques and algorithmic thinking to analyze and solve a variety of computational problems, demonstrating proficiency in using different strategies and approaches.
CO3	Design and implement efficient and effective algorithms to solve complex problems, utilizing appropriate control flow structures, functions, and data structures.
CO4	Evaluate and critique algorithms and code solutions, identifying areas for improvement, optimizing performance, and demonstrating an understanding of good programming practices.
CO5	Synthesize and integrate problem-solving skills and computational thinking into real-world scenarios, demonstrating the ability to apply problem-solving techniques to solve practical problems in various domains.

REFERENCES

1. Eric Matthhes “Python Crash Course” No Starch Press Edition 1, 2015
2. Mark Lutz “Learn Python” O’Reilly Media,2009
3. Al Sweigart “Automate the boring stuff with Python” No Starch Press Edition 1, 2016
4. Wes McKinney “Python for Data Analysis” O’reilly Media, 2012

COs	POs					
	1	2	3	4	5	6
1	1	1	1	-	-	1
2	1	1	1	-	-	1
3	1	1	1	-	-	1
4	1	1	1	-	-	1
5	1	1	1	-	-	1
Avg	1	1	1	-	-	1

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MR3011	MACHINE VISION AND COMPUTER VISION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To recall and explain the fundamental principles and components of machine vision and computer vision systems, including the role of vision in human perception and the benefits of machine vision.
2.	To apply knowledge of lighting parameters, techniques, and sources to design effective lighting setups for machine vision applications, considering scene constraints and specific requirements.
3.	To understand the physics of light and its interactions, such as refraction and thin lens equation, and apply this knowledge to explain image formation in machine vision systems.
4.	To analyze and evaluate different image acquisition techniques, including machine vision lenses, optical filters, and imaging sensors, and make appropriate selections based on specifications and application requirements.
5.	To apply image processing techniques, including spatial and frequency domain operations, edge detection, morphology, and feature extraction, to enhance and analyze digital images in the context of machine vision applications

UNIT I	**INTRODUCTION TO VISION AND LIGHTING**	**9**

Human Vision – Machine Vision and Computer Vision – Benefits of Machine Vision – Block Diagram and Function of Machine Vision and computer vision, Nomenclature of Image– Physics of Light – Interactions of Light – Refraction at a Spherical Surface – Thin Lens Equation-Scene Constraints – Lighting Parameters – Lighting Sources, Selection – Lighting Techniques – Types and Selection.

UNIT II	**IMAGE ACQUISITION**	**9**

Machine Vision Lenses and Optical Filters, Specifications and Selection – Imaging Sensors – CCD and CMOS, Specifications – Interface Architectures – Analog and Digital Cameras – Digital Camera Interfaces – Camera Computer Interfaces, Specifications and Selection – Modelling Geometrical Image Formation Models – Camera Calibration - Intrinsic and Extrinsic Parameters, Estimation of Projection Matrix.

UNIT III	**IMAGE PROCESSING AND IMAGE ANALYSIS**	**9**

Machine Vision Software – Fundamentals of Digital Image – Image Acquisition Modes – Image Processing in Spatial and Frequency Domain – Point Operation, Thresholding, Grayscale Stretching – Neighborhood Operations, Image Smoothing and Sharpening – Edge Detection – Binary Morphology – Colour image processing-Feature extraction – Region Features, Shape and Size features – Texture Analysis – Template Matching and Classification

UNIT IV	**3-D IMAGE RECONSTRUCTION**	**9**

3D Machine Vision Techniques – Decision Making, Computational Stereopsis – Geometry, Parameters – Correspondence Problem, Epipolar Geometry, Essential Matrix and Fundamental Matrix, Eight Point Algorithm – Reconstruction by Triangulation, Visual Motion – Motion Field of Rigid Objects – Optical Flow – Estimation of Motion Field – 3D Structure and Motion from Sparse and Dense Motion Fields – Motion Based Segmentation – Image Processing.

UNIT V	**VISION APPLICATIONS**	**9**

Machine Vision Applications - Metrology and Gauging-GD&T, OCR and OCV, Vision Guided Robotics – Field and Service Applications – Agricultural, and Bio Medical Field, Augmented Reality, Surveillance, Bio-Metrics-Reverse Engineering.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the key principles, components, and functions of machine vision and computer vision systems.
CO2	Apply image acquisition techniques, including lenses, sensors, and interfaces, for machine vision systems.

CO3	Implement image processing algorithms and techniques to enhance and analyze digital images.
CO4	Recognize and utilize 2D and 3D machine vision techniques for reconstruction and analysis.
CO5	Develop machine vision applications for various fields, considering the requirements and constraints of each domain

REFERENCES

1. Alexander Hornberg, “Handbook of Machine Vision”, John Wiley & Sons, 2006.
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4. Eugene Hecht, “Optics”, Pearson, 2017.
5. Rafael C.Gonzales, Richard.E.Woods, “Digital Image Processing”, Pearson, 2017.
6. Forsyth and Ponce, “Computer Vision: A Modern Approach”, Pearson, 2015.
7. Boguslaw Cyganek, J. Paul Siebert, “An Introduction to 3D Computer Vision Techniques and Algorithms”, Willey, 2013.
8. Davies E.R, “Computer and Machine Vision: Theory, Algorithm, Practicalities”, Academic Press, Elsevier, 2012.
9. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, Prentice Hall, 1998
10. Rafael C. Gonzales, Richard.E.Woods, “Digital Image Processing”, Pearson, 2018.
11. Emanuele Trucco, Alessandro Verri, “Introductory Techniques for 3D Computer Vision”, Prentice Hall, 1998.
12. Forsyth and Ponce, “Computer Vision: A Modern Approach”, Pearson, 2015

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	3	2	1	2
2	1	1	2	1	1	2
3	1	1	3	2	1	2
4	1	1	2	2	2	2
5	1	1	3	2	2	2
Avg	**1**	**1**	**2.6**	**1.8**	**1.4**	**2**

MR3012	MACHINE LEARNING AND DEEP LEARNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the fundamental concepts and principles of machine learning, deep learning, and neural networks.
2.	To apply various supervised, unsupervised, and semi-supervised learning techniques to solve real-world problems.
3.	To implement and evaluate reinforcement learning algorithms for sequential decision-making tasks.
4.	To design, train, and optimize neural networks and deep learning models for different applications.
5.	To analyze and interpret the performance of machine learning and deep learning models and make informed decisions for improvement.

UNIT I	**SUPERVISED LEARNING METHODS AND REGRESSION**	**9**

Introduction to Machine Learning - Platforms for ML- Classifiers - LDA, Naive Bayes Classifier and KNN and SVM, Decision Tree, Regression methods.

UNIT II	**SEMI-SUPERVISED LEARNING AND UNSUPERVISED LEARNING**	**9**

Semi-Supervised Learning Methods- Association Rule Learning - Apriori Algorithm - Unsupervised Learning Methods- Expectation-Maximization (EM)- Vector Quantization- Clustering- Fuzzy K-means and C-means Algorithm- Density-Based Spatial Clustering of Applications with Noise (DBSCAN)- Conceptual Clustering.

UNIT III	**REINFORCEMENT LEARNING, FUZZY AND GENETIC ALGORITHMS**	**9**

Reinforcement Learning Methods- Markov Decision Processes (MDPs)-Q-learning-SARSA, Basic Concepts in Fuzzy Set Theory - Fuzzy Classification, Genetic Algorithms- Initialization, Selection, Mutation and termination. Swarm Intelligence (PSO) -Ant Colony Optimization (ACO).

UNIT IV	**NEURAL NETWORKS AND DEEP LEARNING FUNDAMENTALS**	**9**

Introduction to Neural Networks, Perceptron, Multi-Layer Perceptron (MLP), Back Propagation (BPN), Tuning Neural Networks and Best Practices-Training Neural Networks and Update Rules- Neural Networks vs Conventional Neural Networks vs Deep Learning - Convolutional Neural Networks (CNN)-Convolution, Pooling, Activation Functions - Initialization, Dropout, Batch Normalization, Deep Learning Hardware (CPU, GPU, TPU).

UNIT V	**CONVOLUTIONAL NEURAL NETWORKS AND DEEP LEARNING APPLICATIONS**	**9**

Deep Learning Frameworks - Data Augmentation-Transfer Learning-Popular CNN Architectures for Image Classification (AlexNet, VGG, ResNet, Inception)-CNN Architectures for Object Detection (RCNN, YOLO)-Semantic Segmentation (FCN)-Instance Segmentation (Mask RCNN).

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the key principles and algorithms of machine learning, deep learning, and neural networks.
CO2	Apply different supervised, semi-supervised, and unsupervised learning methods to analyze and interpret data.
CO3	Implement reinforcement learning algorithms, fuzzy logic, and genetic algorithms for solving complex problems.
CO4	Design, train, and evaluate neural networks and deep learning models for various applications.
CO5	Develop program for neural network and advanced deep learning models for image classification, object detection, and semantic/instance segmentation.

REFERENCES

1. Ethem Alpaydin, “Introduction to Machine Learning” The MIT Press, Cambridge, London, 2020.
2. Klir G.J. Yuan Bo, “Fuzzy sets and Fuzzy Logic: Theory and Applications”, Prentice Hall, 2019.
3. Laurene Fausett, “Fundamentals of Neural Networks, Architectures, Algorithms and Applications”, Prentice Hall, Englewood Cliffs, 2000.
4. Rajasekaran S, Vijayalakshmi Pai GA, “Neural Networks, Fuzzy Logic and Genetic Algorithms”, Prentice Hall of India Private Limited, 2011.
5. Randy L. Haupt, Sue Ellen Haupt Practical Genetic Algorithms, Wiley Inter science 2004.
6. Simon Haykin, “Neural Networks – A Comprehensive Foundation”, Prentice Hall, Third Edition, 2004.
7. Ian Goodfellow and Yoshua Bengio and Aaron Courville, “Deep Learning”, First Edition, MIT Press, 2018

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	-	1	1
2	1	1	1	-	1	1
3	1	1	1	-	2	1
4	1	1	1	-	2	2
5	1	1	1	-	2	2
Avg	**1**	**1**	**1**	**-**	**1.6**	**1.4**

MR3013	HAPTICS AND MIXED REALITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To identify the terminologies of haptic devices.
2.	To understand the structure of haptic system and to aware the tele-operation for various applications.
3.	To acquire the knowledge on modelling for haptic system development relevant to the human.
4.	To emphasize the significance of knowledge in virtual and augmented reality.
5.	To know the concepts and hardware of mixed reality.

UNIT I **INTRODUCTION TO HAPTICS** **9**

Definition - Importance of Touch - Tactile Proprioception - Tactual Stereo Genesis - Kinesthetic Interfaces - Tactile Interfaces - Human Haptics - Overview of Existing applications - Basics of Force Feedback Devices - Kinesthetic Vs. Tactile Haptic Devices - Configurations of Kinesthetic Devices -Types of Kinesthetic Devices

UNIT II **KINESTHETIC HAPTIC DEVICES AND TELEOPERATION** **9**

Mechatronics in Haptics System - Haptic Kinematics - Haptic Dynamics - Existing Kinesthetic Devices - Haptic Device Static Rendering - Haptic Device Dynamic Rendering - Control of Haptic Devices - Stability Analysis of Haptic Devices - Stability Analysis of the Rendered Model -Passivity of the Rendered Model. Types of Sensors - Measurement of Haptic Parameters - Types of Actuators - Types of Transmission - Admittance Type Kinesthetic Device - Admittance Control - Comparison of Impedance and Admittance Type Devices - Genesis of Tele-Operation - Tele-Operation Controllers -Tele-Operator Transparency - Stability Analysis of Tele-operator - Tracking and Transparency - Surface Haptic - Exogenous Force Inputs.

UNIT III **HUMAN HAPTICS ITS PLATFORM** **9**

Introduction - Types of Haptic Sensing - Active vs. Passive Touch - Mechanoreception-Mechanoreceptive Afferents - Kinesthetic Sensing - Force Sensing and Proprioception-Introduction to Psychophysics - Measurement Thresholds - Laws of Psychophysics - Weber's Law - Fechner's Law - Fitt's Law - Psychophysical Methods of Limit, Constant Stimuli and Adjustment -Introduction to Virtual Reality Modelling Language (VRML) – Open Haptic Platform - OpenGL- Virtual Environment Manager-Modelling of Simple Haptic System.

UNIT IV **VIRTUAL AND AUGMENTED REALITY** **9**

The Reality – Virtuality Continuum - Virtual Reality Definitions - Software, Hardware, Sensation and Perception - Multi-Modal Interaction Challenges - System Architecture of Virtual Reality. Aspects of Geometrical Modelling and Environmental Modelling General Solution for Calculating Geometric & Illumination Consistency in the Augmented Environment. Usability Guidelines - Design and Implementation of an Immersive User Experience - Case Study for VR and AR.

UNIT V **MIXED REALITY** **9**

System Architecture of a Mixed Reality System - Common Interaction Techniques for Mixed Reality Environments - Common Navigation Techniques - Common Interface for MR - Menu Design Directions - Haptic Control Panel - Performance of an Interaction Techniques, Advanced Interaction Techniques, Design and Implementation of an Immersive User Experience - Case Study for MR.

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire a comprehensive understanding of haptics, including its definition, components, and applications.
CO2	Describe the principles and theories underlying haptics, kinesthetic devices, and teleoperation.
CO3	Apply the knowledge of haptics and kinesthetic devices to design and control haptic systems, ensuring stability and rendering accuracy.

CO4	Analyze haptic parameters, sensor measurements, and psychophysical laws to evaluate and optimize haptic systems.
CO5	Integrate haptic technologies into virtual, augmented and mixed reality environments, considering interaction techniques, user experience, and system performance.

REFERENCES

1. Burdea, G. C. and P. Coffet. “Virtual Reality Technology”, Wiley-IEEE Press, 2006.
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3. Hannaford B and Okamura A. M “Haptics: Handbook of Robotics”, Springer, pp. 718-735, 2008.
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6. MacLean K. E, “Haptic Interaction Design for Everyday Interfaces: Reviews of Human Factors and Ergonomics”, 4:149-194, 2008.
7. Weir D. W and Colgate J. E “Stability of Haptic Display: Haptic Rendering: Foundations, Algorithms, and Applications”. AK Peters, 2008.
8. Sherman, William R. and Alan B. Craig. “Understanding Virtual Reality – Interface, Application, and Design”, Morgan Kaufmann, 2019.
9. Yuichi Ohta, Hideyuki Tamura, “Mixed Reality: Merging Real and Virtual Worlds”, Springer-Verlag, 2013.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	1	2	1	1	1
2	3	1	3	2	2	2
3	3	1	3	2	2	2
4	2	1	2	3	3	3
5	2	-	2	3	3	3
Avg	**2.6**	**1**	**2.4**	**2.2**	**2.2**	**2.2**

MR3014	APPLIED SIGNAL PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the generation and characteristics of various types of signals, including speech, seismic, radar, vibration, ultrasonic, pressure, strain, temperature, and bio signals.
2.	To learn the pre-processing techniques for signals, including noise reduction, filtering, and denoising concepts.
3.	To study digital signal processing techniques, such as time series analysis, time-frequency representation, signal modeling, and power spectral density estimation.
4.	To explore feature extraction methods for signals, including short-time Fourier transform (STFT), discrete Fourier transform (DFFT), wavelet transform, empirical mode decomposition (EMD), and time-frequency representation.
5.	To analyze and apply signal processing techniques in various applications, such as speech analysis, bio signals analysis, radar signal processing, affective state computation, brain-computer interface, and fusion techniques

UNIT I	**SOURCES OF SIGNALS**	**9**

Generation and Characteristics of Speech Signals – Seismic Signals – Radar - Vibration – Ultrasonic - Pressure – Strain - Temperature Signals - Bio Signals - ECG, EEG, Phonocardiogram - EMG.

UNIT II	**PRE-PROCESSING OF SIGNALS**	9

Noise Sources & Characteristics – Filters - IIR and FIR Filters -Design of Filters Low Pass, High Pass Filter, Band Pass Filter, Notch Filter Chebshiv Filters. Elliptic Filters, Butter Worth Filters – Kalman Filter - Adaptive Filtering - Comb Filter- Denoising Concepts.

UNIT III	**DIGITAL SIGNAL PROCESSING**	9

Time Series Analysis –Time Varying Analysis - Time Frequency Representation - ARMA Signal Modelling - FFT - Power Spectral Density Estimation.

UNIT IV	**FEATURE EXTRACTION METHODS**	9

STFT – DFFT – Sine and Cosine Transform – Wavelet Concept – Empirical Mode Decomposition (EMD) – Time Frequency Representation, Spectrogram – Methods for Extracting the Features of the Signal: Energy, Average Magnitude - Introduction to Feature Extraction and Classification Techniques.

UNIT V	**ANALYSIS AND APPLICATION OF SIGNAL PROCESSIONG**	9

Cepstral Analysis of Speech Signals – Spectral Analysis Bio Signals and Vibration Signals - Radar Signal Processing for Multiple Sensor Informations - Signal Processing in Affective State Computation and Brain Computer Interface – Introduction to Fusion Technique.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of signal generation, characteristics, and various types of signals, as well as noise sources and filtering techniques.
CO2	Demonstrate an understanding of pre-processing techniques for signals, including filter design and denoising concepts.
CO3	Apply digital signal processing techniques, such as time series analysis, spectral analysis, and signal modeling, to analyze and process signals.
CO4	Analyze and interpret different time-frequency representations and feature extraction methods for signals, evaluating their effectiveness for specific applications.
CO5	Evaluate the application of signal processing techniques in diverse areas, such as speech analysis, bio signals analysis, radar signal processing, affective state computation, and brain-computer interface, and assess the potential of fusion techniques for signal processing tasks.

REFERENCES

1. Arnon Cohen, “Bio-Medical Signal Processing Vol-I and Vol-II”, CRC Press Inc., Boca Rato, 2019.
2. Emmanuel C. Ifeachor, Barrie W.Jervis, “Digital Signal Processing- A Practical Approach”, Pearson, 2002.
3. Raghuveer M. Rao and Ajith S.Bopardikar, “Wavelets Transform – Introduction to Theory and its Applications”, Pearson, 2000.
4. Rangaraj M. Rangayyan, “Biomedical Signal Analysis - A Case Study Approach”, Wiley-Interscience / IEEE Press, 2002.
5. Willis J. Tompkins, “Biomedical Digital Signal Processing”, Prentice Hall of India, New Delhi, 2006.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	3	1	1	3	2	2
2	2	1	1	2	2	2
3	2	1	1	3	3	2
4	2	1	1	3	2	2
5	3	-	1	3	2	2
Avg	**2.4**	**1**	**1**	**2.8**	**2.2**	**2**

Attested

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Centre for Academic Courses
Anna University, Chennai-600 025

MR3001	SINGLE BOARD COMPUTERS AND PROGRAMMING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the architecture and features of single-board computers, including on-board system components, communication protocols (SPI, I2C, UART, USB, Ethernet, CAN), and input devices (GPIO, memory, camera).
2.	To explore real-time operating systems, including their architecture, file systems, resource management, process scheduling, and applications in embedded systems.
3.	To learn Python programming language, including data types, functions, file handling, object model, iterative and conditional statements, operators, arrays, and GUI development.
4.	To develop skills in embedded Python programming, including GPIO programming, numerical and communication libraries, image processing, and machine learning.
5.	To explore applications of single-board computers in automotive, mobile robotics, IoT, factory automation, and home automation.

UNIT I	**INTRODUCTION TO SINGLE BOARD COMPUTERS**	**9**

On-Board System Architecture - Processor- Architecture – Features - SPI-I2C- UART- USB -Ethernet- CAN Protocol - Wi-Fi – Bluetooth - HDMI- GPIO- Memory- Input Devices – Camera Interfacing.

UNIT II	**REAL TIME OPERATING SYSTEM**	**9**

Operating System Architecture – File Systems- Resource Management – Process Scheduling – Applications.

UNIT III	**PYTHON PROGRAMMING**	**9**

Python Language – Using the Interpreter – Python Data Types and Functions – Working with Data – List, Dictionary and Set – Processing Primitives – List Comprehensions – File Handling – Object Model Including Variables, Reference Counting, Copying, and Type Checking – Error Handling Iterative Statement- Conditional Statement – Operators – Arrays Libraries- Library - GUI Development.

UNIT IV	**EMBEDDED PYTHON PROGRAMMING**	**9**

GPIO Programming – Numerical Library- Communication Library- Image Processing – Machine Learning.

UNIT V	**APPLICATIONS**	**9**

Automotive – Mobile Robotics - IOT- Factory Automation - Home Automation

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of the architecture, features, and communication protocols of single-board computers, as well as real-time operating system concepts and Python programming language.
CO2	Describe the underlying principles and functioning of single-board computers, real-time operating systems, and Python programming constructs.
CO3	Apply Python programming skills to develop programs for embedded systems, including GPIO programming, numerical operations, communication, and image processing.
CO4	Analyze the requirements and constraints of different applications in automotive, robotics, IoT, and automation, and select appropriate single-board computer solutions.
CO5	Design and implement projects utilizing single-board computers, real-time operating systems, and Python programming, addressing specific application domains such as automotive, mobile robotics, IoT, factory automation, and home automation.

REFERENCES

1. David Beazley and Brian K. Jones, “Python Cookbook”, O'Reilly Media, 2013
2. Gabriele Manduchi and Ivan CibrarioBertolotti, “Real-Time Embedded Systems: Open-Source Operating Systems”, CRC Press, 2017.
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4. NinadSathaye, “Learning Python Application Development”, Packt Publishing, 2016
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6. Warren Gay, “Mastering the Raspberry Pi”, Apress, 2014.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	-	2
2	1	1	2	1	-	1
3	1	1	3	1	-	1
4	1	1	2	2	-	2
5	1	1	3	1	-	2
Avg	**1**	**1**	**2.4**	**1.2**	**-**	**1.6**

Attested

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Centre for Academic Courses
Anna University, Chennai-600 025

MR3015	COMMUNICATION PROTOCOLS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand wired communication buses and protocols, including serial communication protocols, parallel communication, and wired network comparisons.
2.	To explore wireless protocols and technologies, including antenna technology, network topologies, and wireless communication standards like Wi-Fi, Bluetooth, Zigbee, and Wimax.
3.	To gain knowledge of wired networks used in industrial and autonomous systems, such as Modbus, HART, EtherCAT, CAN, PROFINET, and DeviceNet.
4.	To learn about industrial wireless networks, including IWLAN, ISA100, Wireless HART, and remote network technologies.
5.	To apply communication protocols in various industrial and automation applications, considering wired and wireless machine networking, communication network design, and integration with cloud computing and IoT.

UNIT I	**WIRED BUSES AND PROTOCOLS**	**9**

Wireless - Wired Networks Comparison - Serial Communication Protocols - RS232-UART-SPI -I2C –UNI/O Bus -1 Wire - Camara Link - Parallel Communication - PPI - Wishbone Bus – AMBA –JTAG - Fireware IEEE 1394 Bus - Ethernet Overview - RS485

UNIT II	**WIRELESS PROTOCOLS**	**9**

Antenna Technology- Network Topologies - Wireless Local Area Networks (WLAN) - Wireless Personal Area Networks (WPAN) - Wimedia – Wimax - RF – Bluetooth- Wi-Fi – Zigbee – Wireless Industrial Automation Protocols.

UNIT III	**INDUSTRIAL AND AUTONOMOUS SYSTEMS WIRED NETWORKS**	**9**

Overview of Industrial Wired Networks – Terminal Bus- Modbus - HART Network - Mechatrolink-II – Ether CAT- Sercos II/III – CAN- Canopen - Modbus IDA- PROFINET-PROFIBUS-Ethernet/I Ethernet Powerlink- AG Automation and Drives (AS-I) - Device Net

UNIT IV	**INDUSTRIAL WIRELESS NETWORKS**	**9**

Overview of Industrial Wireless Networks - IWLAN - ISA100 Standards – Remote Networks Controller-Based Networks - Wireless HART Technology - 3G/4G for Automation – RFID Data Tags.

UNIT V	**APPLICATION OF COMMUNICATION PROTOCALS**	**9**

Wired Machine Networking of Sub-elements and Machines - Wireless Machine Networking of Sub elements and Machines – Networking of Industry - Communication Network Layout Design - Networking for TIA- Cloud Computing – IOT - Case Studies in Automation Applications

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of wired and wireless communication protocols, network topologies, and standards used in industrial and autonomous systems.
CO2	Describe the differences between wired and wireless networks, as well as the advantages and limitations of various communication protocols.
CO3	Apply wired and wireless protocols in practical scenarios, such as designing communication network layouts for machines and industrial systems.
CO4	Analyze the requirements and constraints of different communication protocols in industrial settings, considering factors like reliability, scalability, and interoperability.
CO5	Design and implement communication networks for specific automation applications, integrating wired and wireless protocols effectively and considering emerging technologies like cloud computing and IoT.

REFERENCES

1. BorkoFurht, “Encyclopedia of Wireless and Mobile Communications - Three Volume Set”, CRC Press, 2012.
2. Dick Caro, “Wireless Networks for Industrial Automation”, 2014.
3. MMC-SD SERCOS Drive, “G&L Motion Control”, Hardware Manual, 2005.
4. Olaf Pfeiffer, Andrew Ayre and Christian Keydel, “Embedded Networking with CAN and CANopen”, Copperhill Technologies Corporation, 2016.
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COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	-	2
2	1	1	2	1	-	2
3	1	1	3	1	-	2
4	1	1	3	1	-	2
5	1	1	3	1	-	2
Avg	**1**	**1**	**2.6**	**1**	**-**	**2**

Attested

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MR3016	FPGA FOR EMBEDDED SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the architecture of FPGA, EPLD, and CPLD, including Xilinx FPGA families and TMS320C54x/C6x architecture.
2.	To learn the design principles of synchronous and asynchronous sequential circuits, including FPGA programming technologies, logic cell structures, programmable interconnect, and I/O ports.
3.	To gain proficiency in programming FPGA devices, including the design of arithmetic circuits, SDRAM, FIR filters, A/D converters, and using hardware description languages like Verilog and VHDL.
4.	To explore fault diagnosis and testability algorithms for FPGA-based systems, including fault table method, path sensitization method, Boolean difference method, tolerance techniques, and built-in self-test.
5.	To develop FPGA-based hardware systems, such as data acquisition devices, controllers for high-speed drives, and applications in automation and automotive industries.

UNIT I	**ARCHITECTURE OVERVIEW OF FPGA**	**9**

Architecture of EPLD, Programmable Electrically Erasable Logic, CPLD Architectures – Xilinx FPGA – Xilinx 2000 - Xilinx 4000 family - Architecture of EPLD, Programmable Electrically Erasable Logic –TMS320C54x and TMS320C6x Architecture - Finite State Machines (FSM).

UNIT II	**SYNCHRONOUS AND ASYNCHRONOUS SEQUENTIAL CIRCUIT DESIGN**	**9**

FPGA Programming Technologies - FPGA Logic Cell Structures - FPGA Programmable Interconnect and I/O Ports - FPGA Implementation of Combinational Circuits - FPGA Sequential Circuits - Timing Issues in FPGA Synchronous Circuits - Analysis of Clocked Synchronous Sequential Networks (CSSN) - Modelling of CSSN – State Stable Assignment and Reduction – Design of CSSN – ASM Chart – ASM Realization - Analysis of Asynchronous Sequential Circuit (ASC) – Flow Table Reduction – Races in ASC – State Assignment Problem and the Transition Table – Design of ASC – Static and Dynamic Hazards – Essential Hazards

UNIT III	**PROGRAMMING OF FPGA**	**9**

FPGA Arithmetic Circuits - Design of SDRAM, Partial Reconfigurable FIR Filter Design, Design of A/D Converter - Introduction to Verilog HDL and FPGA Design Flow with using Verilog HDL - Programming FPGAs - Application Specific Integrated Circuit (ASIC) Systems Design and Library Cell Design - Verilog and Logic Synthesis - VHDL and Logic Synthesis - Types of Simulation - Boundary Scan Test - Fault Simulation - Automatic Test Pattern Generation.

UNIT IV	**FAULT DIAGNOSIS AND TESTABILITY ALGORITHMS**	**9**

Fault Table Method – Path Sensitization Method – Boolean Difference Method – Kohavi Algorithm – Tolerance Techniques-Built-in Self-Test

UNIT V	**DEVELOPMENT OF FPGA BASED HARDWARE**	**9**

Design of Data Acquisition Device – 4 Channel, 8 Channel, Variable Sampling Rate and Design of FPGA Based Controller - Design of Controller for High-Speed Drives - Applications in Automation Automotive.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of FPGA architecture, EPLD, CPLD, Xilinx FPGA families, TMS320C54x/C6x architecture, and programming technologies for FPGA.
CO2	Demonstrate an understanding of synchronous and asynchronous sequential circuit design principles, FPGA logic cell structures, and timing issues in synchronous circuits.

CO3	Apply programming techniques to implement various FPGA circuits, including arithmetic circuits, SDRAM, FIR filters, and A/D converters.
CO4	Analyze and evaluate fault diagnosis and testability algorithms for FPGA-based systems, identifying and addressing potential issues in the design.
CO5	Design and develop FPGA-based hardware systems, such as data acquisition devices and high-speed drive controllers, utilizing the concepts learned in the course and applying them to real-world applications in automation and automotive industries.

REFERENCES

1. Blaine Readler, “Verilog by Example: A Concise Introduction for FPGA Design”, Full Arc Press, 2011
2. Charles H. Roth Jr., “Digital Systems Design using VHDL”, Cengage Learning, 2016
3. Chu P, “FPGA Prototyping by Verilog Examples,” Wiley, 2011.
4.John V.Oldfeild, Richard C.Dorf, ”Field Programmable Gate Arrays”, Wiley India Edition,2008
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COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	3	1	1	-	-	1
2	2	1	1	-	-	1
3	2	1	1	-	-	1
4	2	1	1	-	-	1
5	2	1	1	-	-	1
Avg	**2.2**	**1**	**1**	**-**	**-**	**1**

MR3017	GPU COMPUTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To Understand the fundamentals of GPU computing and its role in heterogeneous parallel computing.
2.	To gain knowledge of the architecture of modern GPUs and their evolution from fixed-function graphics pipelines to unified graphics and computing processors.
3.	To learn parallel programming languages and models, with a focus on CUDA C and OpenCL.
4.	To explore data parallelism and CUDA programming, including program structure, memory management, and thread organization.
5.	To introduce OpenCL and OpenACC as alternative parallel programming frameworks and understand their execution and memory models.

UNIT I	**INTRODUCTION TO GPU COMPUTING**	**9**

Heterogeneous Parallel Computing, Architecture of a Modern GPU, Speeding Up Real Applications, Parallel Programming Languages and Models. Evolution of Graphics Pipelines, The Era of Fixed-Function Graphics Pipelines, Evolution of Programmable Real-Time Graphics, Unified Graphics and Computing Processors, GPGPU, Scalable GPUs, Recent Developments, Future Trends.

UNIT II	**INTRODUCTION TO DATA PARALLELISM AND CUDA C**	**9**

Data Parallelism, CUDA Program Structure, A Vector Addition Kernel, Device Global Memory and Data Transfer, Kernel Functions and Threading.

UNIT III	**DATA-PARALLEL EXECUTION MODEL AND CUDA MEMORIES**	**9**

CUDA Thread Organization, Mapping Threads to Multidimensional Data, Matrix-Matrix Multiplication—A More Complex Kernel, Synchronization and Transparent Scalability, Assigning Resources to Blocks, Thread Scheduling and Latency Tolerance. CUDA Memories -Importance of Memory Access Efficiency, CUDA Device Memory Types, A Tiled Matrix – À Matrix Multiplication Kernel, Memory as a Limiting Factor to Parallelism.

UNIT IV	**AN INTRODUCTION TO OPENCL**	**9**

Data Parallelism Model, Device Architecture, Kernel Functions, Device Management and Kernel Launch, Electrostatic Potential Map in OpenCL

UNIT V	**PARALLEL PROGRAMMING WITH OPENACC**	**9**

OpenACC Versus CUDA C, Execution Model, Memory Model, Basic OpenACC Programs, Parallel Construct, Loop Construct, Kernels Construct, Data Management, Asynchronous Computation and Data Transfer.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of GPU computing, including the architecture of modern GPUs, the evolution of graphics pipelines, and parallel programming languages and models.
CO2	Demonstrate an understanding of the concepts and principles of data parallelism, CUDA C programming, and the execution models of CUDA and OpenCL.
CO3	Apply the CUDA programming model to develop parallel programs for real applications, such as vector addition and matrix multiplication.
CO4	Analyze the performance and efficiency of GPU programs, including memory access efficiency and resource allocation strategies.
CO5	Propose and implement parallel solutions using CUDA C, OpenCL, and OpenACC for complex computational problems, demonstrating an understanding of device management, kernel launch, data management, and asynchronous computation.

REFERENCES

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2. Kirk, D. and Hwu, M., W., Programming Massively Parallel Processors: A Hands-on Approach. Morgan Kaufmann (2016) 3rd Edition.
3. Hwu, M., W., A GPU Computing Gems Emerald Edition (Applications of GPU Computing Series), Morgan Kaufmann (2011) 1st Edition.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	-	1	1
2	1	1	1	-	1	1
3	1	1	1	-	1	1
4	1	1	1	-	1	1
5	1	1	1	-	1	1
Avg	**1**	**1**	**1**	**-**	**1**	**1**

Attested

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MR3018	INDUSTRIAL INTERNET OF THINGS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To provide an overview of Industry 4.0 and its significance in the digitalization and networked economy.
2.	To understand the concepts and components of the Internet of Things (IoT) and its applications in industrial settings.
3.	To explore the protocols and standards used in IoT and their role in enabling seamless communication and interoperability.
4.	To examine the role of cloud computing in supporting IoT systems and leveraging big data for predictive analytics and smart business.
5.	To analyze and discuss the challenges, opportunities, and emerging trends in the implementation of Industry 4.0 and IoT in different industries

UNIT I	**INDUSTRY 4.0**	**9**

Digitalization and the Networked Economy - Introduction to Industry 4.0 - Comparison of Industry 4.0 Factory and Today's Factory - Internet of Things (IoT) - Industrial Internet of Things (IIoT) - Smart Devices and Products - Smart Logistics - Support System for Industry 4.0 - Cyber-physical Systems Requirements - Data as a New Resource for Organizations - Cloud Computing - Trends of Industrial Big Data and Predictive Analytics for Smart Business- Architecture of Industry 4.0.

UNIT II	**IOT AND ITS PROTOCOLS**	**9**

Definitions and Functional Requirements – Motivation – Architecture - Web 3.0 View of IoT – Ubiquitous IoT Applications – Four Pillars of IoT – DNA of IoT - The Toolkit approach for End - User Participation in the Internet of Things. Middleware for IoT: Overview – Communication Middleware for IoT – IoT Information Security. IIoT Reference Architecture - Designing Industrial Internet Systems - Access Network Technology and Protocols Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Issues with IoT Standardization – Unified Data Standards – Protocols – IEEE 802.15.4 – BAC Net Protocol – Modbus –KNX –Zigbee Architecture – Network layer APS layer – Security.

UNIT III	**CLOUD COMPUTING**	**9**

Web of Things versus Internet of Things – Two Pillars of the Web – Architecture Standardization for WoT – Platform Middleware for WoT – Unified Multitier WoT Architecture – WoT Portals and Business Intelligence. Cloud of Things: Grid/SOA and Cloud Computing – Cloud Middleware – Cloud Standards – Cloud Providers and Systems – Mobile Cloud Computing – The Cloud of Things Architecture and Data Analytics

UNIT IV	**INTEGRATED IOT**	**9**

Integrated Billing Solutions in the Internet of Things Business Models for the Internet of Things - Network Dynamics: Population Models – Information Cascades - Network Effects - Network Dynamics: Structural Models - Cascading Behavior in Networks - The Small - World Phenomenon

UNIT V	**APPLICATIONS**	**9**

The Role of the Internet of Things for Increased Autonomy and Agility in Collaborative Production Environments - Resource Management in the Internet of Things: Clustering, Synchronization and Software Agents - Industry 4.0 in Car Manufacturing – Electronics Manufacturing – IOT Based Building Automation - Agricultural Automation.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of Industry 4.0, IoT, cloud computing, and their architectures, standards, and protocols.
CO2	Demonstrate comprehension of the concepts, pillars, and requirements of Industry 4.0 and IoT, including their impact on the networked economy and collaborative production environments.

CO3	Apply IoT protocols, middleware, and information security measures in designing and implementing IoT solutions for industrial and ubiquitous applications
CO4	Analyze the role of cloud computing, data analytics, and unified architectures in IoT and Industry 4.0, and evaluate the business models and network dynamics associated with IoT.
CO5	Propose innovative IoT-based solutions and strategies for resource management, automation, and increased autonomy in various domains, such as car manufacturing, electronics manufacturing, building automation, and agricultural automation.

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1. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things, APress, 2016.
2. Duato J, Yalamanchili S, and Lionel Ni, "Interconnection Networks: An Engineering Approach", Morgan Kaufmann Publishers, 2004.
3. Fayez Gebali, “Haytham Elmiligi, Mohamed Wathed and El -Kharashi “Networks- on chips: Theory and Practice”, CRC Press, Taylor and Francis Group, 2009.
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5. Kiran Kumar Pabbathi, “Quick Start Guide to Industry 4.0: One-Stop Reference Guide for Industry 4.0”, Createspace Independent Publishing Platform, 2018.
6. Natalie Enright Jerger and Li ShiuanPeh, “On-Chip Networks, Synthesis Lectures on Computer Architecture”, Morgan and Claypool Publishers, 2022.
7. William James Dally and Brian Towles, "Principles and Practices of Interconnection Networks", Morgan Kaufmann, 2004.

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	-	-	2
2	1	1	2	1	1	2
3	1	1	3	1	1	2
4	1	1	2	1	1	2
5	1	1	2	1	1	2
Avg	**1**	**1**	**2.2**	**1**	**1**	**2**

MR3019	HUMAN MACHINE INTERFACE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To provide an introduction to Human Machine Interface (HMI) and its applications.
2.	To familiarize students with the elements and considerations of HMI design and implementation.
3.	To explore perception, memory, and cognition principles relevant to HMI.
4.	To introduce an integrated modeling framework for supervisory control and human-machine cooperation.
5.	To discuss Brain-Computer Interface (BCI) technologies and their applications.

UNIT I	INTRODUCTION TO HMI	9

HMI Basics -Human Computer Interaction as an emerging field - Applications of Human Machine Interface (HMI) - HMI types - Human Information Processing -Interaction styles and general design Interaction -strategies Interface metaphors and conceptual models HCI and the World Wide Web HCI - security Accessibility of User Interfaces Usability engineering and evaluation HCI and social computing.

UNIT II	ELEMENTS OF HMI	9

HMI Interfacing Considerations -HMI Hardware Selection -HMI Software Selection - Configuring System Communications - Passive and active – Mental models- Creating a Tag Database - PLC Programming Considerations -Creating Basic Graphical Displays/Screens-Security – Event controlled interface.

UNIT III	PERCEPTION, MEMORY, COGNITION	9

Perception & Cognition - Visual System – Image Generation and Perception-Touch-Hearing- Model Human Processor- STM, LTM, Chunking - Principles of Operation- Power Law - Fitts Law - Hicks Law – Factors Affecting - Perception, Memory, Cognition

UNIT IV	INTEGRATED MODELLING FRAMEWORK	9

Supervisory Control – Criteria for Sharing Task between Operator and Machine – Human – Machine Cooperation - Human–Machine Cooperation - Generic Integrated Modelling Framework - Car Driver Cognitive Architecture of the Human Cognitive System - Control Loops - Tactical Module – HMI in Automation.

UNIT V	BRAIN COMPUTER INTERFACE	9

Introduction to BCI – Brain Regions and Responsibilities - Active Methods for Measuring Brain Activity – Invasive and Non-Invasive Procedures - EEG – P300 - VEP- ERD- NIRS – Application in Prosthetic Control - Neurorehabilitation – Neurotraining – Brain Controlled Wheel Chairs

TOTAL	45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Acquire knowledge of HCI principles, HMI types, perception, memory, cognition, and BCI for effective design and operation of human-machine interfaces
CO2	Demonstrate comprehension of HCI principles, HMI interfacing considerations, and the impact of perception, memory, and cognition on HMI design and user experience.
CO3	Apply HCI principles, usability engineering techniques, integrated modeling frameworks, and control loops to design and develop effective HMIs with user-friendly interfaces and system communications.
CO4	Analyze the role of HCI in security, accessibility, and social computing, and evaluate the impact of perception, memory, cognition, and different BCI methods on HMI design and applications.

CO5	Synthesize knowledge of HCI principles, perception, memory, cognition, and BCI to propose innovative HMI designs, advancements, and solutions addressing complex human-machine interaction challenges and incorporating emerging trends and technologies.

REFERENCES

1. Allen Klinger, “Human Machine Interactive Systems”, New York: Plenum Press, 2013.
2. Bernhard Graimann, Bredan Allison, Gert Pfurtscheller, “Brain – Computer Interfaces”, Springer-Verlag Berlin Heidelberg, 2010.
3. Guy A.Boy ed., “The Hand Book of Human Machine Interaction”, Ashgate Publishing Limited, 2017.
4. Jean-Yves Fiset, “Human-Machine Interface Design for Process Control Applications”, ISA Publisher, 2009.
5. Jonathan Wolpaw, Elizabeth Winter Wolpaw, “Brain Computer Interfaces: Principles and Practice”, Oxford University Press, 2012.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	-	-	2
2	1	1	2	1	1	2
3	1	1	3	1	1	2
4	1	1	2	1	1	2
5	1	1	2	1	1	2
Avg	**1**	**1**	**2.2**	**1**	**1**	**2**

MR3020	ADVANCED CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the principles and design of PID controllers and various tuning methods.
2.	To explore and apply advanced control techniques such as feed-forward, cascade, inferential, and sliding mode control.
3.	To gain proficiency in state space analysis and design control systems using state observers.
4.	To analyze and handle nonlinear systems by linearization, stability analysis, and phase portrait analysis.
5.	To familiarize with other control methods including LQR, adaptive control, optimal control, robust control, and model predictive control.

UNIT I	**CONTROLLER AND PERFOMANCE MEASURES**	**9**

Review of Feedback Systems and Design of PID Controllers - Electronic PID Controller – Digital PID Algorithm – Auto/Manual Transfer - Reset Windup – Practical Forms of PID Controllers - Evaluation Criteria – IAE, ISE, ITAE And ¼ Decay Ratio – Tuning Using Process Reaction Curve Method, Continuous Cycling Method and Damped Oscillation Method – Pole Placement – Lambda Tuning.

UNIT II	**ENHANCEMENT TO SINGLE LOOP CONTROL**	**9**

Feed-Forward– Ratio Control – Cascade Control – Inferential Control – Split-Range – Override Control – Selective Control – Sliding Mode Control - Auto Tuning

UNIT III	**STATE SPACE ANALYSIS**	**9**

Concepts of State Variable and State Model – State Space to Transfer Function and Transfer Function to State Space Modes – Solving Time Invariant State Equation – Controllability – Observability – State Observers – Design of Control Systems with Observers.

UNIT IV	**NONLINEAR SYSTEMS AND CONTROL**	**9**

Non-Linear Systems – Common Physical Nonlinearities – Linearization of Nonlinear Systems – Phase Portrait Analysis – Isocline Method – Liapnov's Stability Concept – Popov Criterion – Kalman Algorithm.

UNIT V	**OTHER CONTROL METHODS**	**9**

LQR - Adaptive Control – Optimal Control – Robust Control – Model Predictive Control – Multivariable Control systems.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Understand feedback systems, PID controllers, Tuning and different control methods.
CO2	Interpret performance measures and evaluate PID controller effectiveness.
CO3	Apply tuning methods to optimize PID controller performance and implement advanced control techniques in practical scenarios
CO4	Analyze state space models and perform stability analysis.
CO5	Design control systems with observers, develop control strategies for nonlinear systems and integrate multiple control techniques for multivariable control systems.

REFERENCES

1. Bequette. B.W., “Process Control Modelling, Design and Simulation”, Prentice Hall of India, 2023.
2. Gopal. M, “Control Systems Principles and Design”, Tata McGraw Hill Publishing Ltd, 2012.
3. Kuo. B.C, “Automatic Control Systems”, Prentice Hall, 2004.
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5. Ogata.K, “Modern Controls Engineering”, Prentice Hall, 2010.
6. Zbigniew Ogonowski , “Advanced Control with MATLAB and Simulink”, Ellis Horwood, Ltd, 1995

COs	POs					
	1	2	3	4	5	6
1	1	1	1	2	2	1
2	1	1	1	2	1	1
3	1	1	1	2	2	1
4	1	1	1	2	2	1
5	1	1	1	2	1	1
Avg	1	1	1	2	1.6	1

Attested

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MR3021	MOTION CONTROL TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the fundamental concepts and principles of motion control systems, including dynamic system modeling, control system design, and motion control drives.
2.	To demonstrate a deeper understanding of motion control architectures, including programmable automation controllers, digital/analog I/Os, and intelligent motors with integrated drives.
3.	To apply the acquired knowledge to design and configure motion control systems, select appropriate components, and program motion controllers for specific applications.
4.	To analyze and evaluate the performance of motion control systems, identify potential issues or limitations, and propose solutions for optimization.
5.	To integrate knowledge and skills to develop advanced motion control strategies, such as motion profiling, CAM profiling, and multi-axis control, for complex applications.

UNIT I	**INTRODUCTION MOTION CONTROL SYSTEMS**	**9**

Introduction to Motion Control System - Dynamic System Modeling - Control System Design Fundamentals – Parameters in Control – Actuators and Measurement in Motion Control Systems -Multi-Body Dynamics – Need for Motion Controller – Specification of Motion Control

UNIT II	**ARCHITECTURE OF MOTION CONTROL SYSTEM**	**9**

Introduction to Motion Controller – Programmable Automation Controllers – Features & Specification of Motion Controllers – Digital I/O – Analog I/O – Standards in I/O – I/O Specific to Sensors – Modular and Expansion Concepts - Drives

UNIT III	**MOTION CONTROL DRIVES**	**9**

Programmable Automation Controllers – Features & Specification of Motion Controllers – Digital I/O – Analog I/O – Standards in I/O – I/O Specific to Sensors – Modular and Expansion Concepts - Drives

UNIT IV	**INTELLIGENT MOTORS WITH INTEGRATED DRIVE**	**9**

Intelligent motors – intelligent drives – features of drives – programmable I/Os-communication protocols – features – Software - Programming – current, position and speed loops – Application in robots and portable systems

UNIT V	**PROGRAMMING OF MOTION CONTROLLER**	**9**

IEC 61131 standards and Its Programming Languages overview- CoDeSys Platform - status Diagram – PLC Open - Motion Planer - PID - Servo Tuning – Position- velocity, Acceleration and Torque Profiling – CAM Profiling – Multi- Axis Motion Controllers – CNC Machines – Robot case study

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the fundamental concepts, principles, and components of motion control systems.
CO2	Summarize and interpret the architecture and features of motion control systems, including programmable automation controllers, I/Os, and intelligent motors with integrated drives.
CO3	Apply the acquired knowledge to design and configure motion control systems for specific industrial applications.
CO4	Analyze and evaluate the performance of motion control systems, identify potential issues or limitations, and propose solutions for improvement.
CO5	Develop and implement advanced motion control strategies, such as motion profiling, CAM profiling, and multi-axis control, to achieve precise and optimized motion control in complex applications.

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REFERENCES

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4. 2-Axis Motion Controller User Guide, Parker Hannifin Corporation, 1995.
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COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	2	1	2
2	1	1	2	2	1	2
3	1	1	3	2	1	2
4	1	1	2	2	1	2
5	2	1	1	2	1	2
Avg	**1.2**	**1**	**2**	**2**	**1**	**2**

Attested

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MR3052	DIGITAL TWIN AND INDUSTRY 5.0	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the fundamental principles and concepts of digital twin technology.
2.	To apply digital twin techniques to analyze and optimize complex systems.
3.	To develop skills in designing and implementing digital twin models for real-world applications.
4.	To evaluate the benefits and limitations of digital twin technology in various industries.
5.	To critically analyze and interpret data obtained from digital twin simulations.

UNIT I	**INTRODUCTION**	**9**

Digital twin – Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin – Virtual CAD Models – control Parameters- Real time systems – control Parameters – Handshaking Through Internet – cyber physical systems

UNIT II	**DIGITAL TWIN IN A DISCRETE INDUSTRY**	**9**

Basics of Discrete Industry, Trends in the discrete industry, control system requirements in a discrete industry, Digital Twin of a Product, Digital Thread in Discrete Industry, Data collection & analysis for product & production improvements, Automation simulation, Digital Enterprise

UNIT III	**DIGITAL TWIN IN A PROCESS INDUSTRY**	**9**

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

UNIT IV	**INDUSTRY 5.0**	**9**

Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0

UNIT V	**ADVANTAGES OF DIGITAL TWIN**	**9**

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the key principles and concepts of digital twin technology.
CO2	Apply digital twin techniques to model and simulate complex systems.
CO3	Design and implement digital twin models for specific applications.
CO4	Evaluate the effectiveness of digital twin technology in improving system performance and efficiency.
CO5	Analyze and interpret data generated from digital twin simulations to make informed decisions.

REFERENCES

1. Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing the Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2018
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019
3. Uthayan Elangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press, 2022.
4. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress., United States ,2015.

5. Christoph Jan Bartodziej, “The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics”, Springer Gambler., Germany, 2017.
6. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0”, Springer., Switzerland, 2016.
7. Ronald R. Yager and Jordan Pascual Espada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018
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COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	1	2
2	1	1	2	2	1	2
3	1	1	3	2	1	2
4	2	1	2	1	1	2
5	1	1	1	2	1	2
Avg	**1.2**	**1**	**2**	**1.6**	**1**	**2**

Attested

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MR3022	MECHATRONICS IN MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the principles and functioning of unconventional machining processes and additive manufacturing.
2.	To apply knowledge of mechatronics to analyze and operate additive manufacturing equipment and processes.
3.	To create CAD models and utilize reverse engineering techniques for rapid prototyping and additive manufacturing.
4.	To analyze the different liquid-based and solid-based additive manufacturing processes, their strengths, weaknesses, and applications.
5.	To evaluate the powder-based and other additive manufacturing techniques, their capabilities, and material systems.

UNIT I	**UNCONVENTIONAL MACHINING PROCESSES**	**9**

Architecture – Key Elements of Mechatronics in USM – EDM – WCEDM – MEDM – ECDM – ECM – EBM – LBM – IBM – PAM – AJM – WJM.

UNIT II	**INTRODUCTION TO ADDITIVE MANUFACTURING**	**9**

Need - Classification of AM Processes – SLA – SLS – FDM – LOM – SGC – PLT – LENS - Architecture of Additive Manufacturing Equipment – Key Elements of Mechatronics – Functions Development of AM Systems – AM Process Chain - Impact of AM on Product Development - Virtual Prototyping - Rapid Tooling – RP to AM

UNIT III	**REVERSE ENGINEERING AND CAD MODELLING**	**9**

Basic Concept - Digitization Techniques – Model Reconstruction – Data Processing for Rapid prototyping: CAD Model Preparation, Data Requirements – Geometric Modelling Techniques: Wireframe, Surface and Solid Modelling – Data Formats - Data Interfacing, Part Orientation and Support Generation, Support Structure Design, Model Slicing, Tool Path Generation - Software for AM.

UNIT IV	**LIQUID AND SOLID BASED ADDITIVE MANUFACTURING**	**9**

Stereo-Lithography Apparatus (SLA): Principle, Pre-Build Process, Part-Building and Post-Build processes, Photo Polymerization of SL Resins, Part Quality and Process Planning, Recoating Issues, Materials, Advantages, Limitations and Applications. Solid Ground Curing (SGC): Working Principle, Process, Strengths, Weaknesses and Applications Fused Deposition Modelling (FDM): Principle, Details of Processes, Process Variables, Types, Products, Materials and Applications. Laminated Object Manufacturing (LOM): Working Principles, Details of Processes, Products, Materials, Advantages, Limitations and Applications

UNIT V	**POWDER BASED AND OTHER ADDITIVE MANUFACTURING**	**9**

Selective Laser Sintering (SLS): Principle, Process, Indirect and Direct SLS- Powder Structures, Materials, Post Processing, Surface Deviation and Accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, Materials, Products, Advantages, Limitations and Applications -Three-Dimensional Printing (3DP): Principle, Basic Process, Physics of 3DP, and Types of Printing, Process Capabilities, and Material System. Solid Based, Liquid Based and Powder Based 3DP Systems, Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Demonstrate an understanding of the principles and key elements of unconventional machining processes and additive manufacturing.
CO2	Apply mechatronics principles to operate and control additive manufacturing equipment.
CO3	Create CAD models and utilize reverse engineering techniques for additive manufacturing processes.

CO4	Analyze and evaluate different additive manufacturing processes and their suitability for specific applications.
CO5	Evaluate the capabilities and limitations of powder-based and other additive manufacturing techniques for different materials and applications.

REFERENCES

1. Chua, C.K., Leong K.F. and Lim C.S., “Rapid Prototyping: Principles and Applications”, World Scientific Publishers, 2010.
2. Gebhardt, A., “Rapid Prototyping”, Hanser Gardener Publications, 2003.
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COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	2	-	2
2	1	1	2	1	-	2
3	1	1	2	1	-	2
4	2	1	2	3	-	2
5	1	1	2	3	-	2
Avg	**1.2**	**1**	**2**	**2**	**-**	**2**

MR3023	MEDICAL MECHATRONIC SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the role of mechatronics in the field of medical applications.
2.	To recall the functioning of human systems and their measurement techniques.
3.	To apply knowledge of mechatronics principles to analyze and operate assisting and therapeutic medical equipment.
4.	To analyze the functioning and principles of cardiac and regulatory assist systems.
5.	To evaluate the different imaging techniques and their applications in medical diagnostics.

UNIT I	**INTRODUCTION TO MEDICAL MECHATRONICS**	**9**

Role of Mechatronics in Medical – Overview of Human Functional System – Cell and Origin Bioelectric Potential - Measurement of Blood Pressure - Invasive and Noninvasive Methods- Transducers Role in Measurement – Heart Rate – Pressure - Temperature- Heart Sound – Pulmonary Function Measurements. ECG, EEG and EMG Systems.

UNIT II	**ASSISTING AND THERAPEUTIC EQUIPMENTS**	**9**

Diathermy – Heart Lung Machine –– Dialyzers – Centrifuge- Coagulators- Aspirator – Oximeter – Spirometer - Nebulizer – Anesthesia Machine - Operating Table – Examination Couches - Infusion Systems – Surgical Robots.

UNIT III	**CARDIAC AND REGULATORY ASSIST SYSTEM**	**9**

Pacemakers – Defibrillators – Ventilators – Nerve and Muscle Stimulators - Location for Stimulation - Synchronous Counter Pulsation, assisted through Respiration Right Ventricular Bypass Pump, Left Ventricular Bypass Pump, Open Chest and Closed Chest Type, Intra-Aortic Balloon Pumping Veno Arterial Pumping, Prosthetic Cardio Valves, Principle and Problem, Biomaterials for Implantable Purposes, its Characteristics and Testing. Lithotripsy - Indication and Principle of Hemodialysis, Membrane, Dialysate, Different Types of Hemodialysis, Monitoring Systems, Wearable Artificial Kidney, Implanting Type.

UNIT IV	**MEDICAL IMAGING**	**9**

Radio Graphic and Fluoroscopic Techniques – XRAY Machine - Computer Tomography – MRI – FMRI- Ultrasonography – Endoscopy – Colonoscopy -Thermography – Different Types of Biotelemetry Systems and Patient Monitoring – PET- Introduction to Biometric Systems.

UNIT V	**SENSORY ASSIST DEVICES AND AUTOMATED ANALYZER**	**9**

Types of Deafness, Hearing Aids, Application of DSP in Hearing Aids - Ear Irrigator- Voice Synthesizer, Speech Trainer. Ultra Sonic and Laser Canes, Intra Ocular Lens, Braille Reader - Tactile Devices for Visually Challenged - Ophthalmoscopy - Text Voice Converter - Screen Readers and Automated Analyzer

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Demonstrate an understanding of the role and significance of mechatronics in medical applications.
CO2	Recall and describe the functioning of various medical measurement techniques and equipment.
CO3	Apply mechatronics principles to operate and troubleshoot assisting and therapeutic medical equipment.
CO4	Analyze the functioning and principles of cardiac and regulatory assist systems and their applications.
CO5	Evaluate the effectiveness and limitations of different medical imaging techniques and sensory assist devices.

REFERENCES

1. Albert M Cook and Webster J G, “Therapeutic Medical Devices’’, Prentice Hall Nee York, 1982.
2. Alfred Horowitz, “MRI Physics for Radiologists – A Visual Approach”, Springer Verlag Network, 1994.
3. Geddes L A and Baker L.E, “Principals of Applied Biomedical Instrumentation”, John Wiley and Sons New York, 1989.
4. Jerry L.Prince and Jnathan M.Links, ”Medical Imaging Signals and Systems”, Pearson Education Inc., 2014
5. Khandpur R.S, “Hand Book of Bio-Medical Instrumentation”, Tata McGraw Hill Publishing Co Ltd., 2003.
6. Kolff W.J., “Artificial Organs”, John Wiley and Sons, New York, 1979.
7. Leslie Cromwell, Fred J. Weibell, Erich A. Pfeiffer, “Bio-Medical Instrumentation and Measurements”, Pearson Education, 2002.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	2	1	2
2	1	1	1	2	1	2
3	1	1	1	2	1	2
4	1	1	1	2	1	2
5	1	1	1	2	1	2
Avg	**1**	**1**	**1**	**2**	**1**	**2**

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MR3024	BIO-MECHATRONICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To recall the fundamental principles and vocabulary of biomechanics and bio-mechatronics.
2.	To understand the relationship between mechanics and medicine in the context of biomechanics.
3.	To apply the principles of mechanics to analyze and evaluate the mechanical properties of biological tissues and fluids.
4.	To analyze the kinematics and kinetics relationship of the skeletal and muscular systems.
5.	To design and manufacture biomechatronic products by integrating mechanical and electronic components.

UNIT I	**BIOMECHANICS**	**9**

Introduction to Bio-Mechanics, Relation between Mechanics and Medicine, Newton's Laws, Stress, Strain, Shear Rate, Viscosity, Visco-Elasticity, Non-Newtonian Viscosity, Soft Tissue Mechanics, Mechanical Properties of Soft Biological Tissues - Bio Fluid Mechanics - Introduction to Biomechatronic Systems

UNIT II	**MECHANICS IN SKELETAL AND MUSCULAR SYSTEM**	9

Bones, Types and Functions **-** Axial and Appendicular Skeleton. Joints: Definition, Types and Functions, Mechanical Properties of Bones. Kinetics and Kinematics Relationship of Skeletal and Muscular System.

UNIT III	**CONTROL MECHANISM OF BIOLOGICAL SYSTEMS**	9

Design and manufacturing of Biomechatronic products, Skeletal Muscles Servo Mechanism, Cardio Vascular Control Mechanism, Respiratory Control Mechanism – Interfacing Techniques with Natural Servo Mechanism.

UNIT IV	**PROSTHETIC AND ORTHOTIC DEVICES**	9

Artificial tissue and organ, Analysis of Force in Orthopedic Implants, Hand and Arm Replacement, Different Types of Models for Externally Powered Limb Prosthetics, Lower Limb, Upper Limb Orthotics, and Material for Prosthetic and Orthotic Devices, Functional Electrical Stimulation, Sensory Assist Devices. Exoskeletons, Exomusculatures, Space Suits, Physical Therapy and Rehabilitation, Wheelchairs and other Mobility Assistance.

UNIT V	**SIMULATION AND MODELLING OF BIOMECHANTRONICS**	9

Physics-Based Modelling and Simulation of Biological Structures - Variables Of Interest – Geometry - Introduction to Model the Skeletal System Using Open Source Software – Human Leg Prosthesis And Normal Gait vs. Prosthesis Leg Analysis - Upper Extremity Kinematic Model – Application in Sports, exercise, entertainment.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the concepts, vocabulary, and principles of biomechanics and bio-mechatronics.
CO2	Demonstrate an understanding of the relationship between mechanics and medicine in the field of biomechanics.
CO3	Apply the principles of mechanics to analyze and evaluate the mechanical properties of soft biological tissues and biofluids.
CO4	Analyze the kinematics and kinetics relationship of the skeletal and muscular systems.
CO5	Design and fabricate biomechatronic products by integrating mechanical and electronic components to solve practical problems.

REFERENCES

1. Dawson.D and Right, “Introduction to Bio-mechanics of Joints and Joint Replacement”, Mechanical Engineering Publications Ltd., 1989.
2. Fung. Y.C, “Biomechanics: Mechanical Properties in Living Tissues”, Springer Verlag, 1981.
3. Susan J.Hall, “Basics Bio-Mechanics”, McGraw-Hill, 2002.
4. Gillian Pocock & Christopher D.Richards, “The Human Body”, Oxford University Press, 2009.
5. Jacob Segil, “Handbook of Biomechatronics”, Acadamic Press, 2019.
6. Marko Popovic, Biomechatronics, Academic Press, 2019.
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8. Scott L. Delp., “Open Sim: Open-Source Software to Create and Analyze Dynamic Simulations of Movement”, IEEE Transaction on Biomedical Engineering, Vol.54 No.11, 2007.
9. Myer Kutz, Editor, Biomedical Engineering and Design Handbook, Second Edition, Volume 1: Fundamentals, McGraw-Hill Companies, 2009
10. Mark J. Schulz, Vesselin N. Shanov, Yeoheung Yun, Nanomedicine Design of Particles, Sensors, Motors, Implants, Robots, and Devices, Artech House, 2009

COs	POs					
	1	2	3	4	5	6
1	1	1	1	-	-	-
2	1	1	1	1	1	-
3	1	1	1	1	1	-
4	1	1	1	1	1	1
5	1	1	1	1	1	1
Avg	1	1	1	1	1	1

MR3053	DRONE TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the concept, vocabulary, and history of drone technology, and its impact on businesses.
2.	To learn the design, fabrication, and programming of drones, including the classification of UAVs, assembling drone parts, and programming methods.
3.	To gain practical skills in drone flying and operation, including flight modes, drone controls, sensor usage, and mobile device integration.
4.	To explore the commercial applications of drones in various industries such as insurance, logistics, agriculture, inspection, and filmmaking.
5.	To discuss the future trends in drone technology, safety risks, aviation regulations, miniaturization, autonomy, and the use of drones in swarms.

UNIT I	**INTRODUCTION TO DRONE TECHNOLOGY**	**9**

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses - Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability

UNIT II	**DRONE DESIGN, FABRICATION AND PROGRAMMING**	**9**

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program -Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection

UNIT III	**DRONE FLYING AND OPERATION**	**9**

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls F-light operations –management tool –Sensors- Onboard storage capacity -Removable storage devices- Linked mobile devices and applications

UNIT IV	**DRONE COMMERCIAL APPLICATIONS**	**9**

Choosing a drone based on the application -Drones in the insurance sector- Drones in delivering mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lines and power distribution -Drones in filming and panoramic picturing

UNIT V	**FUTURE DRONES AND SAFETY**	**9**

The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recall and explain the concepts, vocabulary, and historical development of drone technology.
CO2	Analyze and evaluate the design, fabrication, and programming aspects of drones, demonstrating technical knowledge of drone components and their functions.
CO3	Demonstrate practical skills in flying and operating drones, including understanding flight modes, controlling drones, utilizing sensors, and integrating mobile devices.
CO4	Apply knowledge of drone technology to identify and discuss the commercial applications of drones in various industries, evaluating their benefits and limitations.
CO5	Evaluate and discuss the future trends and safety considerations in drone technology, demonstrating an understanding of aviation regulations, miniaturization, autonomy, and swarm usage.

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REFERENCES

1. Daniel Tal and John Altschuld, “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, John Wiley & Sons, Inc, 2021.
2. Terry Kilby and Belinda Kilby, “Make: Getting Started with Drones “, Maker Media, Inc,2016.
3. John Baichtal, “Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs”, Que Publishing, 2016
4. Zavrsnik, “Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance”, Springer, 2018.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	1	3	-	1
2	1	1	3	2	-	1
3	1	1	2	2	-	1
4	1	1	3	2	-	2
5	1	1	1	2	-	2
Avg	**1**	**1**	**2**	**2.2**	**-**	**1.4**

Attested

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MR3025	MARINE ROBOTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the different types of marine vehicles, including their functions and applications.
2.	To analyze the design and construction principles of submersibles, ROVs, AUVs, and manned submersibles.
3.	To evaluate the control systems and simulation techniques used in remotely operated and autonomous underwater vehicles.
4.	To examine the operational considerations, safety measures, and certification requirements for manned submersibles.
5.	To apply knowledge of marine vehicle design and technologies to real-world applications in the marine industry.

UNIT I	**MARINE VEHICLES**	**9**

Types – general – by function – commercial marine vehicles- submersibles types - applications

UNIT II	**SUBMERSIBLES**	9

Manned and unmanned submersibles – towed vehicles – gliders – crawler – Design and construction

UNIT III	**REMOTELY OPERABLE VEHICLE (ROV)**	9

Remotely Operable Vehicles (ROV) – The ROV business – Design theory and standards – control and simulation – design and stability – components of ROV - applications

UNIT IV	**AUTONOMOUS UNDERWATER VEHICLE (AUV)**	9

AUV – Design and construction – components – sensors – Navigation -control strategies – applications

UNIT V	**MANNED SUBMERSIBLE**	9

Introduction – Design and operational consideration – pressure hull exostructure – ballasting and trim – maneuvering and control – Life support and habitability – emergency devices and equipment's – certification and classification

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Recognize and describe the various types of marine vehicles and their applications.
CO2	Explain the design and construction principles of submersibles, ROVs, AUVs, and manned submersibles.
CO3	Apply control systems and simulation techniques to design and operate remotely operated and autonomous underwater vehicles.
CO4	Analyze the operational considerations, safety measures, and certification requirements for manned submersibles.
CO5	Integrate knowledge of marine vehicle design and technologies to propose innovative solutions for real-world marine industry applications.

REFERENCES

1.	Jonathan M. Ross, human factors for naval marine vehicle design and operation, CRC press,2009.
2.	Robert D. Christ, Robert L. Wernli, Sr. "The ROV Manual A User Guide for Remotely Operated Vehicles", Elsevier, second edition, 2014
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5.	Ferial L hawry, The ocean engineering handbook, CRC press,2001
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COs	POs					
	1	2	3	4	5	6
1	1	1	2	1	1	2
2	1	1	2	1	1	2
3	1	1	2	2	1	1
4	1	1	2	3	1	1
5	1	1	2	2	1	2
Avg	1	1	2	1.8	1	1.6

Attested

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MR3026	MICRO AND NANO SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To understand the fundamental concepts and principles of nanotechnology and MEMS.
2.	To gain knowledge of various methods and techniques used for nano structuring and synthesis of nano materials.
3.	To develop an understanding of the properties and characteristics of nano materials and their applications in micro and nano technology.
4.	To acquire skills in different lithography and micromachining processes used in micro and nano fabrication.
5.	To familiarize with the materials used in MEMS and their suitability for specific applications

UNIT I **INTRODUCTION TO MICRO AND NANO TECHNOLOGY** **9**

Overview of Nanotechnology and MEMS - Nano Structuring - Nano Particles and Nano Layers - Properties - Science and Synthesis of Nano Materials – Lithography - Micromachining - Photolithography, Deposition Methods, DIRE, LIGA and Laser-Assisted Processing - Overview of Materials for MEMS – Si Wafer, Si Based Products, Polymers

UNIT II **CHARACTERIZATION OF MATERIALS** **9**

Principles and Applications of Nano Measuring Systems – Microscopy Techniques, Confocal LASER Scanning Microscopy - Scanning Electron Microscopy - Transmission Electron Microscopy, Scanning Tunnelling Microscopy, Atomic Force Microscopy, Diffraction Techniques – Auger Electron Spectroscopy (AES), X-Ray Photoelectron Spectroscopy (XPS), Electron Probe Micro-Analyser (EPMA) - Application.

UNIT III **MICRO AND NANO SENSORS** **9**

Si Active Tactile Sensor - Fabric Tactile Sensor and its application – Accelerometer-Capacitive Silicon – Wall in-Tube Flow Sensor and its application- Inertial Sensors – Accelerometer – Gyroscope – Pressure Sensors – Piezoresistive – Capacitive - Micro Channel Heat Sinks – Optical MEMS – Visual Display– Optical Data Switching – RF MEMS – MEMS Variable Capacitors – MEMS Switches – Resonators - Pressure Sensor - Nano Tweezers

UNIT IV **MICRO AND NANO ACTUATORS** **9**

Requirement for Micro Actuators - Nano Positioners, Micro Mechanical Testing Apparatus - Classification of Micro Actuator - Electrostatic Distributed Actuator- Force Distance various Actuators– Inch Worm, Zipper and Scratch Drive. Thermal Actuation-Bimorph-Buckle Beam -Frequency and Force Characteristics and Advantages -Electro thermal Actuator - Electro Thermal Relay with Mechanical Latch – Force vs Displacement Curve - Piezoelectric Actuation Advantages - MEMS Switch -Thin Film Bulk Acoustic Resonator (FBAR) - Magnetic Actuation - External Magnetic Field Actuators & Issues - Variable Reluctance Actuators - Shape Memory Actuators - Micro Pump and Micro Fluidics.

UNIT V **MICRO AND NANO SYSTEM** **9**

Micro Fluidic Systems - Micro Engine Driven by Electrostatically Actuated Comb Drive – Micro Robots and Nano Robots – Micro Insects, Night Vision System, BioMEMS- Principle and Application of Micro and Nano position Systems.

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Apply the principles and theories of nanotechnology and MEMS to independently carry out research and development work in the field of Micro and Nano technology.
CO2	Demonstrate the ability to critically analyze and evaluate the performance of materials, sensors, actuators, and systems in Micro and Nano technology.

CO3	Generate and present substantial technical reports and documents that effectively communicate research findings and innovative solutions in the field of Micro and Nano technology.
CO4	Exhibit mastery and deep understanding of key concepts, methods, and core elements in Micro and Nano technology, showcasing expertise in design, fabrication, and characterization.
CO5	Develop and optimize solutions for complex engineering problems in Micro and Nano technology, integrating knowledge from multiple disciplines and employing advanced tools and techniques.

REFERENCES

1. Mahalik N P, “MEMS”, McGraw Hill (India), 2009
2. Marc Madou, “Fundamentals of Micro Fabrication”, CRC Press, 2011.
3. Mohamed Gad-el-Hak, “MEMS Handbook”, CRC Press, 2006
4. Sami Franssila, Introduction to Micro Fabrication, John Wiley & Sons Ltd, 2010.
5. Tai – Ran Hsu, “MEMS and Microsystems Design and Manufacture”, Tata-McGraw Hill, New Delhi, 2007.
6. Waqar Ahmed and Mark J. Jackson, “Emerging Nanotechnologies for Manufacturing”, Elsevier Inc., 2014

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	1	1
2	1	1	2	1	1	1
3	1	1	2	1	2	1
4	1	1	2	1	2	1
5	3	1	2	1	1	2
Avg	**1.4**	**1**	**2**	**1**	**1.4**	**1.2**

MR3027	MODELLING AND FINITE ELEMENT ANALYSIS OF ELECTROMECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To comprehend the fundamental principles of finite element analysis.
2.	To apply appropriate selection and utilization of finite elements in solving physical and engineering problems across different applications.
3.	To analyze and evaluate the effectiveness of shape functions and higher-order formulation in finite element analysis.
4.	To demonstrate proficiency in executing preprocessing tasks, including meshing, assigning boundary conditions, and post-processing of engineering problems.
5.	To evaluate and assess the capabilities of FEM software through real-time problem-solving and case studies.

UNIT I	**INTRODUCTION**	**9**

Basics of FEM – Initial Value and Boundary Value Problems – Weighted Residual Galerkin and Raleigh Ritz Methods – Review of Variational Calculus – Integration by Parts – Basics of Variational Formulation.

UNIT II	**ONE DIMENSIONAL ANALYSIS**	**9**

Steps in FEA – Discretization, Function – Derivation of Element Characteristics Matrix, Shape Function, Assembly and Imposition of Boundary Conditions – Solution and Post Processing – One Dimensional Analysis in Solid Mechanics, Heat Transfer, Fluid Dynamics, Electrostatics and Electromagnetics.

UNIT III	**SHAPE FUNCTIONS AND HIGHER ORDER FORMULATIONS**	**9**

Global and Natural Co-Ordinates – Shape Functions for One- and Two-Dimensional Elements – Three Noded Triangular and Four Noded Quadrilateral Element – Nonlinear Analysis – Isoparametric Elements – Jacobian Matrices and Transformations – Basics of Two Dimensional Axi Symmetric Analysis.

UNIT IV	**ELECTROMECHANICAL SYSTEMS AND IMPLEMENTATION**	**9**

Basic quantities – Energy Stored in Electric Field – Capacitance – Magnetic Field – Linked Flux – Inductance – Force – Torque – Stress- Flow- Pre-Processing, Mesh Generation, Elements Connectivity, Boundary Conditions, Input of Material and Processing Characteristics – Solution and Post Processing

UNIT V	**CASE STUDIES**	**9**

FE Analysis of biomechanical Modelling – Tissue Modelling - Actuators – Rotating Machines- Sensors - Robot Arm- Overview of Application Packages - ANSYS, ABAQUS and COMSOL – Development of Model and Validation.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State the fundamental principles of finite element analysis and their application in engineering problems.
CO2	Apply appropriate finite element elements and techniques to solve physical and engineering problems in various domains.
CO3	Analyze and evaluate the performance of one-dimensional and two-dimensional finite element elements in different engineering applications.
CO4	Select and implement appropriate pre-processing techniques, including element selection, boundary condition specification, and meshing strategies, for efficient finite element analysis.
CO5	Evaluate and interpret the results of finite element analysis using post-processing techniques to make informed engineering decisions.

REFERENCES

1. Bathe, K. J. “Finite Element Procedures” Klaus-Jürgen Bathe, 2014.
2. Binns K.J, Lawrenson P.J, Trowbridge C.W, “The Analytical and Numerical Solution of Electric and Magnetic Fields”, John Wiley & Sons, 1993.
3. Matthew. N.O. Sadiku, “Elements of Electromagnetics”, Oxford University Press, 2021.
4. Nathan Ida, Joao P.A.Bastos , “Electromagnetics and Calculation of Fields”, Springer Verlage, 1997.
5. Nicola Biyanchi , “Electrical Machine Analysis using Finite Elements”, Taylor and Francis Group, CRC Publishers, 2005.
6. Reddy, J.N, “An Introduction to the Finite Element Method”, McGrawHill, 2019.
7. Salon S.J, “Finite Element Analysis of Electrical Machines” Kluwer Academic Publishers, 1995.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	3	1	1	1	1	1
2	3	1	2	1	1	1
3	3	1	2	1	1	1
4	3	1	2	3	2	2
5	3	1	3	3	3	3
Avg	**3**	**1**	**2**	**1.8**	**1.6**	**1.6**

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MN3051 CONCEPTS IN PRODUCT DEVELOPMENT L T P C
3 0 0 3

COURSE OBJECTIVES:

The main objective of this course is to prepare the students to:

1. Apply concurrent engineering principles in structuring work and deploying teams effectively in product development projects.
2. Analyse the role of customer involvement throughout the stages of the Product Life Cycle (PLC).
3. Utilize analysis tools such as Failure Mode and Effects Analysis (FMEA) to identify and mitigate potential risks in product design.
4. Assess the significance of intellectual property rights (IPR) in protecting new product innovations and conducting patent searches to ensure compliance.
5. Conduct quantitative and qualitative analysis to estimate future cash inflows and outflows in product development projects.

UNIT I PRODUCT DEVELOPMENT PROCESS & METHODOLOGIES 9

Integrated Product development process - Conceive – Specification, Concept design, Design - Detailed design, Validation and analysis (simulation), Tool design, realize – Plan manufacturing, Manufacture, Build/Assemble, Test (quality check), Service - Sell and Deliver, Use, Maintain and Support, Dispose. Bottom-up design, Top-down design, Front loading design workflow, Design in context, Modular design. Concurrent engineering - work structuring and team Deployment - Product and process systemization - problem, identification and solving methodologies. Product Reliability, Mortality Curve. Design for Manufacturing, Design for Assembly. Design for Six Sigma.

UNIT II INTRODUCTION TO PRODUCT LIFE CYCLE ENVIRONMENT 9 Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components/Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM, Transfer file, Database integration, System roles ERP, CAD, Configurators, EAI, PLM and Service Industry, PLM and E- Business and PLM Softwares, Tools.

UNIT III PRODUCT MODELLING AND ANALYSIS TOOLS 9

Product Modelling - Definition of concepts - Fundamental issues - Role of Process chains and product models -Types of product models - model standardization efforts-types of process chains - Industrial demands. Design for manufacturing - machining - casting and metal forming - optimum design - Design for assembly and disassembly - probabilistic design concepts - FMEA - QFD - Taguchi Method for design of experiments -Design for product life cycle. Estimation of Manufacturing costs, Reducing the component costs and assembly costs, Minimize system complexity.

UNIT IV PROJECT SELECTION, EVALUATION AND IPR 9

Collection of ideas and purpose of project - Selection criteria - screening ideas for new products (evaluation techniques). New Product Development Research - Patents - Patent search - Patent laws - International code for patents - Intellectual property rights (IPR). Design of proto type - testing - quality standards - marketing research - Understanding Customer Needs, Establishing Product Function - Product Teardown and Experimentation, Benchmarking and Establishing Engineering Specifications, Product Architecture.

UNIT V PRODUCT DEVELOPMENT ECONOMICS 9

Elements of Economics analysis - Quantitative and qualitative analysis-Economic Analysis process-Estimating magnitude and time of future cash inflows and out flows Sensitivity

analysis-Project trade-offs-Trade-offs rules-Limitation of quantitative analysis- Influence of qualitative factors on project success.

COURSE OUTCOMES

Upon successful completion if the course, students should be able to

1. Apply problem-solving strategies and methodologies to address challenges encountered during the product development process.
2. Evaluate the impact of customer involvement at different stages of the product life cycle and propose strategies for effective customer engagement.
3. Apply various product modelling techniques, such as CAD software and simulation tools, to create and optimize product designs.
4. Apply intellectual property rights (IPR) principles and conduct patent searches to protect and manage new product innovations.
5. Analyse and interpret quantitative and qualitative data to assess the economic viability of product development projects.

References

1. Grieves, Michael. Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
2. Product Life Cycle Management - by Antti Saaksvuori, Anselmi Immonen, Springer, 1st Edition (Nov.5, 2003)
3. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realisation, Springer-Verlag, 2004. ISBN 1852338105
4. Karl T. Ulrich and Steven D. Eppinger "Product Design and Development"
5. John Stark "Product Lifecycle Management: Volume 1 - 21st Century Paradigm for Product Realisation"
6. Gerhard Pahl, Wolfgang Beitz, and Jörg Feldhusen "Engineering Design: A Systematic Approach"
7. Michael N. Kennedy "Product Development for the Lean Enterprise: Why Toyota's System is Four Times More Productive and How You Can Implement It"
8. Anil Mital, Anoop Desai, and Anand Subramanian "Product Development: A Structured Approach to Consumer Product Development, Design, and Manufacture"
9. Michael Pfeifer "Design for Manufacturability and Statistical Design: A Constructive Approach"
10. Richard Stim "Intellectual Property: Patents, Trademarks, and Copyrights"
11. Marc Annacchino "New Product Development: Successful Innovation in the Marketplace"
12. Niall M. Fraser "Engineering Economics: Financial Decision Making for Engineers"

COs	POs					
	1	2	3	4	5	6
1	2	1	2	2	1	1
2	2	1	2	2	1	1
3	2	1	2	2	1	1
4	2	1	2	2	1	1
5	2	1	2	2	1	1
Avg	2	1	2	2	1	1

MR3028	CNC TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To interprete the classification of conventional machine tools and differences of NC, CNC and DNC**.**
2.	To understand the architecture of CNC and to identify the mechatronic elements and its functions in CNC machine reliable performance.
3.	To know the function various instrumentation system for parameter measurement and interface
4.	To understand standards and programing techniques in CNC machine.
5.	To learn the testing and maintance of various sub systems of CNC.

UNIT I	**NC, CNC, AND DNC**	**9**

Classification of Machine Tools – Types, Functions and Processes - Fundamentals of NC and CNC Technologies Adaptive Control - Types, Application and Benefits - General Configuration of Adaptive Control and Function – Reasons for Process Change - Practical Problems with Adaptive Control - Example for Feedback and Adaptive Control

UNIT II	**MECHATRONIC ELEMENTS IN CNC MACHINE TOOLS**	9

CNC Systems - Configuration of the CNC System – Interfacing – Monitoring – Diagnostics - Machine Data - Compensations for Machine Accuracies - PLC in CNC – PLC Programming for CNC, Steps in Programming and Case Studies - Machine Structure -Types of Loads on CNC Machine - Guide Ways and Types - Mechanical Transmission Elements - Elements for Rotary Motion to Linear Motion - Ball Screw and Types - Roller Screw and Types - Rack and Pinion - Various Torque Transmission Elements - Requirements of Feed Drives and Spindle Drive.

UNIT III	**INSTRUMENTATION SYSTEM AND AUTO TOOLING**	9

Measuring Systems - Feedback Devices - Velocity Feedback - Analog and Digital - Position Feedback - Rotary and Linear. Tooling - Requirement and Planning - Preset, Qualified and Semi Qualified Tools. Fixtures – Requirement - Unified and Modular Fixtures - Tool Identification - Touch Trigger Probe- Tool Coding - Tool Condition Monitoring - Various Indirect and Direct Methods. Identification and Gauging of Work Piece. Tool Locking System - Ball Lock Mechanism and Contact Pressure Monitoring. Automatic Tool Changing System - Types and Benefits - Tool Magazine – Sensors in CNC.

UNIT IV	**CNC PROGRAMMING**	9

ISO 6983 Standards - Machine Axes Identification - Primary, Secondary and Tertiary - Manual CNC Programming - Milling Programming Fundamentals - Compensation and Offset in Milling -Fixed Cycles in Milling - Repetitive Programming - Loops, Sub Programs and Macros. Turning Programming Fundamentals - Compensation and Offset in Turning - Fixed Cycles in Turning. Computer Assisted Programming in APT - Basic Geometry Definition - Cutter Motion Definition - Postprocessor Statements - Generation and Execution of APT Programs

UNIT V	**TESTING AND MAINTENANCE OF CNC MACHINES**	9

Verification of Technical Specification and Functional Aspects, Verification During Idle Running & Machine Tool and the Work Piece Accuracy - Installation of CNC Machines - Maintenance of CNC Machines - Machine Elements – Hydraulic Elements - Electrical and Electronic Elements – Maintenance Schedules

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	State and compare the differences between Numerical Control (NC), Computer Numerical Control (CNC), and Direct Numerical Control (DNC) systems.
CO2	Evaluate the architecture of CNC machines and assess the functions of mechatronic elements for ensuring reliable performance.
CO3	Apply CNC programming techniques in machine tools to accurately control and automate machining operations.

CO4	Implement testing and maintenance procedures for various subsystems of CNC machines to ensure their proper functioning.
CO5	Create diverse products by utilizing NC and CNC programming skills, demonstrating the ability to apply programming concepts to practical applications.

REFERENCES

1. Grahamt.Smith, “Advanced Machining: The Handbook of Cutting Technology”, IFS Publications Ltd., 1989
2. Groover,M.P., “Automation, Production System and CIM”, Prentice Hall of India Pvt. Ltd, 2019.
3. HMT Limited, “Mechatronics”, Tata Mcgraw-Hill Publishing, 2002.
4. Jayakumar,V., and Mahendran,B., “Computer Aided Manufacturing”, Lakshmi Publications, 2005.
5. Jonathan Lin,S.C., “Computer Numerical Control (From Programming to Networking)”, Delmar Publishers Inc., 2000.
6. Radhakrishnan,P., “CNC Machine”, New Central Book Agency, 2015.
7. Sehrawatt,M.S., and Narang,J.S., “CNC Machine”, Dhanpat Rai and Co, 2002.
8. Stenerson and Curran, “Computer Numerical Control-Operation and Programming”, PHI Learning Pvt. Ltd., 2008

COs	**POs**					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	-	1	2	2
2	1	1	2	1	2	2
3	1	1	-	1	2	2
4	1	1	1	1	2	1
5	1	1	-	1	2	2
Avg	**1**	**1**	**1.5**	**1**	**2**	**1.8**

MR3029	COMPUTER AIDED INSPECTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To learn the standards, instrumentation and errors in measurement.
2.	To learn the measurement principle and methods used in basic and advanced instruments.
3.	To learn the applications of opto-electronics device for measurements.
4.	To observe the machine vision-based inspections.
5.	To acquire the measurement strategies in inspection using CMM.

UNIT I	**FUNDAMENTALS AND CONCEPTS IN METROLOGY**	**9**

Standards of Measurement – Analog and Digital Measuring Instruments - Comparators – Limits, Fits and Tolerances – Gauge Design –Surface Roughness – Form Errors and Measurements.

UNIT II	**INSPECTION AND GENERAL MEASUREMENTS**	**9**

Linear Measuring Instruments – Evolution – Types – Classification – Limit Gauges – Gauge Design – Terminology – Procedure – Concepts of Interchange Ability and Selective Assembly – Angular Measuring Instruments – Types – Bevel Protractor Clinometers Angle Gauges, Spirit Levels Sine Bar – Angle Alignment Telescope – Autocollimator – Applications - Inspection of Gears And Threads – Tool Makers' Microscope – Universal Measuring Machine – Use of Laser Interferometer in Machine Tool Inspection – Uses of Laser in On-Line Inspection – Laser Micrometer – Laser Alignment Telescope.

UNIT III	**OPTO ELECTRONICS IN ENGINEERING INSPECTION**	**9**

Use of Optoelectronics in Tool Wear Measurements – Microhole Measurement and Surface Roughness – Applications in In-Process Measurement and On-Line Inspection.

UNIT IV	**MACHINE VISION**	9

Fundamentals of Image Processing – Steps Involved in Image Processing – Machine Vision Applications in Manufacturing and Metrology.

UNIT V	**COORDINATE METROLOGY AND QUALITY CONTROL**	**9**

Architecture of Coordinate Measuring Machines - Cycle Time Estimation for Measurement – Applications and Case Studies of CMM in Inspection – Use of Computers in Quality Control – Control Charts – Reliability.

TOTAL	**45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Apply measurement standards and protocols to ensure accurate and error-free measurements.
CO2	Utilize both basic and advanced metrology instruments effectively for precise measurements.
CO3	Acquire knowledge and understanding of non-contact opto-electronics devices for measurement applications.
CO4	Apply machine vision-based inspection techniques to enhance quality control processes.
CO5	Plan and develop measurement strategies using Coordinate Measuring Machines (CMM) for inspection and implement quality control measures.

REFERENCES

1. Anil. K. Jain, “Fundamentals of Digital Image Processing”, Prentice Hall of India Pvt. Ltd., 2004.
2. Alan S. Morris, “The Essence of Measurement”, Prentice Hall of India, 1996.
3. Beckwith, Marangoni, Lienhard, “Mechanical Measurements”, Pearson Education, 2014.
4. Charles Reginald Shotbolt, “Metrology for Engineers”, Cengage Learning EMEA, 1990.
5. Jain R.K., “Engineering Metrology”, Khanna Publishers, 2013.
6. Robert G. Seippel, “Opto-Electronics for Technology and Engineering”, Prentice Hall, 1989.
7. Robert J. Hocken, Paulo H. “Coordinate Measuring Machines and Systems”, Second Edition, 2016.

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	1	2
2	1	1	1	2	1	1
3	1	1	2	2	1	1
4	1	1	1	2	1	2
5	1	1	2	1	1	2
Avg	**1**	**1**	**1.6**	**1.6**	**1**	**1.6**

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MR3030	DESIGN OF EXPERIMENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To familiarize the concepts of Single Factor Experiment and Post hoc tests
2.	To illustrate understanding of Factorial experiments
3.	To enable students with the extensions of Factorial experiments and Response Surface Methods
4.	To provide students with an understanding of Taguchi method for parameter optimization
5.	To provide students with understanding of Shainin DOE

UNIT I **SINGLE FACTOR EXPERIMENTS** **9**

Introduction to Hypothesis testing – Experimentation – Need, Conventional test strategies, terminology, basic principles of design – steps in experimentation – Completely Randomized Design- effect of coding the observations- model adequacy checking - estimation of model parameters, residuals analysis- treatment comparison methods – Duncan's multiple range test, Newman-Keuel's test, Fisher's LSD test, Tukey's test- Testing using contrasts-Randomized Block Design – Latin Square Design- Graeco Latin Square Design – Applications

UNIT II **FACTORIAL DESIGNS** **9**

Main and Interaction effects - Two and three factor full factorial designs- Fixed effects and random effects model – Rule for sum of squares and Expected Mean Squares - 2^K Design with two and three factors– Yate's Algorithm – Fitting regression model– Randomized Block Factorial Design- Introduction to MANOVA&ANCOVA.

UNIT III **SPECIAL FACTORIAL DESIGNS & RESPONSE SURFACE METHODS** **9**

Blocking and Confounding in 2^K Designs- blocking in replicated design – 2^K Factorial Design in two blocks– Complete and partial confounding – Confounding 2^K Design in four blocks – Two level Fractional Factorial Designs - Construction of one-half and one-quarter fraction of 2^K Design - Introduction to Response Surface Methods- Designs for fitting First –order Model -Central Composite Design – Box- Behnken Designs.

UNIT IV **TAGUCHI DESIGN OF EXPERIMENTS** **9**

Taguchi's Quality Loss Function- Philosophy- Design of Experiments using Orthogonal Arrays, Data analysis from Orthogonal experiments - Response Graph Method- ANOVA- Attribute data analysis- Robust design- noise factors, Signal to Noise ratios, Inner/outer OA design- case studies.

UNIT V **SHAININ DESIGN OF EXPERIMENTS** **9**

Basics of Shainin DOE - Comparison between Taguchi DOE Vs Shainin DOE methods - Problem Solving Algorithm - Problem Identification Tools- Shainin Design of Experiments Tools - Case studies

TOTAL **45 PERIODS**

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1	Understand the fundamental principles of Classical Design of Experiments
CO2	Apply single factor experiment for process parameter understanding and optimization.
CO3	Apply Factorial Design principles for understanding of process parameters and its optimization
CO4	Gain knowledge on Taguchi's approach to experimental design for attaining robustness.
CO5	Apply Response Surface Method and Shainin DOE to evaluate quality

TEXT BOOKS

1. Krishnaiah K, and Shahabudeen P, "Applied Design of Experiments and Taguchi Methods", PHI,1st Edition, 2011.

REFERENCES

1. Douglas C. Montgomery, “Design and Analysis of Experiments”, John Wiley & sons, 2012.
2. Krishnaiah K, Applied Statistical Quality Control and Improvement,1 st Edition,2014
3. Box, G. E., Hunter,W.G., Hunter, J.S., Hunter,W.G., “Statistics for Experimenters: Design, Innovation, and Discovery”, 2nd Edition, Wiley, 2005.
4. Phillip J. Ross, “Taguchi Techniques for Quality Engineering”, Tata McGraw-Hill, India, 2005

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	2	-	1	1	1	-
2	2	1	2	1	1	-
3	2	1	2	1	1	-
4	2	1	2	1	1	-
5	2	1	2	1	1	-
Avg	**2**	**1**	**1.8**	**1**	**1**	**-**

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IL3152	OPERATIONS MANAGEMENT	L T P C
		3 0 0 3

COURSEOBJECTIVES:

1. To describe different operations management strategies for competitive advantage.
2. To know various techniques in forecasting the future Demand with accuracy.
3. To learn planning of production schedule and apply techniques like Aggregate plan, MRP, MRP II, DRP and ERP.
4. To learn how to determine the lot size and EOQ using the inventory systems. Also to learn how to classify the inventories for a better control.
5. To calculate the plant capacity and exercise control on production. Also to learn JIT implementation and control procedures.

UNIT I UNDERSTANDING OPERATIONS AND ITS DESIGN 9

Introduction to Operations Management, Manufacturing trends in India, Systems Perspective, Functions of Operations Management, Challenges and current priories for operations management; Operations Strategy- Corporate Strategy-Environmental Scanning -Developing Core Competencies -Developing Core Processes-Developing Global Strategies-Market Analysis-Market Segmentation-Competitive Priorities and Capabilities- Order Winners and Qualifiers-Identifying Gaps between Competitive Priorities and Capabilities - Addressing the Trends and Challenges in Operations Management –Global Competition -Comparative Cost Advantages- The Internet of Things- Need for Sustainable thinking for Operations Managers- Concerns and Barriers.

UNIT II DEMAND FORECASTING 9

Forecasting as a planning tool, need for forecast, forecasting time horizon, Design of forecasting system, Developing the forecasting Logic, Sources of data, Models for forecasting, Explorative Methods using Time Series - Moving averages, The exponential smoothing method, Extracting the components of time series, Estimating the trend using linear regression and Extracting the seasonal component; Causal Methods of forecasting, Accuracy of Forecasts and the Forecasting System.

UNIT III PRODUCTION PLANNING 9

Aggregate Production Planning and Master Production Scheduling; Resources Planning – Dependent demand attributes, the basic building blocks of a planning frame work, MRP logic, Using the MRP system, Capacity Requirements (CRP), Distribution Requirement Planning (DRP), and Resources Planning; Manufacturing Resources Planning (MRP II), Enterprise Resource Planning (ERP) and Resources Planning in Services.

UNIT IV INVENTORY PLANNING AND CONTROL 9

Inventory planning for independent Demand items, Types of inventory, Inventory Costs, Inventory Control for Deterministic Demand items, Handling Uncertainty in Demand, Inventory Control Systems, Selective Control of Inventory, Inventory Planning for Single - Period Demand and other issues in Inventory Planning and Control.

UNIT V CAPACITY ANALYSIS AND OPERATIONAL CONTROL 9

Defining capacity, Measures of capacity, The time horizon in capacity planning, The capacity planning framework, Alternatives for capacity augmentation, Decision tree for capacity planning; Operational control – Input - Output Control, Operational Control issues in mass production systems and Operations planning and control based on the theory of constraints; Elements of JIT Manufacturing and Production planning and Control in JIT.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1. Identify different operations management strategies for competitive advantage.

CO2. Apply various techniques in forecasting the future Demand with accuracy.

CO3. Plan the production schedule and apply techniques like Aggregate plan, MRP, MRP II, DRP and ERP.

CO4. Determine the lot size and EOQ using the inventory systems. Also will be able to classify the inventories for a better control.

CO5. Plan the capacity and exercise control on production. Also understand JIT implementation and control.

REFERENCES:

1. Lee J. Krajewski, Manoj K. Malhotra, Larry P. Ritzman, "Operations Management: Strategy and Analysis", Pearson, 2018
2. Mahadevan,B. Operations Management- Theory & Practice, Pearson Education, 2018.
3. Panneerselvam,R. Production and operations management, PHI, 2012
4. SeetharamaL.Narasimhan, Dennis W.McLeavey, Peter J.Billington,"Production Planning and Inventory Control" , PHI, 2002

CO's - PO's & PSO's MAPPING

	PO's			PSO's		
CO's	**1**	**2**	**3**	**1**	**2**	**3**
CO1	1	3	3	3	3	-
CO2	1	3	3	3	3	-
CO3	1	3	3	3	3	-
CO4	1	3	3	3	3	-
CO5	1	3	3	3	3	-
Avg	1	3	3	3	3	-

MR3031	TEROTECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1.	To study the approaches and techniques to assess quality by statistical process control.
2.	To study the methodology to assess and sampling of parameters
3.	To Impart knowledge in reliability concepts and assess the various configurations
4.	To Impart knowledge in reliability monitoring methods
5.	To Analyze effectively various techniques to improve reliability of the system.

UNIT – I	**QUALITY AND STATISTICAL PROCESS CONTROL**	**9**

Quality – Definition – Quality Assurance – Variation in process – Factors – process capability –control charts – variables X, R and X, - Attributes P, C and U-Chart tolerance design. Establishing and interpreting control charts – charts for variables – Quality rating – Short run SPC

UNIT – II	**ACCEPTANCE SAMPLING**	**9**

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer ‘s risk and consumer ‘s risk. AQL, LTPD, AOQL, Concepts – standard sampling plans for AQL and LTPD – use of standard sampling plans

UNIT– III	**RELIABILITY CONCEPTS AND ASSESSMENT**	**9**

Reliability definition – Reliability mathematics – Reliability functions – Hazard rate – Measures of Reliability – Design life –A priori and posteriori probabilities – Mortality of a component – Mortality curve – Useful life-Different configurations – Redundancy – k out of n system – Complex systems: RBD – Baye’s approach – Cut and tie sets – Fault Trees – Standby systems.

UNIT – IV	**RELIABILITY MONITORING**	**9**

Life testing methods: Failure terminated – Time terminated – Sequential Testing –Reliability growth monitoring – Reliability allocation – Software reliability-Human reliability.

UNIT – V	**RELIABILITY IMPROVEMENT**	**9**

Analysis of downtime – Repair time distribution – System repair time – Maintainability prediction – Measures of maintainability – Inspection decisions –System Availability.

TOTAL	**45 PERIODS**

COURSE OUTCOMES

Upon successful completion of the course, students should be able to:

CO1	Apply quality principles, process variation, and control charts for effective quality management.
CO2	Discuss different sampling plans.
CO3	Explain reliability concepts and assess the various configurations.
CO4	Build knowledge in reliability monitoring methods.
CO5	Examine effectively various techniques to improve reliability of the system

REFERENCES:

1. Amitava Mitra, “Fundamentals of Quality Control and Improvement”, Pearson Education, 5th Edition, 2021.
2. Charles E Ebling, “An Introduction to Reliability and Maintainability Engineering”, Tata-McGraw Hill, Third Edition, 2019.
3. David J Smith, “Reliability, Maintainability and Risk: Practical Methods for Engineers”, Butterworth, Tenth Edition, 2022.
4. Dhillon, “Engineering Maintainability – How to design for reliability and easy maintenance”, PHI, 2008.
5. Patrick D T O’Connor, Andre Kleyner, “Practical Reliability Engineering”, John-Wiley and Sons Inc, 5th edition ,2015.
6. Roy Billington and Ronald N. Allan, “Reliability Evaluation of Engineering Systems”, Springer, 2007.

COs	POs					
	1	2	3	4	5	6
1	2	2	1	2	2	1
2	2	2	1	2	2	2
3	2	2	1	1	2	2
4	2	2	1	2	2	2
5	2	2	1	2	2	3
Avg	2	2	1	1.8	2	2

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QE3251	LEAN SIX SIGMA	L T P C
		3 0 0 3

COURSE OBJECTIVES

1. To understand Lean production principles, eliminate waste, and improve efficiency through case studies.
2. To learn steps for Value Stream Mapping, apply Lean metrics, and implement improvements in value streams.
3. To explore Six Sigma's relationship with Lean Manufacturing, cultural changes, quality assessment, and cost implications.
4. To gain knowledge of various Six Sigma tools and techniques for problem-solving and project management.
5. To evaluate Six Sigma quality economics, focus on continuous improvement using Lean principles, Kaizen, and 5S methodologies.

UNIT I LEAN MANUFACTURING 9

Evolution of Mass production, Traditional versus Mass production, Evolution of Toyota (Lean) Production System, Business Dynamics of Lean production, Principles of Lean production – Value, Value stream, Flow, Pull, Perfection- 3Ms – Muda, Mura, Muri, 7 Wastes in Manufacturing, Lean Tools to eliminate Muda - 5S, Standardised work, TPM, SMED, Jidoka – Poka Yoke, JIT, Heijunka, Kanban, One piece production, Case studies.

UNIT II VALUE STREAM MAPPING 9

Need for Value Stream mapping; Steps involved in Value stream mapping – Choose value stream – PQ and PR analysis, Current State map, Lean Metrics, Future State Map, Kaizen plans; Lean implementation - Cultural change, Hoshin planning; Lean in the Supply chain.

UNIT III SIX SIGMA 9

Six sigma - lean manufacturing and six sigma- six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments - implications of quality levels, Cost of Poor Quality (COPQ)

UNIT IV SIX SIGMA SCOPE OF TOOLS AND TECHNIQUES 9

Tools for definition – IPO diagram, SIPOC diagram, Flow diagram, CTQ Tree, Project Charter – Tools for measurement – Check sheets, Histograms, Run Charts, Scatter Diagrams, Cause and effect diagram, Pareto charts, Control charts, Flow process charts, Process Capability Measurement, Tools for analysis – Process Mapping, Regression analysis, RU/CS analysis, SWOT, PESTLE, Five Whys, interrelationship diagram, overall equipment effectiveness, TRIZ innovative problem solving – Tools for improvement – Affinity diagram, Normal group technique, SMED, 5S, mistake proofing, Value stream Mapping, forced field analysis – Tools for control – Gantt chart, Activity network diagram, Radar chart, PDCA cycle, Milestone tracker diagram, Earned value management.

UNIT V EVALUATION AND CONTINUOUS IMPROVEMENT METHODS 9

Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen – 5S

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1. Demonstrate understanding of Lean production principles, waste identification, and efficiency improvement.

CO2. Apply Value Stream Mapping steps and Lean metrics to enhance organizational performance.

CO3. Analyze the relationship between Six Sigma and Lean Manufacturing, evaluate cultural changes, quality levels, and cost implications.

CO4. Acquire knowledge of Six Sigma tools and techniques for effective problem-solving and project management.

CO5. Evaluate Six Sigma quality economics and demonstrate commitment to continuous improvement through Lean principles, Kaizen, 5S methodologies, and customer focus.

REFERENCES:

1. Michael L.George, David Rownalds, Bill Kastle, What is Lean Six Sigma, McGraw – Hill 2003
2. Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill,2000
3. Fred Soleimannejed , Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004
4. Forrest W. Breyfogle, III, James M. Cupello, Becki Meadows, Managing Six Sigma:A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success, John Wiley & Sons, 2000
5. James P. Womack, Daniel T.Jones, Lean Thinking, Free Press Business, 2003

CO's- PO's & PSO's MAPPING

CO's	PO's			PSO's		
	1	**2**	**3**	**1**	**2**	**3**
1	-	3	3	-	-	2
2	-	3	3	-	-	2
3	2	3	3	-	-	2
4	3	-	3	2	3	2
5	2	-	3	2	3	2
Avg	**2.33**	**3**	**3**	**2**	**3**	**2**

1-low, 2-medium, 3-high, '-"- no correlation

IL3251 SUPPLY CHAIN SYSTEMS AND MANAGEMENT L T P C

3 0 0 3

COURSE OBJECTIVES:

1. To describe the role and drivers of and supply chain management in achieving competitiveness.
2. To explain about Supply Chain Network Design.
3. To illustrate about the issues related to inventory in Supply Chain.
4. To appraise about transportation and sourcing in Supply Chain.
5. To application of Information Technology and Emerging Concepts in Supply Chain.

UNIT I INTRODUCTION TO SUPPLY CHAIN MANAGEMENT 9

Definition and Objective of Supply Chain, The importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process View of Supply Chains. Competitive and Supply Chain Strategies, Achieving Strategic fit, Expanding Strategic Scope. Drivers of Supply Chain Performance, Frame work for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics

UNIT II DISTRIBUTION NETWORK DESIGN IN SUPPLY CHAIN 9

The Role of Distribution in the Supply Chains, Factors influencing Distribution Network design, Design Options for a Distribution Network, Online sales and the Distribution network, Distribution Networks in practice. Factors influencing network design decisions, Framework for Network design decisions, The impact of uncertainty on network design, The impact of Globalization on Supply Chain networks, Risk Management in Global Supply Chains, Discounted cash flow analysis, Evaluating Network Design Decisions

UNIT III INVENTORY IN SUPPLY CHAIN 9

The Role of Cycle inventory in a Supply Chain, Economies of Scale to Exploit Fixed costs, Managing Multi-echelon Cycle Inventory. The Role of Safety Inventory in a Supply Chain, Determining appropriate level of Safety inventory, Impact of supply Uncertainty on Safety inventory, Impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, Managing Safety Inventory in a Multi-echelon Supply Chain, The Role of IT in inventory management.

UNIT IV TRANSPORTATION AND SOURCING IN SUPPLY CHAIN 9

The role of transportation in a Supply chain, Modes of transportation and their performance characteristics, Transportation infrastructure and policies, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation, The role of IT in transportation, Problems. Sourcing Decisions In A Supply Chain: The role of sourcing in a supply chain, in-house or outsource, Third-and Fourth-party logistics providers, Total cost of Ownership, Supplier selection, Auctions and Negotiations, Sharing Risk and Reward in the supply chain.

UNIT V INFORMATION TECHNOLOGY IN SUPPLY CHAIN 9

The role of IT in a supply chain, The supply chain IT framework, The supply chain macro processes, Lack of Supply Chain co-ordination and the Bullwhip effect, managerial levers to achieve coordination, continuous replenishment and vendor-managed inventories, collaborative planning, forecasting and replenishment (CPFR).

TOTAL:45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1. Understand supply chain concepts, systemic and strategic role of SCM in global competitive environment.

CO2. Evaluate alternative supply and distribution network structures using optimization models.

CO3. Develop optimal inventory policies in the supply chain context.

CO4. Develop optimal sourcing and Transportation decisions in the supply chain.

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CO5. Select appropriate information technology frameworks for managing supply chain processes.

REFERENCES:

1. Sunil Chopra, Peter Meindl and D.V. Kalra, “Supply Chain Management: Strategy, Planning, and Operation", Pearson Education, 2016.
2. Sarika Kulkarni & Ashok Sharma, Supply Chain Management – Creating Linkages for Faster Business Turnaround, 1st Edition, TATA Mc Graw Hill, 2004.
3. David Simchi Levi, Philip Kaminsky, Edith Simchi Levi & Ravi Shankar, Designing & Managing the Supply Chain – Concepts Strategies and Case Studies, McGraw-Hill higher education, 3rd Edition, 2008.
4. Jeremy F Shapiro, Modelling the Supply Chain, 2nd Edition, Cengage Learning,2009.

CO’s-PO’s & PSO’s MAPPING

CO’s	PO’s			PSO’s		
	1	**2**	**3**	**1**	**2**	**3**
1	1	2	1			
2	3	3	1	1	1	1
3	3	3	1	1	1	1
4	3	3	1	1	1	1
5	3	3	1	1	3	1
Avg.	**2.6**	**3**	**1**	**1**	**1.5**	**1**

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