ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

Abbreviation used:

AC	Audit course	LC	Lab Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC	Mandatory/ Common Course	EA	End-Semester Assessment		

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering) **BH:** Basic Sciences and Humanities **CS:** Computer Sciences **EE:** Electrical Sciences **EI:** Electronic Sciences **IP:** Infrastructure and Planning **MS:** Mechanical Sciences **BT:** Biotechnology **TE:** Textile Engineering		**Level** **1:** UG/ Int. Msc. (1st Year) **2:** UG/ Int. Msc. (2nd Year) **3:** UG/ Int. Msc. (3rd Year) **4:** UG/ Int. Msc. (4th Year) **5:** UG/ Int. Msc. (5th Year) **6:** PG (1st Year) **7:** PG (2nd Year) **8:** Ph.D.	**0:** AC **1:** PC **2:** PE **3:** OE **4:** MC **5:** LC **6:** PR **7:** SE **8:** **9:**	**Serial Number (01 to 99)** 01/ 03/…/ 19: Odd Sem. (IEM) 21/ 23/…/ 39: Odd Sem. (MML) 41/ 43/…/ 59: Odd Sem. (MSD) 61/ 63/…/ 79: Odd Sem. (THE) 81/ 83/…/ 99: Odd Sem. (MBA) 02/ 04/…/ 20: Even Sem. (IEM) 22/ 24/…/ 40: Even Sem. (MML) 42/ 44/…/ 60: Even Sem. (MSD) 62/ 64/…/ 80: Even Sem. (THE) 82/ 84/…/ 98: Even Sem. (MBA)	

1st Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC 1	MS6121	Fundamentals of Mechatronics	3	0	0	3	40	60	-	100
2	PC 2	MS6123	Artificial Intelligence	3	0	0	3	40	60	-	100
3	PE 1 (Any One)	MS6221	Sensors and Actuators in Industries	3	0	0	3	40	60	-	100
		MS6223	Introduction to Internet of Things								
		MS6225	Design and Control of Mechatronic Systems								
4	MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3	40	60	-	100
5	MC 2	MS6403	Research Methodology and IPR	2	0	0	2	40	60	-	100
6	LC 1	MS6521	Data Modeling Lab	0	0	4	2	-	-	100	100
7	LC 2	MS6523	Mechatronics Laboratory	0	0	4	2	-	-	100	100
8	AC 1	Any One from the List of AC 1 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**16**	**0**	**8**	**18**	**240**	**360**	**200**	**800**

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2nd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC 3	MS6122	Foundations of Machine Learning	3	0	0	3	40	60	-	100
2	PC 4	MS6124	Robot Mechanics and Control	3	0	0	3	40	60	-	100
3	PE 2 (Any One)	MS6222	Mechatronics System Design	3	0	0	3	40	60	-	100
		MS6224	Microprocessor and Embedded Systems								
		MS6226	Autonomous Robotics								
4	PE 3 (Any One)	MS6228	Advanced Machine Learning	3	0	0	3	40	60	-	100
		MS6230	Big Data Analytics								
		MS6232	Deep Learning								
5	OE 1	Any One from the List of OE 1 (Appendix-I)		3	0	0	3	40	60	-	100
6	PR 1	MS6622	Project (Specialization Related)	0	0	4	2	-	-	100	100
7	LC 3	MS6522	Advanced Data Modeling Lab	0	0	4	2	-	-	100	100
8	AC 2	Any One from the List of AC 2 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**17**	**0**	**8**	**19**	**240**	**360**	**200**	**800**

3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PE 4* (Any One)	MS7221	System Modelling and Simulation	3	0	0	3	40	60	-	100
		MS7223	Hardware Integration of Mechatronics System								
		MS7225	Advanced Control System								
		MS7227	Hydraulic and Pneumatic Control System								
2	PR 2	MS7621	Dissertation (Phase-I)	0	0	24	12	-	-	100	100
			Total	**3**	**0**	**24**	**15**	**40**	**60**	**100**	**200**

* Virtual/Online Course either offered by OUTR or available in MOOCs platform (No physical class)

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PR 3	MS7622	Dissertation (Phase-II)	0	0	32	16	-	-	100	100
			Total	**0**	**0**	**32**	**16**	**-**	**-**	**100**	**100**

Credits and Maximum Marks

Sl. No.	Semester	Credits	Maximum Marks
1	1st	18	800
2	2nd	19	800
3	3rd	15	200
4	4th	16	100
	Total	68	1900

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1st Semester

PC 1	MS6121	Fundamentals of Mechatronics	3	0	0	3

Course Objectives:

1. To educate the student to understand the fundamentals of Mechatronics.
2. To study the design of hydraulic circuits

Course Outcomes:

Students will be able to:

CO1: Understand the concept of Mechatronics and its characteristics and components in mechatronics systems.
CO2: Apply the concept of Drives and Indexing mechanism in Mechatronic system
CO3: Understand the role of Signal Conditioning, Op-Amp and Microprocessor in Mechatronics
CO4: Discuss the concept of Hydraulic systems and Pneumatics and evaluate part programming in Mechatronics system

Module I:

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach.

Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by Camshafts, electronic cams, indexing Mechanisms, tool magazines and transfer systems.

Module II:

Introduction to Signal Conditioning & Op-Amp, OP-AMP As Signal Conditioner, Analogue To Digital Converters, Digital To Analogue Converters, Microprocessor, Microcontroller, Artificial Intelligence.

Module III:

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, and pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, Design of systems, Description of PID controllers, CNC machines and part programming

Text Books:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar. II, Machine design for mobile and industrial applications, SAE, 1994.

Reference Books:

1. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall, 1996.

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PC 2	MS6123	Artificial Intelligence	3	0	0	3

Course Objectives:

1. To educate the student to understand the concept of AI and its real applications in digital world.
2. To study the various types of logic Programming and Learning Paradigms in AI

Course Outcomes:

Students will be able to:

CO1: Understand the concept of AI and solve the problems of different Heuristic search techniques
CO2: Apply the concept of logic programming and Fuzzy logic in AI
CO3: Acquire the knowledge of Artificial Neural Network and Convolutional Neural Network
CO4: Demonstrate proficiency developing applications in 'AI language', expert system shell and data mining tools.

Module I:

Introduction: What is AI, History, AI problems, Production Systems, Problem characteristics, Intelligent Agents, Agent Architecture, AI Application (E-Commerce, & Medicine), AI Representation, Properties of internal representation, Future scope of AI, Issues in design of search algorithms.
Heuristic search techniques: Heuristic search, Hill Climbing, Best first search, mean and end analysis, Constraint Satisfaction, A* and AO* Algorithm, Knowledge Representation: Basic concepts, Knowledge representation Paradigms, Propositional Logic, Inference Rules in Propositional Logic, Knowledge representation using Predicate logic, Predicate Calculus, Predicate and arguments, ISA hierarchy, Frame notation, Resolution, Natural Deduction

Module II:

Logic Programming: Introduction, Logic, Logic Programming, Forward and Backward reasoning, forward and Backward chaining rules. Knowledge representation using non monotonic logic: TMS (Truth maintenance system), statistical and probabilistic reasoning, structure knowledge representation, semantic net, Frames, Script, Conceptual dependency
Fuzzy Logic: Crisp sets, fuzzy sets, fuzzy set operations, properties, membership function, Fuzziness, fuzzification and defuzzification methods, fuzzy relations, operation on fuzzy relations, fuzzy numbers and arithmetic, fuzzy implications, approximate reasoning, systems based on fuzzy rules, fuzzy inference, Neuro fuzzy systems, adaptive neuro-fuzzy inference system, evolutionary neural networks, fuzzy evolutionary systems, Neuro Genetic, Genetic-Fuzzy systems Application of fuzzy-logic to engineering problems, Fuzzy control systems, Fault diagnosis
Artificial Neural Network: Introduction, Biological foundation, Mathematical model of biological neuron, Types of activation function, Feed-forward and Feedback ANN model

Module III:

Learning Paradigms: Supervised and unsupervised learning, learning rules, single layer and multilayer perceptron model, error back propagation learning algorithm, pattern classification, clustering, Introduction to generative AI and CNN, radial basis function network, support vector machines, Hopfield network, Associative memory and CNN, applications of ANN models to engineering problems
Evolutionary Techniques: Introduction and concepts of genetic algorithms and evolutionary programming

Textbooks:

1. Nils J. Nilsson, “Artificial Intelligence: A new Synthesis”, Harcourt Asia Pvt. Ltd., 2000.
2. Elaine Rich and Kevin Knight, “Artificial Intelligence”, 2nd Edition, Tata McGraw-Hill, 2003. 3. George
3. F. Luger, “Artificial Intelligence-Structures and Strategies for Complex Problem Solving”, Pearson Education / PHI, 2002.

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PE 1	MS6221	Sensors and Actuators in Industries	3	0	0	3

Course Objectives:

1. To understand basics of sensors, actuators and their operating principle.
2. To study the various sensors and actuators, applications of MEMS to disciplines beyond Electrical and Mechanical.

Course Outcomes:

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

CO1: Use concepts in common methods for converting a physical parameter into an electrical quantity.

CO2: Design and develop sensors using optical methods with desired properties.

CO3: Analyse the applications of Strain gauges, strain gauge, beam force sensor, piezoelectric force sensor, load cell, torque sensor in industries

CO4: Evaluate performance characteristics of different types of actuator.

Module I:

Sensor fundamentals and characteristics, Sensor Classification: Position, Direction, Displacement and Level sensors, Performance and Types, Error Analysis characteristics.

Optical Sources and Detectors: Electronic and Optical properties of semiconductor as sensors, LED, Semiconductor lasers, Fiber optic sensors, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs. Brief overview of measurement systems, classification, characteristics and calibration of different sensors.

Module II:

Strain gauges, strain gage beam force sensor, piezoelectric force sensor, load cell, torque sensor, Piezo-resistive and capacitive pressure sensor, optoelectronic pressure sensors, vacuum sensors.

Hydraulic and Pneumatic Actuators: Actuators, definition, example, types, selection. Pneumatic actuator, Electro Pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection

Module III:

Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors.

Piezoelectric actuator: characterization, operation, and fabrication; shape memory alloys, Linear actuators

Text Books:

1. Gregory Kovacs, “Micro machined Transducers Sourcebook”, McGraw-Hill, New York (1998).

Reference Books:

1. John G. Webster, Editor-in-chief, “Measurement, Instrumentation, and Sensors Handbook”, CRC Press (1999).

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PE 1	MS6223	Introduction to Internet of Things	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Understand the basic concepts of IoT

CO2: Analyse the different Python programming.

CO3: Apply the concept of IoT in Industry 4.0/Smart factories

CO4: Use the knowledge of IoT in Industrial domains

Module I:

Introduction to IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi, Introduction to SDN, SDN for IoT, Data Handling and Analytics, Cloud Computing, Sensor-Cloud, Fog Computing, Examples of IoT based Systems: Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring

Module II:

Introduction to Industry 4.0/Smart Factories, Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Cybersecurity in Industry 4.0

Module III:

Basics of Industrial IoT, Industrial Sensing & Actuation, Industrial Internet Systems. Industrial IoT-Introduction, Industrial IoT Business Model and Reference Architecture, Industrial IoT- Layers: Industrial IoT Sensing, Industrial IoT Processing, Industrial IoT Communication, Industrial IoT Networking, Big Data Analytics and Software Defined Networks, IIoT

Analytics - Introduction, Introduction to Machine Learning and Data Science, Introduction to R and Julia Programming, Data Management with Hadoop. SDN in Industrial IoT, Data Center Networks, Security and Fog Computing, Cloud Computing in Industrial IoT,

Industrial IoT- Application Domains: Factories and Assembly Line, Food Industry, Healthcare, Power Plants, Inventory Management & Quality Control, Plant Safety and Security (Including AR and VR safety applications), Facility Management, Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Industrial IoT Case studies Self.

Text Books:

1. Pethuru Raj and Anupama C. Raman, The Internet of Things: Enabling Technologies, Platforms, and Use Cases", (CRC Press)
2. Arshdeep Bahga and Vijay Madisetti Internet of Things: A Hands-on Approach"

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Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 1	MS6225	Design and Control of Mechatronic Systems	3	0	0	3

Course Objectives:

1. Appreciate the need for feedback control in practical mechatronic systems.
2. Derive dynamical models and represent them in block diagram notation.
3. Analyse stability and performance of systems in the time and frequency domain using step and impulse responses, root-locus, Bode and Nyquist diagrams.

Course Outcomes:

CO1: Identification of key elements of mechatronics system and its representation in terms of block diagram.
CO2: Understanding the concept of Frequency response design.
CO3: PID control implementation on real time systems.
CO4: Time and Frequency domain analysis of system model (for control application) & Development of PLC ladder programming and implementation of real life system.

Module I:

Time response design: Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design.
Frequency response design: Bode, polar, Nyquist, Nichols plot, lag, lead, lag-lead compensator, time delay, process plant response curve. PID controller design.

Module II:

Modern control: Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, Lunenburg observer, reduced order observer, observer based control.
Optimal control design: Solution-time criterion, control-area criterion, performance indices; zero steady state step error systems; modern control performance index: quadratic performance index, Ricatti equation.

Module III:

Digital control: Sampling process, sample and hold, Analog to digital converter, use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, digital control design using state feedback. Non-Linear Control System: Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, Popov's stability criterion.

Text Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall India (2002).
2. Gene F. Franklin, J. D. Powell, A E Naeini, "Feedback Control of Dynamic Systems", Pearson (2008).

Reference Books-

1. Thomas Kailath, "Linear Systems", Prentice Hall (1980).
2. Alok Sinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).
3. Brian D. O. Anderson and John B. Moore, "Optimal Control: Linear Quadratic Methods", Dover

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MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3

Refer Appendix-I for detailed Syllabus.

MC 2	MS6403	Research Methodology and IPR	2	0	0	2

Refer Appendix-I for detailed Syllabus.

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LC 1	MS6521	Data Modeling Lab	0	0	4	2

1. Kinds of data: structured, unstructured, semi-structured and corresponding representation techniques and examples
2. Data representation: relational, NoSQL
3. Data type: Text, audio, images, videos
4. Input Data Representation & Output Data Representation
5. Data gathering and pre-processing

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LC 2	MS6523	Mechatronics Laboratory	0	0	4	2

1. Demonstration of Mechatronics Hardware's;
2. Servo- Position and Velocity Control;
3. Process Control; Basic Programming Using Microprocessor/Microcontroller;
4. ADC and DAC Interfacing with Microcontroller/ Microprocessor;
5. Machine Condition Monitoring; Development of Multiple Sensor Fusion;
6. Image Based Navigation and Control of Robot;
7. Control of Non-Linear Systems; Machine Vision Inspection and Image Surveillance;
8. Mini-Projects on Mechatronic System Design.

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AC 1	Any One from the List of AC 1 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

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2nd Semester

PC 3	MS6122	Foundations of Machine Learning	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Apply concepts and techniques of Machine Learning.

CO2: Develop the skills in using recent machine learning software for solving practical problems.

CO3: Understand the concepts of over fitting, under fitting and gain knowledge in Probability

CO4: Evaluate and know the concept of stochastic process and random variables

Module I:

Learning: What is Learning, Overview of Machine Learning, Types of Learning (Rote, Direct instruction Analogy, Induction, Deduction, Hypothesis space and inductive bias, Evaluation. Training and test sets, cross validation, Different forms of learning- Generative learning- Gaussian parameter estimation- maximum likelihood estimation- MAP estimation- Bayesian estimation- bias and variance of estimators- missing and noisy features- nonparametric density estimation- applications- software tools.

Module II:

Concept of over fitting, under fitting, Bias and Variance. Linear Regression: Introduction, Linear regression, Simple and Multiple Linear regression, Polynomial regression, evaluating regression fit.

PROBABILITY: Classical, relative frequency and axiomatic definitions of probability, addition rule and conditional probability, multiplication rule, total probability, Bayes' Theorem and independence

Module III:

RANDOM VARIABLES: Discrete, continuous and mixed random variables, probability mass, probability density and cumulative distribution functions, mathematical expectation, moments, moment generating function, Chebyshev's inequality

STOCHASTIC PROCESSES: Introduction to Stochastic Processes (SPs), Stationary Processes, Discrete-time Markov Chains (DTMCs), Continuous-time Markov Chains (CTMCs)

Text Books:

1. T. Hastie, R. Tibshirani and J. Friedman, "Elements of Statistical Learning", Springer, 2009.
2. E. Alpaydin, "Machine Learning", MIT Press, 2010.
3. K. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.
4. C. Bishop, "Pattern Recognition and Machine Learning, Springer", 2006.

Reference Books:

1. Shai Shalev-Shwartz, Shai Ben-David, "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014.
2. John Mueller & Luca Massaron, "Machine Learning For Dummies", John Wiley & Sons, 2016
3. Arshdeep Bahga, V. Madisetti, Big Data Science & Analytics: A Hands On Approach,VPT, 2016
4. Bart Baesens "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)", John Wiley & Sons,2014

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PC 4	MS6124	Robot Mechanics and Control	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Understand the basic concepts of robotics

CO2: Analyse the mechanism of robot kinematics.

CO3: Apply the concept of Trajectory planning and robot dynamics in robotics

CO4: Utilize the concept of dynamics modelling and simulation and apply in robot control

Module I:

Introduction to robotics, Robot Degrees of Freedom, Robotic joints, Robot coordinates, Robot reference frames, Basic concepts of linear algebra and feedback control, Rigid bodies and homogeneous transformations, Robot modelling

ROBOT KINEMATICS: Direct kinematics, Inverse kinematics problem, Dot and cross products, Co-ordinate frames, Rotations, Homogeneous Coordinates, Link coordinates, D-H Representation, Arm equation -Two axis, three axis, four axis, five axis and six axis robots. Inverse Kinematic problem, General properties of solutions, Tool configuration, Inverse Kinematics of Two axis, Three axis, Four axis and Five axis robots.

Module II:

Trajectory planning, Geometric Jacobian / Analytical Jacobian, Singularities and redundancy, Inverse kinematics algorithms, Statics and manipulability, Kinematic solutions and trajectory planning

ROBOT DYNAMICS: Forward Dynamics and Inverse Dynamics – Importance – Spatial description and transformations – Different types of dynamic formulation schemes – Lagrangian formulation for equation of motion for robots and manipulators. Properties of the dynamic model, Dynamic model of simple manipulator structures, Dynamic parameters identification, Operational space dynamics model, Differential kinematics.

Module III:

DYNAMIC MODELING AND SIMULATION: Modeling of motion of robots and manipulators using Newton – Euler equations – State space representation of equation of motion and system properties – Importance of Simulation and its types – Numeric Integration solvers and their role in numeric simulation - Numeric simulation of robots and manipulators using MATLAB / Simulink module.

INTRODUCTION TO ROBOT CONTROL: Introduction – Need and types of control schemes for robots – joint space control schemes with an example – task space control schemes with an example.

Text Books:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Siciliano, Bruno. Robotics: modelling, planning and control [on line]. London: Springer, 2009.
3. Corke, Peter I. Robotics, vision and control: fundamental algorithms in Matlab. 1st ed. New York: Springer, 2011. ISBN 978- 3-642-20143-1.

Reference Books:

1. Devendra K Chaturvedi, ―Modeling and Simulation of Systems using MATLAB and Simulink , CRC press, 2010
2. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).
3. Kelly R, Santibanez V and Loria A, ―Conrol of Robot Manipulators in Joint Space‖, Springer, 2005.

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PE 2	MS6222	Mechatronics System Design	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Demonstrate how mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products that are useful in everyday life.

CO2: Apply theoretical knowledge: understanding selection of suitable sensors and actuators; designing electro-mechanical systems.

CO3: Work with mechanical systems that include digital and analogue electronics as a data acquisition model.

CO4: Understand the concept of Data Acquisition and Control and Mechatronics product.

Module I:

Mechanical Systems and Design - Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.

Real time interfacing - Introduction Elements of data acquisition and control Overview of I/O process-Installation of I/O card & software - Installation of application software - Over framing.

Module II:

Microcontrollers: Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages; web and mobile phone apps.

Case studies on Data Acquisition - Transducer calibration system for Automotive applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers.

Module III:

Case studies on Data Acquisition and Control - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.

Case studies on design of Mechatronics products - Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

Text Books:

1. W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.
2. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997
3. Bradley, D. Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products and Processes, Chapman and Hall, London, 1991.

Reference Books:

1. Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
2. Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 2	MS6224	Microprocessor and Embedded Systems	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Understand the concept of Embedded Systems and microcomputers

CO2: Apply theoretical knowledge in Microcontroller and analyse different programming models.

CO3: Analyse the concept of Microcontroller Interfacing and Data Acquisition systems.

CO4: Apply the concept of Advanced Embedded Processor and Software in real time operating system

Module I:

Introduction to Embedded Systems and microcomputers: Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Challenges for Embedded system Design, Evolution of computing systems and applications. Classification of the processors used in embedded design, Basic Computer architecture: Von- Neumann and Harvard Architecture. Basics Processing Cores – RISC & CISC. Computing performance, Throughput and Latency, Microcomputer applications to embedded systems and Mechatronics.

Module II:

Microcontroller:

Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Serial Communication, LCD Controller. Different types of Sensors.

Microcontroller Interfacing: Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, Data Acquisition Systems, controllers and Drivers for DC, Servo and Stepper Motor.

Module III:

Introduction to MSP 430: Memory Model, Overview of Instructions, I/O Ports, Timers and Interrupts.

Introduction to Advanced Embedded Processor and Software: ARM Processor, Real Time Operating System (RTOS), Embedded C.

Text Books:

1. Introduction to Embedded Systems: Shibu K V, McGRAW Hill Publications.
2. Embedded Systems: Raj Kamal, TATA McGRAW Hill Publications

Reference Books:

1. PIC Microcontrollers and Embedded Systems: M. A. Mazidi, R.D. Mckinlay and D. Casey, Pearson Publications
2. Programming and Customizing the PIC Microcontroller: M. Predko, McGRAW Hill Publications.

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 2	MS6226	Autonomous Robotics	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Understand the basic components of robots.

CO2: Differentiate types of robots and robot grippers.

CO3: Model forward and inverse kinematics of robot manipulators.

CO4: Analyse forces in links and joints of a robot and Programme a robot to perform tasks in industrial applications.

MODULE I:

Robotics: Introduction, classification with respect to geometrical configuration (Anatomy), Robot components, Robot Joints and coordinates, robot programming modes, Robot characteristics and workspace, Robot applications

Industrial robot specifications: Selection based on the Application. Controlled system and chain type: Serial manipulator and Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy and repeatability- Dynamic characteristics- speed of motion, load carrying capacity and speed of response.

MODULE II:

Sensors: Characteristics of sensing devices, Criterion for selections of sensors, Classification, and applications of sensors. Internal sensors: Position sensors and Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, and Force or Torque sensors.

Drives: Basic types of drives. Advantages and Disadvantages of each type. Selection / suitability of drives for Robotic application.

Controllers: Types of Controller and introduction to close loop controller

Grippers: Mechanical Gripper-Grasping force--mechanisms for actuation, Magnetic gripper vacuum cup gripper-considerations in gripper selection and design.

MODULE III:

Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, D-H transformation matrix, D-H method of assignment of frames. Direct and Inverse Kinematics for industrial robots. Differential Kinematics for planar serial robots.

Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Programming and Languages: Methods of robot programming, Introduction to various languages such as RAIL and VAL II etc., Features of each type and development of languages for recent robot systems.

Artificial Intelligence: Brief introduction to AI, relevance of AI with robotics, Probabilistic Robotics.

Text Books:

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)

Reference Books:

1. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
2. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
3. S. B. Nikku, Introduction to Robotics Analysis, Control, Applications, 3rd ed., John Wiley & Sons Ltd., (2020)
4. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE , McGraw Hill Education (India) Pvt Ltd (2012)

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 3	MS6228	Advanced Machine Learning	3	0	0	3

Course Outcomes:

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

CO1: Understand the concept of different machine learning methods, concepts and models

CO2: Apply the concept of clustering methods

CO3: Understand the concept of HADOOP and NoSQL database

CO4: Analyse the concept of ANN in solving multilayer networks and back propagation algorithm

Module I:

Introduction to Machine learning, Classification Methods-Nearest neighbour- Decision trees- Linear Discriminant Analysis - Logistic regression- Perceptions- large margin classification- Kernel methods- Support Vector Machines. Classification and Regression Trees. Graphical and sequential models- Bayesian networks- conditional independence Markov random fields- inference in graphical models- Belief propagation- Markov models- Hidden Markov models- decoding states from observations- learning HMM parameters.

Module II:

Clustering Methods-Partitioned based Clustering - K-means- K-medoids; Hierarchical Clustering - Agglomerative- Divisive- Distance measures; Density based Clustering - DBScan; Spectral clustering.

Map Reduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases - S3 - Hadoop Distributed File Systems – Visualization.

Module III:

Artificial Neural Networks: Introduction, Biological motivation, ANN representation, appropriate problem for ANN learning, Perceptron, multilayer networks and the back propagation algorithm

Ensembles: Introduction, Bagging and boosting, Random forest, Discussion on some research papers.

Text Books:

1. Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997. Alpaydin, Ethem.
2. Introduction to machine learning. MIT press, 2020.

Reference Books:

1. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
2. Christopher Bishop, “Pattern Recognition and Machine Learning” Springer, 2007.

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 3	MS6230	Big Data Analytics	3	0	0	3

Course Outcomes:

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

CO1: Understand the concept of Big Data Analytics

CO2: Apply the concept of different Mining Data Streams.

CO3: Understand the concept of HADOOP and its components

CO4: Understand the different frameworks and its applications in Big data.

Module I:

INTRODUCTION TO BIG DATA-Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis vs Reporting.

MINING DATA STREAMS-Introduction to Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real Time Analytics Platform (RTAP) Applications - Case Studies - Real Time Sentiment Analysis- Stock Market Predictions.

Module II:

HADOOP-History of Hadoop- the Hadoop Distributed File System – Components of Hadoop Analyzing the Data with Hadoop- Scaling Out- Hadoop Streaming- Design of HDFS-Java interfaces to HDFS Basics Developing a Map Reduce Application-How Map Reduce Works-Anatomy of a Map Reduce Job run Failures-Job Scheduling-Shuffle and Sort – Task execution - Map Reduce Types and Formats- Map Reduce Features Hadoop environment.

Module III:

FRAMEWORKS-Applications on Big Data Using Pig and Hive – Data processing operators in Pig – Hive services – HiveQL – Querying Data in Hive - fundamentals of HBase and ZooKeeper - IBM Info Sphere Big Insights and Streams.

PREDICTIVE ANALYTICS- Simple Linear Regression-Multiple linear regression- Interpretation of regression coefficients; Visualizations - Visual data analysis techniques- interaction techniques - Systems and applications.

Text Books:

1. Michael Berthold, David J. Hand, “Intelligent Data Analysis”, Springer, 2007.
2. Tom White “Hadoop: The Definitive Guide” Third Edition, O’reilly Media, 2012.
3. Chris Eaton, Dirk DeRoos, Tom Deutsch, George Lapis, Paul Zikopoulos, “Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data”, McGrawHill Publishing, 2012.
4. Anand Rajaraman and Jeffrey David Ullman, “Mining of Massive Datasets”, CUP, 2012

Reference Books:

1. John Mueller & Luca Massaron, “Machine Learning For Dummies“, John Wiley & Sons, 2016
2. Arshdeep Bahga, V. Madisetti, Big Data Science & Analytics: A Hands On Approach, VPT, 2016
3. Bart Baesens “Analytics in a Big Data World: The Essential Guide to Data Science and its Applications (WILEY Big Data Series)”, John Wiley & Sons, 2014

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 3	MS6232	Deep Learning	3	0	0	3

Course Outcomes:

Student will be able to

CO1: Understand the fundamentals of neural networks.

CO2: Design feed forward networks with backpropagation.

CO3: Analyze neural networks for performance.

CO4: Apply attention mechanism to the neural network.

Module I:

Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear separability. Convergence theorem for Perceptron Learning Algorithm.
Introduction to neural network and multilayer perceptrons (MLPs), representation power of MLPs, sigmoid neurons, gradient descent, feedforward neural networks representation, Backpropagation.

Module II:

Gradient Descent, Batch Optimization, Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Saddle point problem in neural networks, Regularization methods (dropout, drop connect, batch normalization).
Autoencoders, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

Module III:

Introduction to CNN, Building blocks of CNN, Transfer Learning, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing CNNs, Guided Backpropagation, Fooling Convolutional Neural Networks. Introduction to RCNN, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs, Encoder Decoder Models, Attention Mechanism.

Text Books:

1. Deep Learning- Ian Goodfelllow, Yoshua Benjio, Aaron Courville, The MIT Press

Reference Books:

1. Neural Networks: A Systematic Introduction, Raul Rojas, 1996
2. Pattern Recognition and Machine Learning, Christopher Bishop, 2007

OE 1	Any One from the List of OE 1 (Appendix-I)	3	0	0	3

Refer Appendix-I for detailed Syllabus.

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PR 1	MS6622	Project (Specialization Related)	0	0	4	2

Mechatronics and Robotics Project

1. NC machine tool.
2. Sequence planning & automatic quality inspection in CIM.
3. Microprocessor/microcontroller based control.
4. Three DOF gyroscope.
5. Design and fabrication of piezo-actuator, Hydraulic actuator and Pneumatic actuator
6. Design and characterization of optical sensor.

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

LC 3	MS6522	Advanced Data Modeling Lab	0	0	4	2

1. Exploratory Data Analysis
2. Basic ML algorithms and Use cases
3. Optimization, Diagnostic and Model Evaluation
4. Accuracy and Error measures
5. Robot Operating system
6. Panda Library in Python
7. Open Computer Vision Library, Open CV-Python
8. Relay Logic, Ladder Logic-PLC's
9. Embedded systems- Von Nuemann & Harvard Architecture
10. Cyber Physical systems

AC 2	Any One from the List of AC 2 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

3rd Semester

PE 4	MS7221	System Modelling and Simulation	3	0	0	3

Course Outcome:

CO1: To understand modelling mechatronics systems to meet the desired specifications
CO2: To analyse different block diagrams, mathematical models in mechanical and electrical systems
CO3: To solve different simulation techniques and analyse different solution model equations.
CO4: To identify different simulation tools and apply in MATLAB environment.

Module I:

Physical Modelling: Mechanical and electrical systems, physical laws, continuity equations, compatibility equations, system-engineering concept, system modelling with structured analysis, modelling paradigms for mechatronic system, block diagrams, mathematical models, systems analysis of electrical systems, thermal systems, fluid systems, mechanical rotational system, electrical coupling.

Module II:

Simulation Techniques: Solution of model equations and their interpretation order system, solution of 2nd order, Frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis

Module III:

Design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, coupling of simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment.

Text Books:

1. L. Ljung, T. Glad, "Modeling of Dynamical Systems", Prentice Hall Inc. (1994).
2. D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, "System Dynamics: A Unified Approach", 2nd Edition, Wiley-Interscience (1990).

Reference Books:

1. G. Gordon, "System Simulation", 2nd Edition, PHI Learning (2009).
2. V. Giurgiutiu and S. E. Lyshevski, "Micromechatronics, Modeling, Analysis, and Design with MATLAB", 2nd Edition, CRC Press (2009).

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Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 4	MS7223	Hardware Integration of Mechatronics System	3	0	0	3

COURSE OUTCOMES

At the end of the course, students will be able to

CO1: Understand the characteristics and concept of robots.

CO2: Understand the mechanism of robot end effecters and actuators

CO3: Apply sensors in robot programming languages

CO4: Understand the application of robot and other mechatronic applications

Module I:

Introduction

Definition of robot, classification of robots according to coordinate system and control method, Main components of robots – manipulator, sensors, controller etc, Robot Characteristics – payload, reach, repeatability, accuracy, resolution.

Kinematics of Robot

Homogenous coordinates, Homogeneous transformation matrices, Direct and Inverse Kinematics of robots, Trajectory Planning.

Module II:

Robot End effecters & Actuators

Types, mechanical grippers, other types of grippers, Tools as end effecters. Characteristics of actuating systems, Actuating System – Hydraulic devices, Pneumatic devices, electric motors, other special actuators.

Sensors

Characteristics of Sensors, Position sensors, velocity sensors, acceleration sensors, Force and pressure sensors, force and torque sensors, micro switches, touch and slip sensors, non-contact proximity sensors, Robot Vision System, Robot programming Languages – VAL, AML/2, ARM BASIC.

Module III:

Application of Robots

Handling, loading, & unloading, Welding, Spray painting, Assembly, Machining, Inspection, Rescue robots, underwater robots, Parallel robot, and Medical robot.

Mechatronic Elements of Modern CNC Machines

Machine Structure, Guide ways, Feed drives, Spindle and Spindle bearings, Measuring systems, Controls, software & operator interface, Ganging, Tool Monitoring.

Mechatronic Applications

Electronic Thermostat, Automatic Camera, Air fuel ratio controller in Automobiles, Digital Engine Control, Vehicle Motion Control, Mobile robots etc.

Text Books:

1. Mechatronics: Principles and applications: Godfrey ONWUBOLU

2. W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.

3. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 4	MS7225	Advanced Control System	3	0	0	3

Course Outcomes:

The students will be able to

CO1: Demonstrate non-linear system behaviour by phase plane and describing function methods

CO2: Perform the stability analysis nonlinear systems by Lyapunov method

CO3: Apply the concept of Modal control effect of State Feedback on Controllability and Observability

CO4: Describe the Control Variable Inequality Constraints

Module I:

State space Analysis State Space Representation, Solution of State Equation, State Transition Matrix, Canonical Forms – Controllable Canonical Form, Observable Canonical Form, Jordan Canonical Form. Tests for Controllability and Observability for Continuous Time Systems – Time Varying Case, Minimum Energy Control, Time Invariant Case, Principle of Duality, Controllability and Observability Form Jordan Canonical Form and Other Canonical Forms. Describing Function Analysis -Introduction to Nonlinear Systems, Types of Nonlinearities, Describing Functions, Describing Function Analysis of Nonlinear Control Systems.

Module II:

Phase-Plane Analysis Introduction to Phase-Plane Analysis, Method of Isoclines for Constructing Trajectories, Singular Points, Phase-Plane Analysis of Nonlinear Control Systems.

Stability Analysis, Stability in The Sense of Lyapunov, Lyapunov's Stability and Lypanov's Instability Theorems. Direct Method of Lypanov for The Linear and Nonlinear Continuous Time Autonomous Systems.

Modal Control Effect of State Feedback on Controllability and Observability, Design of State Feedback Control Through Pole Placement. Full Order Observer and Reduced Order Observer. Calculus of Variations Minimization of Functional of Single Function, Constrained Minimization. Minimum Principle.

Module III:

Control Variable Inequality Constraints. Control and State Variable Inequality Constraints. Euler Lagrangine Equation. Optimal Control Formulation of Optimal Control Problem. Minimum Time, Minimum Energy, Minimum Fuel Problems. State Regulator Problem. Output Regulator Problem. Tracking Problem, Continuous-Time Linear Regulators.

Text Books:

1. K. Ogata, Modern Control Engineering, Prentice Hall of India, 3rd edition, 1998
2. I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age International (P) Ltd.
3. M. Gopal, Digital Control and State Variable Methods, Tata Mc Graw-Hill Companies, 1997.
4. Stainslaw H. Zak, Systems and Control, Oxford Press, 2003.
5. M. Gopal Modern Control System Theory, New Age International Publishers, 2nd edition, 1996

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

PE 4	MS7227	Hydraulic and Pneumatic Control System	3	0	0	3

Course Objectives:

To expose the learner to the fundamentals of hydraulic and pneumatic power control and their circuits with industrial applications.

Course Outcomes:

Students will be able to:

CO1: Understand characteristics and different hydraulic components of mechatronics systems.

CO2: Acquire the knowledge of different fluid power circuits

CO3: Analyse different techniques of Electro & Pneumatics Circuit

CO4: Discuss the different Hydraulic systems used in mechatronic process.

Module I:

HYDRAULIC COMPONENTS

Hydraulic pumps- Gear, Vane and Piston pumps valves-pressure control- flow control and direction control valves

PNEUMATIC COMPONENTS unit- Air dryer- Control valves- Logic valves, Characteristics and applications.

Module II:

FLUID POWER CIRCUITS

Cascade method- KV Map method-Industrial Hydraulic circuits Regenerative circuits- Safety circuits- Synchronizing circuits

Module III:

ELECTRO- PNEUMATICS AND HYDRAULICS

Valves- Timer- Counter- Servo and proportional control electro pneumatic and hydraulic circuits

Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations.

PLC: Evolution of PLC's PLC - Relay logic - Ladder logic - Gates, Flip flops and Timers. Communication in PLC's to computer - Interlocks and alarms - Case study of Tank level control system and Sequential switching of motors.

Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits.

Text Books:

1. Andrew Parr, “Hydraulics and pneumatics, Jaico Publishing House
2. Perter Croser, Frank Ebel “Fundamentals of Pneumatics”, FESTO

Reference Books:

1. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall, 1996.
2. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005.
3. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012.

PR 2	MS7621	Dissertation (Phase-I)	0	0	24	12

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Syllabus (Effective from 2023-24)

School/ Department: School of Mechanical Sciences
Course: M. Tech., Programme: Mechatronics and Machine Learning (MML),
Duration: 2 years (Four Semesters)

4th Semester

PR 3	MS7622	Dissertation (Phase-II)	0	0	32	16