Bharatiya Vidya Bhavan's

SARDAR PATEL COLLEGE OF ENGINEERING

(Government Aided Autonomous Institute under Mumbai University) Andheri (W), Mumbai – 400058

COURSE CONTENTS

MINOR IN ROBOTICS

Academic Year: 2024-2025

List of Courses

MRB01 Introduction to Robotics

MRB02 Mechanics of Robotics

MRB03 Microprocessor and Embedded System1

MRB04 Control of Robotic Systems

MRB05 Project in Robotics

Course Code: MRB01 Course:-Introduction to Robotics (AY 2024-25)

Course Objectives:

To familiarize students with basic terminologies of the robotics sciences and essential knowledge required to get started in the field of Robotics.

Course Outcomes:

At the end of the course the students shall be able to

1. Explain terminology used in robotics
2. Select sensors and drive based on application
3. Write code for robotic applications

Course Content

Module	Details	Hrs
1	**Introduction to robotics :** Brief History, Basic Concepts of Robotics such as Definition , Three laws, Elements of Robotic Systems i.e. Robot anatomy, DOF, Misunderstood devices etc., Classification of Robotic systems on the basis of various parameters such as work volume, type of drive, etc., Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device etc., Introduction to Principles & Strategies of Automation, Types & Levels of Automations, Need of automation, Industrial applications of robot.	07
2	Grippers **and Sensors for Robotics:** Grippers for Robotics - Types of Grippers, Guidelines for design for robotic gripper, Force analysis for various basic gripper system. Sensors for Robots - Types of Sensors used in Robotics, Classification and applications of sensors, Characteristics of sensing devices, Selections of sensors. Need for sensors and vision system in the working and control of a robot.	07
3	**Drives and Control for Robotics:** Drive – Types of Drives, Types of transmission systems, Actuators and its selection while designing a robot system. Control Systems: Types of Controllers, Introduction to closed loop control.	07
4	**Programming and Languages for Robotics**: Robot Programming: Methods of robot programming, WAIT, SIGNAL and DELAY commands, subroutines, Programming Languages: Generations of Robotic Languages, Introduction to various types such as VAL, RAIL, AML, Python, ROS etc., Development of languages since WAVE till ROS.	07

5	**Related Topics in Robotics:** Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and standards, Introduction to Artificial Intelligence, AI techniques, Need and application of AI, New trends & recent updates in robotics.	07

Text Books:-

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014)
2. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
3. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
4. R. K. Mittal, I. J. Nagrath, Robotics and Control, TATA McGraw Hill Publishing Co Ltd, New Delhi (2003)
5. S. B. Niku, Introduction to Robotics – Analysis, Contro, Applications, 3rd edition, John Wiley & Sons Ltd., (2020)
6. J. Angeles, Fundamentals of Robotic Mechanical Systems Theory Methods and Algorithms, Springer (1997)
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)

Sr. No.	Examination	Module
1	T – I	1
2	T – II	2-3
3	Final exam	1-5

Course Code: MRB02 Course:-Mechanics of Robotics (AY 2024-25)

Course Objectives:

To inculcate thorough understanding about basic knowledge of mathematics, kinematics and dynamics required for understanding motion programming and operational / control functionality in robotics

Course Outcomes:

At the end of the course the students shall be able to

1. explain terminologies related to Kinematics and Dynamics of Robotics.
2. Apply mathematics for manipulator positioning and motion planning.
3. Analyse basics of motion programming as per kinematics.
4. Estimate the force/torque required to drive a robot.

Course Content

Module	Details	Hrs
1	**Mathematical Preliminaries of Robotics:** Spatial Descriptions: positions, orientations, and frame, mappings: changing description from frame to frame, Operators: translations, rotations and transformations, transformation arithmetic, compound Transformations, inverting a transform, transform equations, Euler Angles, Fixed Angles, Euler Parameters.	07
2	**Robot Kinematics:** Manipulator Kinematics, Link Description, Link to reference frame connections, Denavit-Hartenberg Approach, D-H Parameters, Position Representations, Homogeneous Transformation Matrix, Forward Kinematics. Inverse Kinematics, Geometric and analytical approach.	07
3	**Velocities & Statics**: Cross Product Operator for kinematics, Jacobians - Direct Differentiation, Basic Jacobian, , Jacobian Jv / Jw, Jacobian in a Frame, Jacobian in Frame {0}, Kinematic Singularity, Kinematics redundancy.	07
4	Force balance equation, Forces, Velocity/Force Duality, Virtual Work, Force ellipsoid, Jacobian, Kinematic Singularity, Kinematics redundancy, Mechanical Design of robot linkages,	07
5	**Robot Dynamics:** Introduction to Dynamics, Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton – Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration.	07

Text Books:-

1. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).
2. Dilip Kumar Pratihar, Fundamentals of Robotics, Narosa Publishing House, (2019)
3. Asitava Ghoshal, Robotics: Fundamental concepts and analysis, Oxford University Press (2006)
4. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).
5. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).

Sr. No.	Examination	Module
1	T – I	1
2	T – II	2-3
3	Final exam	1-5

Course Code: MRB03 Course:-Microprocessor and Embedded Systems

(AY 2024-25)

Course Objectives:

To discuss the detailed functioning of microprocessors and the role of embedded systems in a robotic system.

Course Outcomes:

At the end of the course the students shall be able to

1. Prepare block diagrams for any robotic control-hardware design,
2. Select appropriate flow of embedded systems for a specific application.
3. Write code for micro controller devices.
4. Use advanced embedded processor and software

Course Content

Module	Details	Hrs
1	**Introduction to Embedded Systems and microcomputers:** Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded System Models, Embedded System development cycle, Challenges for Embedded System Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics.	07
2	**Microprocessor:** 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts. Introduction to C language, Instruction format, C language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor.	07
3	**Microprocessor Interfacing:** Introduction to interfacing, Memory Interfacing, Programmable Peripheral Interfacing, Programmable I/O, Programmable Interrupt Controller, Programmable Timers, Programmable DMA Controller, Programmable Key Board Controller, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing. Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, addressing modes, Instruction sets, Assembly and C programming for	07

	Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller.	
4	**Microcontroller Interfacing:** Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor.	07
5	**Introduction to Advanced Embedded Processor and Software:** ARM Processor, Unified Model Language (UML), Embedded OS, Real Time Operating System (RTOS), Embedded C.	07

Text Books:-

1. K. V. Shibu, Introduction to Embedded Systems, McGRAW Hill Publications (2009).
2. Raj Kamal, Embedded Systems, TATA McGRAW Hill Publications (2003).
3. M. Morris Mano, Computer System Architecture, 3ed, Pearson Publication, (2007).
4. D. V. Hall, 8086 Microprocessors and Interfacings, TATA McGRAW Hill, (2005).
5. B. B. Brey, The Intel Microprocessors, Prentice Hall Publications, 8th ed, (2018).
6. M. A. Mazidi, R.D. Mckinlay and D. Casey, PIC Microcontrollers and Embedded Systems, Pearson Publications, (2008).
7. M. Predko, Programming and Customizing the PIC Microcontroller, McGRAW Hill Publications. 3ed, (2017).

Sr. No.	Examination	Module
1	T – I	1
2	T – II	2-3
3	Final exam	1-5

Course Code: MRB04 Course:-Control of Robotics Systems (AY 2024-25)

Course Objectives:

To develop the understanding of control systems, its designing and application..

Course Outcomes:

At the end of the course the students shall be able to

1. Apply linear, non-linear control systems Course Content
2. Design motion control algorithms

Module	Details	Hrs
1	**Basics of Control time Domain:** Differential Equation, Modeling of physical systems, Transient response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design.t.	07
2.	**Basics of Control frequency Domain:** Transfer function, Frequency response, Bode, polar, Nyquist plot, phase lead and phase-lag design, lag-lead design.	07
3	**Linear Control:** Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, P, PI & PID Controller, control law partitioning, modeling and control of a single joint.	07
4	**Non-Linear Control System:** Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, the control problems for manipulators.	07
5	**Motion Control**: Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system.	07

Text Books:-

1 M. Gopal, Control Systems, McGraw-Hill (2012)

2. K. Ogata, "Modern Control Engineering", Prentice Hall India (2009).

3. M. Spong, M. Vidyasagar, S. Hutchinson, Robot Modeling and Control, Wiley & Sons, (2005).

4. J. J. Craig, "Introduction to Robotics: Mechanics and Control", 3rd edition, Addison-Wesley (2003).

5. S. K. Saha, Introduction to Robotics 2e, TATA McGraw Hills Education (2014).

6. Thomas Kailath, "Linear Systems", Prentice Hall (1980).

7. Alok Sinha, “Linear Systems: Optimal and Robust Control”, Taylor & Francis (2007).

Sr. No.	Examination	Module
1	T – I	1
2	T – II	2-3
3	Final exam	1-5

Course Code: MRB05 Course:-Project in Robotics (AY 2024-25)

Course Objective:
To assimilate the theoretical knowledge gained in the lecture courses (MINOR R-1 to 4) for real-life practical applications in order have effective learning and skill-development, mainly, from the point of view of the employability in industries.

Course Outcomes:

1. To Practice how to work together in a team.
2. To apply the theoretical knowledge learnt from other courses,which is required by an industry.
3. To learn how to make presentation in a team. A soft skill needed in research and industry.
4. Peer learning from the evaluation of other teams' work. A skill which is essential when one is in a workforce.
5. To examine different hardware components and their working/control using software.

The projects should include

a. Literature Survey.

b. Algorithm development

c. Design/synthesis

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COURSE CONTENTS

MINOR DEGREE
IN
AI and Machine Learning

Year: 2024-2025

List of Courses

MML-01 Introduction to AI and Machine Learning

Course Pre-requisites: Mathematics, Knowledge of programming language (Python preferred)

Course Objective:

The students after studying these topics should be able to

1. understand applications of Artificial Intelligence and Machine Learning for engineering applications
2. apply suitable algorithms for simple engineering problems

Course Outcomes:

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

1. discuss applications of Artificial Intelligence for engineering problem solving
2. apply fundamental concepts in machine learning and select popular machine learning algorithms for engineering problem solving
3. compose computer code for solving problems using machine learning algorithms
4. explain advanced machine learning concepts such as Neural Network, Reinforcement Learning.

Course Content:

Module No.	Details	Hrs.
01	Fundamental Concepts of AI, Agents, Environments, General Model, Problem Solving Techniques, uninformed search techniques, Heuristic search.	4
02	Knowledge representation, Propositional and predicate calculus	3
03	Introduction to Machine Learning Learning algorithm: Supervised and Unsupervised Learning,	3
04	Linear, multivariate regression, overfitting/underfitting and regularization,	4
05	Training/Testing/Validation datasets, Model evaluation metrics, Feature reduction and Principal Component Analysis (PCA)	4
06	Classification Algorithms: Logistic regression, Naive Bayes, Instance based learning: K-Nearest Neighbors (KNN) classifiers, Support Vector Machine, Kernel function and Kernel SVM, Decision trees	6
07	Clustering: k-means, DBSCAN and hierarchical clustering	4

Term Work/Laboratory:

- Journal work shall consist of e-folder with computer code for solution to problems based on each module.
- Seminar
- Mini-project

Text Books:

1. Saroj Kaushik, Artificial Intelligence, Cengage Learning, 1st Edition 2011.
2. Anindita Das Bhattacharjee, "Practical Workbook Artificial Intelligence and Soft Computing for beginners, Shroff Publisher-X team Publisher.
3. Yuxi (Hayden) Liu, "Python Machine Learning by Example", Packet Publishing Limited, 2017.Tom Mitchell, Machine Learning, First Edition, McGraw- Hill (1997).
4. Stuart Russel and Peter Norvig, Artificial Intelligence – A modern approach, Pearson (2015)
5. Ethem Alpaydin, Introduction to Machine Learning, PHI (2015).
6. Gopal M., Applied Machine Learning, McGraw Hill (2018)

Corresponding Online Resources:

1. Artificial Intelligence, https://swayam.gov.in/nd2_cec20_cs10/preview

Sr. No.	Examination	Module
1	T-I	1,2
2	T-II	3,4
3	End Sem	1 to 7

MML-02 Introduction to Data Analytics
Course Pre-requisites: Introduction to Machine Learning

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

1. Explain how data is collected, managed and stored for data science;
2. Discuss the key concepts in data science, including their real-world applications and the toolkit used by data scientists;
3. Implement data visualization tools
4. Implement data collection and management scripts using MongoDB

Course Content:

Module No	Details	Hrs.
01	Introduction to Data Science, Different Sectors using Data science, Purpose and Components of Python in Data Science.	7
02	Data Analytics Process, Knowledge Check, Exploratory Data Analysis (EDA), EDA- Quantitative technique, EDA- Graphical Technique, Data Analytics Conclusion and Predictions.	7
03	Feature Generation and Feature Selection (Extracting Meaning from Data)	4
04	Motivating application: user (customer) retention- Feature Generation (brainstorming, role of domain expertise, and place for imagination)- Feature Selection algorithms.	7
05	Data Visualization- Basic principles, ideas, and tools for data visualization,	7
06	Examples of inspiring industry projects for data visualization - Exercise: create your own visualization of a complex dataset.	3
07	Applications of Data Science, Data Science and Ethical Issues- Discussions on privacy, security, ethics- A look back at Data Science- Next-generation data scientists.	7

Lab Work:

1. Python Environment setup and Essentials.
2. Mathematical computing with Python (NumPy).
3. Scientific Computing with Python (SciPy).
4. Data Manipulation with Pandas.
5. Prediction using Scikit-Learn
6. Data Visualization in python using matplotlib

Text books:

1. Joel Grus, Data Science from Scratch, Shroff Publisher Publisher /O'Reilly Publisher Media
2. Annalyn Ng, Kenneth Soo, Numsense! Data Science for the Layman, Shroff Publisher Publisher
3. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk from The Frontline. O'Reilly Publisher Media.

4. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.
5. Jake VanderPlas, Python Data Science Handbook, Shroff Publisher Publisher /O'Reilly Publisher Media
6. Philipp Janert, Data Analysis with Open Source Tools, Shroff Publisher Publisher /O'Reilly Publisher Media.

Sr. No.	Examination	Module
1	**T-I**	1, 2
2	**T-II**	3, 4
3	**End Sem**	1 to 7

M**ML-03 Deep Learning and Neural Network**
Course Pre-requisites: Introduction to Machine Learning

Course Outcomes:
At the end of the course the students shall be able to
1. design Artificial Neural networks.
2. decide when to use which type of NN.
3. discuss application of CNN and RNN
4. implement NN using online libraries

Course Content:

Module No.	Details	Hrs
1.	Neural network: Perceptron, multilayer network	4
2.	Information flow in a neural network, Backpropagation, understanding basic structure and ANN.	6
3.	Training a Neural network, how to determine hidden layers, Deep Neural Networks	6
4.	Convolutional neural networks, image classification and CNN.	8
5.	RNN and LSTMs: Applications of RNN in real world.	8
6.	Case studies in application of Deep Learning to analyse industrial problems	4
7.	Creating and deploying networks using Tensor Flow and Keras.	6

Lab Work:
1. Introduction to Kaggle and how it can be used to enhance visibility.
2. Build general features to build a model for text analytics.
3. Build and deploy your own deep neural network on a website using tensor flow.

Text Books:

1. John Paul Mueller, Luca Massaron, Deep Learning for Dummies, John Wiley & Sons.
2. Adam Gibson, Josh Patterson, Deep Learning, A Practitioner's Approach, Shroff Publisher /O'Reilly Publisher Media.
3. Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford.
4. Russell Reed, Robert J Marks II, Neural Smithing: Supervised Learning in Feedforward Artificial Neural Networks, Bradford Book Publishers.

Corresponding Online Resources:
1. Fuzzy Logic and Neural Networks, https://swayam.gov.in/nd1_noc20_ge09/preview

Sr. No.	Examination	Module
1.	**Test-I**	1,2
2.	**Test-II**	3,4
3.	**End Sem**	1 to 7

MML-04 Special Topics in AI and Machine Learning
Course Pre-requisites: Introduction to AI and Machine Learning

Course Outcomes:

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

1. Discuss various advanced AI techniques.
2. Discuss Reinforcement learning
3. Describe techniques to process audio, image and natural language processing
4. To correlate the AI and solutions to modern problem

Module no.	Details	Hrs
1	Recommender systems, Introduction to Reinforcement Learning	**4**
2	Self-Play Networks, Generative Adversarial Networks, Learning from Concept-Drifting Data Streams.	**4**
3	Audio Signal Processing Basics, mirtoolbox contains many useful audio processing library functions, VOICEBOX: Speech Processing Toolbox for MATLAB, Audio processing in Matlab.	**4**
4	Natural Language Processing (NLP): Knowledge in Speech and Language processing, ambiguity and models and algorithm	**4**
5	Image processing: Digital Image Representation, Fundamental Steps in Image Processing, Elements of a Digital Image Processing System	**4**
6	Emotion Recognition using human face and body language, AI based system to predict the diseases early, Smart Investment analysis, AI in Sales and Customer Support.	**4**
7	AI-Optimized Hardware, Digital Twin i.e. AI Modelling, Information Technology & Security using AI.	**4**

Term work:

1. Assignments based on above modules
2. Seminar based on recent advances in the course

Text / Reference Books:

1. Dr. Nilakshi Jain, Artificial Intelligence: Making a System Intelligent, John Wiley & Sons.
2. Artificial Intelligence & Soft Computing for Beginners, 3rd Edition-2018, by Anindita Das, Shroff Publisher Publisher.
3. Artificial Intelligence: A Modern Approach, 3rd Edition, by Stuart Russell and Peter Norvig, Pearson Publisher.
4. New Artificial Intelligence (Advanced), Takashi Maeda and Fumio Aoki, Ohmsha Publisher.
5. Sameer Dhanrajani, AI and Analytics, Accelerating Business Decisions, John Wiley & Sons.
6. Life 3.0: Being Human in the Age of Artificial Intelligence by Max Tegmark, published July 2018.

7. Homo Deus: A Brief History of Tomorrow by Yuval Noah Harari, published March 2017.
8. Artificial Intelligence in Practice: How 50 Successful Companies Used AI and Machine Learning to Solve Problems, Bernard Marr, Matt Ward, Wiley.

Sr. No.	Examination	Module
1	**T-I**	1, 2
2	**T-II**	3, 4
3	**End Sem**	1 to 7

MML-05 Project on Applications of AI and Machine Learning
Pre-requisite Courses: recommended - all courses till semester VI

Course Outcomes:

1. Student will be able to integrate the knowledge of the fundamentals of subjects to search the related literature and devise solution
2. Student will be able to use knowledge for formulation / fabrication of the desired project
3. Student will be able to analyze the available resources and to select most appropriate one
4. Student will be able to apply principles of ethics and standards, skill of presentation and communication techniques

Course content:

Sr.no.	Description	Hrs./week
1	Student shall study the topic of project work and define problem statement. The student shall evolve design and/or do experimental study and/or fabricate engineered device to obtain solution to the identified problem. The student shall prepare a report and shall present a seminar on the basis of work done at the end of semester.	**2 (contact) + 6 (self-study)**