COEP Technological University

(COEP Tech)

A Unitary Public University of Government of Maharashtra

w.e.f 21st June 2022

(Formerly College of Engineering Pune)

CURRICULUM STRUCTURE

M.Tech. (Robotics and Artificial Intelligence)

(Effective From AY 2023-2024)

COEP Technological University Pune

(An Autonomous Institute of Govt. of Maharashtra)

Programme: MTech [Robotics and Artificial Intelligence]
Program Educational Objectives (PEO's)

PEO1. *Core Competence*: Fundamental and technical knowledge with skills in Artificial Intelligence & Robotics area to enable and empower to solve problems of the modern industrial world.

PEO2. *Depth (Research culture)*: Imbibing a scientific perspective to make a decision of Robotic systems and Artificial Intelligence using Mathematical, Engineering, Computational & Simulation tools.

PEO3. *Professionalism:* Make acquaint with technical, managerial and human skills and familiarize with professional issues like ethics and morality, Intellectual property Rights, Constitution of India and Environmental responsibility.

PEO4, *Learning Environment:* Motivation for entrepreneurship and inculcating a spirit of continuous lifelong learning for a successful professional career.

Programme: MTech [Artificial Intelligence and Robotics]
Program Outcomes (PO's)

PO1 An ability to independently carry out research /investigation and development work to solve practical problems in the field of Robotics & Artificial Intelligence

PO2 An ability to write and present a substantial technical report/document

PO3 An ability to demonstrate a degree of mastery in the area of Artificial Intelligence & Robotics

PO4 They will develop capacity to understand multidisciplinary engineering areas and display skills for Robotic system design, Artificial Intelligence programming tools, Control systems and Machine learning.

PO5 The graduates will exhibit effective communication skills with equal expertise to communicate with engineers and with the community at large.

PO6 The graduates will have a sound foundation of business ethics, professional integrity and social responsibility along with introspection skills and positive outlook for taking corrective measures based on external feedback.

M. Tech. (Robotics and Artificial Intelligence)
Curriculum Structure
(w. e. f. 2023-2024)

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
PSMC	Program Specific Mathematics Course	1	4	5.88 %
PSBC	Program Specific Bridge Course	1	3	4.41 %
PCC	Program Core Course	7	17	25.00 %
PEC	Program Specific Elective Course	3	9	13.24 %
LC	Laboratory Course	6	6	8.82 %
VSEC	Vocational and Skill Enhancement Course	2	18	26.47 %
OE	Open Elective	1	3	4.41 %
SLC	Self-Learning Course	2	6	8.82 %
AEC	Ability Enhancement Course	1	1	1.47 %
MLC	Mandatory Learning Course	2	--	--
CCA	Co-curricular & Extracurricular Activities	1	1	1.47 %
	Total	**26**	**68**	**100%**

Semester I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1.	PSMC	PSMC-01	Fundamentals of Mathematics	3	1	--	1	4
2.	PSBC	PSBC-01	Program specific Bridge Course i) Principles of Electronics ii) Principles of Design of Machine Elements	2	1	--	2	3
3.	PEC	PEC-01	Department Elective Course - I	3	--	--	--	3
4.	PCC	PCC-01	Knowledge Engineering & Expert System	2	--	--	2	2
5.	PCC	PCC-02	Fundamentals of Robotics	2	--	--	2	2
6.	PCC	PCC-03	Artificial Intelligence & Neural Networks	2	--	--	2	2
7	PCC	PCC-04	Sensors and Actuators in Robotics	2	--	--	2	2
8	AEC	AEC-01	Seminar	0	0	2	2	1
9	LC	LC-01	Robot Programming Laboratory	--	--	2	1	1
10	LC	LC-02	Microcontroller Programming Laboratory	--	--	2	1	1
11	LC	LC-03	AI based Programming Tools Lab	--	--	2	1	1
			Total Credits	16	2	8	14	22

- Exit option to qualify for **PG Diploma in** M. Tech. (Robotics & Artificial Intelligence) :
  - Eight weeks domain specific industrial internship in the month of June-July after successfully completing first year of the program.

Sr. No.	Course Code	Department Elective Course -I
1	Robotics	Mobile and Micro-robotics
2	AI	Data Science
3	Mechatronics	Intelligent Manufacturing
4	Controls	Microcontrollers Architecture and Programming
5	For HELLA Co.	Automotive Embedded Hardware Development *

Semester II

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1.	OE	OE-01	Interdisciplinary Open Course	3	--	--	--	3
2.	PEC	PEC-02	Department Elective Course - II	3	--	--	--	3
3.	PEC	PEC-03	Department Elective Course - III	3	--	--	--	3
4.	MLC	MLC-01	Research Methodology and Intellectual Property Rights	2	--	--	2	--
5.	MLC	MLC-02	Effective Technical Communication	1	--	--	2	--
6.	CCA	CCA-01	Liberal Learning Course	--	1	--	1	1
7.	PCC	PCC-05	Machine Learning & Big Data Analytics	2	1	--	2	3
8.	PCC	PCC-06	Embedded Control Systems	3	--	--	2	3
9.	PCC	PCC-07	Robot Kinematics and Dynamics	2	1	--	2	3
10	LC	LC-04	Robot Simulation Laboratory	--	--	2	1	1
11	LC	LC-05	Software Laboratory for ROS & SLAM	--	--	2	1	1
12	LC	LC-06	Embedded Control Systems Lab	--	--	2	1	1
			Total Credits	19	3	6	16	22

Sr. No.	Course Code	Department Elective Course -II
1	Robotics	Autonomous Robotics and Telecherics
2	AI	Advanced Artificial Intelligence
3	Mechatronics	Mechatronics System Design
4	Controls	Advanced Control System
5	For HELLA Co.	Automotive Embedded Hardware Development *

Sr. No.	Course Code	Department Elective Course -III
1	Robotics	Advanced Robotics Programming
2	AI	Deep learning
3	Mechatronics	Micro Electro Mechanical Systems
4	Controls	Control of Robotic Systems
5	For HELLA Co.	Automotive Embedded Hardware Development *

Semester-III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1.	VSEC	VSEC-01	Dissertation Phase – I	--	--	18	12	9
2.	SLC	SLC-01	Massive Open Online Course-I	3	--	--	3	3
			Total Credits	3	--	18	15	12

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1.	VSEC	VSEC-01	Dissertation Phase – II	--	--	18	12	9
2.	SLC	SLC-02	Massive Open Online Course –II	3	--	--	3	3
			Total Credits	3	--	18	15	12

SEMESTER I

(PSMC-01) Fundamentals of Mathematics

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
T1, T2 – 20 marks each,
End-Sem Exam - 60

Course Outcomes:

At the end of course students will be able to

1. Understand and apply basic concepts of linear algebra and matrix theory.
2. Define various concepts in multivariable calculus and solve problems.
3. Apply various techniques of optimization.
4. Use probability theory in problem solving.
5. Understand support vector machines and error minimization

Syllabus Contents:

Linear Algebra Basics : Vector spaces and subspaces, basis and dimensions, linea transformation, four fundamental subspaces.
Matrix Theory : Norms and spaces, eigenvalues and eigenvectors, Special Matrices anc their properties, least squared and minimum normed solutions.
Matrix Decomposition Algorithms-SVD : Properties and applications, low ranl approximations, Gram Schmidt process, polar decomposition.
Dimensions Reduction Algorithms and JCF : Principal component analysis, linea discriminant analysis, minimal polynomial and Jordan canonical form.
Calculus : Basic concepts of calculus : Partial derivatives, gradient, directional derivatives jacobian, hessian, convex sets, convex functions and its properties.
Optimization : Unconstrained and Constrained optimization, Numerical optimizatior techniques for constrained and unconstrained optimization : Newton's method, Steepes descent method, Penalty function method.
Probability : Basic concepts of probability : Conditional probability, Bayes' theorem independence, theorem of total probability, expectation and variance, few discrete anc continuous distributions, joint distributions and covariance.
Support Vector Machines : Introduction to SVM, Error minimizing LPP, concepts of duality hard and soft margin classifiers.

Reference Books :

1. W. Cheney, Analysis for Applied Mathematics. New York : Springer Science + Business Medias, 2001.
2. S. Axler, Linear Algebra Done Right (Third Edition). Springer International Publishing, 2015.
3. J. Nocedal and S.J. Wright, Numerical Optimization. New York : Springer Science + Business Media, 2006.
4. J.S. Rosenthal, A First Look at Rigorous Probability Theory (Second Edition). Singapore : World Scientific Publishing, 2006.

5. Marc Perter Deisenroth, A. Aldo Faijal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
6. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Publication , 2001.

Program Specific Bridge Course (PSBC-01)

(* For UG in ETC/ Electrical/ Comp/Instru.)

Principles of Design of Machine Elements

Teaching Scheme	**Examination Scheme**
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz – 40
Tutorial: 1 hr/week	End-Sem Exam- 60 marks

Course Outcomes:

At the end of course students will be able to

1. Design simple machine parts and components.
2. apply basic procedure for the selection of machine components
3. Design & analyze various shafts, springs, gears , bearings .

Syllabus Contents:

Simple stresses and strains: Concept of stress and strain linear, lateral, shear and volumetric, Hook's law. Elastic constants and their relationship. Thermal stresses, deflections Shear force and bending moment diagrams:, UDL, uniformly varying loads and couples. Relation between SF, BM and intensity of loading, construction of SF, and BM diagrams for cantilevers, and simple beams.

Stresses due to bending and torsion : Theory of simple bending, Bending stress distribution diagram. Moment of resistance and section modulus calculations. Theory of torsion, torsional stresses and torsional deflections.

Loads and stress in machine elements :Types of loads, static, shock, impact and fluctuating loads, types of stresses, tensile, compressive, direct and torsional shear, bending stresses. Combined effect of direct, bending and torsional stresses.

Design concepts, material and process selection design process, factor of safety & design codes, materials. Design of shafts and different types of levers based on torsional and lateral rigidity, combined loadings. Design of keys, keyways and splines. Standard threads, stresses in threads, preloaded fasteners in tension, joint stiffness factor, power screws.

Design of springs: Spring configurations, materials, design of helical compression, extension and torsion springs. Design of composite springs in parallel, series, concentric, Belleville spring, washers.

Spur Gears: Law of Gearing, Effect of Pressure angle and Centre Distance, Path of Contact, Arc of Contact, Contact Ratio, Interference and Undercutting, Minimum number of teeth to avoid interference, Design of Spur Gears, Selection of Type of Gears, Force Analysis, Gear tooth Failures, Selection of Materials, Beam Strength, Wear Strength, Effective Load

Calculation, Dynamic Load, Gear Design for Maximum Power Transmitting Capacity. Force Analysis, of helical gears, bevel gears and Worm Gears.

Mechanical Vibrations: Importance of the Study of Vibrations, Elements of a Vibratory System, Degrees of freedom, Types of Vibrations, Free Vibrations of linear and torsional systems Free Undamped Vibrations: Methods to determine the Equation of Motion, Vibration Analysis Procedure, Determination of Natural Frequency of Free Transverse Vibrations:, Determination of Natural Frequency of Free Torsional Vibrations:- Equivalent Stiffness of Spring Combinations.

Bearings: Types, Static and Dynamic load Capacity, Stribeck's Equation, Concept of equivalent load, Load life Relationship, Lubrication and Mounting of bearing.

References

1. Ramamrutham S.: Strength of Materials, Dhanpat Rai & Sons, 1991.
2. V. B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007
3. Beer and Johnston: Strength of Materials- CSB Publisher.
4. Rao, J.S. & Dukkipati, R.V.: Mechanism & Machine Theory, New Age International Pvt.Ltd. Publishers.
5. Ramamurthy, V.: Mechanics of Machines, Narosa Publishing House.
6. Manufacturing Technology, P.N. Rao, Tata McGraw-Hill Publishing Limited, II Edition, 2002.
7. S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., 2007

Program Specific Bridge Course (* For UG in Mechanical/Production)

Principles of Electronics

Teaching Scheme	Examination Scheme
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz - 40
Tutorial: 1 hr/week	End-Sem Exam- 60 marks

Course Outcomes:

1. Learn how to develop and employ circuit models for elementary electronic components, e.g., resistors, sources, inductors, capacitors, diodes and transistors;
2. Become adept at using various methods of circuit analysis.
3. Use basic techniques for analyzing analogue and digital electronic circuits

Syllabus Contents:

Role of various Engineering disciplines in Mechatronics, Mechatronics Design elements, Scope and Applications of Mechatronics, Analog electronic components and devices, Oscillators as signal generators, Power supplies and voltage regulators, Power Electronics-Devices, Industrial electronic circuits, Digital Electronics- Arithmetic circuits, Multiplexers/Demultiplexers, Registers, Counters, Memories, Few examples of transducers, Signal conditioning Circuits using Operational amplifiers, Noise Problems, Grounding and shielding, Data acquisition systems,-Single channel and multichannel, Data loggers, Control Systems Components, Classification of Control Systems, Transfer functions, Time and Frequency response Analysis tools.

References

1. Allen Mottershed, "Electronic Devices and Circuits", Prentice Hall International, Third Edition
2. M. D. Singh and J. G. Joshi, "Mechatronics – Principles and Applications", Prentice Hall India publication-EEE.

Department Elective Course-I
(PEC-01) Mobile and Micro-robotics

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Identify and design a suitable manufacturing process for micro robots
2. Understand the importance of visual perception and recognition for cybernetic view
3. Program a robot for wandering and teleoperation

Introduction to Mobile Robots - Tasks of mobile robots, robot_s manufacturers, type of obstacles and challenges, tele-robotics, philosophy of robotics, service robotics, types of environment representation. Ground Robots: Wheeled and Legged Robots, Aerial Robots, Underwater Robots and Surface Robots. Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four - wheeled robots, omni-directional and macanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system, Kinect. Localization and Mapping in mobile robotics. Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.
Microrobotics: Introduction, Task specific definition of micro-robots - Size and Fabrication Technology based definition of microrobots - Mobility and Functional-based definition of micro-robots - Applications for MEMS based micro-robots. Implementation Of Microrobots: Arrayed actuator principles for micro-robotic applications – Micro-robotic actuators - Design of locomotive micro-robot devices based on arrayed actuators. Micro-robotics devices: Micro-grippers and other micro-tools - Micro-conveyors - Walking MEMS Micro-robots – Multi-robot system: Micro-robot powering, Micro-robot communication. Microfabrication And Microassembly: Micro-fabrication principles - Design selection criteria for micromachining - Packaging and Integration aspects – Micro-assembly platforms and manipulators.

References

1. R Siegwart, IR Nourbakhsh, D Scaramuzza, Introduction to Autonomous Mobile Robots, The MIT Press, USA , 2011,
2. SG Tzafestas, Introduction to Mobile Robot Control, Elsevier, USA, 2014,

3. A Kelly, Mobile Robotics, Mathematics, Models, and Methods, Cambridge University Press, USA, 2013,
4. G Dudek, M Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, USA,
5. Mohamed Gad-el-Hak, ―The MEMS Handbook‖, CRC Press, New York, 2002.
6. Yves Bellouard, ―Microrobotics Methods and Applications, CRC Press, Massachusetts, 2011.
7. Patnaik, Srikanta, "Robot Cognition and Navigation An Experiment with Mobile Robots", Springer-Verlag Berlin and Heidelberg, 2007.
8. Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, ―Principles of Robot Motion-Theory, Algorithms, and Implementation, MIT Press, Cambridge, 2005.
9. Margaret E. Jefferies and Wai-Kiang Yeap, "Robotics and Cognitive Approaches to Spatial Mapping", Springer-Verlag Berlin Heidelberg 2008.

Department Elective Course-I
(PEC-01) Data Science

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz -40
	End-Sem Exam- 60 marks

Course Outcomes

1. Describe a flow process for data science problems (Remembering)
2. Classify data science problems into standard typology (Comprehension)
3. Correlate results to the solution approach followed (Analysis)
4. Assess the solution approach (Evaluation)
5. Construct use cases to interpret, and validate the approach using popular data science tools (Application)

Introduction

Data Science, Examples, Challenges, Applications, Comparative Study of data science with databases, scientific computing, computational science

The Data Scientist's Toolbox: R, RStudio, version control, markdown, git, GitHub

Linear algebra and statistics for data science

Algebraic view: vectors, matrices, product of matrix & vector, rank, null space, solution of over-determined set of equations and pseudo-inverse)

Geometric view: vectors, distance, projections, eigenvalue decomposition

Statistical view: Inferential Statistics, Probability distributions, univariate and multivariate normal distributions, hypothesis testing, confidence interval for estimates, ANOVA, Correlation and Regression

Data Modeling

Kinds of data: structured, unstructured, semi-structured and corresponding representation techniques and examples,

Data representation: relational, NoSQL

Data type: Text, audio, images, videos

Input Data Representation: Concepts, instances and attributes

Output Data Representation: Decision tables, Decision trees, Decision rules, Rules involving relations, Instance-based representation.

Data gathering and preprocessing
Reading the data, data preprocessing, data cleaning, data integration and transformation, data reduction, data discretization and concept hierarchy generation

Exploratory Data Analysis
Exploratory techniques for summarizing data: Descriptive and inferential Statistics, 5 number summary of data, box and whisker plot analysis
Data Visualization: Libraries for visualizing one dimensional and multidimensional data (matplotlib and seaborn), Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot, overview of t-SNE technique

Basic ML algorithms and Use cases
Regression: Simple linear regression, Multivariate linear regression, & use case examples
Classification: Logistic regression, classification using k-means clustering, & use examples

Optimization, Diagnostic and Model Evaluation
Optimization: Minimizing or maximizing the cost functions, gradient descent, regularization
Diagnostic: Debugging a learning algorithm, evaluating a hypothesis, procedures for training, validation and testing, diagnosing bias versus variance and vice versa, learning curves, handling the overfitting of the model using regularization techniques

Accuracy and Error measures: classifier accuracy measures, predictor error measure, evaluating the accuracy of a classifier or predictor, Confusion metric, precision, recall, trade off between both, accuracy, Analysis of Receiver Operating Characteristic Curve

Textbooks:

1. Anil Maheshwari, “Data Analytics made accessible,” Amazon Digital Publication, 2014.
2. Song, Peter X. K, “Correlated Data Analysis: Modeling, Analytics, and Applications”, Springer-Verlag New York 2007.
3. Tom Mitchell, Machine Learning, McGraw-Hill, 1997
4. Jiawei Han Micheline Kamber, Data Mining Concepts and Techniques, 3rd Edition

Reference Books:

1. Glenn J. Myatt, Wayne P. Johnson, “Making Sense of Data I: A Practical Guide to Exploratory Data Analysis and Data Mining”, Wiley 2009.
2. Rachel Schutt, Cathy O’Neil, “Doing Data Science”, O’REILLY, 2006.
3. Ethem Alpaydin, Introduction to Machine Learning, PHI, 2005
4. Peter Bruce, Andrew Bruce, “Practical Statistics for Data Scientists”, O’Reilly
5. David Spiegelhalter, “The Art of Statistics: Learning from Data”, Pelican Books
6. Derek Rowntree, “Statistics without Tears: An Introduction for Non-Mathematicians”, Penguin Publications
7. Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, “An Introduction to Statistical Learning: with Applications in R”, Springer Texts in Statistics
8. William Feller, “An Introduction to Probability Theory and Its Applications” Wiley Series in Probability and Statistics

9. Hadley Wickham, Garrett Grolemund, “R for data science: Import, Tidy, Transform, Visualize, And Model Data” O’Reilly

Department Elective Course-I
(PEC-01) Intelligent Manufacturing

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz -40
	End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Summarize the concepts of computer integrated manufacturing systems and manufacturing communication systems
2. Identify various components of knowledge based systems
3. Demonstrate the concepts of artificial intelligence and automated process planning
4. Select the manufacturing equipment using knowledge based system for equipment selection
5. Apply various methods to solve group technology problems and demonstrate the structure for knowledge based system for group technology

Syllabus Contents:

Computer Integrated Manufacturing Systems Structure and functional areas of CIM system, - CAD, CAPP, CAM, CAQC, ASRS. Advantages of CIM. Manufacturing Communication Systems - MAP/TOP, OSI Model, Data Redundancy, Top- down and Bottom-up Approach, Volume of Information. Intelligent Manufacturing System Components, System Architecture and Data Flow, System Operation.
Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition.
Automated Process Planning - Variant Approach, Generative Approach, Expert Systems for Process Planning, Feature Recognition, Phases of Process planning. Knowledge Based System for Equipment Selection (KBSES) - Manufacturing system design. Equipment Selection Problem, Modeling the Manufacturing Equipment Selection Problem, Problem Solving approach in KBSES, Structure of the KRSES.
Group Technology: Models and Algorithms Visual Method, Coding Method, Cluster Analysis Method, Matrix Formation - Similarity Coefficient Method, Sorting-based Algorithms, Bond Energy Algorithm, Cost Based method, Cluster Identification Method, Extended CI Method. Knowledge Based Group Technology - Group Technology in Automated Manufacturing System. Structure of Knowledge based system for group technology (KBSCIT) — Data Base, Knowledge Base, Clustering Algorithm.

References

1. Andrew Kusiak, Intelligent Manufacturing Systems, Prentice Hall, 1990
2. H. R. Parsaei, Mohammad Jamshidi, Design and Implementation of Intelligent Manufacturing Systems: From Expert Systems, Neural Networks, to Fuzzy Logic, Prentice Hall PTR, 1995
3. Kesheng Wang, Applied Computational Intelligence in Intelligent Manufacturing Systems, Advanced Knowledge International, 2005

Department Elective Course-I
(PEC-01) Microcontroller Architecture and Programming

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the basic principles of Microcontroller based design and development.
2. design real world applications using Microcontroller
3. understand interfacing technologies and itsapplications.
4. Identify problem and strategy for designing the solution using appropriate Microcontrollers.

Syllabus Contents:

Introduction to Microprocessors: Registers - File registers - Memory Organization - Tristate logic – Buses - Memory Address register – Read/Write operations. ROM, RAM, PROM, EPROM, E2PROM. Introduction to elementary processor – Organization - Data Transfer Unit (DTU)operation - Enhanced Data Transfer Unit (EDTU) – opcode - machine language - assembly language - pipeline and system clock. Architecture of 8085 – Addressing modes - Data transfer, data processing and program flow control instructions - Simple assembly language programs.

Introduction to Microcontrollers: PIC16F877 Architecture - Program and Data memory organization - Special Function Registers - Addressing modes, Instruction set. MPLAB Integrated Development Environment – Introduction to Assembly language and Embedded C programming – Stack – Subroutines - Interrupt structure – Peripherals – Input/Output Ports.

PIC Peripherals: Timers/Counters - Watchdog Timer – Capture/Compare/PWM (CCP) - Analog to Digital Converter(ADC) – EEPROM - Serial Communication – USART - Development of Application Programs and interfacing - LED, LCD, Keyboard, DC and Stepper motor interface. Introduction to 8051 Microcontroller: Architecture – Ports - Timers.

References

1. Kenneth J. Ayala, “The 8051 Microcontroller Architecture, Programming & Applications”, Penram International.
2. Raj Kamal, “Embedded Systems: Architecture , Programming and Design”, Tata McGraw-Hill Education, 2008.

(PCC-01) Knowledge Engineering and Expert System

Teaching Scheme
Lectures : 2 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Explain and describe the concepts central to the creation of knowledge bases and expert systems.
2. use the tools and the processes for the creation of an expert system.
3. conduct an in-depth examination of an existing expert system with an emphasis on basic methods of creating a knowledge base
4. examine properties of existing systems in a case-study manner, comparing differing Approaches
5. Demonstrate proficiency developing applications in expert system shell

Course Contents:

Introduction, The history of knowledge-based expert systems, Characteristics of current expert systems, Basic concepts for building expert systems.
Building and Expert System, The architecture of expert systems, Constructing an expert system, including computer inference and knowledge acquisition; knowledge representation schemes; conceptual date analysis; plausible reasoning techniques, Tools for building expert systems .
Evaluating an Expert System, Reasoning about reasoning, validation and measurement methods; production-rule programming, Issues and case studies
Language and Tools for Knowledge Engineering, A Case Study in Knowledge Engineering

References

1 Buchanan, B. B. & Shortliffe, E. H. Building Expert Systems with Production Rules: The Mycin Experiments. Addison-Wesley Publishing Company
2. Davis, R. & Lenat, D. B. Knowledge-Based Systems in Artificial Intelligence. McGraw-Hill International Book Company
3. Hayes-Roth, F., Waterman, D. A. & Lenat, D. B. (eds) Building Expert Systems. Addison-Wesley Publishing Company, Inc.
4. Torsun, I. S. Expert Systems: State of the Art , Addison-Wesley Publishing Company

(PCC-02) Fundamentals of Robotics

Teaching Scheme
Lectures : 2 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the basic components of robots.
2. Differentiate types of robots and robot grippers.
3. Model forward and inverse kinematics of robot manipulators.
4. Analyze forces in links and joints of a robot.

5. Programme a robot to perform tasks in industrial applications.
6. Design intelligent robots using sensors.

Robotics-Introduction-classification with respect to geometrical configuration (Anatomy), Industrial robots specifications. Selection based on the Application. Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability-Dynamic characteristics- speed of motion, load carrying capacity & speed of response-
Sensors – Characteristics of sensing devices, Criterion for selections of sensors, Classification, & applications of sensors. Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & 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 & design.
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.
Introduction to AI, relevance of AI with robotics.

References

1. John J. Craig, Introduction to Robotics, Pearson Education Inc., Asia, 3rd Edition, 2005
2. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
4. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
5. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
6. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
7. Mikell Groover, Mitchell Weiss, Roger N. Nagel, Nicholas Odrey, Ashish Dutta, Industrial Robotics 2nd edition, SIE , McGraw Hill Education (India) Pvt Ltd (2012)
8. R. D. Klafter, Thomas A. Chmielewski, and Mechael Negin, Robotic Engineering – An Integrated Approach, EEE, Prentice Hall India, Pearson Education Inc. (2009)

(PCC-03) Artificial Intelligence and Neural Networks

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz - 40
	End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Use different machine learning techniques
2. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning
3. Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents, artificial neural networks
4. Demonstrate proficiency developing applications in AI and Machine Learning.
5. Demonstrate an ability to share in discussions of AI, its current scope and limitations, and societal implications.

Course Contents:

Overview: foundations, scope, problems, and approaches of AI. Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.

Problem-solving through Search: forward and backward, state-space, blind, heuristic, problem reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.

Knowledge Representation and Reasoning: ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications.

Planning: planning as search, partial order planning, construction and use of planning graphs. Representing and Reasoning with Uncertain, Applications of AI(vision/robotics etc.)

Introduction to Machine Learning & Predictive Modeling Types of AI-ML problems - Mapping of Techniques - Regression vs. classification vs. segmentation vs. Forecasting, Major Classes of Learning Algorithms -Supervised vs Unsupervised Learning

Neural Network: Basic neuron models: McCulloch-Pitts model and the generalized one, distance or similarity based neuron model, radial basis function model, Basic neural network models: multilayer perceptron, distance or similarity based neural networks, associative memory and self-organizing feature map, radial basis function based multilayer perceptron, neural network decision trees, etc.

Basic learning algorithms: the delta learning rule, the back propagation algorithm, self-organization learning, the r4-rule, Applications: pattern recognition, function approximation, information visualization.

References

1. Russell, Stuart and Norvig, Peter, Artificial Intelligence: A Modern Approach" Prentice Hall, 2003.
2. Aleksander, Igor and Burnett, Piers ,Thinking Machines Oxford, 1987.
3. Bench-Capon, T. J. M., Knowledge Representation: An approach to artificial intelligence Academic Press, 1990.
4. Genesereth, Michael R. and Nilsson, Nils J, Logical Foundations of Artificial Intelligence Morgan Kaufmann,1987.
5. Michael Negnevitsky, Artificial Intelligence: A Guide to Intelligent Systems (3rd Edition)
6. Vinod Chandra S.S., Anand Hareendran S, " Artificial Intelligence And Machine Learning"
7. Luger " Artificial Intelligence", Edition 5, Pearson, 2008
8. Jacek M. Zurada, Introduction to Artificial Neural Systems, PWS Publishing Company, 1995.
9. Simon Haykin, Neural Networks: A Comprehensive Foundation, Macmillan College Publishing Company, 1994.
10. Mohamad H. Hassoun, Foundamentals of Artificial Neural Networks, The MIT Press, 1995.

(PCC-04) Sensor and Actuators in Robotics

Teaching Scheme	**Examination Scheme**
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz -40
	End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Analyze sensory systems in robotics.
2. Select the sensor for robotic application and design the system.
3. Analyze actuators and configuring the parameters of Actuators

Syllabus Contents

Anatomy of Robotic system,

Types of sensors: Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors Ultrasonic sensors, Touch and Slip sensors. sensors for motion and position, Force , torque and tactile sensors, Flow sensors, Temperature sensing devices,

Vision Sensors :- Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation.

Advanced Sensor Technology - Smart sensors, MEMS based sensors, Innovations in sensor technology

Actuators and its selection while designing a robot system. Types of transmission systems, Electric Actuators - Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotatory actuators, Piezo electric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper motors Servomotors.

Pneumatic & Hydraulic actuators - Hydraulic and pneumatic power actuation devices Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators , design considerations and selection, pneumatic cylinders , pneumatic drive system, Linear & rotary actuators.
Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, underactuated robotic hand

References

1. Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.
2. Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd ed. Berlin ; Heidelberg: Springer, 2008. ISBN 9783540705338.
3. Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
4. D. Patranabis, Sensors and Transducers, PHI, 2nd Ed 2013
5. Jon S.Wilson, Sensor Technology Handbook, Elsevier, 2005
6. Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007
7. S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013
8. Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008

(LC-01) Robot Programming

Teaching Scheme	**Examination Scheme**
Practicals : 2 hrs/week	Term work : 100

Course Outcomes: The students will be able to

1. use fundamental and technical knowledge of robot Programming
2. learn Robot Programming using teach Pendant for various applications
3. use RAPID Language and AML
4. Program using Robot studio software

Contents

1. Robot Programming using Flex Pendant- Lead through programming including Coordinate systems of Robot,
2. Wrist Mechanism-Interpolation-Interlock commands
3. VAL language commands motion control, hand control, program control, pick and place applications,
4. Palletizing applications using VAL,
5. Object detection and Sorting
5. Robot welding application using VAL program-
6. RAPID Language and AML
7. Programming using Robot studio software

(LC-02) Microcontroller Programming Laboratory

Teaching Scheme
Practicals : 2 hrs/week

Examination Scheme
Term work : 100

Course Outcomes: The students will be able to

1. Program the Arduino Microcontroller for various applications
2. Interface basic sensors with Arduino
3. Use GSM & Bluetooth module on Arduino
4. Use Raspberry Pi for different applications
5. Program the microcontroller using C and Python

Contents

1. Arduino microcontroller I/O and interfacing
2. Basic sensors interfacing with Arduino
3. Networking with Arduino: GSM and Bluetooth
4. GPS and data logging with Arduino
5. Raspberry Pi microcomputer I/O and interfacing
6. Microcontroller programming using C+ & Python

(LC-03) AI Based Programming Tools Laboratory

Teaching Scheme
Practicals : 2 hrs/week

Examination Scheme
Term work : 100

Course Outcomes: The students will be able to

1. use python editors and IDE's
2. understand Jupyter notebook &Spyder
3. use Modules for Machine Learning
4. use AI based Programming tools and ANN experiments

Assignments based on :

1. Python Editors &IDE's (Pycharm, Jupyter, Spyder etc…) ·
2. Understand Jupyter notebook &Spyder and Installing & loading Packages & Name Spaces·
3. Introduction to strings, Tuples, Lists, Dictionaries. List, Set and Dictionary Comprehensions
4. Modules for Machine Learning (scikit-learn library, scipy, nltk)
5. AI based programming tools like Classical AI - LISP, Prolog, TensorFlow
6. H20.AI ,Cortana and IBM WATSON
7. ANN virtual lab experiments : http://cse22-iiith.vlabs.ac.in/

Semester II

Department Elective Course-II
(PEC-02) Autonomous Robots and Telecherics

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz -40
End-Sem Exam- 60 marks

Course outcomes: The students will be able to

1. learn principles of working of autonomous robots
2. demonstrate the sensing, perception, and cognition of autonomous robots
3. understand anatomy of autonomous robots
4. Understand operation of Humanoid robot
5. Understand principles of operation of telecheric robots

Introduction to the fundamentals of mobile robotics, basic principles of locomotion, Kinematics and Mobility, Classification of mobile robots, AI for Robot Navigation.
Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots, mobile manipulators, Current challenges in mobile robotics.

Autonomous Mobile Robots – need and applications, sensing, localisation, mapping, navigation and control.
The Basics of Autonomy (Motion, Vision and PID), Programming Complex Behaviors (reactive, deliberative, FSM), Robot Navigation (path planning), Robot Navigation (localization), Robot Navigation (mapping), Embedded electronics, kinematics, sensing, perception, and cognition,

Telecheric robots – Concepts of teleoperations, Need and applications of Telecheric robots, Humanoid Robots, Swarm Robotics, Robot Applications and Ethics.

References

1. Designing Autonomous Mobile Robots, John M Holland, Elsevier, 2004
2. Morgan Quigley , Brian Gerkey, Programming Robots with ROS, Quigley et al, O'Rielly Publishers, Murphy 2000.
3. Autonomous Mobile Robots, Edited by Shuzhi Sam Ge, Frank L Lewis, Taylor and Francis, 2006
4. Roland Siegwart, Illah Reza Nourbakhsh, Davide Scaramuzza, Introduction to Autonomous Mobile Robots", MIT Press, 2nd Edition, 2011.
5. Peter Corke, Robotics Vision and Control, Springer 2011.

Department Elective Course-II
(PEC-02) Advanced Artificial Intelligence

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz -40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Explain in detail how the techniques in the perceive-inference-action loop work
2. Choose, compare, and apply suitable basic learning algorithms to simple applications
3. Ability to explain how deep neural networks are constructed and trained, and apply deep neural networks to work with large scale datasets
4. Understand and develop deep reinforcement learning algorithms for suitable applications

Syllabus Contents

Overview of Probability Theory, Bayes Networks, Independence, I-Maps, Undirected Graphical Models, Bayes Networks and Markov Networks, Local Models, Template Based Representations, Exact Inference: Variable Elimination; Clique Trees, Belief Propagation Tree Construction,

Intro to Optimization, Approximate Inference: Sampling, Markov Chains, MAP Inference, Inference in Temporal Models, Learning Graphical Models : Intro Parameter Estimation, Bayesian Networks and Shared Parameters, Structure Learning, Structure Search Partially Observed Data, Gradient Descent, EM, Hidden Variables, Undirected Models, Undirected Structure Learning, Causality, Utility Functions, Decision Problems, Expected Utility, Value of Information, Decision-Making: basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample application

References

1. Daphne Koller and Nir Friedman Probabilistic Graphical Models, MIT Press, 2009.
2. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach by, 3rd Edition.
3. Christopher Bishop, Pattern Recognition and Machine Learning, Springer-Verlag New York, 2006.
4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning. MIT Press. 2017
5. Sebastian Raschka, Python Machine Learning. Packt Publishing. 2016.

Department Elective Course-II
(PEC-02) Mechatronics System Design

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Demonstrate how mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products that are useful in everyday life.
2. Apply theoretical knowledge: understanding selection of suitable sensors and actuators; designing electro-mechanical systems.
3. Work with mechanical systems that include digital and analogue electronics as a data acquisition model.

Course Contents:

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.

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.

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.

References

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
4. and Processes, Chapman and Hall, London, 1991.
5. Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
6. Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher.

Department Elective Course-II
(PEC-02) Advanced Control System

Teaching Scheme
Lectures :3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Demonstrate non-linear system behavior by phase plane and describing function methods
2. Perform the stability analysis nonlinear systems by Lyapunov method
3. Develop design skills in optimal control problems
4. Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z domain (transfer function using z-transform).
5. Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
6. Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers

Syllabus Contents

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. 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 Functionals Of Single Function, Constrained Minimization. Minimum Principle. 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.

References

1. K. Ogata, Modern Control Engineering, Prentice Hall of India, 3rd edition, 1998
2. I.J. Nagarath 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

Department Elective Course-III
(PEC-03) Advanced Robotics Programming

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz - 40
	End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the basic principles of Robotics programming and development.
2. Design real world applications using available software.
3. Understand integration technologies and its applications.
4. Identify problems in integrating the system / simulations / programming.

Prerequisites: Knowledge of i) ROS1, 2) C/C++ 3) Python and 4) Robot fundamentals

Syllabus Contents :

Introduction to ROS2 :- Architectural overview of the Robot Operating System, Framework and setup with ROS2 environment, ROS2 workspace structure, essential command line utilities. ROS2 nodes, topics, services, parameters, actions and launch files. Programming nodes, topics, services, actions with C/C++/Python. Real time programming with ROS2.
Robot Simulation Engines - Physics simulations of Robots with Gazebo, Mujoco and Pybullet C++/Python APIs.
Path Planning :- Intro to Path Planning and Navigation, Classic Path Planning, Number of classic path planning approaches that can be applied to low-dimensional robotic systems. Coding the BFS and algorithms in C++. Sample-Based and Probabilistic Path Planning and improvement using the classic approach. Programming in Moveit framework.
Motion Planning, Mapping and SLAM :- Use of EKF ROS package to a robot to estimate its pose. Monte Carlo Localization :- The Monte Carlo Localization algorithm which uses particle filters to estimate a robot's pose. Build MCL in C++ :- Coding the Monte Carlo Localization algorithm in C++. Simultaneous Localization and Mapping (SLAM) implementation with ROS2 packages and C++. Combining mapping algorithms with the localization concepts.
Introduction to the Mapping and SLAM concepts and algorithms. Occupancy Grid Mapping :- Mapping an environment with the Occupancy Grid Mapping algorithm.
Grid-based FastSLAM:- Simultaneous mapping an environment and localize a robot relative to the map with the Grid-based FastSLAM algorithm.
Introduction to Microros :- Concepts of microros, Client library, features of microros, real time operating systems (RTOS- Free RTOS, Zephyr), implementation of microros on ARM/ESP32 based microcontrollers.

List of Assignments / Practical :

1. Nodes, topics in ROS2
2. Services, actions in ROS2
3. Mujoco and Gazebo Simulations
4. Motion planning with Moveit2
5. Simulation of 6-dof manipulator in ROS2
6. Simulation of autonomous vehicle in ROS2
7. Microros implementation on ESP32
8. Microros implementation on STM32L4 Discovery kit IoT

References

1. Learning ROS for Robotics Programming, Aaron Martinez, Enrique Fernandez, PACKT publishing, 2013
2. Programming Robots with ROS, Morgan Quigley, Brian Gerkey, & William D Smart, SPD Shroff Publishers and Distributors Pvt Ltd., 2016
3. Mastering ROS for Robotics Programming: Design, build, and simulate complex robots using the Robot Operating System, Lentin Joseph, PACKT publishing, 2015

Department Elective Course-III
(PEC-03) Deep Learning

Teaching Scheme
Lectures : 3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes:

Student will be able to

1. Understand the fundamentals of neural networks.
2. Design feed forward networks with backpropagation.
3. Analyze neural networks for performance.
4. Apply attention mechanism to the neural network.

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.

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.

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

References:

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

Department Elective Course-III
(PEC-03) Micro Electro Mechanical Systems

Teaching Scheme
Lectures: 3 hrs/week

Examination Scheme
100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40Marks, End Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the scope, importance and application of miniaturized products
2. Analyse and Demonstrate design skills of MEMS devices and products
3. Select a relevant microfabrication/ micromachining technique
4. Select an appropriate microsensor and microactuator in a given application.
5. Recommend a suitable packaging technique or method for a MEMS product.

Syllabus Contents:

Introduction
Overview of MEMS & Microsystems: Evolution of microsensors, MEMS & microfabrication – typical MEMS and Microsystems and miniaturization – applications of Microsystems.
Materials demand for Extreme conditions of operation, material property mapping, Processing, strengthening methods, treatment and properties
MEMS materials: Overview of Smart Materials, Structures and Products Technologies Smart Materials (Physical Properties) Piezoelectric Materials, Electrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials, Magneto rheological Fluids Electro rheological Fluids, Shape Memory Materials, Bio-Materials, metal matrix composites (MMC), their applications in aerospace and automobiles, Super-plastic materials
Micro manufacturing/Micro fabrication
Preparation of the substrate, Physical Vapour Deposition, Chemical Vapour Deposition, Ion Implantation, Coatings for high temperature performance, Electrochemical and spark discharge and Plasma coating methods, electron beam and laser surface processing, Organic and Powder coatings, Thermal barrier coating, LIGA process
Micro sensors
Smart Sensor, Actuator and Transducer Technologies, Smart Sensors: Accelerometers; Force Sensors; Load Cells; Torque Sensors; Pressure Sensors; Microphones; Sensor Arrays
Micro actuators

Smart Actuators: Displacement Actuators; Force Actuators; Power Actuators; Vibration Dampers; Shakers; micro Fluidic Pumps; micro Motors Smart Transducers: Ultrasonic Transducers; Sonic Transducers

References

1. Tai Ran Hsu, MEMS and Microsystems: Design and Manufacture, , Tata McGraw Hill, 2002.
2. M.V. Gandhi and B.S. Thompson, Smart Materials and Structures, Chapman & Hall, London; New York, 1992 (ISBN: 0412370107).
3. Westbrook J.H & Fleischer R.L., Micro sensors, MEMS and smart Devices, Julian W. Gardner & Vijay K. Varadan, John Wiley & Sons, 2001.
4. A.V. Srinivasan, Smart Structures: Analysis and Design, , Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).
5. B. Culshaw, Smart Structures and Materials, , Artech House, Boston, 1996 (ISBN:

Department Elective Course-III
(PEC-03) Control of Robotic Systems

Teaching Scheme
Lectures :3 hrs/week

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Demonstrate non-linear system behavior by phase plane and describing function methods
2. Perform the stability analysis nonlinear systems by Lyapunov method
3. Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z domain (transfer function using z-transform).
4. Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
5. Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers

Basics of robotic system's kinematics and dynamics : Forward and inverse dynamics. Properties of the dynamic model and case studies. Introduction to nonlinear systems and control schemes. Symbolic Modelling of Robots for Direct Kinematic Model and inverse kinematics.
System Stability and Types of Stability Lyapunov stability analysis, both direct and indirect methods. Lemmas and theorems related to stability analysis.
Joint Space and Task Space Control Schemes Position control, velocity control, trajectory control and force control. Description of Force Control tasks, Force Control Strategies, Hybrid Position / Force Control, Impedance Force / Torque Control.
Nonlinear Control Schemes Proportional and derivative control with gravity compensation, computed torque control, sliding mode control, adaptive control, observer based control and robust control.

Optimal Control: Introduction - Time varying optimal control – LQR steady state optimal control – Solution of Ricatti's equation – Application examples.
Nonlinear Observer Schemes: Design based on acceleration, velocity and position feedback. Numerical simulations using software packages.

Text Books:

1. R K Mittal, I J Nagrath, Robotics and Control, TMGH Publishing Co Lmt, 2003.
2. R Kelly, D. Santibanez, LP Victor and Julio Antonio, "Control of Robot Manipulators in Joint Space", Springer, 2005.
3. A Sabanovic and K Ohnishi, "Motion Control Systems", John Wiley & Sons (Asia), 2011.
4. R M Murray, Z. Li and SS Sastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press, 1994.
5. J J Craig, "Introduction to Robotics: Mechanics and Control", Prentice Hall, 2004. 3. J J E Slotine and W Li, "Applied Nonlinear Control", Prentice Hall, 1991.
6. Sebastian Thrun, Wolfram Burgard, Dieter Fox, "Probabilistic Robotics", MIT
7. Carlos, Bruno, Georges Bastin, "Theory of Robot Control", Springer, 2012.

MLC
(MLC-01) Research Methodology and Intellectual Property Rights

Teaching Scheme	**Examination Scheme**
Lectures : 2 hr/week	Assignments/Presentation/Quiz/Test

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Understand research problem formulation and approaches of investigation of solutions for research problems
2. Learn ethical practices to be followed in research
3. Apply research methodology in case studies
4. Acquire skills required for presentation of research outcomes (report and technical paper writing, presentation etc.)
5. Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario
6. Study the national & International IP system

Research Methodology

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis
Plagiarism , Research ethics
Effective technical writing, how to write report, Paper
Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

Intellectual Property Rights

Introduction to the concepts Property and Intellectual Property, Nature and Importance of Intellectual Property Rights, Objectives and Importance of understanding Intellectual Property Rights
Understanding the types of Intellectual Property Rights: -Patents-Indian Patent Office and its Administration, Administration of Patent System – Patenting under Indian Patent Act , Patent Rights and its Scope, Licensing and transfer of technology, Patent information and database. Provisional and Non Provisional Patent Application and Specification, Plant Patenting, Idea Patenting,
Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies
New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development,
International Scenario: WIPO, TRIPs, Patenting under PCT

References:

1. Aswani Kumar Bansal : Law of Trademarks in India
2. B L Wadehra : Law Relating to Patents, Trademarks, Copyright, Designs and Geographical Indications.
3. G.V.G Krishnamurthy : The Law of Trademarks, Copyright, Patents and Design.
4. Satyawrat Ponkse: The Management of Intellectual Property.
5. S K Roy Chaudhary & H K Saharay : The Law of Trademarks, Copyright, Patents
6. Intellectual Property Rights under WTO by T. Ramappa, S. Chand.
7. Manual of Patent Office Practice and Procedure
8. WIPO : WIPO Guide To Using Patent Information
9. Resisting Intellectual Property by Halbert ,Taylor & Francis
10. Industrial Design by Mayall, Mc Graw Hill
11. Product Design by Niebel, Mc Graw Hill
12. Introduction to Design by Asimov, Prentice Hall
13. Intellectual Property in New Technological Age by Robert P. Merges, Peter S. Menell, Mark A. Lemley

MLC
(MLC-02) Effective Technical Communication

Teaching Scheme	**Examination Scheme**
Lectures : 1 hr/week	100M: 4 Assignments (25M each)

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Produce effective dialogue for business related situations
2. Use listening, speaking, reading and writing skills for communication purposes and attempt tasks by using functional grammar and vocabulary effectively
3. Analyze critically different concepts / principles of communication skills
4. Demonstrate productive skills and have a knack for structured conversations
5. Appreciate, analyze, evaluate business reports and research papers

Contents

Fundamentals of Communication,7 Cs of communication, common errors in English, enriching vocabulary, styles and registers

Aural-Oral Communication, The art of listening, stress and intonation, group discussion, oral presentation skills

Reading and Writing
Types of reading, effective writing, business correspondence, interpretation of technical reports and research papers

References:

1. Raman Sharma, "Technical Communication", Oxford University Press.
2. Raymond Murphy "Essential English Grammar" (Elementary & Intermediate) Cambridge University Press.
3. Mark Hancock "English Pronunciation in Use" Cambridge University Press.
4. Shirley Taylor, "Model Business Letters, Emails and Other Business Documents" (seventh edition), Prentise Hall
5. Thomas Huckin, Leslie Olsen "Technical writing and Professional Communications for Non-native speakers of English", McGraw Hill.

(PCC-05) Machine Learning and Big Data Analytics

Teaching Scheme
Lectures : 2 hrs/week
Tutorial:1 Hr

Examination Scheme
T1/T2/ Assignments/ Quiz -40
End-Sem Exam- 60. marks

Course Outcomes: The students will be able to

1. Apply concepts and techniques of Machine Learning.

2. Develop the skills in using recent machine learning software for solving practical problems.
3. Apply a set of well-known supervised, semi-supervised and unsupervised learning algorithms
4. Learn big data platforms and use analytic Processes
5. Sample the Data in a Stream

Syllabus Contents

Introduction- overview of machine learning- 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. 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. Clustering Methods-Partitioned based Clustering - K-means- K-medoids; Hierarchical Clustering - Agglomerative- Divisive- Distance measures; Density based Clustering - DBScan; Spectral clustering.

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

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

References

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.
5. Shai Shalev-Shwartz, Shai Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014.
6. John Mueller & Luca Massaron, “Machine Learning For Dummies“, John Wiley & Sons, 2016
7. Arshdeep Bahga, V. Madisetti, Big Data Science & Analytics: A Hands On Approach,VPT, 2016
8. 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

(PCC-06) Embedded Control System

Teaching Scheme	Examination Scheme
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz - 40
	End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand Concepts of Embedded system
2. Design and Selection of a Real Time operating system.
3. Use of Development tools and Programming

Contents

Introduction to Embedded Systems, Its Architecture and system Model, Introduction to the HCS12/S12X series Microcontrollers, Embedded Hardware Building Block. HCS12 System Description and Programming: The HCS12 Hardware System ,Modes of Operation, The B32 Memory System , The HCS12 DP256 Memory System, Exception Processing–Resets and Interrupts, Clock Functions, TIM, RTI, Serial Communications, SPI-Serial Peripheral Interface, I2C, HCS12 Analog-to-Digital Conversion System.

Basic Input /Output Interfacing Concepts: Input Devices, Output Devices and their Programming, Switch Debouncing, Interfacing to Motor, LCDs, Transducer, The RS-232 Interface and their Examples.

Development tools and Programming: Hardware and Software development tools, C language programming, Codewarior tools- Project IDE, Compiler, Assembler and Debugger, JTAG and Hardware Debuggers, Interfacing Real Time Clock and Temperature Sensors with I2C and SPI bus.

Real-time Operating Systems (RTOS): Basic concepts of RTOS and its types, Concurrency, Reentrancy, Intertask communication, Implementation of RTOS with some case studies..

References

1. Barrett, S.F. and Pack, J.D., Embedded Systems, Pearson Education (2008).
2. Haung, H.W., The HCS12 / 9S12: An Introduction to Software and Hardware Interfacing, Delmar Learning (2007).
3. Fredrick, M.C., Assembly and C programming for HCS12 Microcontrollers, Oxford University Press (2005).
4. Ray, A.K., Advance Microprocessors and Peripherals – Architecture, Programming and Interfacing, Tata Hill (2007).–McGraw

(PCC-07) Robot Kinematics and Dynamics

Teaching Scheme	**Examination Scheme**
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz -40
Tutorial:1 Hr	End-Sem Exam- 60 marks

Syllabus Contents

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.
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.
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 & types of control schemes for robots – joint space control schemes and task space control schemes with an examples.

References

1. Siciliano, Bruno. Robotics : Modelling, planning & control. London: Springer, 2009.
2. Corke, Peter I. Robotics, vision and control : fundamental algorithms in Matlab. 1st ed. New York: Springer, 2011. ISBN 978- 3-642-20143-1.
3. Kelly R, Santibanez V and Loria A, ―Conrol of Robot Manipulators in Joint Space‖, Springer, 2005.
4. Devendra K Chaturvedi, ―Modeling and Simulation of Systems using MATLAB and Simulink , CRC press, 2010
5. J.J. Craig,"Introduction to Robotics: Mechanics & Control",3rd Ed, Addison-Wesley (2003).
6. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
7. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019).
8. Asitava Ghoshal, Robotics :Fundamental concepts & analysis, Oxford Univ. Press (2006).
9. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).

(LC-04) Robot Simulation Laboratory

Teaching Scheme	**Examination Scheme**
Practicals : 2 hrs/week	Term work : 100

Laboratory Experiments:

1. Dynamic model development and simulation of simple mechanical systems using Matlab and Mathematica.
2. Numerical simulation of simple mechanical systems.
3. Stability analysis of simple mechanical systems using linear system theory namely root locus and Bode plot.
4. State space model development and dynamic simulation using Simulink.

(LC-05) Software Laboratory for ROS and SLAM

Teaching Scheme	**Examination Scheme**
Practicals : 2 hrs/week	Term work : 100

Course Outcomes: The students will be able to

1. Learn fundamentals, including key ROS concepts, tools, and patterns
2. Program robots that perform an increasingly complex set of behaviors, using the powerful packages in ROS
3. See how to easily add perception and navigation abilities to your robots
4. Integrate your own sensors, actuators, software libraries, and even a whole robot into the ROS ecosystem
5. Learn tips and tricks for using ROS tools and community resources, debugging robot behavior using C++ in ROS

Laboratory Experiments:

1. Endowing mobile autonomous robots with planning, perception, and decision-making capabilities
2. Trajectory optimization
3. Robot motion planning and perception
4. Robot, localization, and simultaneous localization and mapping
5. Robot Operating System (ROS) for demonstrations and hands-on activities

(LC-06) Embedded Control System laboratory

Teaching Scheme	**Examination Scheme**
Practicals : 2 hrs/week	Term work : 100

1. Programming of HCS12 with Code warrior for Interrupts, Clock Functions,
2. TIM, RTI, SPI, LCD interfacing,
3. Use of JTAG and Hardware Debuggers, Interfacing Keypad,
4. ADC, DAC, LCD, Real Time Clock
5. Temperature Sensors with I2C and SPI bus
6. Interface 7 segment LED to 8051 to generate flashing action
7. Interface Analog to Digital converter to 8051 and display the result on LCD display
8. Interface Digital to Analog converter to 8051 and view the output on CRO Interface stepper motor to 8051 it through given number of steps
9. Perform serial communication using 8051
10. Descentralized motion control and Centralized motion control
11. Feed-forward compensation,
12. Force control,
13. Visual servoing
14. Stepper motor control (Single motor and two motor).
15. Linear controller (P,PI,PD and PID) design for simple position control of mechanical systems.

Semester-III

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1	VSEC-01	VSEC-01	Dissertation Phase – I	--	--	18	12	9
2	SLC-01	SLC-01	Massive Open Online Course –I	3	--	--	3	3
			Total Credits	3	--	18	15	12

Semester III

Dissertation Phase – I

Teaching Scheme

Practical work 18 hr/week

Examination Scheme

Term Work & Oral Exam: -- 100 Marks

Course Outcomes:

Students will demonstrate the ability to:

1. Identify the case study for a practical problem from industry or research problem.
2. Carry out An extensive literature review will help them in understanding the latest happenings in the field.
3. understand and analyze the problem.

Project should be Industry requirements involving detail analysis or development of the industrial case studies related to Robotics & artificial Intelligence as per the common instructions for all branches of M.Tech

* Massive Open Online Course –I

-MOOC courses available during the academic year through SWAYAM or NPTEL
-Earlier MOOC courses available on various portals

Massive Open Online Course –I - Internet of Things (IoT), Industry 4.0 and Industrial Internet of Things (IIoT)

Teaching Scheme

Examination Scheme

Self learning | T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the drivers and enablers of Industry 4.0
2. Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services
3. Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world
4. Appreciate the power of Cloud Computing in a networked economy
5. Understand the opportunities, challenges brought about by Industry 4.0 and how organisations and individuals should prepare to reap the benefits

Syllabus Contents:

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

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,

Basics of Industrial IoT, Industrial Sensing & Actuation, Industrial Internet Systems. IIoT-Introduction, IIoT Business Model and Reference Architecture, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT 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 IIoT, Data Center Networks, Security and Fog Computing, Cloud Computing in IIoT, 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, IIoT Case studies Self

References

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", (Universities Press

Semester-IV

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme				Credits
				L	T	P	SS	
1	VSEC	VSEC-02	Dissertation Phase – II	--	--	18	12	9
2	SLC	SLC-02	Massive Open Online Course – II	3	--	--	3	3
			Total Credits	3	--	18	15	12

Semester IV

Dissertation Phase – II

Teaching Scheme
Practical work 18 hr/week

Examination Scheme
Term Work & Oral Exam: -- 100 Marks

Course Outcomes:

1. Students will be able to apply the techniques learned during the course.
2. Student will be able to provide solution to the problem
3. Student will be in a position to publish their work in conference and Journals.

Project should be research oriented experimental work, involving detail analysis or development of the industrial case studies related to Robotics & Artificial Intelligence as per the common instructions for all branches of M.Tech.

* Massive Open Online Course –II

-MOOC courses available during the academic year through SWAYAM or NPTEL
-Earlier MOOC courses available on various portals

Massive Open Online Course –II - Design for IoT and Advanced IoT Applications

Teaching Scheme
Self learning

Examination Scheme
T1/T2/ Assignments/ Quiz - 40
End-Sem Exam- 60 marks

Course Outcomes: The students will be able to

1. Understand the challenges of energy power, data explosion
2. Carry out calculations of battery life and other components
3. Select and recommend sensors and protocols for next generation automobiles

4. Provide design solutions in various areas such as cargo monitoring etc.

Syllabus Contents

Introduction to IOTs, Improving Quality of Life, Challenges to solve in IOTs, Energy Power, Data Explosion, System design of an IOT System, Power supply, Processor, Memory Sensor Interface, Wireless Interfaces, LAN - BLE, Wi-Fi, RFID WAN - LORA, LTE-M, Sigfox, NB-IOT,
Power supply design, LDOs, Switching regulators, BuckBoost Converters, Energy Measurements Energy harvesting and battery life calculation, PV, RF , Kinetic Energy, TEGs, aeroelastic flutter, Harvesting ICs in silicon, Protocols, IoT MAC, REST based COAP, Publish subscribe-- MQTT , AMQP, MDNS, Building an IOT System - Case Studies - Joule Jotter, Chhaya

Advanced IoT Applications

First responder IoT networks, Sensors and protocols for next generation automobiles, Automotive IoT, Speech to text processing, Air quality monitoring, Localization in IoT, Smart, energy monitoring, Cargo monitoring

References

1. Arshdeep Bahga, Vijay Madiseti, Internet of Things -