AUTONOMOUS

SYLLABUS

V & VI Semesters

B.E in Robotics and Artificial Intelligence

2023

MITE

Invent Solutions

MANGALORE INSTITUTE OF TECHNOLOGY & ENGINEERING

Institute Vision

*"To attain perfection in providing **Globally Competitive Quality Education** to all our Students and also benefit the global community by using our strength **in Research and Development**"*

Institute Mission

*"To establish world class educational institutions in their respective domains, which shall be **Centers of Excellence** in their stated and implied sense. To achieve this objective, we dedicate ourselves to meet the challenges of becoming **Visionary and Realistic, Sensitive and Demanding, Innovative and Practical,** Theoretical **and Pragmatic**; ALL at the same time"*

Department Vision

Emerge as a center of excellence in Robotics and Artificial Intelligence by nurturing students to become innovative, ethical, and socially responsible technologists who can contribute to national development and global technological advancement.

Department Mission

- *To Impart strong knowledge in Robotics, Artificial Intelligence, and allied domains, fostering innovation and technical competence.*
- *To Equip students with industry-relevant tools and state-of-the-art technologies to address real-world challenges.*
- *To Promote critical thinking, interdisciplinary learning, research, and entrepreneurship for societal benefit.*
- *To Inculcate professional ethics, effective communication, teamwork, and lifelong learning among students.*

Program Educational Objectives (PEOs)

After successful completion of the program, the graduates will be able

- *To Apply the principles of Robotics and Artificial Intelligence to design, develop, and deploy intelligent systems in diverse applications.*
- *To Excel in professional careers, advanced studies, or entrepreneurial ventures through continuous learning, skill enhancement and adaptability to emerging technologies*
- *To Demonstrate ethical responsibility, leadership, and societal impact while contributing to sustainable technological advancement.*

Program Specific Outcomes (PSOs)

At the end of the program, graduates will be able to

- *Apply the Knowledge of Mechanical systems, Electronics, and AI/ML techniques to design intelligent robotic solutions for real-world applications.*
- *Design, develop, and implement robotic systems by integrating sensors, actuators, embedded hardware, and software platforms to meet the needs of industry and society.*

LIST OF COURSES

V / VI Semester Courses			
Sl. No.	**Course Code**	**Course Title**	**Sem**
HUMANITIES & SOCIAL SCIENCE COURSE			
1	23HMCC301	Entrepreneurship, Management & Finance	V
PROFESSIONAL COURSES			
2.	23RIPC302	Kinematics & Dynamics of Robotics	V
3.	23RIPC303	Embedded Systems	V
4.	23RIPC304	Deep Learning	V
5.	23RIPC305	Robot Simulation & Programing Laboratory	V
6.	23RIPC306	Control Systems	VI
7.	23RIPC307	Machine Vision	VI
8.	23RIPC308	Robot Operating System Laboratory	VI
SKILL ENHANCEMENT COURSE			
9	23RISE309	Project Phase I	VI
PROFESSIONAL ELECTIVES COURSES			
10	23RIPE311	Cyber Physical Systems	V
11	23RIPE312	Object Oriented Programming with C++	V
12	23RIPE313	Modern Robotics	V
13	23RIPE321	Cyber Security in Robotics	VI
14	23RIPE322	Data Analytics	VI
15	23RIPE323	Autonomous Robots	VI
OPEN ELECTIVES COURSES			
16	23RIOE311	Principles of Robotics	V
17	23RIOE312	Robotics for Electronics Manufacturing	V
18	23RIOE313	Human Robot Interaction	V
19	23RIOE321	AI Robots	VI
20	23RIOE322	AI Risks,Ethics and Governance	VI
21	23RIOE323	Robot Dynamics and Control	VI
NON-CREDIT MANDATORY COURSES			
22	23NMCC321	Yoga-III	V
23	23NMCC322	Physical Education-III	V
24	23NMCC323	National Service Scheme – III	V
25	23NMCC324	Arts-III	V
26	23NMCC325	Yoga-IV	VI
27	23NMCC326	Physical Education-IV	VI
28	23NMCC327	National Service Scheme - IV	VI
29	23NMCC328	Arts-IV	VI

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V Semester (2023 Scheme): Robotics and Artificial Intelligence

Sl. No	Course Code	Course Title	Category	Teaching Dept.	Teaching Hours /Week			Exam Marks			Duration of Exam (SEE) in Hrs	Credits
					L	T	P	CIE	SEE	Total		
1	23HMCC301	Entrepreneurship, Management & Finance	Humanities & Social Sciences	MBA/Any Department	3	0	0	50	50	100	3	3
2	23RIPC302	Kinematics & Dynamics of Robotics	Professional Core	RAI	3	0	0	50	50	100	3	3
3	23RIPC303	Embedded Systems	Professional Core	RAI	3	0	2	50	50	100	3	4
4	23RIPC304	Deep Learning	Professional Core	RAI	2	0	2	50	50	100	3	3
5	23RIPC305	Robot Simulation & Programing Laboratory	Professional Core	RAI	0	1	3	50	50	100	2.5	2
6	23RIPE31X	Professional Elective -I	Discipline Specific Electives	RAI	3	0	0	50	50	100	3	3
7	23RIOE31X	Open Elective -I	Open Electives	RAI	3	0	0	50	50	100	3	3
8	23NMCC32X	Yoga/Physical Education/NSS/Arts**	Non-Credit Mandatory Course	Yoga Teacher/ PED/NSS Coordinator/ Cultural Coordinator	0	0	1	100	-	100	-	-
										Total Credits		**21**

Note: MOOC Requirements

- Students are required to register and successfully complete one MOOC (Massive Open Online Course) of 8 or 12 weeks duration, offered through the NPTEL/SWAYAM platforms, between the 6th and 7th semesters.
- The list of eligible courses shall be approved and notified by the Board of Studies (BoS) of the respective discipline at least 15 days before the start of the semester.

- The successfully completed MOOC will be considered equivalent to a Professional Elective carrying 2 credits, which will be accounted for in the 8th semester. Students must submit the course completion certificate and the official scorecard issued by NPTEL as proof of completion.
- **Failure Policy:** Students who are unable to clear the MOOC in two consecutive attempts during the 6th and 7th semesters will be allowed to register for a Professional Elective course offered by the department in online mode during the 8th semester to earn the required 2 credits. SEE will be conducted by the department in the offline mode.

Professional Elective Courses-I

Sl. No	Course Code	Course Title
1	23RIPE311	Cyber Physical Systems
2	23RIPE312	Object Oriented Programming with C++
3	23RIPE313	Modern Robotics

Open Elective Courses-1

Sl. No	Course Code	Course Title
1	23RIOE311	Principles of Robotics
2	23RIOE312	Robotics for Electronics Manufacturing
3	23RIOE313	Human Robot Interaction

****Yoga/Physical Education/NSS/Arts:**

Sl.No.	Course Code	Course Title
1	23NMCC321	Yoga-III
2	23NMCC322	Physical Education-III
3	23NMCC323	NSS-III
4	23NMCC324	Arts-III

**Note: ** ** To be offered from 3rd to 6th Semester

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VI Semester (2023 Scheme): Robotics and Artificial Intelligence

Sl. No.	Course Code	Course Title	Category	Teaching Dept.	Teaching Hrs /Week			Exam Marks			Duration of Exam (SEE) in Hrs	Credits
					L	T	P	CIE	SEE	Total		
1	23RIPC306	Control Systems	Professional Core	RAI	2	2	0	50	50	100	3	3
2	23RIPC307	Machine Vision	Professional Core	RAI	3	0	2	50	50	100	3	4
3	23RIPC308	Robot Operating System Laboratory	Professional Core	RAI	0	1	3	50	50	100	2.5	2
4	23RISE309	Project Phase – I	Skill Enchancement	RAI	0	0	6	50	50	100	3	3
5	23RIPC31X	Professional Elective -II	Professional Core	RAI	3	0	0	50	50	100	3	3
6	23RIOE32X	Open Elective-II	Humanities & Social Sciences	RAI	2	0	0	50	50	100	3	3
7	23NMCC32X	Yoga/ Physical Education /NSS/Arts**	Non-Credit Mandatory Course	Yoga Teacher/ PED/NSS Coordinator/ Cultural Coordinator	0	0	1	100	-	100	-	-
											Total	**18**

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Professional Elective Courses-I

Sl. No	Course Code	Course Title
1	23RIPE321	Cyber Security in Robotics
2	23RIPE322	Data Analytics
3	23RIPE323	Autonomous Robots

Open Elective Courses-1

Sl. No	Course Code	Course Title
1	23RIOE321	AI Robots
2	23RIOE322	AI Risks, Ethics and Governance
3	23RIOE323	Robot Dynamics and Control

****Yoga/Physical Education/NSS/Arts:**

Sl.No.	Course Code	Course Title
1	23NMCC325	Yoga-IV
2	23NMCC326	Physical Education-IV
3	23NMCC327	NSS-IIV
4	23NMCC328	Arts-IV

Note: ** To be offered from 3rd to 6th Semester

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V-Semester

VI-Semester

Entrepreneurship, Management & Finance			
Semester	**V**	CIE Marks	**50**
Course Code	**23HMCC301**	SEE Marks	**50**
Teaching Hrs/Week (L: T: P)	**3:0:0**	Exam Hrs	**3**
Total Hours	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart key competencies, qualities, and skills of entrepreneurship
2. Provide insights into the pathways to new venture creation and concepts of management in organizations
3. Familiarize the functions of management and financial aspects of an organization

Module 1: Entrepreneur and Entrepreneurship	**No. of Hrs: 8**

Entrepreneur: Definition, Entrepreneurial competencies, Characteristics of Entrepreneurs, Qualities of an entrepreneur, Entrepreneurial skills. Developing Entrepreneurial competencies, Classification of Entrepreneurs, Entrepreneur vs Professional Managers
Entrepreneurship: Concept, Phases of Entrepreneurship Development, Fostering Entrepreneurship, Barriers to Entrepreneurship, Factors influencing Entrepreneurship

Textbook 1: Chapter 2, 3and 10

Module 2: Opportunities and pathways to Entrepreneurship	**No. of Hrs: 8**

Opportunity identification, Sources of Innovative ideas, Entrepreneurial imagination, and creativity: Concept of Creativity, Rules, Components, Process or phases of creativity, the critical thinking process
Pathways to new ventures: Creating New ventures, Acquiring an established venture, Franchising

Textbook 2: Chapter 5 and 6

Module 3: Introduction to Management	**No. of Hrs: 8**

Management: Nature, Objectives, Importance. Difference between administration and management. Levels of management, Types of managers, Managerial skills, Managerial Competencies, Scope or Functional areas of management.

Textbook 3: Chapter 1

Module 4: Management Functions	**No. of Hrs: 9**

Functions of Management: Planning, Organizing, Staffing, Directing and Controlling.
Planning: Meaning, Features, Importance, Types, and steps. Organizing: Meaning, Need, Principles, and Process. Staffing: Meaning, Nature, and Process. Directing: Meaning, Need, Elements and Techniques. Controlling: Meaning, Need, Characteristics, Steps, and Types.

Textbook 3: Chapter 3, 4, 5 and 6

Module 5: Business Organizations and Finance	**No. of Hrs: 9**

Forms of Business Organization: Sole proprietorship, Partnership, Cooperative Society, and Company. Financial decisions in a firm, Goal of Financial Management, Fundamental principle of finance, building blocks of modern finance, Risk-return tradeoff, Emerging role of financial manager in India, Cost profit volume analysis; Profit volume ratio, Break Even Analysis and Margin of safety

Textbook 4: Chapter 1- Section 1.1, 1.2,1.3, 1.4, 1.5, 1.6 and 1.11
Chapter 13 – Section 13.4

Course Outcomes: At the end of the course, the student will be able to

1. Outline the entrepreneurial skills & qualities required for business development
2. Describe the processes of opportunity identification, creativity, and pathways to establishing new ventures
3. Explain the fundamental concepts of management
4. Apply the functions of management in decision-making
5. Apply financial management principles to assess financial decisions, and determine cost-profit-volume relationship

Textbooks:

1. Vasanth Desai, "The Dynamics of Entrepreneurial Development and Management", 6th Edition, Himalaya Publishing House, 2018
2. Donald F. Kuratko and T.V. Rao, "Entrepreneurship: A South Asian Perspective", 1st Edition, Cengage Learning, 2017
3. Chandrani Singh and Aditi Khatri, "Principles and Practices of Management and Organisational Behaviour", 5th Edition, Sage Texts, 2021
4. Prasanna Chandra, "Financial Management- Theory and Practice",10th Edition, Mc Graw Hill, 2022

Reference Books:

1. Deependra Sharma, "Entrepreneurship in India",1st Edition, Routledge India, 2023
2. Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, and Sabyasachi Sinha, "Entrepreneurship", 11th Edition, McGraw Hill, 2022
3. Charanthimath Poornima M, "Entrepreneurship Development and Small Business Enterprises", 3rd Edition, Pearson, 2018

Web links:

1. Introduction to Entrepreneur: https://www.youtube.com/watch?v=rbmz5VEW90A
2. Pathways to new creations: https://www.youtube.com/watch?v=zkgbss81QKE
3. Concepts of Management: https://www.youtube.com/watch?v=GZ2dmbDmB5I
4. Functions of Management: https://www.youtube.com/watch?v=Vq8GChMK5Zg
5. Types of Business Organizations: https://www.youtube.com/watch?v=UGSlED1Jx1Y

Kinematics and Dynamics for Robotics			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPC302**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Objectives: This course is designed to

1. Impart knowledge on the topological structure of configuration spaces and the mathematical modeling of rigid body motions using exponential coordinates.
2. Familiarize methods to compute forward and inverse kinematics using the Product of Exponentials formula and analyze velocity relationships using Jacobian matrices.
3. Provide knowledge on dynamic modeling formulations, including Lagrangian, and the effects of actuation, gearing, and friction on robot performance.

Module 1: Configuration Space & Rigid-Body Motions	**No. of Hrs: 9**

Degrees of Freedom of a Rigid Body, Robot Joints, Grübler's Formula, Topology and Representation, Configuration Space Topology, Configuration Space Representation, Configuration and Velocity Constraints. Rigid-Body Motions in the Plane, Rotations and Angular Velocities, Rotation Matrices, Exponential Coordinate Representation of Rotation and Twists.

Textbook 1: 2.1-2.6, 3.1-3.3

Module 2: Forward Kinematics	**No. of Hrs: 8**

Product of Exponentials Formula, First Formulation: Screw Axes in the Base Frame, Second Formulation: Screw Axes in the End-Effector Frame, The Universal Robot Description Format.

Textbook 1: 4.1.1-4.1.3, 4.2

Module 3: Velocity and Inverse Kinematics	**No. of Hrs: 9**

Velocity Kinematics and Statics: Manipulator Jacobian, Space Jacobian, Body Jacobian, Visualizing the Space and Body Jacobian, Relationship between the Space and Body Jacobian, Alternative Notions of the Jacobian,
Analytic Inverse Kinematics: 6R PUMA-Type Arm, Stanford-Type Arms, Numerical Inverse Kinematics, Newton–Raphson Method, Numerical Inverse Kinematics Algorithm, Inverse Velocity Kinematics

Textbook 1: 5.1.1-5.1.6, 6.1-6.4

Module 4: Dynamics of Open Chains	**No. of Hrs: 8**

General Formulation, Understanding the Mass Matrix, Lagrangian Dynamics vs. Newton–Euler Dynamics. Classical Formulation, Twist–Wrench Formulation, Dynamics in Other Frames

Textbook 1: 8.1-8.3

Module 5: Advanced Dynamics and Actuation Modeling	**No. of Hrs: 8**

Dynamic Equations in Closed Form, Forward Dynamics of Open Chains, Dynamics in the Task Space, Constrained Dynamics, Robot Dynamics in the URDF**,** DC Motors and Gearing, Apparent Inertia, Newton–Euler Inverse Dynamics Algorithm for Motor Inertias and Gearing, Friction, Joint and Link Flexibility

Textbook 1: 8.4-8.9

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the fundamental concepts of configuration space topology, rigid body motions, and kinematic formulations for open-chain manipulators.
2. Describe the principles of dynamic modeling methods, actuation characteristics, and the physical constraints affecting robotic systems.
3. Derive the Product of Exponentials formula for forward kinematics, Jacobian matrices for velocity analysis and dynamic equations of motion to determine joint torques.
4. Calculate the degrees of freedom, homogeneous transformation matrices, inverse kinematic parameters, and static forces/torques for robotic mechanisms.
5. Apply kinematic and dynamic models to identify the singularities, stability and workspace constraints of robotic systems.

Textbooks:

1. Kevin M. Lynch, Frank C. Park, Modern Robotics: Mechanics, Planning, and Control, Cambridge University Press, 1st Edition, 2017.

Reference Books:

1. John J. Craig, Introduction to Robotics: Mechanics and Control, Pearson Education, 3rd Edition, 2005.
2. Saeed B. Niku, Introduction to Robotics: Analysis, Control, Applications, Wiley, 3rd Edition, 2020.

Web Links:

1. Modern Robotics: Mechanics, Planning, and Control, https://www.coursera.org/specializations/modernrobotics, Coursera (Northwestern University)
2. Modern Robotics Course Materials, http://modernrobotics.org/, Northwestern University
3. Modern Robotics (YouTube Lecture Series), https://www.youtube.com/playlist?list=PLggLP4f-rq02vXH6ZsA8c3yLk3KQ9e7lI, Northwestern University

Embedded System			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPC303**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:2**	Exam Hrs	**3**
Total Hrs	**64**	Credits	**4**

Course Learning Objectives: This course is designed to

1. Introduce the fundamentals of embedded systems and ARM Cortex-M architecture used in robotic applications.
2. Familiarize students with ARM programming and serial communication devices and protocols for embedded system interfacing.
3. Impart knowledge of RTOS-based embedded system design and **Provide** exposure to embedded robotic system design including differential drive and omni-directional robot.

Module 1: Introduction to Embedded Systems and ARM Cortex-M Architecture	**No of Hrs: 08+02**

Definition, Embedded Systems versus General-purpose systems, classification, Core of the embedded system, memory, embedded firmware, Cortex-M Architecture: Registers, Stack, reset and clock system.

Text Book 1 : Sec 1.1 ,1.2, 1.4, 2.1, 2.2, 2.5

Text Book 2 : Sec 1.1.2 , 1.2 , 1.3

Lab Components :

1. Implement a program to demonstrate ARM Cortex-M register operations (load/store, move, add/sub) and observe results using debugger in register window.

Module 2: ARM cortex-M Assembly language	**No of Hrs : 09+06**

Syntax, addressing modes and operands, twelve instructions set, accessing memory, functions, conditional execution, and stack usage and keil directives.

Textbook 2 : Sec 1.5.1-1.5.4,1.5.5,1.5.7,1.5.8,1.5.10

Lab Components :

1. Implement an ARM Cortex-M4 assembly program to find the sum of N 32-bit integers stored in memory using register indirect addressing mode and store the result in a register.
2. Implement an ARM Cortex-M4 assembly program to find the largest 8-bit number in a given array using CMP instruction and conditional branch instructions.
3. Implement an ARM Cortex-M4 assembly program to perform addition of two 16-bit numbers using a subroutine call and demonstrate stack operation using PUSH and POP instructions.

Module 3: Serial Communication Devices and Protocols	**No. of Hrs: 08+04**

Serial Communication Devices, timer and counting devices, real time clock, network embedded system, serial bus communication bus protocols, and Internet enabled systems-network protocol.

Text book 3: Sec 3.2,3.6,3.8-3.10,3.12

Lab Components:

1. Implement a program to interface UART and perform serial transmit/receive (echo) between MCU and PC terminal.
2. Implement a program to interface I²C protocol to communicate with an external Real Time Clock (RTC) sensor (DS1307) using ARM Cortex-M microcontroller.

Module 4: Introduction to RTOS based embedded system design	**No. of Hrs: 09+04**

Operating System basics, Types of Operating Systems, Tasks, Process, Threads, Multiprocessing and Multi-tasking, Task Scheduling, Threads, Processes- Scheduling putting them together, Task Communication, Task Synchronization, Device Drivers, how to choose an RTOS.
Text book 2: Sec 10.1-10.10

Lab Components:

1. Implement two RTOS tasks with different priorities and observe task scheduling.
2. Implement inter-task synchronization using a binary semaphore to protect a shared variable.

Module 5: Embedded Robotics	**No. of Hrs: 08+06**

Embedded Controllers for robotics, Interfaces, Operating System, Driving Robots, Single Wheel Drive, Differential Drive, Tracked Robots, Synchro-Drive, Mecanum Wheels, Omni-Directional Drive, Kinematics, Omni-Directional Robot Design, Driving Program

Text Book 4 : 1.2-1.4,7.1-7.4,8.1-8.5

Lab Components:

1. Implement a program to simulate differential drive robot motion in EyeSim (forward, reverse, left/right turn).
2. Implement a program to simulate omni-directional robot motion in EyeSim using kinematics-based movement control.

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the architecture and programming of ARM Cortex-M based embedded systems including serial communication protocols, RTOS concepts, and embedded robotic system design principles.
2. Impart ARM programming knowledge to interface serial communication devices and protocols using UART, SPI, I²C, timers, and RTC.
3. Apply RTOS concepts such as task scheduling, synchronization, and inter-task communication in embedded robotic systems.
4. Apply embedded robotic system concepts to implement differential drive and omni-directional robot kinematics for motion control.

Textbooks:

1. Shibu K V, “Introduction to Embedded Systems”, 2nd Edition, Tata McGraw Hill Education, 2017
2. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to ARM Cortex-M Microcontrollers", 2nd Edition, Pearson Education, 2017.
3. Raj Kamal, "Embedded Systems: Architecture, Programming and Design", 2nd Edition, McGraw-Hill Education, 2015.
4. Al-Jazari Institute, “Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems”, 2nd Edition, Springer International Publishing, 2019.

Reference Books:

1. Andrew N. Sloss, Dominic Symes, Chris Wright**,** "ARM System Developer's Guide", Morgan Kaufmann Publishers, 2008.

Web links:

1. Embedded Systems: https://onlinecourses.nptel.ac.in/noc21_cs07/preview, IIT Madras. NPTEL Online Courses
2. ARMBased Embedded Systems: https://onlinecourses.nptel.ac.in/noc22_ee64/preview, IIT Kharagpur. NPTEL Online Courses

Deep Learning			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPC304**	SEE Marks	**50**
Teaching Hrs./Week (L:T: P)	**2:0:2**	Exam Hrs.	**03**
Total Hrs.	**52**	Credits	**03**

Course Learning Objectives: This course is designed to

1. Introduce the fundamental concepts and significance of deep learning.
2. Impart knowledge on training and optimization techniques.
3. Provide insights into generalization and performance improvement methods.
4. Familiarize the deep learning architectures such as Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN).
5. Familiarize the principles of deep reinforcement learning.

Module 1: Fundamentals of Deep Learning	**No. of Hrs: 5+4**

Introduction, Deep Learning Challenges, Training Deep Neural Networks, Setup and Initialization issues, the vanishing and Exploding Gradient Problems, Gradient descent Strategies, Batch Normalization.

Lab Experiments

1. Write a Python program to train a Deep Neural Network (DNN) on MNIST dataset using different weight initialization methods and plot training loss.
2. Write a Python program demonstrating vanishing/exploding gradient problems using Sigmoid and ReLU activations and improve training using Batch Normalization

Text Book 1: 3.1,3.2,3.3,3.4,3.5.1-3.5.6,3.6

Module 2: Generalization in Deep Learning	**No. of Hrs: 5+4**

Introduction, The Bias-Variance Trade off, Generalization Issues in Model Tuning and evaluation, Penalty-based Regularization, Ensemble Methods, Early Stopping.

Lab Experiments

1. Write a Python program to illustrate Bias–Variance tradeoff by training neural networks with varying model complexities and comparing validation accuracy.
2. Write a Python program implementing L1, L2 regularization and Dropout with Early Stopping to improve model generalization.

Text Book 1: 4.1,4.2,4.3,4.4,4.5,4.6

Module 3: Recurrent Neural Network	**No. of Hrs:5 + 6**

Introduction, Architecture of RNN, Challenges of training RNN, Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), Applications of RNN.

Lab Experiments

1. Write a Python program implementing a Simple RNN for sequence prediction or text generation using sequential input data.
2. Write a Python program comparing performance of RNN, LSTM, and GRU models for time-series prediction or sentiment classification.

Text Book 1: 7.1,7.2,7.3,7.5,7.6,7.7.2,7.7.6,7.7.8,7.7

Module 4: Convolutional Neural Networks	**No. of Hrs: 5+6**

9Introduction, Basic structure of a Convolutional Network, Training a Convolutional Network, Case Studies of Convolutional Architecture: Alexnet, VGG, ResNet, Visualization and Unsupervised learning, Application of Convolutional networks

Lab Experiments

1. Write a Python program to design and train a CNN for image classification using MNIST/CIFAR-10 dataset.
2. Write a Python program implementing transfer learning using pretrained CNN models (VGG/ResNet) and visualize convolutional feature maps.

Text Book 1: 8.1,8.2,8.3.,8.4.3,8.4.4,8.4.5,8.5,8.6

Module 5: Deep Reinforcement Learning	**No. of Hrs: 6+6**

Introduction, Stateless Algorithms: Multi armed Bandits, Basic Framework of Reinforcement Learning, Bootstrapping for Value Function Learning, Policy Gradient Methods, Monte Carlo Tree Search.

Lab Experiments

1. Write a Python program simulating a Multi-Armed Bandit problem using random action selection and compute average reward.
2. Write a Python program to implement a basic reward-based agent that learns optimal actions in a simple 1D Grid World environment using Q-table updates.

Text Book 1:9.1,9.2,9.3,9.4,9.5,9.6,9.7.2.2

Course Outcomes:

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

1. Explain deep learning concepts, training processes, optimization challenges, and batch normalization.
2. Articulate generalization and regularization techniques to improve performance and robustness of deep learning models.
3. Apply CNN and RNN models to solve image-based and sequential data problems.
4. Apply deep reinforcement learning principles to model decision-making tasks in dynamic environments.

Textbook:

1. Charu C. Aggarwal, "Neural Networks and Deep Learning", Springer International Publishing, 2018.
2. M. Arif Wani, Farooq Ahmad Bhat, Saduf Afzal, Asif Iqbal Khan, "Advances in Deep Learning", Springer, 2020.

Reference Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2017.
2. François Chollet, "Deep Learning with Python", Manning Publications, 2018.

Weblinks:

1. Deep Learning, https://nptel.ac.in/courses/106106224, NPTEL (IIT Madras)
2. Deep Learning Specialization, https://www.coursera.org/specializations/deep-learning, Coursera (DeepLearning.AI)
3. CS231n: Convolutional Neural Networks for Visual Recognition, https://cs231n.stanford.edu/, Stanford University

Robot Simulation & Programming Laboratory			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPC305**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**0:1:3**	Exam Hrs	**2.5**
Total Hrs	**36+12**	Credits	**2**

Course Learning Objectives: This course is designed to

1. Introduce fundamental concepts of robot programming and simulation for industrial robotic applications.
2. Provide hands-on experience in programming material handling and process operations using simulation tools and industrial robots.

Introduction to Robot Programming and Simulation	**No. of Hrs: 12**

Robot programming for pick-and-place, sorting, palletising, write-draw and robot-based 3D printing; basic motion control, tool handling, task sequencing; offline simulation in RobotStudio with CAD import and validation; RAPID programming basics, conveyor tracking, and vision-based simulation.

List of Experiments: Robot Programming and Simulation	**No. of Hrs: 36**

1. Simulation of Rectangular Trajectory Generation Using Linear Interpolation in Cartesian Space
2. Simulation of Point-to-Point Drilling Operation on a Single Workpiece
3. Simulation of Multi-Point Drilling Operation Using Loop Structures and Program Control Statements
4. Simulation of Continuous Path Welding Operation Using Smooth Trajectory Planning
5. Simulation of Pick-and-Place Operation Using TCP Configuration and Digital I/O Control
6. Simulation of Palletizing Operation Using Position Offsets and Coordinate Transformation
7. Simulation of Conveyor Tracking Operation Using Dynamic Work Object and Real-Time Position Update
8. Program Development for Pick-and-Place Operation Using Position Teaching, TCP Calibration, and Digital I/O Control
9. Linear Trajectory Generation and Execution Using Cartesian Interpolation and Path Accuracy Control
10. Robot Programming Using VAL (Versatile Assembly Language) for Industrial Task Execution (Virtual Lab)
11. Forward Kinematics Analysis of PUMA 560 Manipulator Using Denavit–Hartenberg Parameters (Virtual Lab)
12. Inverse Kinematics Solution of PUMA 560 Manipulator for End-Effector Positioning (Virtual Lab)

Course Outcomes: At the end of the course, the student will be able to

1. Develop robot programs to execute basic and advanced motion tasks in an industrial robotic environment.
2. Simulate automated pick-and-place and palletizing operations by configuring work objects, tool frames, and motion parameters using robot programming software.
3. Simulate coordinated robotic operations such as multi-component processing and conveyor tracking using industrial robot programming software.

Textbooks:

1. ABB Robotics, “Product Specification: IRB 1600 / IRB 1660”, ABB Robotics, Industrial Robot Documentation.

Reference books:

1. ABB Robotics, "Operating Manual – RobotStudio", ABB Robotics.
2. ABB Robotics, "RAPID Reference Manual", ABB Robotics.

Web Links:

1. Robot Programming and Simulation (NPTEL): https://nptel.ac.in/courses/112/105/112105124/ (IIT Kharagpur)
2. Industrial Robotics – ABB RobotStudio Tutorials: https://new.abb.com/products/robotics/robotstudio
3. RAPID Programming Reference (ABB): https://library.e.abb.com/public/rapid-reference-manual
4. Machine Vision Basics – COGNEX: https://www.cognex.com/support/vision-software/in-sight-explorer

Cyber Physical Systems			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPE311**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce operating principles and characteristics of Cyber-Physical Systems (CPS)
2. Provide knowledge of layered CPS architectures, system dynamics, networking, and decision-making.
3. Introduce real-world applications of Cyber-Physical Systems.

Module 1: Introduction	**No. of Hrs: 8**

Cyber physical systems, Classification of Systems, Uncertainty, information and its different forms, Network types, process of network and applications, decision and actions, forms of decision making, Rule based decision

Text Book 1: 1.1, 2.4, 3.1, 4.3, 5.2, 5.3, 6.1,6.2,6.5

Module 2: The Three Layers of Cyber-Physical Systems	**No. of Hrs: 8**

Introduction, Physical Layer, Measuring, and Sensing Processes, Data Layer and Informing Processes, Decision Layer and Acting Processes, Self-developing Reflexive–Active System and Cyber-Physical Systems, Layer-Based

Text Book 1: 7.1-7.7

Module 3: Communication Technologies	**No. of Hrs: 8**

Data Networks and Wireless Communications, Network Layers and Their Protocols, Network: Edge and Core, IoT, Machine-Type Communications, and 5G, Decentralized Computing and Distributed Ledger Technology, Future Technologies: A Look at the Unknown Future

Text Book 1:Chapter 9.1-9.5

Module 4: Robotics and Smart Systems in Cyber Context	**No. of Hrs: 9**

Robotics Architecture, Design a Cyber-Physical Robotic System, Organization of a Cyber-Physical Robotic System, Applications of Cyber-Physical Robotic System, Energy Usage Awareness in CPS Design, Smart Energy System.

Text Book 2:Chapter 10.4,10.5, 13.2,13.3

Module 5: Applications of CPS	**No. of Hrs: 9**

Cyber-Physical Industrial System, Cyber-Physical Energy System, Cyber-Physical Public Health Surveillance System, Mobile Application for Real-Time Traffic Routes.

Text Book 1: Chapter 10

Course Outcomes: At the end of the course, the student will be able to

1. Explain the fundamental concepts, classifications, and architectural components of Cyber-Physical Systems.
2. Describe the layered architecture, dynamic behavior, and performance characteristics of Cyber-Physical Systems.
3. Apply Cyber-Physical System principles and enabling technologies in real-world applications.

Textbooks:

1. Pedro H. J. Nardelli,"Cyber-physical Systems Theory, Methodology, and Applications",IEEE Press willy, 2022.
2. Gaddadevara Matt Siddesh, Ganesh Chandra Deka, Krishnarajanagar Gopala Iyengar Srinivasa, “Cyber physical Systems a Computational Perspective”, CRC Press, 2016

Reference Books:

1. Rajeev Alur, “Principles of Cyber-Physical Systems”, MIT Press, 2015.
2. Fei Hu,”Cyber Physical Systems Design: Modeling, Simulation and Analysis”, CRC Press, 2017.

Web links:

1. Cyber-Physical Systems: Modeling and Simulation, https://www.coursera.org/learn/cyber-physical-systems-1, Coursera (University of California, Santa Cruz)
2. Cyber Physical System Modeling (Video Lecture), https://www.youtube.com/watch?v=KDTDM6oCUeY, YouTube

Object Oriented Programming with C++			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPE312**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**2:0:2**	Exam Hrs	**3**
Total Hrs	**26+26**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce the fundamental concepts of C++
2. Provide the knowledge of object-oriented principles for problem solving
3. Integrate theory with hands-on laboratory practice

Module 1: Problem Solving Using C++ — **No. of Hrs: 6 + 4**

Introduction to C++, Programming Style, Data Types, Arithmetic Operations, Variables and Declaration Statements,

Text Book 1: 2.1-2.5

Lab Components:

1. Write a C++ program to read values of voltage and current and compute electrical power using P=V×I.
2. Write a C++ program to compute the area and perimeter of a rectangle using appropriate data types and declaration statements.

Module 2: Introduction to Classes — **No. of Hrs: 6+6**

Abstract Data Types in C++ (Classes), Constructors, Calling Constructors, Overloaded and Inline Constructors, Destructors

Text Book 1: chapter 10.1,10.2

Lab Components:

1. Write a C++ Program to define a Box class with private data members (length, width, height) and public member functions to compute area and volume.
2. Write a C++ program demonstrating: Default constructor, Parameterized constructor For a student class
3. Write a C++ program to display the order of execution of constructors and destructors using a simple class.

Module 3: Object Modeling — **No. of Hrs:4+4**

A Case Study: Constructing a Room Object, Object Identification and UML

Text Book 1: Chapter 10.3,10.4

Lab Components :

1. Write a C++ program based on the Room Object case study to calculate area and volume of a room.
2. Write a C++ Write a C++ program to create multiple objects of a class and demonstrate interaction among them (e.g., comparing two rooms).

Module 4: Class Functions and Operator Functions — **No. of Hrs: 4+6**

Assignment, Copy Constructors, Additional Class Features, Static Class Members, Friend Functions, Operator Functions.

Text Book 1: Chapter 11.1-11.3

Lab Components :

1. Write a C++ Program demonstrating copy constructor
2. Write a C++ program to count the number of objects created using a static data member.
3. Write a C++ program to overload the + operator to add two complex numbers.

Module 5: Conversions, Inheritance, and Polymorphism	**No. of Hrs: 6+6**
Data Type Conversions, Class Inheritance, Polymorphism Book 1: Chapter 11.4-11.7 **Lab Components :** 1. Write a C++ program to demonstrate class-to-basic or basic-to-class type conversion. 2. Write a C++ Program illustrating single inheritance with access control 3. Write a C++ Program demonstrating polymorphism using base-class pointers	
Course Outcomes: At the end of the course, the student will be able to	
1. Explain the fundamental concepts of C++. 2. Describe the object oriented programming in C++ 3. Apply C++ fundamentals, statements, and functions, classes to solve programming problems 4. Apply operator overloading and exception handling to develop C++ programs	
Textbooks: 1. Gary J. Bronson, "C++ for Engineers and Scientists", 3rd Edition, Cengage Learning, 2010.	
Reference Books: 1. Bjarne Stroustrup, "The C++ Programming Language" Addison wesley, 4th Edition 2013.	
Web links: 1. Programming in C++, https://nptel.ac.in/courses/106104128, NPTEL (IIT Kharagpur) 2. Object Oriented Programming in C++, https://nptel.ac.in/courses/106105151, NPTEL (IIT Madras) 3. Problem Solving Through Programming in C++, https://onlinecourses.nptel.ac.in, NPTEL (IITs & IISc) 4. Object-Oriented Programming in C++, https://www.coursera.org/learn/object-oriented-programming-in-cpp,	

Modern Robotics			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIPE313**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Impart knowledge on the mathematical formulations of robot trajectory generation, such as point-to-point paths and time-scaling algorithms.
2. Familiarize deterministic and probabilistic motion planning algorithms for navigating complex configuration spaces.
3. Provide knowledge on advanced robot control strategies, including error dynamics, feedforward control, and force control mechanisms.
4. Familiarize kinematic modeling, constraints and motion control of wheeled mobile robots.

Module 1: Trajectory Generation in Robots	**No. of Hrs: 8**

Point-to-Point Trajectories. Polynomial Via Point Trajectories.

Time-Optimal Time Scaling: Phase Plane, Time-Scaling Algorithm, Variation on the Time-Scaling Algorithm, Assumptions and Caveats.

Textbook 1: 9.1-9.4

Module 2: Motion Planning in Robots	**No. of Hrs: 9**

Types of Motion Planning Problems, Properties of Motion Planners, Motion Planning Method.

Configuration Space Obstacles, Distance to Obstacles and Collision Detection, Graphs and Trees, Graph Search.

Complete Path Planners, Multi-Resolution Grid Representation, Grid Methods with Motion Constraints.

Textbook 1: 10.1-10.4

Module 3: Probabilistic Motion Planning and Nonlinear Optimization	**No. of Hrs: 8**

The RRT Algorithm, The PRM Algorithm.

A Point in C-space, Navigation Functions, Workspace Potential, Use of Potential Fields in Planners, Nonlinear Optimization, Smoothing.

Textbook 1: 10.5-10.8

Module 4: Robot Control	**No. of Hrs: 9**

Error Response, Linear Error Dynamics, Motion Control of a Single Joint and Multi-joint Robot, Task-Space Motion Control.

Hybrid Motion - Force Control: Natural and Artificial Constraints, Impedance-Control Algorithm, Admittance-Control Algorithm, Low-Level Joint Force/Torque Control.

Textbook 1: 11.1-11.8

Module 5: Wheeled Mobile Robots	**No. of Hrs: 8**
Types of Wheeled Mobile Robots. Omnidirectional Wheeled Mobile Robots. Nonholonomic Wheeled Mobile Robots. Odometry. Mobile Manipulation. **Textbook 1:** 13.1-13.5	
Course Outcomes: At the end of the course, the student will be able to	
1. Describe the concepts of trajectory generation, time-scaling, and the working principles of probabilistic motion planning algorithms for high-degree-of-freedom robots. 2. Articulate the principles of robot control, including error dynamics and feedforward strategies, and contrast the differences between holonomic and nonholonomic constraints in mobile robotics. 3. Apply node expansion strategies to determine the shortest path sequence in a discretized workspace. 4. Calculate global pose coordinates and individual wheel velocities for differential drive robots using forward and inverse kinematic equations.	
Textbooks: 1. Kevin M. Lynch, Frank C. Park, "Modern Robotics: Mechanics, Planning, and Control",Cambridge University Press, 1st Edition, 2017.	
Reference Books: 1. Frank L. Lewis, Draguna L. Vrabie, Vassilis L. Syrmos, "Optimal Control", John Wiley and Sons, 3rd Edition, 2012. 2. Yuxi Li, "Deep Reinforcement Learning for Robotic Systems", Springer, 1st Edition,2021. 3. Simon Haykin, "Optimization Algorithms for Robotics and Machine Learning", Routledge, 1st Edition, 2019.	
Web links: 1. Modern Robotics Specialization – https://www.coursera.org/specializations/modernrobotics 2. Modern Robotics Course 1 (YouTube) – https://www.youtube.com/watch?v=zrDh66RQb-w 3. Introduction to Robotics (IITM) – https://nptel.ac.in/courses/107106090]	

Principles of Robotics			
Semester	**V**	CIE Marks	**50**
Course Code	**2RIOE311**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Objectives: This Course is designed to

1. Familiarize with the history, evolution, configurations and components of robotic systems.
2. Provide knowledge on the working principles of various sensors, actuators and drive systems used in robotics.
3. Familiarize with robot programming methods and motion interpolation.
4. Provide an overview of advanced robot types such as humanoids, bio-inspired, and soft robots.
5. Introduce the emerging fields of micro-robotics including scaling laws and actuation challenges.

Module 1: Basics of Robotics	**No. of Hrs: 10**

Automation and Robotics. History of Robotics. The Robotics Market and Future Prospects. Robot Anatomy. Work Volume. Robot Configurations. Robot Drive and Control Systems, End Effectors (Grippers and Tools).

Textbook 1: 1.1, 1.3, 1.4, 2.1, 2.2, 2.3, 2.4, 2.6, 5.1-5.4.

Module 2: Sensors and Actuators in Robots	**No. of Hrs: 8**

Sensors in Robotics: Tactile Sensors. Proximity and Range Sensors. Sensor based systems.

Characteristics of Actuating Systems. Hydraulic and Pneumatic Actuators. Electric Motors: DC, AC, Servo & Stepper. Pulse width modulation, Direction Control of DC Motors with an H-Bridge.

Textbook 1: 6.2-6.5
Textbook 2: 9.2, 9.4, 9.5, 9.6.2, 9.6.3, 9.6.6, 9.6.7, 9.7

Module 3: Robot Programming Methods	**No. of Hrs: 7**

Methods of Robot Programming. Lead-through Programming. A Robot Program as a Path in Space. Programming Commands: WAIT, SIGNAL and DELAY Commands. Branching. Capabilities and Limitations of Lead-through Methods.

Textbook 1: 8.1-8.7

Module 4: Micro Robotics	**No. of Hrs: 10**

Scaling Laws for Microrobots: Dynamic Similarity and Non-Dimensional Numbers, Scaling of Surface Area and Volume and Its Implications. Scaling of Mechanical, Electrical, Magnetic, and Fluidic Systems. Surface Forces in Air and Vacuum: van der Waals forces, Capillary forces, Electrostatic forces. Microscale Sensing Principles: Capacitive sensing, Piezoresistive sensing. Piezoelectric Actuation: Unimorph piezo actuators, Bimorph piezo actuators, Piezo film actuators. Shape Memory Materials-Based Actuation

Textbook 3: 2.1-2.3, 3.2.1-3.2.3, 6.1.1, 6.1.3, 6.1.4, 6.2

Module 5: Future Robotic Technologies and Applications	**No. of Hrs: 7**
Robot Intelligence, Advanced Sensor Capabilities, Telepresence, Mechanical Design Features, Mobility, Locomotion, and Navigation. Characteristics of Future Robot Tasks, Manufacturing Applications of Robots, Hazardous and Inaccessible Non-Manufacturing Environments. **Textbook 1:** 19.1-19.5, 20.1-20.3.	
Course Outcomes: At the end of the course, the student will be able to	
1. Articulate the basic concepts of robotics, sensors, actuators, robot programming methods, micro-robotics and advanced robotic applications. 2. Calculate robotic grip force and surface forces in microrobots. 3. Develop robot program logic using motion commands and conditional branching to perform basic spatial tasks.	
Text books: 1. Groover, M. P., Weiss, M., Nagel, R. N., & Odrey, N. G.,"Industrial Robotics: Technology, Programming, and Applications", McGraw-Hill Education 2. Niku, S. B., "Introduction to Robotics: Analysis",Control, Applications, 3rd Edition, Wiley. 3. Metin Sitti, Mobile Microrobotics, MIT Press, 1st Edition, 2017	
Reference Books: 1. Saha, S. K., Introduction to Robotics, McGraw-Hill Education. 2014 2. Mittal, R. K., & Nagrath, I. J., Robotics and Control, McGraw-Hill Education. 2003	
Weblinks: 1. Microrobotics – https://onlinecourses.nptel.ac.in/noc25_me177/preview 2. Introduction to Robotics – https://onlinecourses.nptel.ac.in/noc22_de11/preview 3. Robotics (Stanford) https://www.youtube.com/playlist?list=PLDD0012CC14956C28]	

Robotics for Electronics Manufacturing			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIOE312**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Objectives: This Course is designed to

1. Impart knowledge on manufacturing in cleanroom and vacuum environments.
2. Familiarize with design principles, material selection and drive train mechanisms required for atmospheric and vacuum robots.
3. Provide knowledge on robotic cell layouts, workcell control strategies, interlocks and error detection and recovery systems.
4. Familiarize with industry standards, robot cycle times and machine interference.

Module 1: Industry Overview & Cleanroom Standards	**No. of Hrs: 9**

History of industrial robotics, The global robotics industry, Applications and operational stock by region, Socioeconomic impact, Definitions, standards and terminology, Applicable and related standards.

Manufacturing in cleanroom environments, Semiconductor manufacturing, Flat panel display manufacturing, Substrate-handling robots, Applicable and related standards for industrial robots.

Textbook 1: Chapter 1 & 2

Module 2: Design of atmospheric robots	**No. of Hrs: 8**

Clean materials, Prevention of electrostatic charge, Surface finishes for cleanroom robotics, clean drive trains, Arm compliance, End-effectors, Robot assembly and handling, Applicable and related standards for atmospheric robots.

Textbook 1: Chapter 3

Module 3: Design of Vacuum Robots	**No. of Hrs: 8**

Robotics challenges in vacuum environments, Static vacuum barrier, Dynamic vacuum barrier, clean drive trains, External and internal leaks, Materials and surface finishes, Assembly and installation of vacuum robots, Applicable and related standards for vacuum robots.

Textbook 1: 4.1–4.4, 4.7

Module 4: Robot Cell Design and Control	**No. of Hrs: 9**

Robot Cell Layouts, Multiple Robots and Machine Interference, considerations in Workcell design, Work cell Control, Operator Interface, Interlocks, Error Detection and Recovery, The Workcell Controller, Robot Cycle Time Analysis,

Textbook 2: 2.1.1,2.1.2,2.2,3.1,3.2

Module 5: Economic Analysis, Safety and maintenance for Robotics	**No. of Hrs: 8**

Economic Analysis: Basic Data Required, Methods of Economic Analysis, Subsequent Use of The Robot, Other Factors More Difficult to Quantify, Safety in Robotics.

Textbook 1: Chapter 12.1-12.5,17.1,17.3

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the history of robotics, cleanroom standards, and the fundamental design principles of atmospheric and vacuum robots, including material and drive train selection.
2. Describe robot cell layouts, workcell control architectures, interlocks and error recovery strategies used in industrial automation.
3. Explain the structural configurations of robotic workcells and distinguish the material selection criteria and operational trade-offs for vacuum versus atmospheric robotic systems.
4. Compute the safety and maintenance costs, and economic factors involved in robotics implementation

Textbooks:

1. Karl Mathia, Robotics for Electronics Manufacturing - Principles and Applications in Cleanroom Automation, Cambridge University Press. 2010.
2. Groover, M. P., Weiss, M., Nagel, R. N., & Odrey, N. G., Industrial Robotics: Technology, Programming, and Applications, McGraw-Hill Education, Second special Indian Edition, 2012.

Reference Books:

1. Saha, S. K., Introduction to Robotics, McGraw-Hill Education. 2014
2. Mittal, R. K., & Nagrath, I. J., Robotics and Control, McGraw-Hill Education. 2003

Weblinks

1. Robotics (NPTEL) – https://nptel.ac.in/courses/112105249
2. VLSI Technology (Cleanroom Standards) – https://nptel.ac.in/courses/117106093
3. Electronics Manufacturing Automation – https://www.youtube.com/@allaboutelectronics_india]

Human-Robot Interaction			
Semester	**V**	CIE Marks	**50**
Course Code	**23RIOE313**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Objectives: This course is designed to

1. Familiarize with communication foundations of Human-Robot Interaction.
2. Provide knowledge on robot perception and anthropomorphism.
3. Impart knowledge on emotion, empathy and methodologies for designing and evaluating HRI systems.
4. Introduce the diverse applications of robotics in healthcare, education and service.

Module 1: Foundations of Human-Robot Interaction (HRI)	**No. of Hrs: 8**

Human-Robot Interaction, Overview of HRI, Robots in HRI, Interaction Modalities, Spatial Interaction, Visual Communication, Semantic Communication.

Textbook 1: 2.1-2.3, 3.1-3.4.

Module 2: Design & Spatial Interaction	**No. of Hrs: 9**

Design in HRI, Anthropomorphizing in HRI design, Design methods, Prototyping tools, Culture in HRI design, Use of space in human interaction, Spatial interaction for robots.

Textbook 1: 4.1-4.5, 5.1, 5.2

Module 3: Communication & Emotion	**No. of Hrs: 9**

Functions of nonverbal cues, Types of nonverbal interaction, Nonverbal interaction in robots, Human-human verbal interaction, Speech recognition, Turn-taking in HRI, Emotion and interaction, Understanding human emotions, Emotions for robots.

Textbook 1: 6.1-6.3, 7.1, 7.2, 7.4, 8.1, 8.2, 8.4

Module 4: Research Methods in HRI	**No. of Hrs: 9**

Qualitative, quantitative and mixed methods, Research participants and study designs, Context of interaction, Selection of Robot for study, Mode of interaction, HRI measures, Research standards.

Textbook 1: 9.2, 9.3, 9.4, 9.5, 9.6, 9.7, 9.8

Module 5: Applications of HRI	**No. of Hrs: 8**

Service robots, Robots for learning, Robots for entertainment, Robots in healthcare and therapy, Robots as personal assistants, Collaborative robots, Self-driving cars, Problems for robot application (Expectations, Addiction, Abuse).

Textbook 1: 10.1, 10.2, 10.3, 10.4, 10.5, 10.7, 10.8, 10.11

Course Outcomes: At the end of the course, the student will be able to

1. Identify the core components of a robot and the historical evolution of the HRI field.
2. Articulate the design principles, spatial dynamics, communication modalities, operational requirements and challenges of robotic applications in service, healthcare, and education sectors.
3. Relate the concepts of emotion and anthropomorphism to the development of effective human-robot interfaces.
4. Select appropriate research methods, study designs, and metrics to evaluate HRI scenarios.

Textbooks:

1. Christoph Bartneck, Tony Belpaeme, Friederike Eyssel, Takayuki Kanda, Merel Keijsers, Selma Sabanovi´, "Human–Robot Interaction An Introduction", Cambridge University Press, 2019.

Reference Books:

1. Goodrich, M. A., & Schultz, A. C. (2007). Human-Robot Interaction: A Survey. Foundations and Trends in Human-Computer Interaction.
2. Breazeal, C. (2002). Designing Sociable Robots. MIT Press.

Weblinks

1. Foundations of Cognitive Robotics – https://onlinecourses.nptel.ac.in/noc24_me82/preview
2. Human-Computer Interaction – https://nptel.ac.in/courses/106103115
3. Human-Robot Interaction (UMass Lowell) – https://www.youtube.com/playlist?list=PLpRE0Zu_k-BzsA3sOVD0wbO44XjW0qJ2J]

Yoga – III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC321**	SEE Marks	-
Teaching Hrs/Week (L:T: P)	**0:0:1**	Exam Hrs	-
Total Hrs	**13**	Credits	-

Course Learning Objectives: This course is designed to

1. Empower students to achieve and maintain good health.
2. Promote the practice of mental hygiene.
3. Facilitate students in attaining emotional stability.
4. Impart moral values and higher level of consciousness.

Contents	**No. of Hrs: 13**

- Ashtanga Yoga
  1. Asana
  2. Pranayama
  3. Pratyahara
- Suryanamaskar13 count- 3 rounds of practice
- Asana its meaning by name, technique, precautionary measures and benefits of each asana
- Different types of Asanas
  a) Sitting
     1. Ardha Ushtrasana
     2. Vakrasana
     3. Yogamudra in Padmasana
  b) Standing
     1. UrdhvaHastothanasana
     2. Hastapadasana
     3. ParivrittaTrikonasana
     4. Utkatasana
  c) Prone line
     1. Padangushtha Dhanurasana
     2. Poorna Bhujangasana
  d) Supine line
     1. Sarvangasana
     2. Chakraasana
     3. Navasana/Noukasana
     4. Pavanamuktasana
- Revision of Kapalabhati practice 30 strokes/min 3 rounds
- Meaning by name, technique, precautionary measures and benefits of each Pranayama
  1. Ujjayi
  2. Sheetali
  3. Sheektari

Course Outcomes: At the end of the course, the student will be able to

1. Describe the meaning, aim and objectives of Yoga.
2. Perform Suryanamaskar and able to analyze its benefits.
3. Exhibit the different Asanas by name, its importance, methods and benefits.
4. Perform Kapalabhati.
5. Perform the different types of Pranayama by its name, precautions, procedure and uses.

Textbooks:

1. Ajitkumar ,"YogaPravesha in Kannada" 1st Edition, Raashtroththaana Saahithya, 2017,ISBN-13: 978-8175310124
2. BKS Iyengar, "Light on Yoga", 1st Edition, Thorsons, 2017, ISBN-13: 978-0008267919
3. Dr. M L Gharote& Dr. S K Ganguly,"Teaching Methods for Yogic practices", 1st Edition, Kaivalyadhama, 2001, ISBN-13 : 978-8189485252

Reference Book:

YaminiMuthanna, "Yoga for Children step by step", 1st Edition, Om Books International, 2022, ISBN-13: 978-9394547018

Web links:

1. My Life My Yoga: https://youtu.be/KB-TYlgd1wE
2. Adiyoga: https://youtu.be/aa-TG0Wg1Ls

Scheme and Assessment:

Sl.No.	Activity	Marks
1	Quiz	20
2	Practical demonstration	50
3	Final Report	30

Physical Education – III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC322**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Impart the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness
2. Familiarization of health-related Exercises, Sports for overall growth and development
3. Build a strong foundation for the professionals in Physical Education and Sports

Contents	**No. of Hrs: 13**

- Ethics in Sports & Moral Values in Sports and Games
- Sports Training Methods and its Impacts: Continuous Training, Interval Training, Circuit Training, Weight Training.
- FITT Implementing FITT principles to design personalized fitness programs. (Lectures & Practical Sessions)
- Specific Games (Students continue prior semester's game by practicing Intermediate Skills)

Basket Ball	Crossover dribble - Between-the-legs dribble - Bounce pass and no-look pass Shooting with form from mid-range - Defensive stance and footwork
Cricket	Advanced batting shots (cover drive, square drive, pull shot) - Swing and seam bowling variations - Fielding positions and strategies - Game sense and awareness
Football	Shielding the ball - Crossing the ball - Long passing and through balls - Tackling techniques (sliding & standing) - Shooting with power and accuracy - Playing different positions
Hockey	Stickhandling in tight spaces - Slapshot and sweep shot techniques - Passing with speed and accuracy - Dodging defenders - Defensive positioning and checking
Kabaddi	Advanced raiding techniques (frog jump, jump over) - Diverse raiding holds (frog kick, thigh hold) - Anticipation and countering defense - Effective raiding strategies - Advanced team defense formations
Karate	Kihon (repetition of basic techniques) - Kata (forms to practice technique and flow) - Combinations of punches and kicks - Footwork and movement - Basic kumite (sparring) techniques
Table Tennis	Looping technique (forehand and backhand) - Topspin and backspin serves - Footwork for attacking and defense - Blocking and countering techniques - Match strategy and tactics
Throwball	Long throws and bounce passes - Fake passes and deception moves - Dodging techniques to create space - Defensive positioning and guarding techniques - Team offense and set plays
Volleyball	Attack, Block, Service, Upper Hand Pass and Lower hand Pass

Course Outcomes: At the end of the course, the student will be able to

1. Develop strategies to promote ethical conduct and a positive sporting culture.
2. Understand the importance of ethics and moral values in sports and games.
3. Perform in the selected sports or athletic events

Textbooks:

1. Muller, J. P., "Health, Exercise and Fitness", 1st Edition, Sports Publication, 2018.
2. Uppal, A.K., "Physical Fitness", Friends Publication New Delhi, 1992.
3. Russell R.P., "Health & Fitness through Physical Education: Human Kinematics", Human Kinetics Publishers, 1994

Reference Books:

1. Anaika , "Play Field Manual", Friends Publication New Delhi, 2005.
2. IAAF Manual
3. Pinto John & Roshan Kumar Shetty, "Introduction to Physical Education"

Web links:

1. https://www.youtube.com/watch?v=wvlztaJYKYI
2. https://www.youtube.com/playlist?list=PLHCNPOIaj2Wc8P5xAWq9g2DUrrbixoTOK
3. https://www.youtube.com/watch?v=K9X_wB1Yu84
4. https://www.youtube.com/watch?v=HEHggOOds1w&list=PLgVaM7Baa_8myp4njEDcoYyZkBq-542S5

Scheme & Assessment of students for auditing the course & Grades

SN	Activity	Marks
1	Participation of students	20
2	Quizzes-2, each of 15 marks	30
3	Final presentation/Exhibition/Participation in Competitions (Certificate of participation in National/International)	50
	Total	**100**

National Service Scheme - III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC323**	SEE Marks	
Teaching Hours/Week (L:T: P)	**0:0:1**	Exam Hrs	
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Develop discipline, character, brotherhood, the spirit of adventure and ideals of selfless service amongst young citizens
2. Develop youth leadership in the students.
3. Induce social consciousness among students through various societal activities.
4. Impart knowledge in finding practical solutions to individual and community problems

NSS -Contents	**No. of Hrs: 13**

Introduction:

- Promoting a healthy lifestyle among youth
- Nutrition education, stress management and mental health activities

Activities:

- Village awareness programs on women hygiene, various superstitious beliefs, avoiding self-medication, etc.
- Helping local schools to achieve good results and enhance their enrolment in Higher/technical/ vocational education

Note:

- Students in individual or in a group should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
- At the end of every semester, activity report should be submitted for evaluation.

Course outcomes: At the end of the course, the student will be able to

1. Understand the importance of nation building and individual contribution to the betterment of the society.
2. Discover grassroots challenges of community and solve them by technological intervention.
3. Create societal impact by upholding the value of one for all and all for one.
4. Maintain discipline and team spirit.

Textbooks:

1. Ministry of Youth Affairs & Sports, Government of India (2022) "National Service Scheme Manual"
2. Rajiv Gandhi National Institute of Youth Development, Ministry of Youth Affairs & Sports, Government of India, (2017)"Introduction Training Module for National Service Scheme (NSS) Program officers",
3. Gurmeet Hans (1996), "Case material as Training Aid for field workers" TISS

Reference Books:

1. Dr. G R Bannerjee, (2012),Social service opportunities in Hospitals, TISS
2. Ram Ahuja (Third Edition) 2014, Social Problems in India, Rawat publications

Web links:

1. History of NSS https://thebetterindia.com/140/national-service-scheme-nss/
2. NSS – an introduction https://www.youtube.com/@nationalserviceschemeoffic4034/videos

Assessment details (CIE): Students will be assessed with the

Weightage	CIE
Participation of students	30 Marks
Individual contribution to success of the program	40 marks
Report preparation	30 Marks
Total marks	100 Marks

Arts - III			
Semester	**V**	CIE Marks	**100**
Course Code	**23NMCC324**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. To impart an understanding of the creative process from initial concept to final execution.
2. Create and demonstrate proficiency in a chosen arts discipline through practical application.
3. Analyze and appreciate diverse art forms and styles
4. To participate in art competitions at regional, state, national, and international levels, as well as in cultural events

Contents	**No. of Hrs: 13**

Note: Student will continue the arts form selected in previous semester.

Performing Arts (Dance)	Orientation, Cinema Acting Basics, Facial Expression Exercises, Body Language, Camera Angles, Characterization demo and Practice, Individual Presentations, Evaluation.
Music	Orientation, Film Songs, Karaoke Singing, Rhythm Fusion and voice, Individual Presentation, song styles demo and practical, Evaluation.
Arts & Crafts	Orientation, Craft Forms, Paper Craft, Mask Making, Model Making, Thermocol Art, Finger Puppet Making, Group Presentation, Evaluation.
Theatre	Orientation, Introduction to Theatre Sets and properties, Practical use of properties, Set Designing, Costume Design, Headgears and Masks, Theatre Makeup, Evaluation.

Course Outcomes: At the end of the course, the student will be able to

1. To be capable of creating choreography and delivering live performances for an audience.
2. Employ a range of acting techniques and use them to create a performance.
3. Evolve into creative, effective, independent, and reflective individuals capable of making informed decisions in both process and performance.
4. Acquire knowledge and comprehension of the roles and processes used in current theatre arts practice.

Textbooks:

1. Music in Theory and Practice by Bruce Benward and Marilyn Sake, McGraw-Hill Education,2014
2. Art Fundamentals: Theory and Practice by Otto G. Ocvirk, Robert E. Stinson, Philip R. Wigg, Robert Bone, and David L. Cayton, McGraw-Hill Education,2012
3. The Viewpoints Book: A Practical Guide to Viewpoints and Composition by Anne Bogart and Tina Landau, Theatre Communications Group,2004

Reference Books:

1. Dance Composition: A practical guide to creative success in dance making, Jacqueline M. Smith
2. The Artist's handbook of method and materials by Ralph Mayer
3. Glimpses of Indian music and dance by Dr. Arun Bangre.

Web links:
https://ccrtindia.gov.in/audio-visual-catalogue/

Scheme & Assessment of students for auditing the course & Grades		
SN	**Activity**	**Marks**
1	Students Participation	20
2	Quizzes-2 (each of 15 marks)	30
3	Final presentation/Exhibition/Participation in Competitions	50
	Total	**100**

Control Systems			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPC306**	SEE Marks	**50**
Teaching Hrs./Week (L:T: P)	**2:2:0**	Exam Hrs.	**3**
Total Hrs.	**52**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce the fundamentals of control systems and digital control concepts.
2. Familiarise students with signal processing, discrete-time system modeling, and Z-transform techniques for stability analysis.
3. Familiarise students with modeling and design of digital control systems and controllers.
4. Provide understanding of state-space methods for analysis of digital control systems.

Module 1: Introduction to Digital Control Systems	**No. of Hrs:6+4**

Control system, closed-loop control, open-loop control, time and frequency domain system response and stability analysis. computer-based control, need for digital control systems.

Text book 1: 1.1, 1.2, 1.4, 2.1,2.2
Text book 2: 5.3,5.4,6.1,8.1,8.2

Module 2: Signal processing in digital control	**No. of Hrs:6+4**

Principles of Signal Conversion, Basic Discrete time signal, Time domain models for Discrete-Time System, Transfer function models, Sampled Spectra aliasing.

Text book 1**:** 2.3,2.4,2.5,2.7,2.9,2.11

Module 3: Z-Transform	**No. of Hrs:6+6**

Introduction, Region of convergence, Properties of z-Transform, Poles and Zeroes of rational function of Z, Analysis of LTI Discrete time system using z-Transform.

Text book 3: 7.1,7.2,7.3,7.4 7.6

Module 4: Models of Digital Control Devices and Systems	**No. of Hrs.: 6+4**

Introduction, description of sampled continuous-time plants, implementation of digital controllers, PID controllers, Digital position control systems, Stepping Motors and control.

Text book 1: 3.1, 3.2,3.4, 3.5, 3.7,3.8

Module 5: State Variable Analysis	**No. of Hrs.: 6+4**

Introduction to state variable methods, state variable representation, conversion of state variable models to transfer functions, state description of digital processors, Solution of state difference equations, Controability and Observability.

Text book 1: 5.1, 5.3, 5.4, 6.2, 6.5, 6.6

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the concepts of digital control systems, signal processing, Z-transform, modeling of digital control systems, and state-space methods.
2. Apply signal processing and Z-transform techniques for discrete-time system analysis.
3. Formulate the models of digital control systems.
4. Apply state-space methods for modeling of digital control systems.

Textbooks:

1. M. Gopal "Digital Control and State Variable Methods: Conventional and Intelligent Control Systems" McGraw Hill Education Publisher,2012.
2. I.J. Nagarath and M. Gopal, "Control system" New Age International Publisher, 2002
3. A. Nagoor Kani , "Signals and Systems", 2nd Edition, McGraw Hill Education (India) Private Limited, 2010.

Reference Books:

1. Benjamin C. Kuo, "Automatic Control Systems", Pearson, 9th Edition, 2014.
2. John J. Craig, "Introduction to Robotics: Mechanics and Control", Pearson, 3rd Edition, 2005.

Weblinks:

1. Digital Control Systems: https://nptel.ac.in/courses/108103008/, IIT Guwahati, NPTEL Online Courses.
2. Robotics and Control Systems: https://nptel.ac.in/courses/108101037/, IIT Kanpur, NPTEL Online Courses.
3. Robotics Control Systems Virtual Lab: http://vlabs.iitkgp.ernet.in/rcs/, IIT Kharagpur, NPTEL Virtual Labs.
4. Digital Control in Switched Mode Power Converters: https://nptel.ac.in/courses/108105186/, IIT Kharagpur, NPTEL Online Courses.

Machine Vision			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPC307**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:2**	Exam Hrs	**3**
Total Hrs	**64**	Credits	**4**

Course Learning Objectives: This course is designed to

1. Introduce the concepts of image formation, sensing, and system architecture.
2. Provide a Knowledge of image acquisition, processing, segmentation, and analysis techniques used in robot vision systems.
3. Impart the knowledge required to design and implement vision-based robotic applications.

Module 1: Introduction	**No. of Hrs: 8 +4**

Industrial Machine Vision and Image Understanding, Sensory Feedback for Manufacturing Systems, Industrial machine vision problems and solutions, Typical System Architecture, Illumination, Sensors

Sampling and Quantization, inter pixel distance, Adjacency Conventions, Image Acquisition Hardware, Speed Considerations,

Laboratory Component:

1. Capture images using camera/webcam under different illumination conditions and display the image
2. Implement image sampling and quantization at different resolutions

Text Book 1: 1.1 – 1.5, 2.1-2.2

Module 2: Intensity Transformations and Spatial Filtering	**No. of Hrs: 9 +6**

The Basics of Intensity Transformations and Spatial Filtering, Some Basic Intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing (Low pass) Spatial Filters, Sharpening (High pass) Spatial Filters, Mathematical Morphology

Laboratory Component:

1. Perform Grayscale conversion, contrast stretching and slicing of an image
2. Perform histogram equalization for an image
3. Implement Lowpass and High Pass filtering for an image

Text Book 2: 3.1-3.5, 4.1-4.5

Module 3: Image Segmentation and Image Analysis	**No. of Hrs: 9 +6**

Image Segmentation: Region-Based and Boundary-Based Approaches, Thresholding, an overview of Edge detection techniques, Region Growing, Boundary Detection, Template Matching, Decision-Theoretic Approaches.

Laboratory Component :

1. Implement Edge Detection Techniques for Boundary Extraction and Object Segmentation using python
2. Implement Region-Based Segmentation and Template Matching for Object Detection using python

Text Book 1: : 5.1 – 5.5, 6.2 – 6.4

Module 4: Feature Extraction	**No. of Hrs: 9 + 6**

Introduction, Boundary Preprocessing, Boundary Feature Descriptors, Region Feature Descriptors, Principal Components as Feature Descriptors

Laboratory Component:

1. Extract geometric, boundary, and region-based features from a given image
2. Implement PCA for dimensionality reduction for a given image
3. Classify shapes (circle, square, triangle) using prototype matching / minimum distance classifier technique

Text Book 2: 11.1-11.5

Module 5: Image Pattern Classification	**No. of Hrs: 7+4**

Patterns and Pattern Classes, Pattern Classification by Prototype Matching, Optimum (Bayes) Statistical Classifiers, Neural Networks and Deep Learning.

Laboratory Component:

1. Implement Face Recognition using Open CV
2. Implement Object identification using Neural network

Text Book 2: 12.1 – 12.4

Course Outcomes: At the end of the course, the student will be able to

1. Illustrate the fundamental concepts of machine vision and robot vision, including sensing, illumination, and system architecture.
2. Articulate image acquisition, processing, segmentation, and analysis techniques used in robotic vision systems.
3. Apply digital image processing, segmentation, and analysis techniques to extract meaningful features for object detection and classification in robotic vision systems.

Textbooks:

1. David Vernon, "Machine Vision: Automated Visual Inspection and Robot Vision", Prentice Hall, 1991.
2. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", Prentice Hall, 4th Edition, 2008.

Reference Books:

1. Peter Corke, "Robotics, Vision and Control Fundamental algorithms in Python" , Springer 3rd Edition 2023
2. Fairhurst, M.C., "Computer Vision for Robotic Systems", Prentice Hall.

Web links:

1. Computer Vision / Robot Vision Courses, https://onlinecourses.nptel.ac.in, NPTEL (IITs & IISc)
2. OpenCV Documentation, https://opencv.org/, OpenCV.org
3. Computer Vision Tutorials, https://www.geeksforgeeks.org/computer-vision/, GeeksforGeeks

Robot Operating System Laboratory			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPC308**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**0:1:3**	Exam Hrs	**2.5**
Total Hrs	**36+12**	Credits	**2**

Course Learning Objectives: This course is designed to

1. Impart knowledge of ROS 2 node development and communication models using Python for robotic applications.
2. Establish familiarity with sensor data acquisition and integration using ROS 2 with ultrasonic and IMU sensors.
3. Provide exposure to robot modeling, visualization, and simulation using URDF, RViz2, and Gazebo.

Introduction to Sensors and Actuators — **No. of Hours: 12**

Overview of Robot Operating System (ROS) and ROS 2, ROS architecture and computational graph, ROS 2 installation and workspace setup, ROS packages, nodes, topics, messages, and services, Publisher–subscriber communication model, Service–client interaction, Actions and parameters in ROS 2, Launch files and namespaces, ROS command-line tools and introspection utilities, Visualization tools: rqt and Rviz, Introduction to robot description using URDF, Coordinate frames and TF concepts, Overview of simulation using Gazebo

Lab Experiments — **No. of Hours: 36**

1. Develop a ROS 2 Python program for a node that prints a message every one second for a duration of thirty seconds.
2. Develop a ROS 2 Python publisher node that publishes string messages on the /chatter topic at a rate of 2 Hz.
3. Design a ROS 2 Python subscriber node that subscribes to the /chatter topic and displays the received messages along with a message counter.
4. Implement a ROS 2 publisher node that publishes integer values on the /numbers topic and a subscriber node that computes and displays the running sum and average of the received values.
5. Implement a ROS 2 service server using example interfaces/srv/AddTwoInts and a corresponding client to send user inputs and display the computed sum.
6. Develop an ESP32 application to measure distance using an **ultrasonic sensor** and display the measured distance in centimetres on the serial monitor at regular intervals.
7. Develop a ROS 2 Python node to read ultrasonic distance data from ESP32 via serial communication and publish the data on the /ultrasonic distance topic.
8. develop a ROS 2 subscriber node that monitors ultrasonic sensor distance and displays SAFE when the distance exceeds a predefined threshold and OBSTACLE when the distance is less than or equal to the threshold.
9. Develop an ESP32 application to acquire IMU sensor data including linear acceleration and angular velocity and continuously stream the data through serial communication.
10. Implement a ROS 2 Python node to read IMU data from ESP32 via serial communication and publish the data using sensor_msgs/Imu on the /imu/data topic.
11. Configure RViz2 to visualize IMU data published on the /imu/data topic and observe changes during sensor motion.
12. Simulate a mobile robot in Gazebo, integrate it with ROS 2, and perform basic motion control while visualizing the robot model and sensor data in RViz2.

Course Outcomes: At the end of the course, the student will be able to
1. Develop ROS 2 Programs to implement publisher–subscriber and service–client communication for robotic applications. 2. Visualize and simulate robotic systems using URDF, RViz2, and Gazebo.
Text books: 1. Edouard Renard, ROS 2 from Scratch: Get Started with ROS 2 and Create Robotics Applications with Python and C++, Packt Publishing, 2024.. 2. Morgan Quigley, Brian Gerkey, and William D. Smart, Programming Robots with ROS, O'Reilly Media.
Reference Books: 1. Aaron Martinez and Enrique Fernández, Learning ROS 2, Packt Publishing. 2. Andrzej M. Pawlak, Sensors and Actuators in Mechatronics: Design and Applications, CRC Press.
Web links: 1. ROS 2 Documentation: https://docs.ros.org/ 2. ROS Tutorials: https://wiki.ros.org/ROS/Tutorials 3. ROS 2 Examples (GitHub): https://github.com/ros2/examples

PROJECT PHASE – I			
Semester	**VI**	CIE Marks	**100**
Course Code	**23RISE309**	Credits	**03**
Teaching Hours/Week (L:T:P)	**0:0:6**	Mode	**Experiential**

Course Learning Objectives: This course is designed to

1. To develop the students' ability to independently or collaboratively identify a problem, review literature, define objectives, and propose a preliminary methodology for solving an engineering problem, which will be realized in Project Phase – II
2. The course also aims to develop leadership and interpersonal communication skills within team members

General Guidelines:

1. A project guide (faculty member) will be allocated by the department
2. The HoD shall appoint a project coordinator who will take the responsibility of monitoring all the activities related to the project execution
3. The HoD shall constitute project evaluation/review committee(s) & the composition shall be as follows:
    a. HOD or one of the HODs in case of an interdisciplinary project, shall be the Chairman of the committee
    b. Project Coordinator shall be member - Convener
    c. Project guide shall be the member
    d. One/Two senior faculty members nominated by the HOD (may be from different departments in case of an interdisciplinary project jointly nominated by the HODs)
4. Each project team shall consist of 2 to 4 students from the same department or different departments
5. Interdisciplinary projects may be allowed with prior approval from the concerned HODs only
6. Project teams must arrive at problem statements that address either real-world challenges or research-related issues relevant to their domain of study. Each team must formulate an appropriate project title in consultation with their project guide
7. Each project team shall maintain a project dairy and record their project progress at regular interval of time. This shall carry signature of the students and the project guide
8. There is no Semester End Examination (SEE) for this course and evaluation is based entirely on Continuous Internal Evaluation (CIE)
9. Marks may be equally or proportionally distributed among team members based on contribution assessed by the guide and committee
10. A student shall obtain minimum of 40% of the total marks to pass this course

11. Plagiarism, data fabrication, or copying of work will result in stringent disciplinary action and /or penalties. (Note: Any disciplinary actions or penalties will be as per institutional policy.)

Deliverables:

1. Comprehensive Project Report comprising of:
    - Abstract
    - Introduction
    - Literature Survey
    - Problem Definition
    - Proposed Methodology
    - Design
    - Summary and Work Plan for Phase-II
    - References
    - Appendices

The project report shall be prepared in the prescribed format provided by the institute

2. A plagiarism report shall be obtained from the Department of Library. Acceptable similarity threshold is generally below 20%, and hence, the plagiarized content shall not exceed 20%. Similarity above 20% will require resubmission after proper revisions

Review and Evaluation:

1. There shall be two reviews and a presentation. Total of 100 CIE marks is distributed as follows:

Review - 1

Topic approval, Problem Definition & Objectives	20 Marks
Literature Review	10 Marks
Innovation/Novelty	10 Marks
Total	**40 Marks**

Review - 2

Methodology & Design	15 Marks
Report Quality & Formatting	15 Marks
Total	**30 Marks**

Presentation

Presentation	20 Marks
Team work	10 Marks
Total	**30 Marks**

Grand Total	**100 Marks**

2. First review shall be conducted after one month from the start of the semester
3. Further, every department shall develop rubrics to assess performance of the students based on the above given parameters

Course Outcomes: At the end of the course, the student will be able to:

1. **Identify** an engineering or research problem through a thorough review of relevant literature
2. **Design** an appropriate solution or methodology to address the identified problem
3. **Prepare** a comprehensive project report
4. **Effectively** present each component of the project report to a knowledgeable audience
5. **Collaborate** and **contribute** effectively as a team member, recognizing the dynamics of both individual and group work

Cyber Security in Robotics			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPE321**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Provide Knowledge on computer security concepts, threats, authentication, and access control principles.
2. Introduce malware, network attacks, and key defense mechanisms like firewalls and intrusion detection.
3. Impart knowledge of cybersecurity challenges, vulnerabilities, and secure practices for robotic systems and ROS.

Module 1: Fundamentals of Computer Security	**No. of Hrs: 8**

Computer Security Concepts, Threats, Attacks, and Assets, Security Functional Requirements, Fundamental Security Design Principles, Attack Surfaces and Attack Trees, Computer Security Strategy, Standards

Text Book 1: Chapter-1

Module 2: Cryptographic tools	**No. of Hrs: 8**

Confidentiality with Symmetric Encryption, Message Authentication and Hash Functions, Public-Key Encryption, Digital Signatures and Key Management, Random and Pseudorandom Numbers

Text Book 1: Chapter- 2

Module 3: Malware, Network Attacks, and System Defense	**No. of Hrs: 9**

Types of Malicious Software (Malware), Advanced Persistent Threats (APT), Attacks, Distributed DoS attacks, Intrusion detection systems, host-based & network-based, the need of Firewalls, Intrusion prevention systems, Network security overview for connected systems

Text Book 1: Chapter 6.1,6.2,7.1,7.3, 8.1,8.4,8.5,9.1,9.6

Module 4: Cybersecurity Issues in Robotic Systems and ROS	**No. of Hrs: 8**

The Need for Cybersecurity in Robotics, Overview of Security Challenges and Solutions, Need for Quantitative Methods, The Robot Operating System, Vulnerabilities of the Robot Operating System, Securing the API, Vulnerabilities of AI-Enabled Robotic Systems

Text Book 2: Chapter 1, 2

Module 5: Security Practice and Design	**No. of Hrs: 9**

Security in ROS Networked Systems, Security for Industrial Multi-Agent Robotic Systems, Penetration Testing, Vulnerability Scanning, DevSecOps, Relevant International Standards

Text Book 2: Chapter 3,4

Course Outcomes: At the end of the course, the student will be able to

1. Articulate threats, vulnerabilities, and security requirements, Authentication and Access Control
2. Describe Malware, Network Attacks, and System Defense, Cybersecurity Issues, Security Practice and Design in Robotic Systems
3. Apply cryptographic techniques such as encryption, authentication, digital signatures, key management, and random number generation for secure communication

Textbooks:

1. William Stallings & Lawrie Brown, "Computer Security: Principles and Practice" , 4th Edition , Pearson, 2018
2. Quanyan Zhu, Stefan Rass, Bernhard Dieber "" Cybersecurity in Robotics: Challenges, Quantitative Modeling, and Practice Foundations and Trends in Robotics, IEEE Press willy, 2022.

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Reference Books:

1. Joseph Steinberg, "Cybersecurity for Dummies", Dummies, 2019.

Web links:

1. Foundations of Cybersecurity, https://www.coursera.org/learn/foundations-of-cybersecurity, Coursera (Google)
2. Cyber Security and Privacy, https://onlinecourses.nptel.ac.in/noc23_cs127/preview, NPTEL (IIT Madras)

Data Analytics			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPE322**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce the Foundations of Business Intelligence and Data Visualization.
2. Impart Knowledge of Data Warehousing and Mining Algorithms.
3. Provide Knowledge of Advanced Mining Paradigms and Cluster Analysis

Module 1: Wholeness of Data Analytics & Business Intelligence	**No. of Hrs: 7**

Introduction, Business Intelligence, Pattern recognition, Data processing chain, BI decision-making, BI tools, BI skills, BI applications

Text Book 1: Chapter -1,2

Module 2: Visualization &Data Warehouse	**No. of Hrs: 8**

Pixel-Oriented Visualization Techniques, Geometric Projection Visualization Techniques, Icon-Based Visualization Techniques, Hierarchical Visualization Techniques, Visualizing Complex Data and Relations, Data Warehouse Modeling: Data Cube and OLAP, Data Warehouse Design and Usage.

Text Book 2: Chapter- 2.3, 4.1-

Module 3: Data mining	**No. of Hrs: 10**

Introduction, Frequent Itemset Mining Methods, Apriori Algorithm: Finding Frequent Itemsets by Confined Candidate Generation, Generating Association Rules from Frequent Itemsets, Improving the Efficiency of Apriori, A Pattern-Growth Approach for Mining Frequent Itemsets, Mining Frequent Itemsets Using the Vertical Data Format, Mining Closed and Max Patterns

Text Book 2: Chapter- 6.1-6.3

Module 4: Advanced Data Mining	**No. of Hrs: 8**

Text mining Introduction, Text mining applications, Text mining process and term–document matrix, Mining the TDM, comparing Text mining and data mining, text best practices, Introduction to Web mining, Web structure mining, web usage mining, Web mining algorithms, Social Network analysis, Applications of NSA, Techniques and algorithms,

Text Book 1: Chapter 11, 14,15

Module 5: Cluster Analysis	**No. of Hrs: 9**

Introduction, Partitioning Methods, Hierarchical Methods, Density-Based Methods

Text Book 2: chapter 10.1-10.4

Course Outcomes: At the end of the course, the student will be able to

1. Describe the Foundations of Business Intelligence and Visualization.
2. Articulate the principles of web mining, text mining, and Social Network analysis.
3. Apply Data Mining and Cluster Analysis Methods for business data.

Textbooks:

1. Anil Maheshwari,, "Data Analytics", McGraw-Hill Education (India), 2018
2. Jiawei Han , Micheline Kamber, Jian Pei "Data Mining concepts and Techniques ",3rd Edition, Elsevier , 2012.

Reference Books:

1. Wes McKinney, "Python for Data Analysis", O'Reilly Media, 2022.
2. Hadley Wickham, Garrett Grolemund, "R for Data Science", O'Reilly Media, 2017

Web links:

1. Data Science Courses, https://www.coursera.org/browse/data-science, Coursera
2. Data Science & Analytics Learning Path, https://learn.microsoft.com/en-us/training/paths/data-science/, Microsoft Learn

Autonomous Robots			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIPE323**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce the fundamental concepts of autonomy in robotic systems
2. Impart knowledge of software architectures for autonomous robots.
3. Familiarize learning and adaptation mechanisms in autonomous robots.
4. Provide Knowledge of autonomous locomotion strategies and Multi Robot systems.

Module 1: Foundations of Autonomy	**No. of Hrs: 8**

Autonomy, Robots, Problems in Robot control, Biological Inspired robot Control, Survey of Current Robots Associated control, homeostasis, Engineering and Biological control system, Multiple Levels of control, Other biological Control Systems, Cost Functions, Control of Functional motions in Humans.

Text book 1 – Chapter 1.1-1.8, 2.1-2.8

Module 2: Software Architectures for Autonomous Robots	**No. of Hrs: 8**

Robot Architecture, Robot Software, History, Deliberative architectures, Reactive and behavior-based architectures, Hybrid reactive- deliberative architectures, Features of Hybrid Architectures, Tropism based Architecture, USC Avatar Architecture, Open robot architectures

Text book 1 – Chapter 5.1-5.10

Module 3: Robot Learning and Adaptation	**No. of Hrs: 9**

Nature of Robot learning, Learning and control, General Issues in Learning by Robots, Reinforcement learning, Q-Learning, learning to avoid obstacles, Learning How to grasp objects, Evolutionary Algorithms, Learning to Walk using genetic algorithm.

Text book 1 – Chapter 6.1-6.6, 6.8-6.10

Module 4: Autonomous Locomotion Strategies	**No. of Hrs: 9**

Animal Locomotion, Wheeled vehicle, Tracked Vehicle, Legged Vehicle, Hopping Robots, Serpentine Robots, under water Robots, Climbing and unusual Locomotion, Flying Robots, Self Reconfigurable Robots, Standing and walking on Two legs, Legged Locomotion in Animals.

Text book 1 – Chapter 7.1- 7.7, 7.9-7.11, 8.1, 9.1

Module 5: Motion Planning for a Mobile Robot	**No. of Hrs: 8**

The Model, Universal Lower Bound for The Path Planning Problem, Basic Algorithms, Combining Good Features of Basic Algorithms, Going After Tighter Bounds, Vision and Motion Planning

Text book 2 – Chapter 3.1-3.6

Course Outcomes: At the end of the course, the student will be able to

1. Explain the fundamental concepts of autonomy and software Architectures in robotic systems
2. Describe learning, adaptation mechanisms and locomotion used in autonomous robots
3. Articulate system-level operation of autonomous robots
4. Apply motion planning algorithms to plan and control robotic motion

Textbooks:

1. George A. Bekey, Autonomous Robots: From Biological Inspiration to Implementation and Control, MIT Press, 2005.
2. Vladimir J. Lumelsky , "Sensing, Intelligence, Motion How Robots and Humans Move in an Unstructured World" John Wiley & Sons, Inc 2006

Reference Books:

1. Roland Siegwart & Illah Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2004

Web links:

1. AI for Autonomous Vehicles and Robotics, https://www.coursera.org/learn/ai-for-autonomous-vehicles-and-robotics, Coursera
2. Autonomous Robotics Courses, https://www.edx.org/learn/autonomous-robotics, edX

AI Robots			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIOE321**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Learning Objectives: This course is designed to

1. Introduce the basics of AI robots, parts, types, robophysics, and ethics.
2. Provide an Understand robot talking, listening, vision, and emotion detection.
3. Impart knowledge of autonomous navigation (SLAM, PID) and swarm algorithms (PSO, ACO).

Module 1: AI-Driven Robotics, Robophysics, and Roboethics	**No. of Hrs: 8**

Robotics and Related Term, Generations of Robotics, Parts of an AI Robot, AI Processor Chips for Robotics, Classification of Robots, Robophysics, Robotics, Understanding the Interrelationship Among Robotics, Ai Robotics, Robophysics, and Roboethics,

Text book 1: 2.1-2.9

Module 2: Talking and Listening Robots, Robot Vision	**No. of Hrs: 8**

Introduction, TTS Synthesis and Voice Generation, Speech Recognition and Understanding, Images, Video, and Vision, 2D Object Detection, Misconstrued Circumstances in Robot Vision, Meeting the Challenges to Robot Vision,

Text book 1: 4.1-4.3, 5.2, 6.2

Module 3: Emotionally Intelligent Robots	**No. of Hrs: 9**

Introduction, Emotional AI, Emotional Robot Algorithm, Specific Algorithms Used in Emotionally Intelligent Robots, HMMs for Robot Emotion Detection, Self-Organizing Maps in Robot Emotion Detection, Support Vector Machines for Robot Emotion Classification, Convolutional Neural Networks for Robot Emotion Processing, Decision Trees for Robot Emotion Detection, Natural Language Processing Algorithms for Robot Emotion Detection, Reinforcement Learning for Robot Emotion Detection

Text book 1: chapter 8.2-8.4, 9.2,

Module 4: Autonomous Robots: SLAM, APF Algorithms	**No. of Hrs: 8**

Introduction, Algorithms Used in Autonomous Robots, Slam Algorithm, APF Algorithm, Decision Matrix Algorithm for Robots, Bug Algorithm, Vector Field Histogram Algorithm, Generalized Voronoi Diagram Algorithm

Text book 1:Chapter 11.1-11.4, 12.2-12.5

Module 5: Robotic Swarms	**No. of Hrs: 9**

Bio-Inspired Algorithms Used in Swarm Robotics, Genetic Algorithm, PSO Algorithm, ACO Algorithm, Robotic Swarms: Exploring Additional Avenues and Vistas, ABC Algorithm, Firefly Algorithm

Text book 1: Chapter 13,14

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the key concepts, components, classifications, and relationships between AI-driven robotics, robophysics, and roboethics.
2. Describe robot perception systems and core algorithms.
3. Compare bio-inspired swarm algorithms and their roles in autonomous robot navigation and decision-making

Textbooks:

1. Vinod Kumar Khanna, " AI Robotics Ethics, Algorithms, and Technology of Artificial Intelligence-Powered Robots", CRC press, 2026.

Reference Books:

1. Álvaro Morena Alberola, Gonzalo Molina Gallego , Unai Garay Maestre "Artificial Vision and Language Processing for Robotics: Create end-to-end systems that can power robots with artificial vision and deep learning techniques", 1st Edition ,Packt2019.
2. Parijat Bhowmick, Sima Das , Farshad Arvin, "Bio-inspired Swarm Robotics and Control: Algorithms, Mechanisms, and Strategies", IGI Global, 2024

Web links:

1. AI for Autonomous Vehicles and Robotics, https://www.coursera.org/learn/ai-for-autonomous-vehicles-and-robotics, Coursera
2. Robotics: Vision Intelligence and Machine Learning, https://www.edx.org/learn/robotics/university-of-pennsylvania-robotics-vision-intelligence-and-machine-learning

AI Risks, Ethics and Governance			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIOE322**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

Course Objectives: This course is designed to:

1. Impart knowledge on the societal-scale risks, malicious threats, and competitive dynamics.
2. Introduce the methods of reliability engineering and safety analysis.
3. Familiarize with implications of AI on economic growth, integration of Fairness and bias principles and ethical frameworks.
4. Provide knowledge on governance structures, legal liability, privacy implications, and the psychological aspects of AI interaction.

Module 1: AI Risks	**No. of Hrs: 7**

Overview of AI Risks, Malicious Use, AI Race, Organizational Risks, Rogue AIs

Textbook 1: 1.1-1.6

Module 2: Robot Reliability and Safety	**No. of Hrs: 10**

Introduction, Classifications of Robot Failures, Causes and Corrective Measures, Robot Effectiveness Dictating Factors, Robot-Related Reliability Measures, Robot Reliability Analysis Methods.

Problems and Hazards, Role of Robot Manufacturers and Users in Robot Safety, Safety Considerations, Robot-Related Safety Problems, Robot Safeguard Approaches, Robot Safety Features.

Textbook 2: 5.1-5.5, 6.1-6.7

Module 3: AI Ethics	**No. of Hrs: 8**

Introduction, Law, Fairness, Wellbeing, Preferences, Happiness, Social Welfare Functions, Moral Uncertainty

Textbook 1: 6.1-6.3, 6.5-6.9

Module 4: AI Governance	**No. of Hrs: 8**

Introduction, Economic Growth, Distribution of AI, Corporate Governance, National Governance, International Governance, Compute Governance

Textbook 1: 8.1-8.7

Module 5: AI Societal Challenges	**No. of Hrs: 9**

Responsibility and Liability in the Case of AI Systems, Psychological Aspects of AI, Privacy Issues of AI.

Textbook 3: 5.1-5.5, 7.1-7.3, 8.1-8.3

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the fundamental concepts of AI risks, malicious use, organizational failures, robot reliability and safety analysis.
2. Describe the frameworks for beneficial AI, machine ethics, governance structures and the legal and psychological implications of AI systems.
3. Compare different categories of AI risks, reliability models, ethical theories and governance strategies.
4. Apply reliability, risk assessment and ethical analysis techniques to assess operational cases involving AI safety.

Textbooks:

1. Hendrycks, D. (2025), Introduction to AI Safety, Ethics, and Society, Taylor & Francis / CRC Press.
2. BS Dhillon, Robot System Reliability and Safety – A modern approach, CRC Press. 2015
3. Christoph Bartneck, An Introduction to Ethics in Robotics and AI, Springer, 2021.

Reference Books:

1. Russell, S., Human Compatible: Artificial Intelligence and the Problem of Control, Viking, 2019.
2. Christian, B., The Alignment Problem: Machine Learning and Human Values, W. W. Norton & Company, 2020.
3. Birolini, A., Reliability Engineering: Theory and Practice, Springer, 2017.

Weblinks:

1. Responsible & Safe AI Systems, https://onlinecourses.nptel.ac.in/noc25_cs118/preview, NPTEL
2. Artificial Intelligence (AI) for Management, https://onlinecourses.nptel.ac.in/noc26_cs10/preview, NPTEL
3. AI Governance Simplified (Video Lecture), https://www.youtube.com/watch?v=LgFBi5XD-Ow, YouTube

Robot Dynamics and Control			
Semester	**VI**	CIE Marks	**50**
Course Code	**23RIOE323**	SEE Marks	**50**
Teaching Hrs/Week (L:T: P)	**3:0:0**	Exam Hrs	**3**
Total Hrs	**42**	Credits	**3**

This course is designed to:

1. Impart knowledge on the mathematical foundations of robotics, including spatial transformations, reference frames, and the kinematic modeling of manipulators.
2. Provide knowledge on robot kinematics, Denavit-Hartenberg representation and forward and inverse kinematic equations.
3. Familiarize the principles of robot dynamics and the derivation of equations of motion using the Lagrangian formulation.
4. Introduce trajectory planning in joint space and cartesian space.
5. Familiarize linear control architectures, design and performance analysis of PID controllers for single-joint robotic systems.

Module 1: Mathematical Foundations of Robotics	**No. of Hrs: 8**

Matrix representation of points and vectors, Homogeneous Transformation Matrices, Representations of transformations: Representation of Pure Translation, Pure Rotation and Combined Transformations, Inverse of transformation matrices.

Textbook 1: 2.4, 2.5, 2.6.1-2.6.3, 2.7

Module 2: Kinematics of Robots	**No. of Hrs: 9**

Forward and Inverse Kinematic Equations: Cartesian & Cylindrical Coordinates, Denavit-Hartenberg Representation, Inverse Kinematic Solution of Robots, General Solution for Articulated Robot Arms, Degeneracy and Dexterity, Stair-Climbing Robot, 3-DOF Robot, Mobile Robot

Textbook 1: 2.8, 2.9.1, 2.9.2, 2.1.2-2.1.4, 2.16, 2.18

Module 3: Robot Dynamics	**No. of Hrs: 9**

Lagrangian Mechanics Overview, Effective Moments of Inertia, Dynamic Equations for Multiple-DOF Robots: Kinetic Energy, Potential Energy, Static Force analysis, Transformation of Forces and Moments between Coordinate Frames

Textbook 1: 6.1-6.3, 6.4.1, 6.4.2, 6.5, 6.6

Module 4: Trajectory Planning for Robots	**No. of Hrs: 8**

Path vs. Trajectory; Joint space vs. Cartesian Space, Trajectory Planning, Joint Space Trajectory Planning: Third-Order and Fifth Order Polynomial Trajectory Planning, Cartesian Space Trajectories, Continuous Trajectory Recording.

Textbook 1: 7.1–7.4, 7.5.1, 7.5.2, 7.6, 7.7

Module 5: Motion Control for Robots	**No. of Hrs: 8**

Components and Terminology, System Dynamics, Laplace Transform, Transfer Functions, Open-Loop vs. Closed-Loop Applications, Multiple-Input and Multiple-Output Systems, State-Space Control Methodology, Digital Control, Nonlinear Control Systems, Electromechanical Systems Dynamics: Robot Actuation and Control

Textbook 1: 8.1-8.5, 8.7, 8.20-8.25

Course Outcomes: At the end of the course, the student will be able to

1. Articulate the mathematical transformations used in robotics, kinematic modeling of serial manipulators using the Denavit-Hartenberg representation and dynamic formulation of robotic systems using Lagrangian mechanics.
2. Describe methodologies for generating smooth robot trajectories in joint and cartesian spaces and principles of linear feedback control systems.
3. Solve numerical problems on forward & inverse kinematics, dynamic equations of motion, polynomial trajectory coefficients and control system transfer functions.
4. Determine the kinematic configurations of robots for degeneracy and dexterity and assess the stability and performance characteristics of robot motion control systems.

Textbooks:

1. Saeed Niku, Introduction to Robotics – Analysis, Control, Applications, Third Edition Wiley. 2020

Reference Books:

1. Frank L. Lewis, Draguna L. Vrabie, Vassilis L. Syrmos, Optimal Control, John Wiley and Sons, 3rd Edition, 2012.
2. Yuxi Li, Deep Reinforcement Learning for Robotic Systems, Springer, 1st Edition, 2021.
3. Simon Haykin, Optimization Algorithms for Robotics and Machine Learning, Routledge, 1st Edition, 2019.

Weblinks:

1. Robotics and Control: Theory and Practice, https://onlinecourses.nptel.ac.in/noc20_me03/preview, NPTEL (IIT Madras)
2. Robotics, https://onlinecourses.nptel.ac.in/noc21_me76/preview, NPTEL (IIT Kharagpur)
3. Control Systems Lectures, https://www.youtube.com/user/ControlLectures, YouTube

Yoga – IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC325**	SEE Marks	-
Teaching Hrs/Week (L:T: P)	**0:0:1**	Exam Hrs	-
Total Hrs	**13**	Credits	-

Course Learning Objectives: This course is designed to

1. Empower students to achieve and maintain good health.
2. Promote the practice of mental hygiene.
3. Facilitate students in attaining emotional stability.
4. Impart moral values and higher level of consciousness.

Contents	**No. of Hrs: 13**

- Ashtanga Yoga 1. Dharana 2. Dhyana (Meditation) 3. Samadhi
- Asana by name, technique, precautionary measures and benefits of each asana
- Suryanamaskar13 count- 4 rounds of practice
- Different types of Asanas
  a) Sitting
     1. Bakasana
     2. Hanumanasana
     3. Ekapada Rajakapotasana
     4. Yogamudra in Vajrasana
  b) Standing
     1. Vatayanasana
     2. Garudasana
  c) Balancing
     1. Veerabhadrasana
     2. Sheershasana
  d) Supine line
     1. Sarvangasana
     2. Setubandha Sarvangasana
     3. Shavasanaa (Relaxation posture).
- Revision of Kapalabhati practice 40 strokes/min - 3 rounds
- Meaning by name, technique, precautionary measures and benefits of Pranayama Bhramari.

Course Outcomes: At the end of the course, the student will be able to

1. Describe the meaning, aim and objectives of Yoga.
2. Perform Suryanamaskar and able to analyze its benefits.
3. Exhibit the different Asanas by name, its importance, methods and benefits.
4. Perform Kapalabhati.
5. Perform the different types of Pranayama by its name, precautions, procedure and uses.

Textbooks:

1. Ajitkumar ,"YogaPravesha in Kannada" 1st Edition, Raashtroththaana Saahithya, 2017,ISBN-13: 978-8175310124
2. BKS Iyengar, "Light on Yoga", 1st Edition, Thorsons, 2017, ISBN-13: 978-0008267919
3. Dr. M L Gharote& Dr. S K Ganguly,"Teaching Methods for Yogic practices", 1st Edition, Kaivalyadhama, 2001, ISBN-13 : 978-8189485252

Reference Book:

YaminiMuthanna, "Yoga for Children step by step", 1st Edition, Om Books International, 2022, ISBN-13: 978-9394547018

Web links:

1. My Life My Yoga: https://youtu.be/KB-TYlgd1wE
2. Adiyoga: https://youtu.be/aa-TG0Wg1Ls

Scheme and Assessment:

Sl.No.	Activity	Marks
1	Quiz	20
2	Practical demonstration	50
3	Final Report	30

Physical Education - IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC326**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Impart the fundamental concepts and skills of Physical Education, Health, Nutrition and Fitness
2. Familiarization of health-related Exercises, Sports for overall growth and development
3. Build a strong foundation for the professionals in Physical Education and Sports

Contents **No. of Hrs: 13**

- Importance of nutrition for optimal performance and healthy eating habits. (Lectures)
- Mindfulness and stress management techniques like meditation. (Practical Sessions)
- Emphasis on teamwork, communication, and sportsmanship. (Practical Sessions)
- Specific Games (Students continue prior semester's game by practicing Advanced Skills)

Basket Ball	Behind-the-back dribble - Spin moves - Alley-oop passes - Shooting off the dribble - Advanced footwork and shot creation techniques
Cricket	Reverse swing and googly bowling - Spin bowling variations (leg spin, off spin) - Captaincy skills - Advanced batting techniques (switch hitting)
Football	Advanced dribbling techniques (stepovers, fakes) - First touch passing and control - Volley control and shooting - Set pieces (free kicks, corner kicks) Advanced heading techniques - Goalkeeper diving and shot-stopping
Hockey	Deke moves and advanced stickhandling - Aerial control - Passing variations (chip pass, scoop pass) - Penalty corner techniques - Advanced defensive strategies
Kabaddi	Advanced raiding maneuvers (super raid) - Quick and deceptive raiding holds - Strategic raiding based on game situation - Strong team defense coordination - Advanced anti-raid tactics
Karate	Advanced kumite strategies and tactics - Complex combinations of attacks and counters - Throwing and takedown techniques (sweeps, trips) -Advanced conditioning and strength training
Table Tennis	Advanced footwork for quick movement - Smashing technique - Serving variations (sidespin, flick serve) - Deceptive spins and tactics - Advanced match play strategies
Throwball	Jump shot and other variations - No-look passes and behind-the-back passes - Quick throws and fast breaks - Advanced dodging techniques and footwork - Zone defense and press defense strategies
Volleyball	Offensive spiking mechanics (jumping and hitting the ball)

Course Outcomes: At the end of the course, the student will be able to

1. Demonstrate an understanding of the link between nutrition, performance, and healthy eating habits
2. Demonstrate improved self-awareness, stress management skills, and effective teamwork through participation in sportsmanship-focused activities.
3. Perform in the selected sports or athletic events

Textbooks:

1. Muller, J. P., "Health, Exercise and Fitness", 1st Edition, Sports Publication, 2018.
2. Uppal, A.K., "Physical Fitness", Friends Publication New Delhi, 1992.
3. Russell R.P., "Health & Fitness through Physical Education: Human Kinematics", Human Kinetics Publishers, 1994

Reference Books:

1. Anaika , "Play Field Manual", Friends Publication New Delhi, 2005.
2. IAAF Manual
3. Pinto John & Roshan Kumar Shetty, "Introduction to Physical Education"

Web links:

1. https://www.youtube.com/watch?v=wvlztaJYKYI
2. https://www.youtube.com/watch?v=d393LzvqG3E&list=PL94CA1fTzfEd8FkpCa0WNTF7y1pFWNFKc
3. https://www.youtube.com/watch?v=m7EhWv4wgP4

Scheme & Assessment of students for auditing the course & Grades		
SN	Activity	Marks
1	Participation of students	20
2	Quizzes-2, each of 15 marks	30
3	Final presentation/Exhibition/Participation in Competitions (Certificate of participation in National/International)	50
	Total	**100**

National Service Scheme - IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC327**	SEE Marks	**-**
Teaching Hours/Week (L:T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. Develop discipline, character, brotherhood, the spirit of adventure and ideals of selfless service amongst young citizens
2. Develop youth leadership in the students.
3. Induce social consciousness among students through various societal activities.
4. Impart knowledge in finding practical solutions to individual and community problems

NSS -Contents	**No. of Hrs: 13**

Introduction:

- Basic first aid skills
- Disaster preparedness, emergency evacuation

Activities:

- Environment Awareness and Conservation
- Obstacle management Training, conflict management and negotiation skills

Note:

- Students in individual or in a group should select any one activity in the beginning of each semester till end of that respective semester for successful completion as per the instructions of NSS officer with the consent of HOD of the department.
- At the end of every semester, activity report should be submitted for evaluation.

Course outcomes: At the end of the course, the student will be able to

1. Understand the importance of nation building and individual contribution to the betterment of the society
2. Discover grassroots challenges of community and solve them by technological intervention
3. Create societal impact by upholding the value of one for all and all for one.
4. Maintain discipline and team spirit

Textbooks:

1. Ministry of Youth Affairs & Sports, Government of India (2022) "National Service Scheme Manual"
2. Rajiv Gandhi National Institute of Youth Development, Ministry of Youth Affairs & Sports, Government of India, (2017)"Introduction Training Module for National Service Scheme (NSS) Program officers",
3. Gurmeet Hans (1996), "Case material as Training Aid for field workers" TISS

Reference Books:

1. Dr. G R Bannerjee, (2012),Social service opportunities in Hospitals, TISS
2. Ram Ahuja (Third Edition, 2014), Social Problems in India, Rawat publications

Web links:

- History of NSS https://thebetterindia.com/140/national-service-scheme-nss/
- NSS – an introduction https://www.youtube.com/@nationalserviceschemeoffic4034/videos

Assessment details (CIE): Students will be assessed with the

Weightage	CIE
Participation of students	30 Marks
Individual contribution to success of the program	40 marks
Report preparation	30 Marks
Total marks	100 Marks

Arts - IV			
Semester	**VI**	CIE Marks	**100**
Course Code	**23NMCC328**	SEE Marks	**-**
Teaching Hours/Week (L: T: P)	**0:0:1**	Exam Hrs	**-**
Total Hours	**13**	Credits	**-**

Course Learning Objectives: This course is designed to

1. To impart an understanding of the creative process from initial concept to final execution.
2. Create and demonstrate proficiency in a chosen arts discipline through practical application.
3. Analyze and appreciate diverse art forms and styles
4. To participate in art competitions at regional, state, national, and international levels, as well as in cultural events

Contents	**No. of Hrs.: 13**

Note: Student will continue the arts form selected in previous semester.

Performing Arts (Dance)	Orientation, Cinema Script Writing, Audition Techniques, Shooting Script, Basics Direction and Camera, Group Assignments, Group Presentation, Evaluation.
Music	Orientation, Western Songs, Voice Culture, Voice Modulation, Rap Singing, Folk Song Revision, Film Song Revision, Group Presentation Evaluation
Arts & Crafts	Orientation, Puppetry: Glow Puppetry- Head Puppets -Animal Puppetry -POP Puppetry- Group Presentation- Evaluation
Theatre	Orientation, Theatre Music, Theatre Choreography, Script Writing, Group Production, Grand Rehearsals, Group Show, Evaluation.

Course Outcomes: At the end of the course, the student will be able to

1. To be capable of creating choreography and delivering live performances for an audience.
2. Employ a range of acting techniques and use them to create a performance.
3. Evolve into creative, effective, independent, and reflective individuals capable of making informed decisions in both process and performance.
4. Acquire knowledge and comprehension of the roles and processes used in current theatre arts practice.

Textbooks:

1. Music in Theory and Practice by Bruce Benward and Marilyn Sake, McGraw-Hill Education,2014

2. Art Fundamentals: Theory and Practice by Otto G. Ocvirk, Robert E. Stinson, Philip R. Wigg, Robert Bone, and David L. Cayton, McGraw-Hill Education,2012

3. The Viewpoints Book: A Practical Guide to Viewpoints and Composition by Anne Bogart and Tina Landau, Theatre Communications Group,2004

Reference Books:

1. Dance Composition: A practical guide to creative success in dance making, Jacqueline M. Smith
2. The Artist's handbook of method and materials by Ralph Mayer
3. Glimpses of Indian music and dance by Dr. Arun Bangre.

Web links:

1. https://ccrtindia.gov.in/audio-visual-catalogue/

Scheme & Assessment of students for auditing the course & Grades

SN	Activity	Marks
1	Students Participation	20
2	Quizzes-2 (each of 15 marks)	30
3	Final presentation/Exhibition/Participation in Competitions	50
	Total	**100**