Pimpri Chinchwad Education Trust's

PIMPRI CHINCHWAD COLLEGE OF ENGINEERING

SECTOR NO. 26, PRADHIKARAN, NIGDI, PUNE 411044

An Autonomous Institute Approved by AICTE and Affiliated to SPPU, Pune

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

Curriculum Structure and Syllabus

of

Minors in

ROBOTICS

(Course 2020)

Effective from Academic Year 2023-24

(Updated with Minor Changes)

Institute Vision

To be one of the top 100 Engineering Institutes of India in coming five years by offering exemplarily Ethical, Sustainable and Value Added Quality Education through a matching ecosystem for building successful careers.

Institute Mission

1. Serving the needs of the society at large through establishment of a state-of-art Engineering Institute
2. Imparting right Attitude, Skills, Knowledge for self-sustenance through Quality Education
3. Creating globally competent and Sensible engineers, researchers and entrepreneurs with an ability to think and act independently in demanding situations

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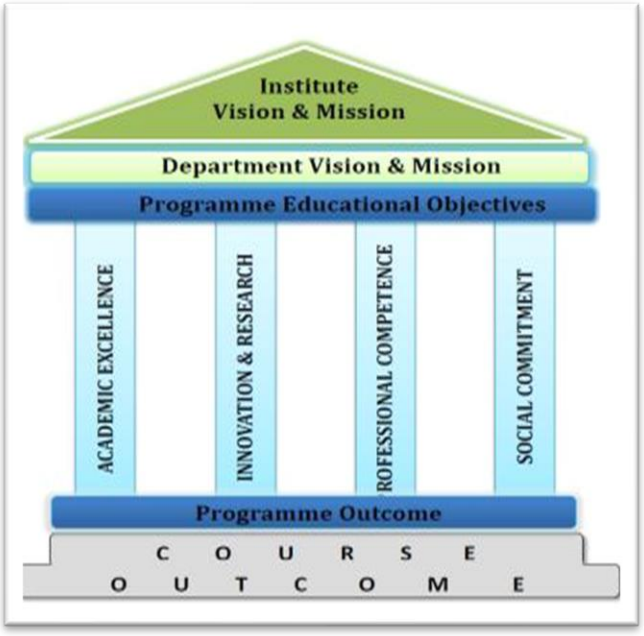
Quality Policy

We at PCCOE are committed to impart Value Added Quality Education to satisfy the applicable requirements, needs and expectations of the Students and Stakeholders. We shall strive for academic excellence, professional competence and social commitment in fine blend with innovation and research. We shall achieve this by establishing and strengthening state-of- the-art Engineering and Management Institute through continual improvement in effective implementation of Quality Management System.



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Preface

Looking at Global Scenario to enhance the employability skills and impart deep knowledge in emerging/ multidisciplinary areas, an additional avenue is provided to passionate learners through the Minors and Honors Degree Scheme in academic structure.

For **Minors degree** program, student has to earn additional 20 credits in multidisciplinary areas of other domains.

Objectives of Minors Degree

- To impart knowledge in multidisciplinary areas.
- To provide effective yet flexible options for students to achieve basic to intermediate level competence in the multidisciplinary area.
- To enhance the employability skills through different combinations in the diverse fields of engineering.
- To provide an academic mechanism for fulfilling multidisciplinary demands of industries.
- To provide a strong foundation to students aiming to pursue research/ higher studies in an interdisciplinary field of study.

Robotics

The robotics minor covers the fundamentals of designing, building and programming robots, and provides a concentrated experience in the multidisciplinary field of robotics. Robotics graduates are in high demand in the many industries dealing with following application like Aerospace, Automotive, Construction, Defence, Electronics, IT industry, Manufacturing and fast-moving consumer goods, Marine.

Objectives of Minor program:

1. To familiarize the students with the significance of robotic system in agile and automated manufacturing processes.
2. To prepare the students to be conversant with robotic elements/ peripherals, their selection and interface with manufacturing equipment.
3. To familiarize the students with the basics of robot kinematics.

Outcomes of Minor program:

On the completion of the course, students will be able to

1. Acquire the skills in understanding robot language and programming.
2. Acquire the skill in robot task planning for problem solving.
3. Develop skills in understanding various sensors, robot peripherals and their use.
4. Develop skills in identifying areas in manufacturing, where robotics can be deployed for enhancing productivity

Curriculum Structure

Minors in

Robotics

Curriculum structure

Sem-ester	Course Code	Course Name	Teaching Scheme					Evaluation Scheme						
			L	P	T	Hrs	CR	IE1	IE2	ETE	TW	PR	OR	Total
V	MET5991	Fundamental of Robotics	4	-	-	4	4	20	30	50	-	-	-	100
	MET5992	Fundamentals of Robotics Lab	-	2	-	2	1	-	-	-	25	-	25	50
VI	MET6991	Robot Programming	4	-	-	4	4	20	30	50	-	-	-	100
	MET6992	Robot Programming Lab	-	2	-	2	1	-	-	-	25	-	25	50
VII	MET7991	Sensors and Actuators in Robotics	4	-	-	4	4	20	30	50	-	-	-	100
	MET7992	Seminar	-	4		4	2	-	-	-	-		50	50
VIII	MET8991 MET8992	Project /Industry Driven Course	-	8		8	4	-	-	-	100		50	150
Total			12	16		28	20	-	-	-	-	-	-	600

Abbreviations:

1 Lecture hour = 1 Credit 2 Lab Hours = 1 Credit 1 Tutorial Hour = 1 Credit Abbreviations are: L-Lecture, P-Practical, T-Tutorial, H- Hours, IE- Internal Evaluation, MTE- Mid Term Evaluation, ETE- End Term Evaluation, TW –Termwork, OR – Oral, CR- Credits

Course Syllabus

Semester - V

Program:	B. Tech. (E&TC)-Minors in Robotics						Semester: V			
Course Name :	Fundamentals of Robotics						Course Code : MET5991			
Teaching Scheme				Evaluation Scheme						
Lecture	Practical	Tutorial	Credit	IE1	IE2	ETE	TW	OR	PR	Total
4	2	-	5	20	30	50	-	-	-	100

Prior Knowledge of

- Basic Electronics Engineering
- Mechanics is essential.

Course Objectives:

1. To familiarize the students with the basic principles of robotics
2. To introduce the Various Parts of Robots and Fields of Robotics.
3. To acquaint the students with the knowledge of applications of robotics.
4. To prepare the students for understanding Planning and control in Robotics.

Course Outcomes:

On the completion of the course, students will be able to,

1. Understand basics of robotics, types, classification and methodology.
2. Acquire the skills in understanding principles of robotics.
3. Acquire the skills in understanding robotics in inspection.
4. Develop skills in understanding industrial robotics.
5. Identifying opportunities for robotics to enhance productivity in manufacturing.
6. Learn Socio-economic aspects of Robotics.

Detailed Syllabus:

Unit	Description	Duration (Hrs.)
1.	**Introduction of Robotics** Historical development of Robotics, Definitions of Industrial Robot, Type and Classification of Robots, Asimov's laws of robotics, Methodology of robotics	10
2.	**Principles of Robotics** Robot configurations, Robot Components, Robot Degrees of Freedom, Work volume and work envelope, Robot Joints and symbols, Robot Coordinates, Robot Reference Frames, Resolution, accuracy and precision of Robot, Work cell control	10
3.	**Robotics in Inspection** Robots for Inspection: Robotic vision systems, image representation, objectrecognition and categorization, depth measurement.	10
4.	**Industrial Applications of Robotics** Introduction of processes like Coating, Deburring, cleaning, Die Casting, Molding, Material handling, Picking, Palletizing, Packaging, hospitals and patient care, sports and recreation, defense and surveillance industry, home automation, mining industry.	10
5.	**Planning and control in Robotics** Trajectory planning, position control, force control, Robot programing methods, hybrid control, Industrial and medical robotics: application in manufacturing processes	10
6.	**Socio-economic aspects of Robotics**	10

	A robot-based manufacturing system, robot cell design considerations and selection of robot, Robot Economics, Functional Safety in Robotic Application	
	Total Hrs.	**60**

Textbooks:

1. M.P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2018.
2. M.P. Groover, M.Naegel, "Industrial Robotics, Technology, Programming & Applications", TMH, 2nd Edition, 2016.

Reference Books:

1. J.G. Keramas, "Robotics Technology Fundamentals", Thompson Learning, 2nd Edition, 2016.
2. J.J.Craig "Introduction to Robotics Mechanics & Control", Pearson Education, 3rd Edition, 2014.
3. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book, 2015.

Program: B. Tech. (E&TC)-Minors in Robotics					**Semester:V**		
Course: Fundamentals of Robotics Lab					**Code:MET5992**		
Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**TW**	**OR**	**PR**	**Total**
	2		1	25	25		50

Prior knowledge of: Sensors, Control Systems and basic of programming is essential

Objectives:

The main objective of this course is to

1. To learn and understand the basics of fundamentals of robotics systems.
2. To be acquainted with different configuration of robotics system
3. To design MATLAB program for robotic configuration

Outcomes:

At the end of Laboratory work, the students will be able to:

1. Identify and understand the unique characteristics and components of robotics systems
2. Compare and understand various types of robotics systems
3. Design, simulate and test kinematic equations for robotic systems in MATALAB
4. Compare and understand various industrial application of robotics systems

General Guidelines: Any Six Experiments is to be performed.

Detailed Syllabus:

Expt. No.	**List of Experiments**
1	Study and analysis of robot grippers (includes the problems based on gripper force)
2	Demonstration of various robotic configurations using industrial robot
3	MATLAB program for simple kinematics of simple robot configuration
4	MATLAB program for inverse kinematics of simple robot configuration
5	To demonstrate simple robotic system using Matlab/ MscAdam / RoboAnalyser software
6	Study of configuration of robots and motion of robot manipulator
7	Study of pick and place industrial robot
8	One Industrial visit for Industrial robotic application

Virtual Lab Links

1. Mechanisms & Robotics Lab
http://vlabs.iitkgp.ernet.in/mr/
2. Robotics Application Lab
https://vlab.amrita.edu/?sub=3&brch=271&sim=1642&cnt=3525
3. Bio Inspired Robotics Virtual Lab
https://vlab.amrita.edu/?sub=3&brch=257

Course Syllabus
Semester - VI

Program: B. Tech. (E&TC)-Minors in Robotics				Semester: VI						
Course Name: Robot Programming				Course code : MET6991						
Teaching Scheme				Evaluation Scheme						
Lecture	**Practical**	**Tutorial**	**Credit**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**PR**	**Total**
4	2	-	4	20	30	50	-	-	50	150

Pre-requisites:

- Fundamentals of Robotics
- System Programming and Operating Systems

Course Objectives:

1. To introduce students with framework used for robot programming.
2. To impart the knowledge of robot programming language.
3. To explain the Virtual Robot Systems and their applications.

Course Outcomes:

On the completion of the course, students will be able to,

1. Understand the significance of Robot operating system (ROS) and various ROS frameworks.
2. Learn the fundamentals robot programming language.
3. Design of Robotic system using VAL Language.
4. Design of Robotic system using VAL -II Language.
5. Acquire knowledge of RAPID Language.
6. Design practical robotics systems.

Detailed Syllabus:

Unit	Description	Duration (Hrs.)
1.	**Introduction to ROS** The ROS Equation, History, Distributions & difference from other meta-operating systems. ROS framework: Operating system and its various releases.	**10**
2.	**Basics of Robot Programming** . Method, Robot Programming as a path in space, Motion interpolation, motion & task level Languages, Robot languages, Programming in suitable languages, characteristics of robot	**10**
3.	**Robot Language: VAL Language: Part 1** Classifications, Structures, VAL language commands, motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program-WAIT, SIGNAL and DELAY command for communications using simple applications	**10**
4.	**Robot Language: VAL Language: Part 2** VAL-II programming-basic commands, Simple problem using conditional statements, Simple pick and place applications, Production rate calculations using robot.	**10**
5.	**Robot Language: RAPID Language** Motion Instructions-Pick and place operation using Industrial robot- manual mode, automatic mode, and subroutine command-based programming. Move master command language- Introduction, syntax, simple problems. AML Language, elements and functions, Statements, constants andvariables-Program control statements, Motion, Sensor commands, Data processing	**10**
6.	**Virtual Robot Systems** Introduction to soft robotics; Robotic Process Automation (RPA); Computer Vision, AR & VR in Robotics. Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot	**10**

	studioonline software- Introduction, Jogging, components, work planning, program modules, input and output signals, Singularities, Collision detection, Repeatability measurement of robot, Robot economics.	
	Total Hrs.	**60**

Textbooks:

1. Kumar Bipin, “Robot Operating System Cookbook”, Packet Publishing, 2018.
2. Lentin Joseph, “Robot Operating Systems (ROS) for Absolute Beginners, A press, 2018.

Reference Books:

1. Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2016.
2. Anis Koubaa, “Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.

Program: B. Tech. (E&TC)-Minors in Robotics					**Semester :VI**		
Course: Robot Programming Lab					**Code :MET7992**		
Teaching Scheme				**Evaluation Scheme**			
Lecture	**Practical**	**Tutorial**	**Credit**	**TW**	**OR**	**PR**	**Total**
	2		1	25	25		50

Prior knowledge of Sensors Technology, Robot Drive Systems is essential

Objectives:

1. **To understand** robot programming methods
2. **To compare and understand different types of languages used for robot programming**
3. **To understand rules to design robot application using robot programming languages**

Outcomes:

At the end of Laboratory work, the students will be able to:

1. Explain the components of robot programming
2. Develop simple program to simulate robot movements
3. Develop robot program for specific application
4. Describe the safety rules in robot handling.

General Guidelines: Any Six Experiments is to be performed.

Detailed Syllabus:

Expt. No.	**List of Experiments**
1	Programming on VAL Language
2	Programming on VAL-II Language
3	Programming on RAPID Language
4	Programming on AML Language
5	Demonstrate Industrial Robot programming using VAL II or equivalent.
6	Programming the robot for pick and place operation using any robot
7	Robot Programming for Colour identification/shape identification/path tracking
8	Industrial visit and its report on industrial applications of robots

Text Books:
1. S. R.Deb, “Robotics technology and flexible automation”, Tata McGraw Hill publishing company limited, 1994.
2. Mikell. P. Groover, “Industrial Robotics Technology”, Programming and Applications, McGraw Hill Co, 1995.
3. Robotcs Lab manual, 2007.

Reference Books:
1. Klafter. R.D, Chmielewski.T.A. and Noggin’s., “Robot Engineering : An Integrated Approach”, Prentice Hall of India Pvt. Ltd.,1994.
2. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., “Robotics control, sensing, vision and intelligence”, McGraw Hill Book co, 1987.
3. Craig. J. J. “Introduction to Robotics mechanics and control”, Addison-Wesley, 1999..

Course Syllabus

Semester – VII/VIII

Program:	**B. Tech. (E&TC)-Minors in Robotics**	**Semester:**	**VII**
Course Name	**Sensors and Actuators in Robotics**	**Course code :MET7991**	

Teaching Scheme				**Evaluation Scheme**						
Lecture	**Practical**	**Tutorial**	**Credit**	**IE1**	**IE2**	**ETE**	**TW**	**OR**	**PR**	**Total**
3	2	-	4	20	30	50	-	-	-	100

Prior Knowledge of

- Basic Electronics Engineering, Basic Electrical Engineering
- Image Processing, Fundamentals of Robotics, Sensors and Automation is essential

Course Objectives:

1. To introduce the various parts of electronics in the field of Robotics.
2. To explain students the need of embedded system technology for robot building.
3. To familiarize with the selection of appropriate sensors and actuators in robotic applications.
4. To help students understand about the smart real-time robot system technologies

Course Outcomes: On the completion of the course, students will be able to,

1. Selection of suitable embedded boards for robots.
2. Understanding the concepts of robotics & automation and working of Robot.
3. Analyze the function of sensors and actuators in the Robot.
4. Write program to use a Robot for a typical application.
5. Develop machine vision-based algorithm for robotic tasks.
6. Apply the knowledge of sensors, embedded systems and actuators for industrial robot development.

Detailed Syllabus:

Unit	**Description**	**Duration (Hrs.)**
1.	**Review of Electronics in Robotics** Fundamentals of electronic blocks in robotics, Traditional and Mechatronics approach, Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs	**10**
2.	**Sensors in Robotics: Part 1** Transducers and sensors, Sensors in robotics, Principles and applications of the following types of sensors- Proximity Sensors, Photo Electric Sensors, Laser Scanners, Position sensors – Piezo Electric Sensor, LVDT, Resolvers. Encoders: Absolute and Incremental: - Optical, Magnetic, Capacitive, pneumatic Position Sensors	**10**
3.	**Sensors in Robotics: Part 2** Range Sensors: Range Finders, Laser Range Meters, Touch Sensors, Force and torque sensors. Safety Sensor: Light Curtain, Laser Area Scanner, Safety Switches;	**10**
4.	**Actuators in Robotics** Mechanical Actuation Systems, Electrical Actuation Systems, A.C. Motor, D.C. Motor, Stepper Motor, Hydraulic & Pneumatic Actuation Systems. Design of hydraulic circuits.	**10**
5.	**Machine vision in Robotics: Part 1** Introduction, Low level & High-level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, **Machine vision algorithms,** Applications	**10**
6.	**Machine vision in Robotics: Part 2**	**10**

	Object Description & recognition, interpretation, Imaging based automatic sorting and inspection, image processing, imaging-based robot guidance, Application	
	Total Hrs.	**60**

Textbooks:

1. M.P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing", PHI, 3rd Edition, 2012.
2. M.P. Groover, M.Naegel, "Industrial Robotics, Technology, Programming & Applications", TMH, 2nd Edition, 2012.

Reference books:

1. Mike Wilson, "Implementation of Robotic Systems", 2014
2. Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill Book co, 2015.
3. S.R. Deb, "Robotics Technology and Flexible Automation", TMH, 2nd Edition, 2018.

Program:	B. Tech. (E&TC)-Minors in Robotics				Semester:	VII /VIII
Course:	Seminar				Code:	HET7992
Teaching Scheme			Evaluation Scheme			
Lecture	Practical	Credit	IE2	TW	OR	Total
-	4	2			50	50

Prior Knowledge of: -- is essential.

Course Objectives:

1. To identify practical learning skills and concepts and learn to communicate it to society.
2. To encourage personal growth of students and development of effective communication skills

Course Outcomes: After learning the course, the students should be able to:

1. Get an overview of the current trends and Learn them in more details
2. Improve Practice written and oral presentations
3. Learn the research methods used in that specific field

Detailed Guidelines:

1. The student should let the course instructor know in advance the intended topic of the seminar.
2. The length of the seminar should be at most 30 minutes, including time at the end for questions from the audience.
3. Each seminar should be given by one single student.
4. The intended audience for the seminar are other students attending the course. Prepare the seminar accordingly.
5. The focus should be on main ideas rather than on technical details
6. The seminar guidelines mentioned in B.Tech (E&TC) structure will be followed for evaluation of performance and certification compliance.

Program:	**B. Tech. (E&TC)-Minors in Robotics**			**Semester:**	**VII /VIII**	
Course:	**Project**			**Code:**	MET8991/ MET8992	
Teaching Scheme			**Evaluation Scheme**			
Lecture	**Practical**	**Credit**	**IE2**	**TW**	**OR**	**Total**
-	-	4		100	50	150

Prior Knowledge of: basics of sensors, circuit simulation and design **is essential.**

Course Objectives:
1. To test students knowledge of course implementation.
2. To make students ready for robot programming and automation

Course Outcomes: After learning the course, the students should be able to:
1. Solve real time problems observed in industry.
2. Deal with industrial and general purpose robotic automation

Detailed Guidelines:
1. The students are encourage to take projects for developing software solutions and hardware platforms using the concept of course taken under the certification.
2. The project guidelines mentioned in B.Tech (E&TC) structure will be followed for evaluation of performance and certification compliance.