M.Tech. Programme
(Robotics and Artificial Intelligence)

School of Mechanical Sciences
IIT Bhubaneswar

16 December 2022

M. Tech. Programme (Robotics and Artificial Intelligence)
School of Mechanical Sciences, IIT Bhubaneswar

Admission Criteria:

M. Tech.	Previous Degree		Essential Requisite
Robotics and Artificial Intelligence	B. Tech. /B. E. or Equivalent	First Class degree in Mechanical Engineering/Manufactruring/ Industrial Production Engineering or equivalent (with valid GATE score)	Mechanical Engineering/ Manufacturing Engineering/ Industrial and Production Engineering

Credit Structure:

Details	Sem. I	Sem. II	Sem. III	Sem. IV	Total Credits
Core Subjects	7	7	-	-	14
Elective Subjects	9/10	9/10	-	-	18/20
Lab. Subjects	4	2	-	-	6
Seminar	2	2	-	-	4
Research Review Paper	-	-	4	4	8
Project	-	-	16	16	32
Total Credits	22/23	20/21	20	20	82/84

Selection: As per Institute norms

Head, School of Mechanical Sciences

INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR
Bhubaneswar - 751013
School of Mechanical Sciences

Detailed Curriculum of M. Tech. Programme in Robotics and Artificial Intelligence

Semester 1				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6L401	Robotics	3-1-0	4
2	CS6L019	Artificial Intelligence	3-0-0	3
3	ME6LXXX	Elective I	3-0-0	3
4	ME6LXXX	Elective II	3-0-0	3
5	ME6LXXX	Elective III	3-0/1-0	3/4
6	ME6P450	Robotics Design and Synthesis Lab	0-0-3	2
7	ME6P451	Robotics and AI Lab	0-0-3	2
8	ME6S401	Seminar I	0-0-3	2
Total L-T-P and Credit			15-1/2-9	22/23
Semester 2				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6L402	Advanced Robotics and AI	3-1-0	4
2	ME6L333	Mechatronics	3-0-0	3
3	ME6LXXX	Elective IV	3-0-0	3
4	ME6LXXX	Elective V	3-0-0	3
5	ME6LXXX	Elective VI	3-0/1-0	3/4
6	ME6P452	Robotics and Mechatronics Lab	0-0-3	2
7	ME6S402	Seminar II	0-0-3	2
Total L-T-P and Credit			15-1/2-6	20/21
Semester 3				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6D401	Thesis - Part I	---	16
2	ME6D402	Research Review Paper – I		4
Total L-T-P and Credit			---	20
Semester 4				
Sl. No.	Course No.	Course Name	L-T-P	C
1	ME6D403	Thesis - Part II	---	16
2	ME6D404	Research Review Paper – II		4
Total L-T-P and Credit			---	20

LIST OF ELECTIVES

Elective – 1, 2 & 3 (Semester I)

Electives from School of Mechanical Sciences				
Course Name	Course No.	L-T-P	C	Contact time
Engineering Design Optimization	ME6L007	3-0-0	3	3
Sensing and Actuation	ME6L008	3-0-0	3	3
Engineering Measurements	ME6L009	3-1-0	4	4
Operations Management	ME6L010	3-0-0	3	3
Finite Element Methods in Engineering	ME6L011	3-0-0	3	3
Applications of Linear Algebra in Mechanical Engineering	ME6L171	3-0-0	3	3
Mobile robots	ME6L411	3-0-0	3	3
Parallel Manipulator/ Design of Mechanisms and Manipulators	ME6L412	3-0-0	3	3
Introduction to Data Structures and Algorithms	ME6L413	3-0-0	3	3
Stream relevant Electives from other Schools				
Machine Learning and Data Analytics- I	ID6L004	3-0-0	3	3
Mathematical Foundations of AI	CS6LXXX	3-0-0	3	3
Introduction to Machine Learning	CS6LXXX	3-0-0	3	3
Advanced Databases and Mining	CS6L017	3-0-0	3	3
Adaptive and Robust Control	EC6L008	3-0-0	3	3
Sensor Networks	EC6L032	3-0-0	3	3
Industrial Instrumentation	EE6L007	3-0-0	3	3
Optimization Techniques	MA5003	3-0-0	3	3
Linear Algebra	MA4001	3-0-0	3	3

LIST OF ELECTIVES

Elective – 4, 5 & 6 (Semester II)

Electives from School of Mechanical Sciences				
Dynamics and Control of Mechanical Systems	ME6L051	3-1-0	4	4
Experimental Modal Analysis	ME6L058	3-0-0	3	3
Soft Computing and Application	ME6L060	3-1-0	4	4
MEMS & Microsystems Technology	ME6L062	3-0-0	3	3
Additive Manufacturing	ME6L331	3-0-0	3	3
Factory Automation	ME6L332	3-0-0	3	3
Bio-robotics	ME6L414	3-0-0	3	3
Under Water Robotics	ME6L415	3-0-0	3	3
Unmanned Aerial vehicles	ME6L416	3-0-0	3	3
Scientific Machine Learning	ME6L417	3-0-0	3	3
Soft Robotics	ME6L418	3-0-0	3	3
Stream relevant Electives from other Schools				
Deep Learning	CS6LXXX	3-0-0	3	3
Internet-of-Things	CS6L024	3-0-0	3	3
Object Oriented Systems Design	CS6L025	3-0-0	3	3
Wireless Sensor Networks	CS6L026	3-0-0	3	3
Advanced Digital Signal Processing	EC6L004	3-1-0	4	4
Adaptive Signal Processing	EC6L023	3-0-0	3	3
Advanced Control	EE6L016	3-0-0	3	3
Numerical Analysis	MA5L010	3-0-0	3	3

In any semester, a student may choose three electives from the the list of electives offered from the School of Mechanical Sciences, as given above. However, for diversification, students are also allowed to take one elective course from other schools (as given in the above list) along with any two elective courses offered by School of Mechanical Sciences.

Syllabi of Core Courses

Subject Code: ME6L401	Subject Name: Robotics	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Course content:

Applications of robot and sensors: Introduction to robots, Internal and external sensors;
Actuators: hydraulic, pneumatic and electric actuators, programming of robots;
Homogeneous transformations, D-H parameter notation, direct & inverse kinematics of manipulators: examples of kinematics of some common manipulator configurations;
Jacobian, dynamics of manipulators; trajectory planning; and
Automation, types of automation, analysis of automated assembly systems, line balancing problems, analysis of automated material handling systems, automated storage and retrieval systems.

Recommended Books:

Robotics: Fundamental concepts and analysis By A. Ghosal, Oxford university press, 2006.
Industrial RoboticsBy M P Groover,Pearson Edu, 2008.
Robotics and ControlBy R K Mittal & I J Nagrath, TMH, 2003.
Robotics: Control, sensing, vision and intelligence By K Fu, R Gonzalez, and C S G Lee, McGraw Hill, 1987.
Robotic Engineering By / Richard D. Klafter, Prentice Hall, 1989.
Introduction to RoboticsBy John J Craig, Pearson Edu. Prentice Hall, 2003
Robot Dynamics & ControlBy Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pte Ltd, 1989.
Automation, Production systems and Computer Intigrated Manufacturing By M P Groover, Prentice Hall India, 1987.

Subject Code: CS6L019	Subject Name: Artificial Intelligence	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to Artificial Intelligence: What is AI? Related Fields, Agents and Environments Problem Solving: problem representation paradigms, state space, satisfiability vs optimality Search Techniques: Principles of search, uninformed search, informed search, constraint satisfaction problems, adversarial search and games

Knowledge Representation: First order and non-monotonic logic; rule based, frame and semantic network approaches, mixed representations, Theorem Proving, knowledge bases and inference

Uncertainty Treatment : formal and empirical approaches including Bayesian theory, belief functions, certainty factors

Fuzzy Logic: Tagaki-Sugeno Fuzzy Logic;, Mamdani Fuzzy Logic, Fuzzy Bayesian Decision Method, Membership Functions, Fuzzification and Defuzzification, Fuzzy system Modeling Planning and making decisions

Reinforcement learning: MDPs, Q-learning algorithm, applications, Bandits and Monte carlo tree search

Text Books:

1. Russell and Norvig. Artifiicial Intelligence: A Modern Approach. Pearson Education (Low Priced Edition), 2004.
2. Nils J. Nilsson, Artificial Intelligence - A New Synthesis, Morgan Kaufmann Publishers, 2000
3. George F.Luger and William A. Stubblefield, AI: Strcutures and Strategies for Complex problem solving, 2nd edition, Benjamin Cummins Publishers

Reference Books:

1. Mark Stefik, Introduction to Knowledge Systems, Morgan Kaufmann.
2. E. Rich and K.Knight, Artificial Intelligence, Tata McGraw Hill
3. E. Charniack and D. Mcdermott, Artificial Intelligence, Addison Wesley

Subject Code: ME6P450	Subject Name: Robotics Design and Synthesis Lab (Proposed)	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s): None			

1.Introduction: why Python

2.Ecosystem: installation, workflow, data types, control flow, functions, scripts and modules, input, output, standard library, Numpy arrays, Pandas Basic, Generators ,List Comprehensions, Multiple Function Arguments, Regular Expressions, Exception Handling, Sets, Serialization, Partial functions, Code Introspection, Closures, Decorators, Map, Filter, Reduce,

3.Visualization with Matplotlib, Libraries for AI.

Textbooks/References

1.Python Data Science Handbook,O'REILLY

Subject Code: ME6P451	Subject Name: Robotics and AI Lab	L-T-P: 0-0-3	Credit: 2

Pre-Requisite(s):

1.Demonstrations on Robot Mechanisms and their design.
2.Studies on Existing Robots, Computer-Aided-Design of Robots.
3.Robot Hardware and Control System Design
4.ROS
5.Topics in Machine Elements.

Textbooks

1) Sandor G.N. and Erdman A.G., Advanced Mechanism Design: Analysis and Synthesis, Vol. 2, Prentice Hall, New Jersey, 1984.
3) Zeid, Ibrahim. CAD/CAM theory and practice. McGraw-Hill Higher Education, 1991.
4) Rivin E.I., Mechanical Design of Robots, McGraw Hill, New York, 1988.
5) D.J. Bell, P.A. Cook, N. Munro, Design of Modern Control Systems, IEE Control Engineering Series, Institution of Engineering and Technology, 1982.

References

1) G. Budynas and J. K. Nisbett, Shigley's Mechanical Engineering Design, 10th Edition, McGraw Hill, 2015.
2) Joseph L., Mastering ROS for Robotics Programming, Packt Publishing, Birmingham, 2015. 3) Nnaji B.O., Computer-aided Design, Selection and Evaluation of Robots, Manufacturing Research & Technology, Elsevier Science Ltd, 1986.

Subject Code: ME6L402	Subject Name: Advanced Robotics and AI	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Introduction to Image Processing and Computer Vision, Introduction to Robotic Vision, Introduction to Python and Keras, Image Processing and Edge Detection in Images, Introduction to Deep Learning and Neural Networks, Convolutional Neural Networks (CNNs)
Basics of Convolution, Padding, and Strided Convolution, Types of Layers and Data Augmentation
Image Recognition, Network Architecture, Transfer Learning, Object Segmentation,
Object Detection; Semantic Segmentation,

Textbooks /References

Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 2016
Michael Nielsen, Neural Networks and Deep Learning, 2016
Yoshua Bengio, Learning Deep Architectures for AI, 2009

Subject Code: ME6L333	Subject Name: Mechatronics	L-T-P:3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, measurement system, control systems, microprocessor based controllers, Products, and design. Comparison between Traditional and Mechatronics approach;

Basic signal processing, different types of sensors, actuators, controllers, DSP, ADC/DAC etc.; Actuation systems, Signal Conditioning, Microprocessors and Microcontrollers;

Modeling and System Response: Modeling of electromechanical systems, block diagrams, control system design, mechanical, electrical, hydraulic and thermal systems, dynamic response of systems, transfer function and frequency response, closed loop controllers.

PLCs and introduction to industrial automation;

Design and Mechatronics: Computer based modular design, remote monitoring and control;

Practical application of mechatronics, design issues, industrial techniques etc.;

Examples of sensor, actuator and controller integration for common micro controllers like atmeag 16, PIC, Arduino, etc..

Recommended Books:

HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.

Bolton, W., "Mechatronics", Longman. 1999

Alciatore, D. G. and Histrand, M. B., "Introduction to Mechatronics", Tata McGraw Hill. 2003

Shetty, D. and Richard, A.K., "Mechatronics System Design", PWS Pub. Boston. 1997

Mahalik, N., "Principles, Concept and Applications: Mechatronics", Tata McGraw. 2003

Bolton, W., "Mechatronics: A Multidisciplinary Approach", 4th Ed., Prentice Hall. 2009

Merzouki R., Samantaray A. K., Pathak P.M., Bouamama B. Ould, Intelligent Mechatronic Systems: Modeling, Control and Diagnosis, Springer 2013

Mechatronics, Intl. J. published by Pergamon Press

Subject Code: ME6P452	Subject Name: Robotics and Mechatronics Lab	L-T-P: 0-0-3	Credit: 2
Pre-Requisite(s):			

Introduction to Artificial Intelligence
1.Searching Techniques: uninformed search strategies, informed (heuristic) search strategies, local search algorithms, searching in non-deterministic and partially observable environment, adversarial search.
2.Temporal Probability models and inference in temporal models: filtering, prediction, smoothing, most likely explanation, Dynamic Bayesian Networks, Hidden Markov Model, Kalman Filter, Extended Kalman Filter, Particle Filter, Learning Probabilistic Models.
3.Decision making: Markov Decision Processes (MDPs), Partially Observable MDPs (POMDPs).
4.Learning: Introduction to supervised learning, unsupervised learning, and reinforcement learning
Textbooks
1) Stuart Russell and Peter Norvig, Artificial Intelligence A Modern Approach, 3rd Edition, Pearson, 2014. References 1) Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012.
2) C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.
3) R.S. Sutton and A.G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018.

Syllabi of Elective Courses
1st Semester (Electives-I, Electives-II & Elective-III)

Subject Code: ME6L007	Subject Name: Engineering Design Optimization	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Applications of robot and sensors: Introduction to robots, Internal and external sensors;
Actuators: hydraulic, pneumatic and electric actuators, programming of robots;
Homogeneous transformations, D-H parameter notation, direct & inverse kinematics of manipulators: examples of kinematics of some common manipulator configurations;
Jacobian, dynamics of manipulators; trajectory planning; and
Automation, types of automation, analysis of automated assembly systems, line balancing problems, analysis of automated material handling systems, automated storage and retrieval systems.

Recommended Books:

Robotics: Fundamental concepts and analysis By A. Ghosal, Oxford university press, 2006.
Industrial RoboticsBy M P Groover,Pearson Edu, 2008.
Robotics and ControlBy R K Mittal & I J Nagrath, TMH, 2003.
Robotics: Control, sensing, vision and intelligence By K Fu, R Gonzalez, and C S G Lee, McGraw Hill, 1987.
Robotic Engineering By / Richard D. Klafter, Prentice Hall, 1989.
Introduction to RoboticsBy John J Craig, Pearson Edu. Prentice Hall, 2003
Robot Dynamics & ControlBy Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pte Ltd, 1989.
Automation, Production systems and Computer Intigrated Manufacturing By M P Groover, Prentice Hall India, 1987.

Subject Code: ME6L008	Subject Name: Sensing and Actuation	L-T-P:3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Sensing Principle: Introduction to Sensing Static and Dynamics Characteristics of Sensors; Motion and Dimensional Sensors; Force, Torque, and Power Sensors; Pressure and Sound Sensors; Fluid Flow Sensors; Temperature Sensors.

Electrical Actuators: Introduction to Electro-Magnetic Principle; Classification of Electrical Actuators; DC Motors and Modeling; DC Motor Drivers; AC Motors and Modeling; AC Motor Drivers; Stepper Motors and Modeling; Stepper Motor Drivers.

Hydraulic and Pneumatic Actuators: Description of Fluid Behavior; Hydraulic Actuator and System; Pneumatic Actuator and System

Sensors and Actuators Design

Recommended Books:

Theory and Design for Mechanical Measurements - Richard S. Figliola, Donald E. Beasley (John Wiley & Sons)

Subject Code: ME6L009	Subject Name: Engineering Measurements	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Course content:

Principles of Measurement: Static characteristics and accuracy in the steady state, Generalized model, Measurement errors and error reduction techniques, Dynamic characteristics, Loading effects and noise, Transfer function, TiMEnd frequency responses, Dynamic errors and compensation, Random signals and effects of noise and interference, Noise sources and reduction methods, Economics of measurement systems: Reliability, Selection of measurement systems, Operating cost; Measurement System Design: Sensing elements: resistive, capacitive, inductive, electromagnetic and other sensing elements, Signal conditioning and processing elements: deflection bridges, amplifiers, AC carrier systems, current transmitters, oscillators and resonators, A/D conversion, sampling, quantization and encoding, Data Acquisition, Multiplexing, Data acquisition system, digital signal analysis; Specialized Measurement Systems: Principles of flow, optical and ultrasonic measurement systems, Heat transfer effects and particle size analysis.

Recommended Books:

Theory and Design for Mechanical Measurements - Richard S. Figliola, Donald E. Beasley (John Wiley & Sons)

Mechanical Measurements - Thomas G. Beckwith, Roy D. Marangoni, John H. Lienhard, V (Pearson)

Instrumentation: Measurement and Analysis - B.C. Nakra and K.K. Chaudhry (Tata Mcgraw-hill Education Private Ltd.)

Subject Code: ME6L323	Subject Name: Operations Management	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Competitiveness, Operations Strategy, Balance Scorecard, Facility Location, Decision Analysis, Facility Layout;

Product and Services, Quality Function Deployment, Process Planning, Process Selection, Quality Control, Inventory Control, Inventory Models, Lean Production System;

Project Management, Work Design and Measurement;

Resource Planning, Scheduling, Forecasting Methods; and

Sustainable manufacturing.

Recommended Books:

Russel, and Taylor, Operations management, Wiley India, 2011.
Krajewski, Ritzman, and Malhotra, Operations management, Pearson Prenctice Hall, 1993.
Heizer, and Render, Operations management, Pearson Education, 2010.
Stevenson, Operations Management, McGraw Hill, 1982.
Chase and Aquilano, Operations Management, Tata McGraw Hill, 2006.

Subject Code: ME6L011	Subject Name: Finite Elements Methods in Engineering	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Integral Formulations and Variational Methods, Second-Order boundary value problems; Bending of Beams; FE Error Analysis; Eigenvalue and Time-Dependent Problems; Numerical Integration and Computer Implementation, Single-Variable Problems; Interpolation Functions, Numerical Integration and Modeling; Plane Elasticity; Flows of Viscous Incompressible Fluids; Bending of Elastic Plates; Computer Implementation, Analysis of Three-Dimensional and Nonlinear Problems.

Recommended Books:

An Introduction to the Finite Element Method – J. N. Reddy (McGraw Hill)
An Introduction to Nonlinear Finite Element Method – J. N. Reddy (Oxford)
Concepts and Applications of Finite Element Analysis – R D Cook (Willey)
The Finite Element Method: Its Basis & Fundamental – O C Zienkiewicz (Elsevier)
The Finite Element Method in Engineering – Rao (Elsevier)
Finite Element Methods for Engineers – U. S. Dixit (Cengage)
Introduction to Finite Elements in Engineering – T. R. Chandrupatla (PHI)

Subject Code: ME6L171	Subject Name: Applications of Linear Algebra in Mechanical Engineering	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Key Ideas of Linear Algebra, Differential Eqns. and Difference Eqns., Solving a Linear System, Eigenvalues and Positive Definite matrix, Springs and Masses, Oscillation, Finite Differences in Time, Least Squares, Graphs and Networks, Kirchhoff's Current Law, Trusses, Finite Elements in 1D, Quadratic/Cubic Elements, Element Matrices; 4th Order Bending Equations, Boundary Conditions, Splines, Gradient, Divergence, Gradient and Divergence, Laplace's Equation, Finite Elements in 2D, Fast Poisson Solver, Fourier Series, Discrete Fourier Series, Fast Fourier Transform, Convolution, Filtering, Fourier Integral Transform, Convolution Equations: Deconvolution, Sampling Theorem

Recommended Books:

1. G. Strang, Introduction to Linear Algebra. 4th ed. Wellesley, MA: Wellesley-Cambridge Press, 2007.
2. Michael Woolfson & Malcolm S. Woolfson, Mathematics for Physics, Oxford Univ. Press, 2006.

Subject Code: ME6L411	Subject Name: Mobile Robots **(Proposed)**	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to Mobile robot architectures, Control Paradigms, Sensors and actuators. Learning Approaches for robots. Navigation Strategies, Detecting and handling Novelty. Behavior-based robotics, AlE and their application to robots. Case studies of learning robots, Laboratory sessions will include study and implementations of the above methodologies using real robots.

Recommended Books:

1. U. Nehmzow, Mobile Robotics - A Practical Introduction, 2nd Ed, Springer, 2003.
2. L. N. de Castro and J. Timmis, Artificial Immune Systems: A New Computational Intelligence Approach, Springer, 2002.
3. D. Dasgupta, Artificial Immune Systems and Their Applications, Springer, 1999.
4. R. C. Arkin, Behaviour Based Robotics, MlT Press, 1998.

Subject Code: ME6L412	Subject Name: Parallel Manipulator/ Design of Mechanisms and Manipulators **(Proposed)**	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Mechanism For Manipulators: Mobility analysis - Degrees of Freedom (DOF) - Mixed Mobility - Total, Partial and Fractional DOF - Closed and Open Chain Systems - Manipulators – Classifications - actuation and transmission systems.

Design Of Robot Mechanism: Structural Analysis and Synthesis of mechanisms - Alternative design solutions - Coding, evaluation and selection of optimum mechanism type synthesis, number synthesis and design of mechanisms. Indexes of merit; Graphical, Algebraic and Optimization techniques - Matrix methods of design and analysis; Design of function, path and motion generators - Structural and mechanical error - Design and Analysis using software.

Manipulator Kinematics: Coordinate transformation - Arm matrix of SCARA – Alpha-II, PUMA articulated robot, polar frame, inverse and forward kinematics – Jacobian – Singularities – Inverse velocity and acceleration.

Manipulator Dynamics: Newton's and Euler's equation – Closed form dynamic equations – Lagrangian formulation of manipulator dynamics – non rigid body effect.

Manipulator Selection: Selecting of robots for robot application - Reliability of robotic and automation systems and their evaluation.

Kinematic model of the finger and thumb - thumb and fingers pose with respect to palm.

Recommended Books:

1. John J Craig, Introduction to Robotics: Mechanics and Control, Pearson Education, New Delhi, 2017.

2. Gerry B. Andeen, Robot Design Hand Book, SRI International, McGraw Hill Publishers, 1988. 3. M. W. Spong, S. Hutchinson and M. Vidyasagar, Robot Modeling and Control, Wiley, 2005.

4. Venkataraman Subramanian T. and Iberall Thea (Eds.), Dextrous Robot Hands, Springer Publications.

5. AppuKuttan, Robotics, I.K. International Publishing house, New Delhi, 2007.

Subject Code: ME6L413	Subject Name: Introduction to Data Structures and Algorithms	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Arrays, Stacks, Queues, Linked-lists, Dynamic Arrays, Aysmptotic Complexity, Sorting: merge, quick, radix, heap, Dictionaries: Skip-lists, Hashing, Trees, Tree Traversal, Binary Search Tree Priority Queues, Binary Heaps, AVL tree / Red-Black tree, 2-4 trees, B-trees, Multiway search tree, Kd-trees, and applications, Introduction to Graphs, Adjacency matrix and List representation Breadth first search and applications, Depth first search in directed and undirected graphs and applications, Dijkstra's algorithm for shortest path, Minimum Spanning Tree

Recommended Books:

1. Data Structures and Algorithms in Java by M. T. Goodrich, R. Tamassia

Subject Code: ID6L004	Subject Name: Machine Learning and Data Analytics- I	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction: Prediction, Classification, Forecasting, Filtering, Regression, Clustering. Review of Linear Algebra, Probability and Statistics. Data Exploration and Pre-processing: Data Objects and Attributes; Statistical Measures, Visualization, Data Cleaning and Integration. Dimensionality Reduction: Linear Discriminant Analysis; Principal Component Analysis; Transform Domain and Statistical Feature Extraction and Reduction. Regression: Least Mean Square Regression; Ridge Regression and LASSO regression; Support Vector Regression. Clustering: K-Means, Hierarchical, and Density-based Clustering, Spectral Clustering. Classification: K-nearest-neighbor, Bayesian and Naïve Bayes Classifier, Decision Tree Induction including Attribute Selection, and Tree Pruning, Random Forests, Logistic Regression; Support Vector Machine; Ensemble Classification including Adaboost. Artificial Neural Networks: Single Layer Neural Network, Multilayer Perceptron, Back Propagation Learning, Functional Link Artificial Neural Network, and Radial Basis Function Network, Recurrent Neural Networks, Deep Learning, Convolutional Neural Networks.

Text Books:

1. Bishop, C., "Pattern Recognition and Machine Learning", Springer, 2006.
2. Mitchell, T. "Machine Learning", 1997 (freely available online)
3. Duda, Hart, Stork. "Pattern Classification". Wiley
4. Daumé, H. III, "A Course in Machine Learning", 2015 (freely available online).
5. Haykin S., "Neural Networks and Learning Machines", Third Edition, Prentice Hall, 2008.
6. Goodfellow I.,Bengio Y. and Courville A.; "Deep Learning", MIT Press, 2016.

Reference Books:

1 Hastie, T., R. Tibshirani, J. Friedman, "The Elements of Statistical Learning", Springer 2009 (freely available online).
2 Shai Shalev-Shwartz and Shai Ben-David. "Understanding Machine Learning: From Theory to Algorithms", Cambridge University Press, 2014

** Already approved and running at **institute level**

Subject Code: CS6L014	Subject Name: Principles of Mathematical Logic	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Propositional Logic: syntax and semantics, Proof theory for Propositional logic, Natural Deduction, Gentzen System, Resolution in Propositional Logic, Soundness and Completeness. First order Logic: Syntax and semantics, Free and bound variables, Substitution, First order structures, Satisfaction and validation of a model, Proof theory of first order languages, Gentzen System for first order languages, Soundness, Herbrand's theorem, Resolution in first order logic, undecidability and Incompleteness. Logic programming: Horn fragment of predicate logic, unification, top-down operational semantics, Prolog basics.

Text Books:

1. Jean, H. Gallier, Logic for Computer Science: Foundations of Automatic Theorem Proving, Dover publications.

Reference Books:

1. M.R. Huth and M.D. Ryan, Logic in Computer Science, Modelling and Reasoning about Systems, ,Cambridge University Press.
2. H. Enderton, A Mathematical Introduction to Logic, Academic Press.

** Already approved and running in M.Tech. **Computer Science and Engineering**

Subject Code: CS6LXXX	Subject Name: Mathematical Foundations of AI	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Advanced Vector Calculus, Multivariate derivatives and chain rule, Backpropagation and automatic differentiation, Linearization and multivariate Taylor series

Advanced Linear Algebra, Eigenvalue and eigenvectors, Singular value decomposition, Matrix approximation

Continuous Optimization, Gradient descent, Constrained optimization and Lagrange multipliers, Convex Optimization, Non-linear optimization

Models and Data, Change of variables, Empirical risk minimization, Parameter estimation, Probabilistic modelling and inference, Model selection

Basic Applications for AI systems, Linear Regression, Dimensionality Reduction with Principal Component Analysis (PCA), Density Estimation with Gaussian Mixture Model

Logic and Deduction: Propositional logic, Predicate Logic, Resolution Refutation, Constraint satisfaction problems

Test Books:

1. Tsang. Foundations of constraints satisfaction, Books on demand Publishers, Available free online.
2. Deisenroth M.P., Faisal, A.A., Ong, C.S.: Mathematics for Machine Learning. Cambridge University Press, Cambridge (2020)

Reference Books:

1. C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006
2. Kishore Tribedi: Probability and statistics with Reliability, Queuing and Computer Science Applications (2^{nd} Ed), Willey.

** Submitted for Approval in M.Tech. **Artificial Intelligence**

Subject Code: CS6LXXX	Subject Name: Introduction to Machine Learning	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Syllabus: Introduction to Machine Learning: History of ML, AI vs. ML, Types of Learning, (supervised, unsupervised, semi, weak, Self, etc.). Types of Data: Tabular, Image, Video, Audio, Sequential, etc. Feature Engineering, ML approaches: Introduction to regression, classification, clustering. Regression: Linear Regression, Multiple Linear Regression, Support Vector Regression, Ridge regression. Classification: Naive Bayes, Logistic regression, Support Vector Machine, K-nearest neighbors, Decision Tree, Random Forest. Clustering: Density-based, Distribution-based, K-means, DBSCAN, Gaussian Mixture Models, Mean-shift clustering. Advanced ML: Perceptron, Artificial Neural Network, Bayesian Network, Gradient Descent algorithm. Evaluation: Train-test split, Cross-validation, k-fold validation, stratified k-fold validation, bootstrapping, cross-entropy loss, binary Cross-entropy, L1-loss, L2-loss, regularization, dropouts, confusion matrix, AUC-ROC, EER, RMS, Precision, Recall and mAP. Reinforced machine learning, Ensemble Methods, Expectation-Maximization.
ML application examples from medicine, business, image processing, sports, social media and Others.

Prerequisite: Calculus, Linear Algebra, Statistics.

Text books:

1. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirany, Jonathan Taylor, "An Introduction to Statistical Learning with Applications in Python," Springer, 2023.

Reference Books:

The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie, Robert Tibshirani, and Jerome Friedman, Springer, 2nd Edition, 2017.

** Submitted for Approval in M.Tech. **Artificial Intelligence**

Subject Code: EC6L008	Subject Name: Adaptive and Robust Control	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction; Models for dynamic systems: State-space models, Input-output models, Parametric models; Stability: Input-output stability, Lyapunov stability, Stability of LTI feedback systems; Online parameter estimation: Adaptive laws with normalization, Adaptive laws with projection, Hybrid adaptive laws; Parametric identifiers and adaptive observers; Model reference adaptive control (MRAC): Simple direct MRAC schemes, MRAC for SISO plants, Direct MRAC with unnormalized and normalized adaptive laws, Indirect MRAC; Adaptive pole placement control (APPC): Simple APPC schemes, PPC for known parameters, Indirect APPC schemes; Robust adaptive laws: Plant uncertainties and robust control, Instability in adaptive systems; Some robust adaptive laws; Robust adaptive control schemes: Robust identifiers and adaptive observers, Robust MRAC, Performance improvement of MRAC, Robust APPC schemes

Texts/References Books:

P. A. Ioannou and J. Sun, 'Robust Adaptive Control', Prentice Hall, Upper Saddle River, NJ, 1996
S. Sastry and M. Bodson, 'Adaptive Control', Prentice-Hall, 1989
K. J. Astrom and B. Wittenmark, 'Adaptive Control', 2nd Edition, Addison-Wesley, 1995
K. S. Narendra and A. M. Annaswamy, 'Stable Adaptive Systems', Prentice-Hall, 1989
I.D. Landau, R. Lozano, and M. M'Saad, 'Adaptive Control', Springer Verlag, London, 1998.

** Already approved and running in M.Tech. **Electronics & Communication Engineering**

Subject Code: EC6L032	Subject Name: Sensor Networks	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Programming and Data Structures			

Course content:

Introduction: Overview, Broad application areas of WSN, Speciality and constrains;

Hardware and software: Overview of hardware architecture of the sensor motes, Types of operating systems for WSN, TinyOS and Contiki, Basic programming in TinyOS, Concepts of protothreads, Basic programming in Contiki, Network stack overview;

MAC layer issues: Types of MAC protocols for WSN, Contention-based and reservation based protocols. Detailed study of specific protocols such as SMAC, RMAC, TMAC, DW-MAC, DMAC, Aloha, CSMA-CA, BMAC, LPL, LPP, AMAC, TICER, RICER, RC-MAC, ZMAC, Y-MAC etc.;

Network layer issues: Routing, classification of the protocols, specific protocols such as SPIN, LEACH etc. Transport layer issues: TCP/IP for WSN and other related issues, Study of specific transport layer protocols. Application layer protocols: Data collection, Data dissemination, Data aggregation, Time synchronization.

Standard based protocols: IEEE 802.15.4

Case Studies: one case study related to IOT

Text Books:

Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Network, John Wiley & Sons, 2005, ISBN 0470095105

Reference Books:

Ibrahiem M. M. El Emary, S. Ramakrishnan, Wireless Sensor Networks: From Theory to Applications, CRC Press, 2013, ISBN 9781466518100.

Ian F. Akyildiz, Mehmet Can Vuran, Wireless Sensor Networks, John Wiley & Sons, 2010, ISBN 9780470036013.

J Zheng, and A Jamalipour. Wireless sensor networks: a networking perspective, John Wiley & Sons, 2009, ISBN 9780470167632.

Anna Hac, Wireless Sensor Network Designs, John Wiley & Sons, 2003, ISBN 0470867361.

** Already approved and running in M.Tech. **Electronics & Communication Engineering**

Subject Code: EE6L007	Subject Name: Industrial Instrumentation	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Static and dynamic characteristics of sensors, Resistive, Inductive and Capacitive sensors and signal conditioning circuits. Temperature, pressure, flow and level measurement techniques. pH and conductivity sensors. Piezo-electric and ultrasonic sensors and its application in process and biomedical Instrumentation. Measurement of viscosity, humidity and thermal conductivity.
Optical Instrumentation: devices, intensity modulation and interferometric technique.
Nucleonic gauges: Sources and Detectors and its application. Interfacing Sensors and actuators using LabVIEW programs. Instrumentation system Design.

Texts/References:

1. K. Krishnaswamy, S Vijayachitra, 'Industrial Instrumentation' New Age International, 2005.
2. William C Dunn, William Dunn 'Fundamentals of Industrial Instrumentation and Process Control' McGraw-Hill, 2005.
3. Al Sutko, Adolph A. Sutko, Jerry Faulk 'Industrial Instrumentation' Cengage Learning, 2009.

** Already approved and running in M.Tech. **Power Electronics and Drives**

Subject Code: MA5003	Subject Name: Optimization Techniques	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Mathematical foundations and basic definitions: concepts from linear algebra, geometry, and multivariable calculus. Linear optimization: formulation and geometrical ideas of linear programming problems, simplex method, revised simplex method, duality, sensitivity analysis, transportation and assignment problems. Nonlinear optimization: basic theory, method of Lagrange multipliers, KarushKuhn-Tucker theory, convex optimization. Numerical optimization techniques: line search methods, gradient methods, Newton's method, conjugate direction methods, quasi-Newton methods, projected gradient methods, penalty methods.

Text Books:

1. M. C. Joshi, Optimization: Theory and Practice, Alpha Science International, Ltd
2. D. G. Luenberger, Linear and Nonlinear Programming, 2nd Ed., Kluwer

Reference Books:

1. S. S. Rao, Optimization: Theory and applications
2. R. Fletcher, Practical Methods of Optimization, John Wiley
3. M. S. Bazarra, J.J. Jarvis, and H.D. Sherali, Linear Programming and Network Flows, WSE
4. U. Faigle, W. Kern, and G. Still, Algorithmic Principles of Mathematical Programming, Kluwe
5. D.P. Bertsekas, Nonlinear Programming, Athena Scientific
6. M. S. Bazarra, H.D. Sherali, and C. M. Shetty, Nonlinear Programming: Theory and Algorithms, John Wiley, WSE
7. N. S. Kambo, Mathematical Programming Techniques, East West Press
8. E.K.P. Chong and S.H. Zak, An Introduction to Optimization, Wiley

** Already approved and running in M.Sc **Mathematics**

Subject Code: MA4001	Subject Name: Linear Algebra	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): Linear Algebra			

Course content:

Vector spaces over fields, subspaces, bases and dimension; Systems of linear equations, matrices, rank,

Gaussian elimination; Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose; Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule; Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, CayleyHamilton Theorem, triangulation, diagonalization, rational canonical form, Jordan canonical form;

Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators; Rayleigh quotient, Min-Max Principle. Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

Text Books:

1. Linear Algebra Done Right, 2nd edition, S. Axler, UTM, Springer
2. Algebra, M. Artin, Prentice Hall of India

Reference Books:

1. Linear Algebra, K. Hoffman and R. Kunze, Pearson Education
2. Linear Algebra, S. Lang, Undergraduate Texts in Mathematics, Springer-Verlag, NewYork.
3. Linear Algebra, H.E. Rose, Birkhauser
4. Linear Algebra and its applications, G. Strang, 4th edition, Cengage Learning

** Already approved and running in M.Sc **Mathematics**

2nd Semester (Electives-IV, Elective-V& Elective-VI):

Subject Code: ME66L051	Subject Name: Dynamics and Control of Mechanical Systems	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Course content:

Revisit to the history of development of mechanics from Galileo to Newton. Kinematics of rigid bodies - coordinate transformation, angular velocity vector, description of velocity and acceleration in relatively moving frames. Euler angles, Review of methods of momentum and angular momentum of system of particles, inertia tensor of rigid body. Dynamics of rigid bodies - Euler's equation, application to motion of symmetric tops and gyroscopes and problems of system of bodies.

Kinetic energy of a rigid body, virtual displacement and classification of constraints. D' Alembert's principle. Introduction to generalized coordinates, derivation of Lagrange's equation from D' Alembert's principle.Small oscillations, matrix formulation, Eigen value problem and numerical solutions.

Introduction to MAPLE® and MATLAB®, computer generation and solution of equations of motion. Introduction to complex analytic functions, Laplace and Fourier transform.

Transfer function and block diagrams, tiMEnd frequency domain system behavior.

Root-locus, Bode and Nyquist plots; stability and sensitivity; PID controllers, Phase lag and Phase lead compensation.

Analysis of Control systems in state space, pole placement, computer simulation through MATLAB - SIMULINK®.

Recommended Books:

Methods of Analytical Dynamics - Leonard Meirovitch – Dover.
Classical Dynamics - Donald T. Greenwood – Dover.
Advanced Dynamics - Donald T. Greenwood – Cambridge University Press.
Analytical Mechanics - Herbert Goldstein - Addison Wesley.
Engineering Mechanics: Dynamics – I. H. Shames, Prentice-Hall of India.
Dynamics: Theory and Applications - T.R. Kane, David A. Levinson - McGraw-Hill.
System Dynamics - Katsuhiko Ogata - Pearson Education India.
Modern Control Theory - William L. Brogan - Prentice Hall.
Modern Control Engineering - Katsuhiko Ogata - Prentice Hall.
Control Systems Engineering - Norman S. Nise – Wiley.
Control System Design: An Introduction to State-Space Methods – B. Friedland – Dover.
>Feedback and Control for Everyone - P. Albertos Pérez, Pedro Albertos – Springer.
Automatic Control Systems - Benjamin C. Kuo, FaridGolnaraghi – Wiley.
A Mathematical Introduction to Control Theory - ShlomoEngelberg - World Scientific Publishing Company.
Computational Methods in Multibody Dynamics - Farid M. L. Amirouche - Prentice Hall.
MATLAB® for Control Engineers - Katsuhiko Ogata - Prentice Hall.
Dynamical Systems with Applications using Maple® - Stephen Lynch - Birkhäuser Boston.

Subject Code: ME6L058	Subject Name: Experimental Modal Analysis	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Overview of vibration, Modal testing, Experimental Modal theory, Excitation techniques (Shaker and Hammer) Transducer and calibration, Digital signal processing for experimental modal analysis Modal parameter extraction, Validation of extracted modal parameters, Model updating, Structural Dynamic modification, Practical discussion and case studies.

Recommended Books:

Modal Testing, Theory, Practice, and Application - D.J. Ewins(Mechanical Engineering Research Studies: Engineering Dynamics Series)

Theoretical and Experimental Modal Analysis - Maia N M M(Mechanical Engineering Research Studies. Engineering Control Series, 9)

Modal Analysis - Zhi-Fang Fu , Jimin He (Butterworth-Heinemann, publisher)

Subject Code: ME6L060	Subject Name: Soft Computing and Applications	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Course content:

Introduction to soft computing: Soft computing vs hard computing, Adaptive systems and update mechanisms, and Need of soft computing to solve engineering and management problems.

Artificial neural networks: ANN, Back propagation, Radial basis function networks, and Functional link artificial neural networks.

Fuzzy logic: Theory and principles of TS and MF systems.

Bio/Nature-inspired techniques based optimization: Genetic algorithm, Differential evolution, Particle swarm optimization, Ant colony optimization, and Bacterial foraging algorithm.

Multi-objective optimization: Non-dominated sorting genetic algorithm — II, Multiobjective particle swarm optimization, and Their applications.

Development of intelligent and hybrid systems.

Applications of ANN, fuzzy logic and bioinspired techniques to real life problems.

Recommended Books:

1. Deb, K v, '*Optimization for Engineering Design Algorithms and Examples*', Prentice Hall of India, 2009.
2. Haykin, S., *'Neural Networks and Learning Machines*', Prentice Hall, 2009.
3. Jang, J. S. R., C. T. Sun and E. Mizutani, '*Neuro, Fuzzy and Sofi computing: A Computational Approach 10 Learning and Machine Intelligence Prentice Hall*', 2009.
4. Jong, K. A. D., *'Evolutionary Computation — A Unified Approach*', PHI Learning, 2009.
5. Pao, Y. H., *'Adaptive Pattern Recognition and Neural Ne/work'*, Addison- Wesley, 1989.
6. Pratihar, D. K, '*Soft Computing fundamentals and Applications'*, Narosa Publications, 2014.

Research publications (will be suggested during the lectures)

** Already approved and running at **the institute level**

Subject Code: ME6L062	Subject Name: MEMS & Microsystems Technology	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to MEMS & MST. Scaling Laws and demand in miniaturization. Working principles of Micro Sensors, Actuators and applications in real systems. Microsystems mechanisms & precision using flexures, design considerations, modeling and innovations. Materials selection, Micro Fabrication. Microfluidics, Chemical Sensors, Biomedical & Bio-MEMS, and Lab-on-a-chip. System Integration and Packaging.

Recommended Books:

Tai-Ran Hsu, "MEMS & MICROSYSTEMS Design and Manufacture", Tata McGraw Hill Education Pvt. Ltd.

Marc Madou, "Fundamentals of Microfabrication: The Science of Miniaturization", Vol. I, II, & III, CRC Press. 2012

Stephen D. Senturia, "Microsystems Design", Springer, 2006.

Subject Code: ME6L331	Subject Name: Additive Manufacturing	L-T-P: 3-0-0	Credit: 3

Pre-Requisite(s): Advanced Manufacturing Processes - I

Course content:

Introduction to Additive Manufacturing (AM), Critical applications, Traditional manufacturing v/s AM;

Rapid Prototyping (RP): Basic principles, Steps, Advantages, Different manufacturing processes, Importance of RP in context of batch production;

RP in integrated CAD CAM environment, FMS and CIM and their application, Introduction to Reverse Engineering;

Different AM processes and relevant physics of AM process chain: Direct and Indirect processes Rapid Prototyping;

Classification of different AM techniques based on raw materials, layering technique (2-D or 3-D) and energy sources: Powder based AM processes involving sintering and melting, Stereo-lithography (SL), Extrusion based fused deposition modeling (FDM), Laminated object manufacturing, Solid ground curing, Repetitive masking and deposition, Beam interference solidification;

CAD/CAM Modeling, Slicing procedures, Internal hatching, Support structure;

Advances in metal additive manufacturing, composite manufacturing and micro additive manufacturing;

Micro- and Nano-lithography;

Tessellation (STL format) and tessellation algorithms, Accuracy and Surface quality in Additive Manufacturing, Effect of part deposition orientation; and

Bio-medical applications.

Recommended Books:

Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010.

Additive manufacturing technologies: rapid prototyping to direct digital manufacturing By Ian Gibson, David W. Rosen, Brent Stucker. Springer, 2010Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing By Andreas Gebhardt. Hanser Publishers, 2011

Rapid Prototyping, Tooling and Manufacturing By R. J. M. Hague, P. E. Reeves, Paperback, 2002.

Rapid Prototyping Technology: Selection and Application By Kenneth Cooper, CRC, 2001.

Rapid Prototyping: Theory and Practice By Kamrani A., Nasr E. A., Springer, 2006

Laser assisted fabrication of materials By J.D. Majumdar and I. Manna. Springer Series in Material Science, 2013

Rapid Prototyping: Laser-Based and Other Technologies By Patri K. Venuvinod, Weiyin Ma, Springer, 2004.

Rapid Prototyping By Andreas Gebhardt, Hanser, 1996.

Rapid Prototyping and Engineering Applications: A Toolbox for Prototype ... By Frank W. Liou, CRC Press, 2007.

Subject Code: ME6L332	Subject Name: Factory Automation	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction: Concept and scope of industrial automation, Socio-economic considerations, Types of automation, Automation strategies, Automation Technologies;

Fluid Power Control: Fluid Power Control elements and standard graphical symbols for them, Construction and performance of fluid power generators, Hydraulic & pneumatic cylinders - construction, design and mounting, Hydraulic & pneumatic valves for pressure, flow & direction control, Simple hydraulic and pneumatic circuits;

Pneumatics: Pneumatic Logic Circuits: Boolean Algebra, Truth tables, Un-complementation algorithm and Karnaugh Maps, Design of pneumatic logic circuits for a given time displacement diagram or sequence of operation;

High Volume Production Systems: Transfer devices, Vibratory bowl feeders, Non-vibratory feeders. Part orienting, feed track, Part placing and part escapement systems; Automation strategies, Analysis of flow lines, Automated assembly systems;

Mechatronics: Mechanical system interfacing, Simple mechatronic devices: Stepping motors, DC motors, Analog / digital conversion; and

Programmable automation: CNC, industrial robotics; Flexible manufacturing systems.

Recommended Books:

Fluid Power with Applications by A. Esposito, Prentice Hal of India, New Delhi, 2008.
Pneumatic Systems by S.R. Majumdar, McGraw Hill, 2017
Assembly Automation and Product Design, by Geoffrey Boothroyd, CRC press, 2005
Automation, Production System and Computer Integrated Manufacturing by M. P. Groover, Prentice Hal of India, New Delhi, 2017

Subject Code: ME6L414	Subject Name: Bio-Robotics/ Bio-Mechatronics **(Proposed)**	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Introduction: biomedical engineering design, engineering approaches to clinical challenges, clinical problems requiring implants/devices for solution; Materials for biomedical implants and devices; Implantable devices and systems: Vascularand cardiovasculardevices, pacemakers, heart valves, stents, synthetic grafts, orthopedic implants, intraocular lens implants, cochlear implants; Wearable devices: Assistive devices for the blind, foetal movement, finger movement, gait analyzer, ventricular assist devices, energy harvesting; Implantable neural prostheses and nerve stimulation: Brain, visual prosthesis, cochlear implants, spinal cord stimulation, cardiology system, artificial limbs; Minimally invasive devices and techniques: Instrumentation for Laparoscopic Surgery, Ocular Surgery; Imaging and image-guided techniques: endoscopy, medical ultrasound devices, medical X-rayimaging, imaging-aided design of personalized devices and assistive reproduction technology; Rehabilitation Engineering: Deafness, blindness, passive and active Orthoses and Prostheses.

Recommended Books:

Andrés D. Lantada. Handbook on Advanced Design and Manufacturing Technologies for Biomedical Devices. Springer London 2013

Aimé Lay-Ekuakille and Subhas C. Mukhopadhyay, Wearable and Autonomous Biomedical Devices and Systems for Smart Environment. Springer-Verlag Berlin, 2010

David D. Zhou and Elias Greenbaum. Implantable Neural Prostheses 1. Devices and Applications. Springer, London, 2009

Gail D. Baura. Medical Device Technologies: A Systems Based Overview Using Engineering Standards Academic Press, Oxford, UK 2012

Paul H. King, Richard C. Fries. Design of Biomedical Devices and Systems. CRC press, Boca Raton, 2009

James Moore and George Zouridakis. Biomedical Technology and Devices Hand Book. CRC press, Washington DC, 2004

Martin Culjat, Rahul Singh, Hua Lee. Medical Devices: Surgical and Image-Guided Technologies, John Wiley & Sons, Inc New Jersey, 2013

ASM Handbook Volume 23, Materials for Medical Devices

Joseph D. Bronzino, Donald R. Peterson. Medical Devices and Human Engineering, CRC Press, New York, 2015

Frank E. Johnson, Katherine S. Virgo, The Bionic Human: Health Promotion for People with Implanted Prosthetic Devices, Humana Press Inc., New Jersey, 2006

Subject Code: ME6L415	Subject Name: Under Water Robotics **(Proposed)**	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s):			

Course content:

Robotic Sailing: History and recent developments in robotic sailing – miniature sailing robot platform (MOOP) – autonomous sailing vessel – design, development and deployment.

Submersibles: Unmanned submersibles- towed vehicles – Remotely Operable Vehicles (ROV) – The ROV business – Design theory and standards – control and simulation – design and stability - components of ROV – applications.

Underwater Vehicle Guidance and Control: Modelling of marine vehicles – kinematics – rigid body dynamics – hydrodynamic forces and moments – equation of motion – stability and control of underwater vehicles

Recommended Books:

Sabiha A. Wadoo, Pushkin Kachroo, Autonomous underwater vehicles, modelling, control design and Simulation, CRC press, 2011

Robert D. Christ,Robert L. Wernli, Sr. The ROV Manual A User Guide for Remotely Operated Vehicles, Elsevier, second edition, 2014

Thor I Fossen, Guidance and control of ocean vehicles, John wiley and Sons, 1999

Subject Code: ME6L416	Subject Name: Unmmaned Aerial Vehicles **(Proposed)**	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to Unmanned Aerial Vehicles (UAVs), types of UAVs, applications, design process and design goals

Unmanned Aerial Systems: description of each sub-system and their roles
Mission specific configuration selection, powerplant selection and preliminary design
Aerodynamics and Performance, equation of motion and dynamics model
Levels of autonomoy, autopilot architecture and design, stability and control analysis, linear control design, gain selection through experimentation, nonlinear control design, state estimation, sensor, actuator, telemetry
Commercial-Off-The-Shelf (COTS) design and system integration
Ground station, Microcontroller programming using Real Time Operating System (RTOS), Robotic Operating System (ROS), Hardware-in-the-loop simulation (HILS), experimental procedures and flight testing
Case studies: Quadrotors, fixed wing, conventional helicopter, innovative new concepts

Recommended Books:

Castillo, P., Lozano, R., and Dzul, A. E., Modelling and Control of Mini-Flying Machines, Springer, London, 2005.
Beard, R., and McLain, T., Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012.
Shkarayev, S. V., Ifju, P. G., Kellogg, J. C., and Mueller, T. J., \emph{Introduction to the Design of Fixed-Wing Micro Air Vehicles Including Three Case Studies}, AIAA Education Series, 2007.
Appriou, A., Aerial Robotics, Journal Aerospace Lab, Issue 8, December 2014.

Subject Code: ME6L417	Subject Name: Scientific Machine Learning (Proposed)	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Introduction: Linear Algebra, Probability review, Programming Basics, Challenges in Data Handling Regression: Simple Linear Regression, Multiple Linear Regression, Nonlinear Regression, Logistic regression Introduction to Machine learning: Supervised Learning, Unsupervised Learning, Classification and Clustering Algorithms Applications of Machine Learning in Mechanics: Case Studies include Identifying faulty/healthy wind turbines, Turbulent Flow Analysis, Leakage Detection in Hydraulic Circuits, Fault Detection in MotorBearings, Human Activity Recognition, Heart Sound Classification etc. Deep learning: Introduction to Neural Networks, Convolution and Artificial Neural Networks, Applications in Engineering Mechanics Practical's: MATLAB tools including Curve Fitting Toolbox, Classification Learner App, Deep Network Designer App, Tensor Flow, Training models on GPUs.

Recommended Books:

- Deep Learning in Computational Mechanics: An Introductory Course, by Davide D'Angella, Leon Herrmann, Moritz Jokeit, Stefan Kollmannsberger, Springer
- Nguyen, Thi Dieu Linh, and Joan Lu, eds. Machine Learning and Mechanics Based Soft Computing Applications. Vol. 1068. Springer Nature, 2023.

Subject Code: ME6L418	Subject Name: Soft Robotics (Proposed)	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s):			

Course content:

Soft robots vs Rigid robots, manufacturing techniques of multifunctional soft robot devices: Modeling soft mechanics (numerical, computational, analytical), Introduction to morphological simulation: Soft actuators (Dielectric, pneumatic, fluidics): Soft sensors (Fluidic, solid, composites, textiles): Soft logic (controllers, semiconducting polymer, thin film silicon):Soft energy (thermodynamics, soft batteries, soft combustion) Applications (wearable robotics, space robotics, deepsea robotics).

Recommended Books:

- Laschi, Cecilia, et al. Soft robotics: trends, applications and challenges. Vol. 17. Springer., 2017
- Verl, Alexander, et al. "Soft robotics." Berlin, Heidelberg: Springer 10 (2015): 978-3.

Subject Code: CS6LXXX	Subject Name: Deep Learning	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Syllabus: Introducti0n to Deep Learning: History of DL, DL vs. ML, Types Of Learning (supervised, unsupervised, semi, weak, self, etc.). Linear Classifiers, Linear Machines with Hinge Loss. Optimization Techniques, Gradient Descent, Batch Optimization. Introduction to Neural Network. Multilayer Perceptron, Back Propagation Learning. Unsupervised Learning with Deep Network. Convolutional Neural Network, building blocks of CNN (activation, normalization, pooling, padding), Transfer Learning, hyper-parameter tunning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam optimizer. Effective training in Deep Net-early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization. Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Fully Connected CNN, LSTM. Autoencoders, Transformers, Multi-branch CNN, Generative Networks (GAN), Recurrent Neural Nets (RNN), GRU, complex models. Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation. Object Detection, Anomaly Detection, Object tracking, optical flow estimation, etc. LSTM Networks, Generative Modelling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer. Natural language processing: word embedding's, sentiment analysis.

Prerequisite: Knowledge of Linear Algebra, Digital signal Processing will be helpful.

Text books:

1. Deep Learning - Ian Goodfelllow, Yoshua Benjio, Aaron Courville, the MIT Press, 2016.
2. Grokking Deep Learning - Andrew W. Trask, Manning Publications, 2019.

Reference Books:

3. Pattern Classification - David G. Stork, Peter E. Hart, and Richard O. Duda, 2nd Edition, Wiley, 1973.
4. Pattern Recognition, Theodoridis, S. and Koutroumbas, K. Edition 4. Academic Press, 2008.

Tools and Software: PyTorch, Keras, Tensorflow.

** Submitted for Approval in M.Tech. **Artificial Intelligence**

Subject Code: CS6L024	Subject Name: Internet-of-Things	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

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, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring

Text books:

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press).

Reference books:

1. "Internet of Things: A Hands-on Approach", by Arshdeep Bahga and Vijay Madisetti (Universities Press).

Subject Code: CS6L025	Subject Name: Object Oriented Systems Design	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

The purpose of this course is to familiarize students with concepts, methods, and tools for object oriented analysis and design of software systems, with emphasis on methods applied in large product development projects. The course introduces common design principles and patterns that support the development of maintainable, reusable and extensible software. The course gives an introduction to UML. Analysis- and design models are expressed using UML models such as use case diagrams, class diagram, sequence diagrams, and state diagrams. Furthermore, techniques and guidelines are introduced for analysis of software domain and requirements.

Text books:

1. Systems Analysis and Design: an Object-oriented Approach with UML (5th edition), Alan Dennis, Barbara Haley Wixom, David Tegarden. ISBN-13: 978- 1118804674 ISBN-10: 1118804678.

Reference books:

1. Some particularly practical are: 'UML Distilled' by Martin Fowler.
2. The Unified Modeling Language User Guide (2nd Edition) by Grady Booch, James Rumbaugh, Ivar Jacobson.
3. Design Patterns: Elements of Reusable Object-Oriented Software. By Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides.

Subject Code: CS6L026	Subject Name: Wireless Sensor Networks	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction: Overview, Broad application areas of WSN, Specialty and constrains; Hardware and software: Overview of hardware architecture of the sensor motes, Types of operating systems for WSN, Overview of event driven programming. MAC layer issues: Types of MAC protocols for WSN, Contention-based and reservation based protocols. Detailed study of specific protocols such as SMAC, RMAC, TMAC, DW-MAC, DMAC, Aloha, CSMA-CA, BMAC, LPL, LPP. Network layer issues: Routing, classification of the protocols, specific protocols such as SPIN, LEACH etc. Data collection, Data dissemination, Data aggregation, Time synchronization.

Recommended Books:

Holger Karl, Andreas Willig, Protocols and Architectures for Wireless Sensor Network, John Wiley & Sons, 2005, ISBN 0470095105.

Reference books:

1. Ibrahiem M. M. El Emary, S. Ramakrishnan, Wireless Sensor Networks: From Theory to Applications, CRC Press, 2013, ISBN 9781466518100.
2. Ian F. Akyildiz, Mehmet Can Vuran, Wireless Sensor Networks, John Wiley & Sons, 2010, ISBN 9780470036013.
3. J Zheng, and A Jamalipour. Wireless sensor networks: a networking perspective, John Wiley & Sons, 2009, ISBN 9780470167632.
4. Anna Hac, Wireless Sensor Network Designs, John Wiley & Sons, 2003, ISBN 0470867361.

Already approved and running in M.Tech. **Computer Science and Engineering

Subject Code: EC6L004	Subject Name: Advanced Digital Signal Processing	L-T-P: 3-1-0	Credit: 4
Pre-Requisite(s): None			

Course content:

Multi-rate digital signal processing: decimation, interpolation, sampling rate conversion, digital filter banks, two-channel quadrature mirror filter bank, M-channel QMF bank.

Linear prediction and optimum linear filters: forward and backward linear prediction, normal equations, AR lattice and ARMA lattice-ladder filters, Wiener filters

Power spectrum estimation: nonparametric and parametric methods, filter bank methods, Eigen analysis algorithms

Time-frequency analysis: uncertainty principle, Short-time Fourier transform, Wigner distribution, Kernel design, Gabor wavelets, multi-resolution analysis

Recommended Books:

Digital Signal Processing: Principles, Algorithms and Applications, Proakis and Manolakis, 4th edition, Pearson, 2012

Time-frequency analysis, Cohen, Prentice-Hall, 1995

Advanced digital signal processing, Vaseghi, 4th edition, Wiley, 2008

Multi-rate systems and filter banks, Vaidyanathan, Pearson, 1992

** Already approved and running in M.Tech. **Electronics & Communication Engineering**

Subject Code: EC6L023	Subject Name: Adaptive Signal Processing	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Introduction to adaptive filters, optimal estimation, linear estimation: normal equation, orthogonality principle, linear models. Constrained linear estimation: minimum variance unbiased estimation, steepest descent algorithms, stochastic gradient algorithms: LMS algorithm, normalized LMS algorithm, RLS algorithm. Steady-state performance of adaptive filters, transient performance of adaptive filters, block adaptive filters, the least-squares criterion, recursive least-squares, lattice filters

Recommended Books:

Fundamentals of adaptive filtering, A. H. Sayed, Wiley, 2003
Adaptive filter theory, Simon Haykin, Fourth edition, Pearson, 2012
Adaptive Signal Processing, Widrow and Stearns, Pearson, 2007

** Already approved and running in M.Tech. **Electronics & Communication Engineering**

Subject Code: EE6L016	Subject Name: Advanced Control	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

State-space representation; Different canonical forms: Controller canonical form, Observer canonical form, Diagonal canonical form, Jordan canonical form, Controllable canonical form, Observable canonical form; Decomposition of transfer functions into different canonical forms; Controllability and Observability; Stabilizability and Detectability; State feedback control; Full and reduced order observers: observer based state feedback control, Separation principle; Optimal control: Linear Quadratic control, Linear Quadratic Gaussian control, Loop transfer recovery control; Internal stability, Well-posedness; Concept of uncertainties and robustness: Structured uncertainties, Unstructured uncertainties, Sensitivity, Complementary Sensitivity and their significance for robustness study, Robust stability of $M - \Delta$ structure; $H\infty$ control: Two block frame work, Four block frame work, mu-synthesis; Approximate linearization; Feedback linearization: Input to state exact linearization, input to output exact linearization; Sliding mode control.

Recommended Books:

1. R. C. Dorf and R. H. Bishop 'Modern Control Systems', Pearson Education, Inc, 2008.
2. R. T Stefani 'Design of Feedback Control Systems', Oxford University Press, 2002.
3. S. Skogestad and I. Postlethwaite 'Multivariable Feedback Control', John Wiley, 2005.

** Already approved and running in M.Tech. **Power Electronics and Drives**

Subject Code: MA4010	Subject Name: Numerical Analysis	L-T-P: 3-0-0	Credit: 3
Pre-Requisite(s): None			

Course content:

Definition and sources of errors, Propagation of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors. Nonlinear equations, Bisection method, Newton's method and its variants, Fixed point iterations, Convergence analysis. Newton's method for non-linear systems. Finite differences, Polynomial interpolation, Hermite interpolation, Spline interpolation, B-splines. Numerical integration, Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature, Richardson Extrapolation IVP: Taylor series method, Euler and modified Euler methods, Runge-Kutta methods, Multistep methods, Predictor-Corrector method Accuracy and stability, Solution for Stiff equations BVP: Finite difference method.

Text Books:

1. Elementary Numerical Analysis - An Algorithmic Approach, S. D. Conte and Carl de Boor, McGraw Hill

Reference Books:

1. Scientific Computing: An Introductory Survey, M. T. Heath, McGraw Hill
2. Introduction to Numerical Analysis, K. E. Atkinson, 2nd Edition, John Wiley
3. Applied Numerical Analysis, C. F. Gerald and P. O. Wheatley, 5th edition, Addison Wesley