RAMAIAH
Institute of Technology

CURRICULUM

Minor Degree

RAMAIAH INSTITUTE OF TECHNOLOGY

(Autonomous Institute, Affiliated to VTU)

BANGALORE – 54

SCHEME

Sl. No.	Course Code	Course	Semester	Credits				Contact Hours
				L	T	P	Total	
01	MEM41	Course – I	IV	3	0	0	3	3
02	MEM51	Course – II (NPTEL)	V	2	0	0	2	2
03	MEM52	Course – III	V	2	0	1	3	4
04	MEM61	Course – IV (NPTEL)	VI	3	0	0	3	3
05	MEM62	Course – V	VI	2	0	1	3	4
06	MEM71	Course – VI	VII	4	0	0	4	4
			TOTAL	**16**	**0**	**2**	**18**	**20**

Course Options

Sl. No.	Course	Course Name	Semester
01	Course – I Compulsory	Introduction to Robotics	IV
02	Course – II (Options)	Robotics and control: theory And practice (112107289)	V
		Mechanism and Robot Kinematics (112105236)	
		Robot Motion Planning (112104308)	
03	Course – III (Options)	Robot Programming	V
		Hydraulics and Pneumatics	
04	Course – IV (Options)	Automation in Manufacturing (112103293)	VI
		Product Design and Manufacturing (112104230)	
		Rapid Manufacturing (112104265)	
05	Course – V (Options)	Industrial and Collaborative Robots	VI
		Analysis of Robot Grippers	
06	Course – VI (Options)	Autonomous Mobile Robot	VII
		Robot System Design	

INTRODUCTION TO ROBOTICS

Course Code: MEM41 **Credit: 2:0:1**

Prerequisite: Nil **Contact Hours: 28L+14P**

Course Coordinator: Dr. Sunith Babu L

Unit I

Concepts of Robotics: Introduction, Robot Definition, Laws of Robotics, Chronological Development of Robot Technology, Laws of Robots, Classifications of Robots, Advantages and Applications of Robots, Robot Components, Degrees of Freedom, Joints and Notation Scheme, Coordinates, Reference Frames, Robot Motions, Robot System Integration

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=0ZnG16reUfc

Unit II

Configuration and Work Volume: Human Body, Human Work Volume, Industrial Robot Configuration, Structural Configuration and Robot Work Volume of industrial robot, Precision of Movement, Degrees of Freedom,

End Effectors: Introduction, Prehension, Automatic Prehension, Impactive Mechanical Grippers, Ingressive Grippers, Astrictive Prehension, Magnetic, Vacuum, Adhesive, Flexi / Soft Grippers, Selection of Grippers

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=edMYmTu5I7Y

Unit III

Coordinate Transformation: Introduction to D-H parameters, Introduction, 2D & 3D Coordinate Transformation, Inverse Transformation, Kinematic Chain, Composite Transformation Matrix, Composite Transformation Matrix, Algorithm, Wrist

Kinematics: Introduction, Joint Coordinate Space, Kinematics and Inverse Kinematics, Two Joint – Two DoF Robot, Homogeneous Transformation

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=BiYu9_BXSBU

Unit IV

Robot Sensors: Introduction, Internal and External Sensors, Application of Robot Sensors, Desirable Features of Robot Sensors, Proximity and Tactile Sensors, Proximity Sensors, Touch Sensors, Slip Sensors, Range Sensors, Opto Range Sensors, Ultrasonic Range Sensors, Force Sensors, Vision System for Inspection.

Robot Vision: Introduction, Robot Vision, Lighting Device, Analogue to Digital Conversion, Image Storage, Illumination, Feature Extraction, Object Inspection, Procedure for Robot Vision

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=sCTgZv33tuA

Unit V

Industrial Applications of Robots: Robot Selection Consideration, Robots in Industry, Pick and Place, Spray Coating, Assembly, Inspection, Welding Robots, Machine Loading and Unloading, Material Transfer, Palletization, Application of Robots in industries, Special

Applications – iRobot (Roomba), KiloBot Spot Mini (Boston Dynamics), Sophia, Robobees, Swarm Robots

Medical Applications: Da Vinci Surgical Robots**,** Rehabilitation Robots, Bio Robots, Telepresence Robots, Exoskeleton Robots

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=sCTgZv33tuA

TEXT BOOK

1. Introduction to Robotics Analysis, Control, Applications Saeed B. Niku, John Wiley & Sons INC, ISBN 978-0-470-60446-5
2. Introduction to Robotics, S K Saha, McGraw Hill Education, (India) Pvt Ltd, ISBN - 978-93-3290-280-0
3. Introduction to Industrial Robotics, Ramachandran Nagarajan, Pearson India, 978-93-325-4480-2

Course Learning Outcomes (COs)

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

1. Illustrate the robot key concepts and develop skill set in developing robot characteristics.
2. Develop appropriate robot work volume and energy efficient grippers for specific applications
3. Prepare forward and inverse kinematics and provide solutions as per the applications.
4. Identify the relevant robot sensor used for specific applications and provide automated solutions using camera functions
5. Provide an understanding of the robot applications in different fields

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

ROBOTICS AND CONTROL: THEORY AND PRACTICE (112107289)

Course Code: NPTEL **Credit: 2:0:0**

Prerequisite: Basic Mathematics **Contact Hours: 8 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112107289

INTENDED AUDIENCE: Electrical Engineering, Computer Science Engineering, Mechanical Engineering, Electronics and Communication Engineering, Mathematics students

COURSE OUTLINE: Robotics has stimulated a growing interest among a wide range of scholars, researchers and students due to its interdisciplinary characteristics. Through this course the participants will acquire the ability to conduct research, develop innovative designs in the field of systems engineering and control of robots and to direct the development of engineering solutions in new or unfamiliar environments by linking creativity, innovation and transfer of technology.

COURSE PLAN:

Week 1: Simple manipulators: Two /three arm manipulators and their kinematics equations, Work space Homogeneous Transformation: Rotation, Translation, Composition of homogeneous transformations

Week 2: Danavit-Hartenberg Algorithm: D-H procedure for fixing joint coordinate frames, Robot parameters, Arm matrix, Inverse Kinematics for PUMA, SCARA manipulators.

Week 3: Introduction to Robotic Exoskeletons, Optimal Design of a Three Finger Exoskeleton for Rehabilitation Purpose.

Week 4: Differential transformation and velocity of a frame: Derivative of a frame, Velocity, Jacobian, Inverse Jacobian, Trajectory Planning: Polynomial trajectory, Biped trajectory

Week 5: Dynamics: Lagrangian method, Robot dynamics equation, Control: Robot dynamics equation as a control system, Trajectory tracking control, PD controller, Neural network control design

Week 6: Redundancy Resolution of Human Fingers using Robotic Principles Manipulability Analysis of Human Fingers during Coordinated Object Rotation Kinematics of Flexible Link Robots

Week 7: Robot Assisted Needling System for Percutaneous Intervention-An Introduction Smart Robotic Needles for Percutaneous Cancerous Interventions

Week 8: Robust Force Control of a Two Finger Exoskeleton during Grasping, Neural Control of an Index Finger Exoskeleton

MECHANISM AND ROBOT KINEMATICS (112105236)

Course Code: NPTEL **Credit: 2:0:0**

Prerequisite: Basic Mathematics **Contact Hours: 8 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112105236

INTENDED AUDIENCE: Mechanical, Aerospace, Electrical, CSE, ISE

COURSE OUTLINE: This course will be a foundation course in analysis of mechanisms and robots. After a brief introduction to the subject matter and terms, the audience will be introduced to kinematic analysis of planar constrained mechanisms, and closed and open chain robot manipulators. The course will dwell upon direct and inverse kinematics, velocity and acceleration analysis, kinematic motion generation, singularities in kinematic chains, principle of virtual work and force analysis, coordinate frames and transformations. The course will demonstrate various concepts by working out problems relevant to applications involving mechanisms and robotic chains. The course is expected to help students and researchers in their basic understanding and use of kinematic analysis. This course will also pave way for more advanced courses on mechanism and robot dynamics and design.

COURSE PLAN:

Week 1: Introduction to Mechanisms and Robotics, Mobility Analysis-I

Week 2: Mobility Analysis-II, Displacement Analysis: constrained mechanisms and Robots-I

Week 3: Displacement Analysis: constrained mechanisms and robots-II

Week 4: Displacement Analysis: constrained mechanisms and robots- III, Velocity Analysis: constrained mechanisms and robots-I

Week 5: Velocity Analysis: constrained mechanisms and robots-II

Week 6: Velocity Analysis: constrained mechanisms and robots-III

Week 7: Velocity Analysis: singularity and path generation,Acceleration Analysis, Force Analysis-I

Week 8: Force Analysis-II, Coordinate Transformations and kinematics of serial robots

ROBOT MOTION PLANNING (112104308)

Course Code: NPTEL **Credit: 2:0:0**

Prerequisite: Basic Mathematics **Contact Hours: 8 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112104308

INTENDED AUDIENCE: Mechanical, Aerospace, Electrical, CSE, ISE

COURSE OUTLINE: The course is intended as a first level introduction to robot motion planning for students, teachers and industry personal. Historically, robot motion planning deals with the design of algorithms that can find collision free paths (if they exist) to take a robot from an initial point to a goal point. Due to recent interests in developing autonomous robotic systems, the subject has become extremely broad and covers not only the traditional areas of finding collision free paths, but automatic assembly, warehouse automation, multi robot cooperation, robotic surgery, etc. The course would cover the fundamental concepts and mathematics required to understand, analyze, and design algorithms required for motion planning of serial robotic arms and mobile robots. After taking this course, students could then take more advanced courses/topics in focused areas like, AI in Motion Planning, unmanned vehicles, probabilistic motion planning, etc. Teachers could use this course to lay the foundation of other courses involving mobile robots like, manufacturing automation, AI, Computer vision applications, etc..

COURSE PLAN:

Week 1: Introduction

Week 2: Transformation, Kinematics and Bug Algorithm

Week 3: Configuration Space, C Obstacles, Topology of C Space

Week 4: Road Map Method, Cell Decomposition, Sampling

Week 5: Potential Field Method, Navigation Function, Basic Search

Week 6: Motion Planning and Controllability

Week 7: Kinematic Constraints, Multifinger Robot Hands

Week 8: Optimization in Motion Planning

ROBOT PROGRAMMING

Course Code: MEM521 **Credit: 2:0:1**

Prerequisite: Introduction to Robotics **Contact Hours:24L + 14P**

Course Coordinator: Dr. Sunith Babu L

Unit I

Introduction: Introduction Robot software functions - coordinate systems, position control, other control functions, subroutines, Program planning for Robot flowcharting for robot programs with few examples.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: //www.youtube.com/watch?v=qA9w-ILWwWI

Unit II

Methods of Robot Programming: Online programming, off-line programming, advantages of off-line programming, lead through methods - powered lead through, manual lead through, Teach pendant, Robot program as a path in space, defining position in space, motion interpolation, WAIT, SIGNAL and DELAY commands, Branching capabilities and Limitations of head through methods**.**

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=BtUfKYsDbKw

Unit III

Robot Languages: Textual ROBOT Languages, first generation and second generation languages, structure of a robot language - operating systems, Elements and Functions, constants, variables and other data objects, Motion commands, points in workspace,

End effector and sensor commands, computations and operations, program control and subroutines, communications and Data processing.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=8mOHS8M1Pmc

Unit IV

VAL II: General description, Monitor commands, motion command, Hand Control, Configuration control, interlock commands, INPUT/OUTPUT Controls, Program Control, examples.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=w9hxh_Ua2-M&t=845s

Unit V

AML: General description, AML statements, Constant and variables, program control statements, motion commands, Sensor commands, Grip sensing capabilities, Data processing, examples.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=0ygOIxj1Ko0

Lab component:

Working of FANUC Robot using ROBOGUIDE software

8 Exercise in FANUC Robot be completed in 14 Classes

Text Book

1. Industrial Robotics, Technology, Programming and Applications, (SE) M.P. Groover, M Wiess, Tata McGraw Hill, 2012, ISBN (13): 978-1-25-900621-0

Course Learning Outcomes (COs)

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

1. Identify the benefits of Robot programming.
2. Utilize the different robot programming syntax and enable productivity of the end user
3. Identify the different programming languages used in a robot development and usage.
4. Provide the solutions related to VAL – II Programming
5. Develop AML programming algorithms and provide economical solutions for different applications.

Course Assessment and Evaluation:

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

HYDRAULICS AND PNEUMATICS

Course Code: MEM522 **Credit: 2:0:1**

Prerequisite: NA **Contact Hours: 24L+14P**

Course Coordinator: Dr. Mohandas K N

Unit I

Introduction to Hydraulic Power: Structure of Hydraulic Control System. The Source of Hydraulic Power: Pumps Pumping theory, pump classification, gear pumps, vane pumps, piston pumps, pump performance, pump selection. Variable displacement pumps.

Hydraulic Actuators: Linear Hydraulic Actuators [cylinders], Mechanics of Hydraulic Cylinder Loading.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=m1NN_LAIMF4

Unit II

Hydraulic Motors: Hydraulic Rotary Actuators, Gear motors, vane motors, piston motors, Hydraulic motor theoretical torque, power and flow rate, hydraulic motor performance.

Control Components in Hydraulic Systems: Directional Control Valves –Symbolic Representation, Constructional features, pressure control valves –direct and pilot operated types, Flow control valves.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=dPD8YuojtN0

Unit III

Hydraulic Circuit Design and Analysis: Control of single and double –acting Hydraulic Cylinder, regenerative circuit, pump unloading circuit, Counter Balance Valve application, Hydraulic

cylinder sequencing circuits. Cylinder synchronizing circuits, speed control of hydraulic cylinder, speed control of hydraulic motors, Accumulators.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=vEvNGr3mSxQ

Unit IV

Introduction to Pneumatic Control: Choice of working medium, characteristics of compressed air. Structure of Pneumatic control system.

Pneumatic Actuators: Linear cylinders –Types, conventional type of cylinder working, end Position cushioning, seals, mounting arrangements applications

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=h-tzh8l1z-M&t=8s

Unit V

Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, Basic pneumatic valves, Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve. Pressure dependent controls types. Time dependent controls. Sensors

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=rSG7llg3z7Y

Experiments on Hydraulic and Pneumatic circuit trainers

HYDRAULIC CIRCUITS:

Experiment 1: Speed Control of a Single Acting Cylinder

Experiment 2: Speed Control of a Double Acting Cylinder

Experiment 3: Flow control of a Single Acting Cylinder

Experiment 4: Flow control of a Double Acting Cylinder

PNEUMATICS CIRCUITS:

Experiment 5: Speed Control of a Single Acting Cylinder

Experiment 6: Speed Control of a Double Acting Cylinder

Experiment 7: Flow control of a Single Acting Cylinder

Experiment 8: Flow control of a Double Acting Cylinder

Experiment 9: Control of double acting cylinder using 'OR' type valve

Experiment 10: Control of double acting cylinder using 'AND' type valve

Experiment 11: Control of double acting cylinder with limit switches using Pilot operated valve

Experiment 12: Control of double acting cylinder with sensors

Text Books:

1. Fluid Power with applications, Anthony Esposito, Fifth edition Pearson education, Inc. 2017.
2. Pneumatics and Hydraulics, Andrew Parr. Jaico Publishing Co. 2017.

Reference Books:

1. Oil Hydraulic Systems - Principles and Maintenance, S.R. Majumdar, Tata Mc Graw Hill Publishing company Ltd. 2012.

2. Pneumatic Systems, S.R. Majumdar, Tata Mc Graw Hill publishing Co., 2019.
3. Industrial Hydraulics, Pippenger, Hicks, McGraw Hill, New York, 2009

Course Learning Outcomes (COs)

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

1. Demonstrate the working of hydraulic and pneumatic systems.
2. Identify the controlling components of hydraulic and pneumatic systems.
3. Design the hydraulic and pneumatic systems for various applications.
4. Examine the choice, preparation and distribution of compressed air.
5. Predict the use of pressure and time dependent controls.

Course Assessment and Evaluation

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

AUTOMATION IN MANUFACTURING (112103293)

Course Code: NPTEL **Credit: 3:0:0**

Prerequisite: **Contact Hours: 12 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112103293

INTENDED AUDIENCE : Mechanical, Aeorspace, Electrical, CSE, ISE

COURSE OUTLINE: Manufacturing industry contributes a major share in the GDP of our country. Application of automated systems is certainly improving the productivity of the manufacturing industry. In view of this, a course on Automation in Manufacturing is designed with the primary focus on the design and development of automated systems in the manufacturing. Initially the course introduces various automated systems being used in the manufacturing industry. Then the building blocks of a typical automated system are described. It presents a study on the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems. It also covers up the microprocessor technology, programming and CNC technology. The contents are lucidly presented with real-life examples. Case studies based on manufacturing industry applications are presented.

COURSE PLAN:

Week 1: Introduction

Week 2: Design of an automated system

Week 3: Selection and fabrication

Week 4: Sensors

Week 5: Signal conditioning and Microprocessor Technology

Week 6: Electrical drives

Week 7: Mechanisms

Week 8: Mechanisms

Week 9: Hydraulic systems

Week 10: Control valves and graphical representation

Week 11: Pneumatic systems

Week 12: CNC technology

PRODUCT DESIGN AND MANUFACTURING (112104230)

Course Code: NPTEL **Credit: 3:0:0**

Prerequisite: Nil **Contact Hours: 12 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112104230

INTENDED AUDIENCE: Mechanical, Aerospace, Electrical, CSE, ISE

COURSE OUTLINE: In the last few decades, the product development process has undergone a noticeable change, which is due to the global competition, international markets, and increasing customer needs. Managing the product development process, right from idea generation to final product manufacturing has to be systematic and effective to meet the customer needs, while incorporating the time-to-market constraint as well. This course presents an overview of the product design and development process, along with the manufacturing aspects. The concepts Design for Manufacturing and Assembly, analytical tools for development, costing and manufacturing would help the students and practitioners learn to conceptualize, design, and manufacture competitively-priced quality products. Prototyping and simulation using soft tools are also incorporated make the students learn the modern tools in manufacturing.

COURSE PLAN:

Week 1: Introduction to product design and manufacturing

Week 2: Engineering Design Process

Week 3 : Elements of Visual Design

Week 4 : Value Engineering

Week 5: Material Selection Process

Week 6: Design for Manufacturing

Week 7: Design for Environment

Week 8: Patent Process

Week 9: Rapid Prototyping

Week 10: Demo on 3D Printing

Week 11: Plant Simulation

Week 12: Reverse Engineering

RAPID MANUFACTURING (112104265)

Course Code: NPTEL **Credit: 3:0:0**

Prerequisite: Nil **Contact Hours: 12 weeks**

Course Coordinator: NPTEL

OFFERED BY: NPTEL - https://nptel.ac.in/courses/112103293

INTENDED AUDIENCE: Mechanical, Aerospace, Electrical, CSE, ISE

COURSE OUTLINE: Manufacturing industry contributes a major share in the GDP of our country. Application of automated systems is certainly improving the productivity of the manufacturing industry. In view of this, a course on Automation in Manufacturing is designed with the primary focus on the design and development of automated systems in the manufacturing. Initially the course introduces various automated systems being used in the manufacturing industry. Then the building blocks of a typical automated system are described. It presents a study on the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems. It also covers up the microprocessor technology, programming and CNC technology. The contents are lucidly presented with real-life examples. Case studies based on manufacturing industry applications are presented.

COURSE PLAN:

Week 1: Introduction

Week 2: Design of an automated system

Week 3 : Selection and fabrication

Week 4 : Sensors

Week 5: Signal conditioning and Microprocessor Technology

Week 6: Electrical drives

Week 7: Mechanisms

Week 8: Mechanisms

Week 9: Hydraulic systems

Week 10: Control valves and graphical representation

Week 11: Pneumatic systems

Week 12: CNC technology

Industrial and Collaborative Robots

Course Code: MEM62 **Credit: 2:0:1**

Prerequisite: Introduction to Robotics **Contact Hours:24L + 14P**

Course Coordinator: Dr. Sunith Babu L

Unit I

Introduction: Industrial Robot Automation - Introduction, Justifying Robotic Automation, Benefits of Implementing Industrial Robot

Implementation of Robot Automation: Introduction, Team Effort, Anatomy of Robot Application - Machine Tending, Welding, Palletization, Material Removal Rate, Press Tending, Robot Size, Reach and Configuration, Judging Good and Bad Project. Gathering Right Criteria.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=s-yne8xTNM0&t=72s

Unit II

Industrial Robots: Introduction Definition, Articulated Robot, SCARA Robot, Delta Robots, Cartesian Robot, Polar Robot, Cylindrical Robot – Introduction, Specifications -Technical Specifications, Working Principle, Work Volume, Configuration, Applications (For above mentioned Robots). System Integration for an Industrial Robot.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=-m1oKuFkSTE

Unit III

Economic Analysis: Introduction, Data Required, Methods of Analysis, Simple Payback Period, Production Rate Appraisal Payback, ROI Evaluation, Net Present Value, Robot Installation,

Quality of Working Life, Attitude Towards Robots, Effect of Employment, Current Capabilities of Robot, Future Capabilities of Robots.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=IwT30VOD8K8

Unit IV

Collaborative Robot: Introduction, Definition, Safety Standards ISO 10218, RIA TS 15066, Collaborative Workspace, Types of Cobots, Bio-Mechanical Limits, Transient and Quasi Static Impact, ABB-Yumi, FANUC-CR, KUKA- LBR IIWA, UNIVERSAL ROBOTS - UR3/UR5/UR10/e Series, Advantages.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=Sb6JjH3Kn34&t=147s

Unit V

Applications of Cobots: Assembly, Dispensing, Machine Tending, Material Handling, Welding, Polishing, Material Removal, Quality Inspection, Food and Beverages, Palletization, Case Studies

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=BE6lbnfDdrU

Lab Component:

Industrial Robot Pick and Place, Palletization using different types of grippers on a FANUC M10iD/12

7 Exercise to be completed in 14 classes

Text Book

1. Industrial Robotics How to Implement the Right System for Your Plant (Andrew Glaser) Industrial Press, New York, ISBN 978-0-83 1 1-3358-0, 2009

Course Learning Outcomes (COs)

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

1. Identify and implement robot automation based on applications.
2. Develop work volume based on the application and provide solutions based on standard robot.
3. Provide an economic analysis of the identified robot solutions and industry needs.
4. Identify the different collaborative robots used in the industry and enable them to suggest appropriate solutions
5. Provide suitable information related to application of cobots in different fields of engineering, medicine, manufacturing.

Course Assessment and Evaluation

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

Analysis of Industrial Robot Grippers

Course Code: MEM62 **Credit: 2:0:1**

Prerequisite: Introduction to Robotics **Contact Hours:24L + 14P**

Course Coordinator: Dr. Balasubramanya H. S

Unit I

Introduction to prehension technology: Grippers for mechanization and automation, definitions, conceptual basics, Historical overview of technical hands

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://bit.ly/3VwyUSB

Unit II

Impactive mechanical grippers: Gripper drivers, Electromechanical drives, pneumatic drives, electrostrictive and piezo electric actuation, parallel impactive grippers, Internal grippers, rotatable jaw grippers, self securing grippers, three finger gripper, four point gripper and four point prehension.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://bit.ly/44yLJzG

Unit III

Miniature grippers and micro grippers:

Impactive micro grippers, electromechanically driven impactive micro grippers, vacuum microgrippers, contigutive micro grippers

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://bit.ly/3VPmFAR

Unit IV

Tool exchange and reconfigurability: Multiple gripper transfer rails, turrets, specialized grippers, gripper exchange systems, manual and automatic exchange systems, Integrated processing

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://bit.ly/3B1OWKw

Unit V

Instrumentation and control & Compliance: Gripper sensor technology, Finger position measurement, Sensory integration, discrete and continues sensing, Remote centre compliance, Near collet compliance, part feeding, Mechanical compliance, shape adaptive grippers, collision protection and safety

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://bit.ly/44xuYox

Lab Component :

A total of 5 experiments on Robot Grippers to carried out in 14 classes covering

- Need
- Modeling
- Design Calculations
- Applications

TextBook's:

1. Robot grippers, Gareth J. Monkman, Stefan Hesse, Ralf Steinmann, Henrik Schunk John Wiley & Sons, 27-Feb-2007 - Technology & Engineering - 463 pages

2. Sensors, Actuators and Their Interfaces: A multi-disciplinary introduction(Control, Robotics and Sensors) 2nd Edition, Nathan Ida, IET ISBN-13: 978-1785618352,2011
3. Deb, S. R., and Sankha Deb. 2010. “Robot Drives, Actuators and Control.” Chap.3 in Robotics Technology and Flexible Automation. 2nd ed. New York: McGraw-HillEducation

ReferencesBook/s:

1. H.R. Everett, “Sensors for mobile robots: Theory and applications”, A K PetersLtd,1995
2. James J.Allen, "Micro Electro Mechanical System Design", CRC Press Publisher,2010

Course Learning Outcomes (COs)

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

1. Explain the need of grippers for automation and mechanization
2. Understand different Gripper drivers, Electromechanical drives, pneumatic drives, electrostrictive and piezo electric actuation,
3. Understand and analyse micro grippers and its operation
4. Explain Tool exchange and gripper exchange systems,
5. Understand Gripper sensor technology, Finger position measurement, Sensory integration, discrete and continues sensing

Course Assessment and Evaluation

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

Autonomous Mobile Robot

Course Code: MEM71 **Credit: 4:0:0**

Prerequisite: NA **Contact Hours: 56**

Course Coordinator: Dr. Sunith Babu L

Unit I

Locomotion: Introduction, Key Issues of Locomotion,

Legged Mobile Robots: Leg Configuration and Stability, Consideration of Dynamics, Examples,

Wheeled Mobile Robots: History of Wheeled Mobile Robots, The Design Space, Wheel Design, Wheel Geometry, Stability, Maneuverability, Controllability, Wheel Locomotion. Aerial Mobile Robots

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=pj3ioPCYOjI

Unit II

Mobile Robot Kinematics: Introduction, kinematic models and constraints, mobile robot workspace, beyond basic kinematics, motion control (kinematic control).

Perception, robotics Architectures and Robot Learning: Sensors Classification, sensor characterization, wheel/motor encoders, heading/orientation sensors, ground based beacons, active ranging

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=-DY2L8E4hJY

Unit III

Mobile Robot Localization: Introduction, Challenge of Localization, Noise and Aliasing, To Localize or Not to Localize – Localization – Based Navigation Vs Programmed Solutions, Map Representation, Probabilistic Map-Based Localization, Autonomous Map Building.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=M0fL5Q6rGws

Unit IV

Navigation and Planning : Introduction, Competences for Navigation, Path Planning, Graph Search – Visibility Graph, Voronoi Diagram, Exact Cell Decomposition

Obstacle Avoidance – Bug0, Bug 1 and Bug 2 Algorithm, Popular Obstacle Avoidance Algorithm, Navigation Architecture

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=mfmTB_5Geug

Unit V

Mobile Robot Maneuverability: Introduction, Degree of Mobility, Degree of Steerability, Robot Maneuverability, Simple Problems.

Applications - AMR's Applications, Goods to Person Picking, Self-driving Forklifts, Autonomous Inventory Robots, UAV's, Security, Healthcare, Benefits of AMR's, Manufacturing, Warehousing, Retail Banking, Hospitality, Logistics, Smart Cities, Agriculture, Special Applications - Bettybot, Roomba Vacuum Cleaner, Spot Mini.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=kN9a7W_hnSQ

Text Book

1. Introduction to Autonomous Mobile Robots Roland Siegwart, Illah Reza Nourbakhsh etc.

Reference Book

1. Wheeled Mobile Robotics. From Fundamentals Towards Autonomous Systems Gregor Klančar, Andrej Zdešar etc.

Course Learning Outcomes (COs)

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

1. Provide suitable solutions related to legged and wheeled robots for specific applications
2. Develop kinematic workflow for the mobile robots
3. Provide solutions for the mobile robot localization
4. Develop mobile robot obstacle avoidance algorithm
5. Identify the mobile robot maneuverability index for a specific developed robot.

Course Assessment and Evaluation

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5

Robot System Design

Course Code: MEM72 **Credit:4:0:0**

Prerequisite: NA **Contact Hours: 56**

Course Coordinator: Dr. Girish V Kulkarni

Unit I

Introduction: Introduction to Mechanical Engineering Design, phases of design process, design consideration, design tools and resources, design engineers responsibilities, codes and standards, safety and product liability, stress and strength, design factor and factor of safety, realibility.

Materials: Material strength and stiffness, Stress, Strain and Hooke's law, Stress strain diagram for brittle and ductile materials, Factor of safety, True stress and strain, hardness, ferrous, non-ferrous, plastics and composite materials.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: ://www.youtube.com/watch?v=wG2MBL-NqeM&list=PLGiGNMkNq6Qu7h6mgBe1LdXEWCRtVhjBA

Unit II

Design Calculation: Calculation of stresses in straight, Stepped and tapered sections, Shear stress and strain, Lateral strain and Poisson's ratio, Elastic constants and relations between them.

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=ukfNnt8abPo

Unit III

Static Strength, Static loads, Theories of elastic failure: Maximum normal stress theory, Maximum shear stress theory, Distortion energy theory; Failure of brittle materials, Failure of ductile materials, Stress concentration factor

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=qbv2rOEMyiA

Unit IV

Spur Gears: Gear terminology, law of gearing, path of contact, arc of contact, contact ratio of spur gear.
Gear Trains: Simple gear trains, compound gear trains. Epicyclic gear trains: Algebraic and tabular methods of finding velocity ratio of epicyclic gear trains

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=qbv2rOEMyiA

Unit V

Belt Drives: Belt Drives, types – flat and v belt, materials, ratio of tensions, centrifugal stress in a belt, Power transmitted, effect of centrifugal tension on power transmitted, Simple numerical problems

- Pedagogy/Course delivery tools: Chalk and talk, PowerPoint presentation
- Links: https://www.youtube.com/watch?v=j6woGQdUPFs&t=191s

Text Book

1. Shigley's Mechanical Engineering Design, McGraw-Hill Series in Mechanical Engineering - Richard Budynas, Keith Nisbett, ISBN - 9780073398204, Publisher - McGraw-Hill Education.

Reference Book

1. Design of Machine Elements, V B Bhandari, Fifth Edition, ISBN - 978-9390177479, Publisher, McGraw Hill

Course Learning Outcomes (COs)

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

1) Selection of suitable materials for robotic applications
2) Establish design calculations for straight and tapered bars
3) Identify the failure of a ductile and brittle materials
4) Establish the parameters in design of spur gears
5) Select suitable belt drives for power transmission.

Course Assessment and Evaluation

Continuous Internal Evaluation (CIE)		
Assessment tool	**Marks**	**Course outcomes addressed**
Internal test-I	30	CO1, CO2, CO3
Internal test-II	30	CO3, CO4, CO5
Average of the two internal tests will be taken for 30 marks		
Other Components	**Marks**	**Course outcomes addressed**
• Assignment • Quiz • Presentation • Model/mini project • Any other	20 (10+10)	CO1, CO2 ,CO3, CO4, CO5
Semester End Examination (SEE)		
Semester End Examination: (Scaled to 50)	100	CO1, CO2, CO3, CO4, CO5