Minor Program
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 students across departments, and preparing students for next-generation technological development, the LNMIIT has introduced the concept of a Minor program for UG students of the LNMIIT.

Minor will be a set of 6 to 7 courses (18-20 Credits) affiliated to any one of the niche areas, which are unique because there is no double count of courses. These courses will be offered within the duration of the B. Tech program through regular or summer term courses. However, flexibilities may allow even those students who may do it with spending one or two terms over and above for completing their minors. Highly motivated students could opt for these courses apart from the course in their curriculum. Those who fulfil all the requirements of a minor successfully will get an additional transcript stating details of the courses in the Minor.

Keeping in view the Institute's objective of emphasizing knowledge and skill development at all levels, the Department of Mechanical-Mechatronics Engineering (MME) is offering a 'Minor program in Robotics & Automation'. The details of subjects and scope of minor in Robotics and Automation have been prepared with the help of domain experts across all engineering departments of The LNMIIT and external experts of the domain.

Introduction

"Robotics & Automation" minor will enable students to learn next-generation robotics and automation systems. Minor 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 minor program, they can be employed in laboratories, space exploration, manufacturing plants, mining, and organizations.

Why Minor 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 fields 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
- Entertainment
- Manufacturing
- Medical research (development of prosthetic parts)

Inadequate availability of Robotics & Automation expertise is one of the challenges to realizing the country's full potential growth. There is an emergent need for developing future talent following 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.

Objectives

The objectives of offering the Minor program are as follows:

- To promote understanding of concepts, techniques, and applications of Robotics & Automation by offering related courses.
- To demonstrate the applicability of techniques to real-world business, social and scientific problems.
- To facilitate using various tools to realize future robotic and Automation systems.
- To enhance employability in industry hiring requiring knowledge and skills in Robotics & Automation.

Program Educational Objectives (PEOs)

PEO1: To provide the strong fundamental knowledge in Engineering Sciences and Mathematics among students so as to enable them to plan, design, construct and maintain 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 robotics and automation.

PEO3: 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.

Learning Outcomes

On completion of this Minor, the students will have the ability to:

- Design & Develop the Robotic and Automation systems efficiently with careful selection of material, sensors, controllers, and other components.
- Model, Simulate & Control the kinematics and dynamics of Robotic & Automation systems.
- Write programs and Algorithms on various programming platforms for Robotic and Automation systems.
- 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 for Minor in Robotics & Automation are limited to 20.

Admission

Students will be admitted to the Minor program at the time of admission in the Institute's B.Tech program / B.Tech. - M.Tech. dual degree program. The option of choosing a Minor program will be provided to students along with other B.Tech programs & B.Tech. - M.Tech. dual degree programs.

a. Eligibility criteria:

- The eligibility criteria will be the same as the 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: For the remaining seats in the Minor program, students can apply for the Minor at the beginning of the 2nd Semester. The official announcement will be made about the number of remaining seats, deadlines, and other requirements to apply for the Minor program. The eligibility criterion at entry point no. 2 will be based on students' performance in 1st Semester.

a. Eligibility criteria:

- Minimum CGPA of 6.0 in the First Semester.

b. Seat Allotment:

An appropriate committee will prepare the final merit list based on small interactions with students.

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.

a) **Factors Considered**

- Compliance with AICTE regulations was taken into consideration. Accordingly, a student is eligible for an Undergraduate degree in Engineering with a Minor if he/she completes additional 18-20 credits, over and above their existing curriculum courses.
- UG Curriculum structure of ECE, CSE and CCE students was considered while placing Minor Courses to ensure that restriction on maximum credit limit allowed is not violated.
- Course sequence, name, and content were finalized in a series of meetings over the last year, including experts across all the departments of LNMIIT and external experts from BITS Pilani, IIT Delhi, and Industry.
- After that, the proposed curriculum underwent various changes based on expert comments from IIT Kanpur, IIT Roorkee, etc., in India and various foreign universities like INRIA France, Carnegie Mellon University, etc.

b) **Courses and Placement**

The courses for Minor Program in Robotics & Automation are shown in Table 1.

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 Minor in Robotics & Automation

The content of all the courses is shown in Table 2.

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.
2	**INTRODUCTION TO AUTOMATION**	Fundamentals of Automation, security, and ethics. Origin of Automation, Classification of robots, Robotics. 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.
3	**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.
4	**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, 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.
5	**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.
6	**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.
7	**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 2: Overall Content of courses for Minor in Robotics & Automation

c) Important Considerations

1. The Minor project of 1.5 credit will start in the month of June. Therefore, students will have 20-30 days to go home after finishing their 2nd Sem Exams.
2. A student will be offered only one extra course per Semester apart from the courses in their UG curriculum from 3rd Semester onwards till 6th Semester.
3. From the 3rd semester to 7th semester, a student will have to take one course i.e. 2.5 credits over and above curriculum.
4. In the 7th Semester, the student will have to take one course and one project, i.e., a total of 6.5 credits over and above its curriculum.
5. The institute will finance the expenses involved in Minor & Major projects by incorporating these expenses in the yearly budget of Relevant Labs.
6. The projects will be given in groups of 2 or 3, and special care will be taken in making heterogeneous groups, i.e., students of different engineering domains will be put together in groups.
7. The topic of Minor & Major projects will be mutually finalized by students & project guide. A topic can be proposed by anyone in the group, including a project guide.
8. The institute has recruited a few faculty members who are experts in Robotics & Automation to run the minor effectively.
9. Fees of the minor will be taken Semester wise.
10. Students can exit the minor program at any stage of tenure if they find it hectic or for any other reason.
11. Additional program electives offered by the MME Department in “Robotics & Automation” are given in Table 3 below.

SNo.	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 3: Additional Program Electives for studying Robotics & Automation

Backlog & Dropout Mechanism

- If a student fails in one or more subjects of Minor, then they will only be allowed to enrol in the subsequent Semester if the course to be taught in that Semester doesn't require failed course/s as a pre-requisite for taking this course.
- A student must pass all pre-requisite courses to take any further course. If not, their Minor will temporarily halt until they pass that course.
- However, to help students complete the Minor program within their B. Tech. tenure, a student can be allowed to take up to 2 courses of Minor per Semester provided one of the courses is not the pre-requisite of the other.
- A student can be allowed to enrol in a Major project if he has passed at least three courses & minor projects.
- If a student cannot pass all the courses and projects of minor even after 2 years of completion of his under graduation, he will be declared incompetent and will be dropped off from Minor.

Criteria for award of Minor in Robotics & Automation

Upon completion of the additional 18 credits, as mentioned in previous section (Table 1), the student will be eligible for the award of Minor in Robotics & Automation as per academic norms of the Institute.

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, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Mechanical, Hydraulic & Pneumatic devices –Power supplies, valves, cylinders, sequencing.	**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	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	-	-	-	-	-	-	-	1	-	-	-
CO2	3	2	2	2	3	-	-	-	-	-	-	1	-	-	-
CO3	3	1	1	2	-	-	-	-	-	-	-	1	-	-	-
CO4	3	2	3	2	-	-	-	-	-	-	-	1	-	-	-

The LNMIIT, Jaipur
Department of Mechanical & Mechatronics Engineering
Modelling 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	**4**
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:

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	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	-	-	-	-	-	-	1	2	2	1
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

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 features, Software package, Protocols, Information transfer, Error detection, The twelve golden rules. CNC fundamentals – Coordinates, Axes, Motion, CNC systems, CNC controls, Program planning, Programming.	**5**
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 PLC Via SFC	**3**
5	Temperature sensing using SCADA	**3**
6	Robot teaching using VAL II Programming	**3**
7	Plan mobile robot paths using RRT in MATLAB	**3**
8	Control of a mobile robot using gesture in Python	**3**
9	NC Part programming of low-carbon steel part using a CNC machining center	**3**
10	Design of an electro-pneumatic circuit	**3**
11	Final Project	**3**

Textbook References:

Text Book:

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

Reference books:

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

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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: **40**	**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.	**2**
4	Designing and tuning a PID controller in MATLAB.	**2**
5	Simulation of Legged walking robots in MATLAB environment.	**2**
6	Interfacing and controlling of stepper motor with microcontroller.	**2**
7	Design and construct microcontroller-based DC motor speed control system.	**2**
8	Final Project	**4**

Textbook References:

Text Book:

1. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 13th edition, Pearson Publication.
2. F. Golnaraghi and B. C. Kuo, *Automatic Control Systems*, 9th edition, John Wiley & Sons INC.

3. S. K. Mandal, *Microprocessors and Microcontrollers, Architecture, Programming and Interfacing using 8085, 8086, 8051*, Tata McGraw Hill Education Private Limited, 2017.

Reference books:

1. G.F. Frenklin, J. D. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 7th edition, Pearson Publication.
2. D. E. Kirk, *Optimal Control Theory: An Introduction*, Illustrated edition, Dover Publications Inc., 2004.
3. K. Ogata, *MATLAB for Control Engineers*, 1st edition, Pearson Prentice Hall, 2007.
4. 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.	**6**

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:

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

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

Reference books:

1. J. Cicolani, *Beginning Robotics with Raspberry Pi and Arduino: Using python and OpenCV*, 2nd edition, Apress Inc.
2. P. Joshi, *OpenCV with Python by Example: Build real world computer vision applications and develop cool demos using OpenCV for python*, Packt Publishing, 2015.
3. B. Siciliano and O. Khatib, *Springer Handbook of Robotics*, 2nd edition, Springer, 2016.
4. D. R. Franceschetti (ed.), *Principles of Robotics and Artificial Intelligence*, 1st edition, Grey House Publishing, 2018.
5. 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
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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
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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