B. Tech. (Hons.) in Mechanical Engineering with Specialization in Robotics & Automation

Overview

With the vision of facilitating skill development in niche areas like Robotics, Automation, Artificial Intelligence, etc., imparting flexibility and outreach of engineering students, and preparing students for next-generation technological development, the LNMIIT has introduced the concept of B. Tech. (Hons.) with Specialization for UG students of the LNMIIT.

As per AICTE, a set of 6 to 7 additional courses, i.e., approximately 18-20 credits in a specific stream, over and above the curriculum credits, is sufficient to obtain a B. Tech. (Hons.) with Specialization in an emerging area. These additional courses will be offered within the duration of the B. Tech. program through regular courses. Highly motivated students could opt for these courses apart from the course in their curriculum and those who fulfil all the requirements of a B. Tech. (Hons.) with Specialization successfully will get an Honours degree and a special mention of Specialization in the niche area.

Keeping in view the Institute's objective of emphasizing knowledge and skill development at all levels, the Department of Mechanical-Mechatronics Engineering (MME) has proposed 'B. Tech. (Hons.) with Specialization in Robotics & Automation.

Introduction

Students of Mechanical Engineering have been given an option of a B. Tech. (Hons.) Specialization in Robotics & Automation, provided they study a specific stream of courses related to this domain.

The B. Tech. (Hons.) Specialization in Robotics & Automation will provide the needed boost and broad exposure to advanced concepts, latest tools, and involved analytical methods in the fascinating world of Robotics & Automation. It will enable the students of the Mechanical Engineering stream to acquire additional vital skills and expertise beyond the knowledge gained in B. Tech. curriculum, to the best, meet their assured job prospects and career goals through these professionally oriented, industrially aligned courses and above all the application-focused hands-on approach to learning.

“Robotics & Automation” Specialization will enable students to learn next-generation robotics and automation systems. Specialization subjects will be exposing our students to course work from multiple disciplines and preparing them to think about robotics from a holistic approach. Our program will prepare a skilled industry workforce and expert researchers who will be able to provide leadership in a world that is increasingly dependent on technology. The students will have career opportunities in manufacturing, research and engineering, agriculture, mining,

space exploration, power-plant maintenance, and various other areas. After completing the Specialization, they can be employed in laboratories, space exploration, manufacturing plants, mining, and organizations.

Why B. Tech. (Hons.) with Specialization in Robotics & Automation

Robotics & Automation is a field of engineering that involves the conception, design, manufacture, and operation of robots and Automation setups. It is a combination and overlaps many areas of engineering, including Electronics, Computer Science, Artificial Intelligence, Automation, Mechatronics, Nanotechnology, and Bio Engineering.

Automation & Robotics plays an essential part in several modern manufacturing companies. However, few positions are readily available for an Automation & Robotics Engineer. The following are the industries where an Automation & Robotics engineer can find work in:

- Aerospace
- Defence contractors
- Entertainment
- Manufacturing
- Medical research (development of prosthetic parts)

Inadequate availability of Robotics & Automation expertise is one of the challenges to realizing the world's total potential growth. There is an emergent need for developing future talent by the changing needs of the job market. The students need to be equipped with the new skill set to prepare for new-age job requirements.

Program Educational Objectives (PEOs)

PEO1: To provide the strong fundamental knowledge in Engineering Sciences and Mathematics among students to enable them to plan, design, construct and maintain mechanical engineering systems as well as robotics and automated systems that are technically sound, economically feasible and socially acceptable to enhance quality of life.

PEO2: To develop ability among the students to apply analytical, computational and simulation tools & techniques to address the challenges faced in mechanical and allied engineering streams such as robotics and automation.

PEO3: To provide opportunities for the students to demonstrate leadership & entrepreneurial skills and prepare them to work with multi-discipline field of engineering.

PEO4: To prepare the students to exhibit professionalism, ethical attitude, team spirit and enable them to understand the need for lifelong learning to achieve career and organizational goals.

PEO5: To prepare students unleash their creativity by solving real life problems of the society through robotics and automation and building the future of the country.

Program Objectives

The objectives of offering B. Tech. (Hons.) with Specialization in Robotics & Automation are as follows:

PO1 - Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and engineering specialization to the solution of complex engineering problems.

PO2 - Problem analysis: Identify, formulate, research literature, and analyse engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3 - Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 - Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 - Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 - The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 - Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 - Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 - Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10 - Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations and give and receive clear instructions.

PO11 - Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one’s own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO12 - Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Learning Outcomes

On completion of B. Tech. (Hons.) with Specialization in Robotics & Automation, the students will have the ability to:

1. Design & Develop the Robotic and Automation systems efficiently with careful selection of material, sensors, controllers, and other components.
2. Model, Simulate & Control the kinematics and dynamics of Robotic & Automation systems.
3. Develop programs and Algorithms on various programming platforms for Robotic and Automation systems.
4. Apply basics of AI, Machine Learning & Image processing for the efficient functioning of Robotic and Automation systems.

Number of seats

The total number of seats combined for B.Tech. in Mechanical Engineering & B. Tech. (Hons.) in Mechanical Engineering with Specialization in Robotics & Automation are 60.

Admission

Students can admit themselves to B. Tech. (Hons.) with Specialization in Robotics & Automation at the time of admission in the institute's B. Tech. program. The option of choosing B. Tech. (Hons.) Mechanical Engineering with Specialization in Robotics & Automation program will be provided to students and other B. Tech. programs & B.Tech. - M. Tech. dual degree programs.

a. Eligibility criteria:

- The eligibility criteria will be same as admission criteria of The LNMIIT in the B. Tech program / B.Tech. - M. Tech. dual degree program at the LNMIIT.

b. Seat Allotment:

Seat allotment will be done based on merit. A merit list will be prepared using the same criteria used for admission in the B. Tech program / B.Tech. - M. Tech. dual degree program in the particular admission cycle.

Note: Students will still be given a provision to convert their degree from B. Tech. in Mechanical Engineering to B. Tech. (Hons.) in Mechanical Engineering with Specialization in

Robotics & Automation at the beginning of 2nd semester subject to the following performance criteria:

- Minimum CGPA of 6.0 in the First Semester.

Structure

While designing the course structure, considerable care was taken regarding regulatory body guidelines, academic guidelines of the Institute, and inputs from industry and academia.

Specialization courses that define the Specialization in Robotics & Automation are intelligently chosen to impart the learning experiences and skill sets that are most vital and focused on the current industry needs and market demands, enhancing the student's ready job deployment and stable job deployment and fulfilling career.

The courses will be offered along with the B. Tech Mechanical Engineering curriculum to convert it into B. Tech (Hons.) with Specialization in Robotics & Automation is given in the Table 1 below:

Sno.	**Course**	**Sem**	**Credits** **L-T-P-C**
1	Minor Project	3rd	0-0-3-1.5
2	Introduction to Automation	3rd	1-0-3-2.5
3	Modelling and Design of Robots	4th	1-0-3-2.5
4	Programming for Automation and Robotics	5th	1-0-3-2.5
5	Control and Optimization of Automation and Robotic Systems	6th	1-0-3-2.5

6	Artificial Intelligence for Robotics and Automation	7th	1-0-3-2.5
7	Major Project	7th	0-0-8-4
Total Credits			**18**

Table 1: Courses for Specialization in Robotics & Automation

Important Considerations

- A student will be offered only one extra course per semester apart from the courses in their UG curriculum from the 3rd semester until the 7th Semester.
- The students taking the specialization programme will have to take up a minor project of 1.5 credits. This project is kept to make them familiar with the Electronics and the Computer Science part since these students would be from Mechanical Background.
- From the 3rd to 7th Semester, a student will have to take one course, i.e., 2.5 credits over and above its curriculum.
- The institute will finance the expenses involved in Major Project by incorporating these expenses in the yearly budget of relevant labs.
- The project will be given in groups of 2 or 3.
- The major project topic will be mutually finalized by students & the project guide. A topic can be proposed by anyone in the group, including a project guide.
- The student may start the major project right from his/her 3rd Semester and the evaluation of this major project would be done at the end of the 7th Semester. This allows the students to give substantial time to his/her project. The project guide will ensure that the progress of the project is sufficient in each semester.
- The institute has recruited a few faculty members who are experts in the domain of Robotics & Automation to run the Specialization subjects effectively.
- Students can switch to B. Tech Mechanical Engineering at any stage of their tenure if they find it hectic or for any other reason.
- Additional program electives offered by the MME Department in Robotics &

Automation are given in Table 2 below. Students who are not enrolled in **B. Tech. (Hons.) in Mechanical Engineering with Specialization in Robotics & Automation** may also take these courses as per academic provisions of the Institute.

S. No.	Course Type	Semester	Credits (L-T-P-C)	Course Names
1.	Program Elective	$5^{th}/6^{th}/7^{th}/8^{th}$	3-0-0-3 3-0-2-4	(1) Mechatronics, (2) Robotics, (3) Industrial Automation, (4) Distributed Control systems & (5) System Dynamics & Control are being offered as program electives. 3 of these courses also have lab component associated with the subject.

Table 2: Additional Program Electives for studying Robotics & Automation

Backlog & Dropout Mechanism

This will be the same as followed by Institute in any other B. Tech program.

Criteria for award of Specialization in Robotics & Automation

Upon completion of the additional 18 credits mentioned in Section VII and credits of B. Tech ME curriculum, the student will be eligible for the Honours degree in Mechanical Engineering with Specialization in Robotics & Automation as per academic norms.

The overall content of the SPC (Specialization core subjects) and SPROJ (Specialization project) is shown in Table 3 below:

Sno.	Course Name	Content
1	**MINOR PROJECT**	This project is to make students aware of the modern technical skills tools through literature survey and their use for doing a project in Robotics & Automation. Getting familiar with a few aspects of hardware & software right at the start of the minor will make them more curious to go deeper into the domain to get the best out of it. The project will attract students to take upcoming courses seriously, and they will also understand the use of every subject in problem-solving. Minor projects will also promote Creativity, teamwork, Leadership, Professionalism, Time Management, Presentation Skills, Communication Skills, Technical Report Writing skills.

1	**INTRODUCTION TO AUTOMATION**	Fundamentals of Automation, security and ethics. Origin of Automation, Classification of robots, Cobotics. Types of joints, work volume, classification of robots, components of robots, sensors: Actuators, power transmission systems, Velocity and position sensors, Force, torque sensors. Range, proximity, touch sensors and actuators for Automation and robotics, hands-on use and control of sensors, actuators using LabView, Atmel studio, Proteus and Multisim.
2	**MODELING AND DESIGN OF ROBOTS**	Mathematical modeling, homogeneous transformations, Forward and Inverse Kinematics. Rotations and translation of vectors. Transformations and Euler angle representations, Homogenous transformations. Velocity kinematics and Jacobian, Statics, singularity and Manipulability, Trajectory planning Dynamics of Robots - acceleration and force analysis. Basic mechanical design concepts, Hands-on sessions on CAD, Solid works, Ansys, MATLAB, LABVIEW for various application oriented Robots.
3	**PROGRAMMING FOR AUTOMATION AND ROBOTICS**	CAM, Electrical-Electronic, Pneumatic, electro-pneumatic, and hydraulic systems used for Automation Hands-on sessions on PLC, SCADA, and CNC programming. Hands on session on automation hardware kits, their interfacing with software, Robot Programming - VAL II, Robot programming languages, pick and place automation setup, hydraulic kit, pneumatic and electro pneumatic kits and process control kit.
4	**CONTROL AND OPTIMISATION OF AUTOMATION AND ROBOTIC SYSTEMS**	Simulation and design of control systems of Automation and robotic systems. Control basics, Model based control, position control, speed control, perturbation control. Microcontrollers, Hands-on sessions on simulating mathematical models and control designs on Matlab and LabView. Implementation of robots and control system for real applications. Optimization of robotic and Automation systems, Functional optimization, case studies.
5	**ARTIFICIAL INTELLIGENCE FOR ROBOTICS AND AUTOMATION**	Basics of artificial intelligence and machine learning for robots and automation systems, Image recognition (OpenCV), Robot Vision, machine vision, Image segmentation, Template matching, Polyhedral objects, Shape analysis hands-on sessions on python. Programming in Path planning, localization, obstacle avoidance etc. of AGV, Manipulators and Automation systems.

6	**MAJOR PROJECT**	This project will involve immersing students in a more active learning experience by developing an idea on their own, applying the knowledge and skills they have learnt beforehand, finding the best solution of the problem and then execute it. The activities such as planning, researching, creating, thinking critically, building, testing, and reporting will help make student industry ready. Students will build on their research skills and deepen their learning of applied content beyond facts or memorization. They will learn to look at problems with a critical thinking lens, asking questions and coming up with possible solutions for their project.

Table 3: Overall Content of courses for Specialization in Robotics & Automation

Course Information Forms (CIFs)

The LNMIIT, Jaipur Department of Mechanical & Mechatronics Engineering Introduction to Automation (INTROAUTO)	LNMIIT The LNM Institute of Information Technology

Subject Code: **INTROAUTO**	Course Title: **Introduction to Automation**	Total Contact Hours: **13**	**L: 1**	**T: 0**	**P: 3**	**C: 2.5**
Pre-requisite: **Basic Electronics**		Year: **2**	Semester: **Odd**			
Type of Course**: Hons./Minor Program**						

***** L Lectures, T Tutorials, P Practical C Credit***

Learning Objective:

This is an undergraduate Hons./Minor Programme course offered to 3rd-semester Engineering students. The course will help the students in acquiring a mix of skills in mechanical, electronics and computing to be able to comprehend and design automation systems. Theoretical knowledge as well as hands-on practice on various sensors, actuators, digital electronics, signal conditioning devices and circuits which are used in automation systems, will be given. Study of methods for designing and analyzing automation systems and how to effectively interface them with controllers will also be done during this course. Practical knowledge on various sensors, actuators, digital electronics, signal conditioning devices and circuits which are used in mechatronic systems will be given so that students can do synergistic integration of mechanics, electronics, control theory, and computer science within product design and manufacturing, in order to improve and/or optimize its functionality. Programming using different software and hardware will be done to effectively interface them with controllers.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		**Bloom's Level**
CO-1	Model and Analyze automation systems for an engineering application.	**4**
CO-2	Identify and Explain sensors and actuators to monitor and control the behavior of a process or product.	**2**
CO-3	Evaluate the performance of automation systems.	**5**
CO-4	Design an automated system for an engineering application.	**6**

Course Topics:

S. No.	**Contents**	**Hours**

1	**Introduction to Automation:** History and Fundamentals of Automation, scope and significance of automation systems, security and ethics of Automation, elements of automation systems, needs and benefits of Automation in Industry. Examples: Pick and place robot, Bar code, Engine Management system, Washing machine etc.	**1**
2	**Sensors for Automation & Robotics:** Introduction to sensors, Static and dynamic characteristics, Types of sensors, Optical Sensors, Temperature Sensors, Magnetic and Electromagnetic Sensors, Mechanical Sensors, Pressure sensors	**2**
3	**Mechatronic system** components, circuits and response Analysis of electric circuits and components, Amplitude Linearity, Bandwidth and Frequency Response, Phase linearity, Distortion of Signals, Response of a zero, first and second order system, system analogies.	**2**
4	**Closed-Loop controllers** Continuous and discrete control, Two-step mode control, Electronic P, I, D, PI and PID controllers, control system performance, tuning, adaptive control.	**2**
5	**Digital Electronics:** Number systems, BCD codes and arithmetic, Gray codes, self-complimenting codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.	**2**
6	**Signal Conditioning:** Operational amplifiers, Protection circuits and devices, comparator, filters, Multiplexer, Pulse width Modulation, Counters, decoders, Data acquisition, Analog to digital conversion, digital to analog conversion.	**2**
7	**Actuators for Automation & Robotics:** Electrical Actuators: Solenoids, Relays, DC motor, Servo motor, BLDC Motor, AC Motor, Stepper motors. Mechanical, Hydraulic & Pneumatic devices.	**2**

S. No.	**Name of Lab Experiment**	**Hours**
1	Fundamental Lab	**2**
2	Designing 'PID' Controller on LabVIEW.	**3**
3	Interfacing Sensors and Actuators using LabVIEW and MyRio.	**3**
4	Design and simulation of LED blinking circuit. Hardware development of LED blinking circuit.	**3**
5	Design and simulation of timer and counter circuit. Hardware development of timer and counter circuit and testing.	**3**
6	Design and simulation of Motor control and LCD Display Circuit. Hardware development of Motor Control and LCD Display circuit.	**3**

7	Design and simulation of Amplifier, filter and motor driver circuit. Hardware development of amplifier, filter and motor driver circuit.	**3**
8	Interfacing Arduino with LabVIEW for Temperature control and ADC of sensor data.	**3**
9	Introduction to the Raspberry Pi and its initialization. Design an IoT based application with Raspberry Pi.	**3**
10	Designing Pneumatic Logic to control systems.	**3**
11	Designing Electro-Pneumatic logic to control systems.	**3**
12	Final Project	**2**

Textbook References:

Text Book:

- William Bolton, *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, 4th edition, Pearson Education, 2008.
- Devdas Shetty & Richard Kolk, *Mechatronics System Design*, 3rd edition. PWS Publishing, 2009.
- Groover, Mikell P., et al., *Industrial robotics: technology, programming, and applications*. McGraw-Hill, 2012.
- David G Alciatore & Michael B Histand, *Introduction to Mechatronics and Measurement Systems*, 4th edition, Tata McGraw Hill, 2006.

Reference books:

- Fraden, Jacob, and Lawrence G. Rubin, *AIP Handbook of Modern Sensors*, Physics Today 47.6 (1994): 74.
- Khazan, Alexander D., *Transducers and their elements: design and application*, Prentice Hall, 1994.
- Muller, Richard S., et al., *Device electronics for integrated circuits*, 1986, 54.
- Sze, Simon M., Yiming Li, and Kwok K. Ng. *Physics of semiconductor devices*, John wiley & sons, 2021.
- R. Siegwart, et.al, *Introduction to Autonomous Mobile Robots*, Prentice Hall of India, 3rd Edition, 2005.
- John Craig, *Introduction to Robotics: Mechanics and Control*, Pearson/Prentice Hall Education, 3rd Edition, 2005.
- Ruocco, S., *Robot sensors and transducers*, Springer Science & Business Media, 2013.

Video References:

1. http://video_demos.colostate.edu/mechatronics
2. http://mechatronics.me.wisc.edu

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Evaluation Method	
Item	**Weightage (%)**
Midterm	30
Final Examination	50
Teacher's assessment (Assignment/ Presentation/ Project/ Quiz)	20

CO and PO Correlation Matrix

CO	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	2	2	1	-	-	-	-	-	-	-	1	2	3	1
CO2	3	2	2	2	3	-	-	-	-	-	-	1	2	3	1
CO3	3	1	1	2	-	-	-	-	-	-	-	1	2	2	1
CO4	3	2	3	2	-	-	-	-	-	-	-	1	3	3	1

The LNMIIT, Jaipur
Department of Mechanical & Mechatronics Engineering
Modeling and Design of Robots

Subject Code:	Course Title: Modelling And Design of Robots	Total Contact Hours: **13**	**L: 1**	**T: 0**	**P: 3**	**C: 2.5**
Pre-requisite: Basic Electronics, Introduction to automation		Year: **2**	Semester: **Even**			
Type of Course**: Hons./Minor Program**						

***** L Lectures, T Tutorials, P Practical C Credit***

Learning Objective:

This is a Hons./Minor programme course offered to 2nd year engineering students. It covers the study of kinematics and dynamics of both manipulators and mobile robots. This course presents an introduction to the fundamentals of manipulators and mobile robotics, spanning the mechanical, motor, sensory, perceptual and cognitive layers that comprise this field of study. One unit is also covering the robot vision, image processing and navigation techniques to make them completely autonomous. Practical knowledge on study of kinematics and dynamics of robot on MATLAB, LABVIEW, ATMEL and other such software will be given so that students can do synergistic integration of mechanics, electronics, control theory, and computer science within a robotics system, in order to improve and/or optimize its functionality.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		**Bloom's Level**
CO1	Understand the basics of manipulator, mobile robots, end-effectors	**2**
CO2	Model forward and inverse kinematics of robots	**3**
CO3	Decide robot perception and navigation algorithms	**5**
CO4	Build and program robots using sensors	**6**

Course Topics:

S. No.	**Contents**	**Hours**

1	**Manipulators and End Effectors:** Types of Manipulators, Manipulator Drive Systems, Manipulator Control Systems, Types of end effectors, Grippers, Gripper joints, Gripper force, Applications of robots	**1**
2	**Kinematics and Dynamics:** Kinematics and Dynamics: Basics of theory of machines, Rotation Matrix, Homogenous Transformation Matrix, Direct and Inverse Kinematics for industrial robots, Manipulator dynamics, Manipulator Jacobean. **Mobile Robot:** Introduction, wheeled mobile robots and their kinematics, humanoid robots..	**6**
3	**Trajectory Planning:** Terminology, Joint Space Techniques, Cartesian Space Techniques, Comparison	**2**
4	**Control Architecture:** position, path velocity and force control systems, computed torque control, adaptive control, and Servo system for robot control	**2**
5	**Robot Perception, Vision and Navigation:** Introduction to robot perception, Feature extraction, Image acquisition, representation and processing. Introduction to localization, obstacle avoidance and navigation.	**2**

S. No.	**Name of Lab Experiment**	**Hours**
1	Introductory Lab	**3**
2	Study of kinematics of manipulators	**3**
3	Design and Analysis of Manipulators on CAD	**3**
4	Programming of 5-DoF Robotic Arm	**3**
5	Fabrication and programming of basic RC mobile robots	**3**
6	Study of kinematics of sbRIO Mobile Robot (Turning & Rotating)	**3**
7	Design a suitable algorithm on LabVIEW for obstacle avoidance using sbRIO mobile Robot	**3**
8	Embedded C programming of firebird V robots	**3**
9	Study of open and closed loop motor control of Mobile Robot	**3**
10	Programming of a humanoid robot for different applications	**3**
11	Project	**3**

Textbook References:

Text Book:

- John Craig, *Introduction to Robotics: Mechanics and Control*, Pearson/Prentice Hall Education, 3rd Edition, 2005
- R. Siegwart, *et.al Introduction to Autonomous Mobile Robots*, Prentice Hall of India, 3rd Edition, 2005.

- Mittal, R. K., and I. J. Nagrath. *Robotics and control*. Tata McGraw-Hill, 2003.

Reference books:

- Richard D. Klafter, *Robotics Engineering, An Integrated approach*, Prentice Hall of India, 3rd Edition, 2003.
- Fu K S, Gomalez R C and Lee C S G, *Robotics: Control, Sensing, Vision and Intelligence*, McGraw Hill Book Company, 1st Edition, 1987.
- Groover, Mikell P., et al. *Industrial robotics: technology, programming, and applications.* McGraw-Hill, 2012.

Additional Resources:

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CO2	3	3	1	1	-	-	-	-	-	-	-	1	3	2	1
CO3	3	2	1	1	-	-	-	-	-	-	-	1	3	2	1
CO4	3	2	3	1	-	-	-	-	-	-	-	1	3	3	1
CO5	3	2	3	2	-	-	-	-	-	-	-	1	3	2	1

The LNMIIT, Jaipur
Department of Mechanical & Mechatronics Engineering
Programming for Automation and Robotics

Subject Code:	Course Title: Programming for Automation and Robotics	Total Contact Hours: **13**	**L: 1**	**T: 0**	**P: 3**	**C: 2.5**
Pre-requisite: Introduction to Automation, Robotics, Basic programming skills		Year: **3rd**	Semester: **Odd**			
Type of Course**:** Hons./Minor Program						

***** L □ Lectures, T □ Tutorials, P □ Practical C □ Credit***

Learning Objective:

This is an undergraduate course offered to 3rd year, Vth Semester Engineering students. The course will help the students in understanding the fundamentals of programming robotics and automated systems. Hands-on sessions on PLC, SCADA and CNC programming will be done. Knowledge of a few robot programming languages will also be provided. Hands-on sessions on hardware and software for automated systems will be given.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		**Bloom's Level**
CO-1	Understand and Apply the PLC, SCADA and CNC programming	**3**
CO-2	Understand and Apply various robot programming languages	**3**
CO-3	Interface hardware and software of automated systems	**4**
CO-4	Understand and Modify the pneumatic, hydraulic, and electrical electronics systems used in automated systems	**6**

Course Topics:

S. No.	**Contents**	**Hours**
1	**Introduction**: Introduction to Automated Systems, Hardware and Software components, PLC, SCADA, CNC, Robots, Pneumatic, Hydraulic, Electrical-Electronic, Electro-Pneumatic systems.	**2**
2	**Programming of PLC, SCADA, and CNC**: PLC fundamentals – Input/Output devices, Digital systems, I/O Processing, Programming methods, Timers and counters, Sequencer, Shift registers, Wiring diagram. SCADA fundamentals – Components of SCADA, Key	**5**

	features, Software package, Protocols, Information transfer, Error detection, The twelve golden rules. CNC fundamentals – Coordinates, Axes, Motion, CNC systems, CNC controls, Program planning, Programming.	
3	**Programming for robots**: Robot fundamentals – Methods of robot programming, Motion Interpolation, Robot programming languages- Generation, VAL II, MATLAB, Python, Language elements, functions, constants, variables, data objects, motion commands, computation and operands, program control and subroutines, etc.	**4**
4	**Electrical-Electronic, Pneumatic, Electro-pneumatic, and Hydraulic systems**: Fundamentals – Pneumatic, Hydraulic, Electrical-Electronic, Electro-Pneumatic systems, Elements, Actuators and valves, Examples.	**2**

S. No.	Name of Lab Experiment	Hours
1	Fundamental lab	**3**
2	Operating a simple loads using relays, switches and pushbuttons using PLC	**3**
3	Programming the PLC Via Ladder logic	**3**
4	Programming the PLC Via SFC	**3**
5	Temperature sensing using SCADA	**3**
6	Robot teaching using VAL II Programming	**3**
8	Plan mobile robot paths using RRT in MATLAB	**3**
9	NC Part programming of low-carbon steel part using a CNC machining center	**3**
11	Design of an electro-pneumatic circuit	**3**
11	Final Project	**3**

Textbook References:

Text Book:

- W. Bolton, *Programmable Logic Controller*, Sixth Edition, Newnes Publisher, 2015.
- D. Bailey and E. Wright, *Practical SCADA for industry*, Newnes Publisher, 2003.
- M. Fitzpatrick, *Machining and CNC Technology*, 3rd edition, McGraw-Hill Education, 2013.
- M. P. Groover, M. Weiss, R. N. Nagel, N. G. Odrey, A. Dutta, *Industrial Robotics: Technology, Programming, and Applications*, 2nd edition, 2017.

Reference books:

- J. R. Hackworth and F. D. Hackworth (Jr), *Programmable Logic Controllers: Programming Methods and Applications*, 1st edition, 2006.
- F. D. Petruzella, *Programmable Logic Controllers*, McGraw Hill, 5th edition, 2019.
- Overby, *CNC Machining Handbook: Building, Programming and Implementation*, McGraw-Hill Education, 2011.
- S. Manesis and G. Nikolakopolous, *Introduction to Industrial Automation*, 1st edition, CRC Press, 2018.
- J. A. Harvey, *CNC trade secrets: A Guide to CNC machine shop secrets*, 3rd edition, Industrial Press Inc., 2014.

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Evaluation Method	
Item	**Weightage (%)**
Midterm	30
Final Examination	50
Teacher's assessment (Assignment/ Presentation/ Project/ Quiz)	20

CO and PO Correlation Matrix

CO	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	3	3	2	3	-	-	-	-	-	-	1	3	3	1
CO2	3	3	3	2	3	-	-	-	-	-	-	1	3	3	1
CO3	3	2	2	-	2	-	-	-	-	-	-	1	2	2	1
CO4	3	2	2	2	2	-	-	-	-	-	-	1	2	2	1

The LNMIIT, Jaipur
Department of Mechanical & Mechatronics Engineering
Control and Optimization of Automation & Robotic Systems

Subject Code:	Course Title: Control and Optimization of Automation & Robotic Systems	Total Contact Hours: **13**	**L: 1**	**T: 0**	**P: 3**	**C: 2.5**
Pre-requisite: Maths, Basic programming skills		Year: **3rd**	Semester: **Even**			
Type of Course**:** Hons./Minor Program						

***** L Lectures, T Tutorials, P Practical C Credit***

Learning Objective:

This is an undergraduate course offered to 3rd year, 6th Semester students. The course will help the students in acquiring a mix of skills in mechanical, electronics and computing to be able to comprehend and design automated systems. Theoretical knowledge on simulation and design of various control systems, microcontrollers will be given. Practical knowledge on simulating mathematical models and control designs will also be provided on MATLAB and LabVIEW. Implementation and optimization of robotic and automated systems will be covered for real applications using case studies.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		**Bloom's Level**
CO-1	Compare and Experiment with microcontrollers	**3**
CO-2	Apply various control designs using MATLAB and LabVIEW	**3**
CO-3	Build and Analyze automatic systems for real applications.	**4**
CO-4	Design and Evaluate a control system	**6**

Course Topics:

S. No.	**Contents**	**Hours**
1	**Introduction**: Introduction to control systems, Brief History, Examples of control systems. Automated vehicles, human-in-the-loop control, humanoid robots, unmanned aerial vehicles, industrial control systems, Control system design, Future evolution of control systems, Different types of controls: Model-based control, position control, speed control, perturbation control	**1**
2	**Microcontrollers:** Introduction, Embedded versus external memory devices, Evolution of microcontrollers, Applications of microcontrollers, 8-bit and 16-bit Microcontrollers, Architecture of Microcontrollers, Memory Organization, Pin diagram, Timer & Counter, Serial Communication, Interrupts, Instruction set and Programming, Comparison between Microprocessor and Microcontroller	**2**

3	**Mathematical models and control designs:** Differential Equations of Physical Systems, Linear approximations of physical systems, Laplace transform, Transfer function of linear systems, block diagram models, Signal-flow graph models.	**2**
4	**Implementation of robots and control system for real applications:** Application areas, Factors to consider, Associated challenges, Financial considerations, Implementation process for robotic systems, Benefits to the system integrator and end-users, Basics of MATLAB & LabVIEW, PID control with MATLAB and LABVIEW, Model-based control of robotic manipulators, feedback control to a speed tachometer system.	**2**
5	**Optimization of robotic and Automation systems:** Optimal control systems, Determination of an optimal system, Computational approach for optimal sets of parameters, Solving quadratic optimal control with MATLAB, Functional Optimization and Performance Evaluation.	**2**
6	**Case studies:** Case studies of the control of robotic and automated systems	**3**

S. No.	**Name of Lab Experiment**	**Hours**
1	Fundamental Lab	**6**
2	Analysis of a typical spring-mass-damper mathematical model of a mechanical system using LabVIEW.	**4**
3	Steering control of a mobile robot using LabVIEW.	**3**
4	Designing and tuning a PID controller in MATLAB.	**3**
5	Simulation of Legged walking robots in MATLAB environment.	**3**
6	Interfacing and controlling of stepper motor with microcontroller.	**3**
7	Design and construct microcontroller-based DC motor speed control system.	**3**
8	Final Project	**4**

Textbook References:

Text Book:

- R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 13th edition, Pearson Publication.
- F. Golnaraghi and B. C. Kuo, *Automatic Control Systems*, 9th edition, John Wiley & Sons INC.
- S. K. Mandal, *Microprocessors and Microcontrollers, Architecture, Programming and Interfacing using 8085, 8086, 8051*, Tata McGraw Hill Education Private Limited, 2017.

Reference books:

- G.F. Frenklin, J. D. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 7th edition, Pearson Publication.

- D. E. Kirk, *Optimal Control Theory: An Introduction*, Illustrated edition, Dover Publications Inc., 2004.
- K. Ogata, *MATLAB for Control Engineers*, 1st edition, Pearson Prentice Hall, 2007.
- C. H. Houpis and S. N. Sheldon, *Linear Control System Analysis and Design with Matlab*, 6th edition, CRC Press, 2013.

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Evaluation Method	
Item	**Weightage (%)**
Midterm	30
Final Examination	50
Teacher's assessment (Assignment/ Presentation/ Project/ Quiz)	20

CO and PO Correlation Matrix

CO	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	**3**	**2**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**3**	**1**
CO2	**3**	**3**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**3**	**1**
CO3	**3**	**3**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**3**	**1**
CO4	**3**	**3**	**3**	**3**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**3**	**1**

The LNMIIT, Jaipur
Department of Mechanical & Mechatronics Engineering
Artificial Intelligence for Robotics & Automation

Subject Code:	Course Title: Artificial Intelligence for Robotics & Automation	Total Contact Hours: **13**	**L: 1**	**T: 0**	**P: 3**	**C: 2.5**
Pre-requisite: Basic programming skills		Year: **4th**	Semester: **Odd**			
Type of Course**:** Hons./Minor Program						

***** L □ Lectures, T □ Tutorials, P □ Practical C □ Credit***

Learning Objective:

This is an undergraduate course offered to 4th year, 7th Semester students. The course will help the students in acquiring the knowledge and skills of Artificial Intelligence (AI) in the area of robotics and Automation. Theoretical knowledge of various image processing modules such as image segmentation, template matching, shape analysis, etc. will be provided. In addition to this, hands-on sessions will be given to impart the practical knowledge of programming for various image processing tasks and path planning, obstacle avoidance, etc. using Python.

Course outcomes (COs):

On completion of this course, the students will have the ability to:		**Bloom's Level**
CO-1	Understand the concepts of image processing techniques.	**2**
CO-2	Apply AI and ML algorithms for robots and automated systems.	**3**
CO-3	Apply different operations on digital images using traditional and machine learning algorithms.	**3**
CO-4	Simplify and Solve the programming challenges for AGV, manipulators for various problems such as motion planning, obstacle avoidance, localization, etc.	

Course Topics:

S. No.	**Contents**	**Hours**
1	**AI and ML for robots and Automation:** Basics of artificial intelligence (AI) for robots and automation systems, Classification of AI, Software development environment, Software components, Nature-inspired algorithm, Deep learning, Machine learning, Cognitive, Transfer learning, Spiking neural networks, AI applications to robotics, Robot control systems and a decision-making framework.	**1**

2	**Image Processing:** Image and its fundamentals, Image Processing, History of image processing, Examples of fields that use image processing, Difference between robot vision, machine vision, and computer vision, Steps in image processing- Calibration, Image acquisition, Enhancement, Restoration, Segmentation, Recognition, Template matching, Polyhedral objects, Shape analysis	**4**
3	**OpenCV and Hands-on sessions on Python:** OpenCV and its fundamentals, History of OpenCV, Camera selection, hands-on sessions on python - 2D Convolution, blurring, detecting edges, motion blur, sharpening and embossing of images, etc. OpenCV Machine Learning Algorithms, Machine learning in Vision.	**4**
4	**Programming of AGV, Manipulators and Automation systems:** Path planning basics, Difference between path planning, motion planning and trajectory planning, Selection of path planning algorithms for AGVs, Application of ML techniques for AGV, Simultaneous localization and mapping (SLAM) and its mathematical basics, Taxonomy of SLAM problem, Motion Planning, Obstacle avoidance basics and its techniques – Potential Field Methods (PFM), Vector field histogram (VFH), Obstacle restriction method (ORM), Velocity obstacles (VO), Nearness diagram navigation (ND). Integration planning. Application of AI techniques in path planning of mobile robots.	**4**

S. No.	**Name of Lab Experiment**	**Hours**
1	Fundamental Lab	**6**
2	Picking up a toy by a robot arm using Q-learning	**3**
3	Robotic arm following the trajectory using nature-inspired algorithm	**3**
4	Detection of Edges and application of image filters on OpenCV	**3**
5	Object detection and classification using the AI techniques	**3**
6	Mapping and localization of mobile robot in environment	**3**
7	Evaluation of optimal path and Path tracking of the AGV using the AI techniques	**3**
8	Final Project	**4**

Textbook References:

Text Book:

- S. J. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3rd edition, Pearson, 2010.
- R.C. Gonzalez and R.E. Woods, *Digital Image Processing*, 4th edition, Pearson, 2018.
- G. Bradski and A. Kaehler, *Learning OpenCV: Computer Vision with the OpenCV library*, 1st edition, O'Reilly Media, Inc.

- K. S. Fu, R.C. Gonzalez, C.S.G. Lee, *Robotics: Control, Sensing, Vision and Intelligence*, ISE edition, McGraw-Hill Book Company.

Reference books:

- J. Cicolani, *Beginning Robotics with Raspberry Pi and Arduino: Using python and OpenCV*, 2nd edition, Apress Inc.
- P. Joshi, *OpenCV with Python by Example: Build real world computer vision applications and develop cool demos using OpenCV for python*, Packt Publishing, 2015.
- B. Siciliano and O. Khatib, *Springer Handbook of Robotics*, 2nd edition, Springer, 2016.
- D. R. Franceschetti (ed.), *Principles of Robotics and Artificial Intelligence*, 1st edition, Grey House Publishing, 2018.
- P. Joshi, *Artificial Intelligence with Python, Build real-world Artificial Intelligence applications with Python to intelligently interact with the world around you*, 1st edition, Packt Publishing, 2017.

Additional Resources:

NPTEL, MIT Video Lectures, Web Resources etc.

Evaluation Method	
Item	**Weightage (%)**
Mid term	30
End term	50
Teacher's assessment (Assignment/ Presentation/ Project/ Quiz)	20

CO and PO Correlation Matrix

CO	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3	1	2	1	2	-	-	-	-	-	-	1	2	3	1
CO2	3	2	2	2	3	-	-	-	-	-	-	1	3	3	1
CO3	3	2	2	2	3	-	-	-	-	-	-	1	2	3	1
CO4	3	3	3	3	2	-	-	-	-	-	-	1	3	3	1