**YESHWANTRAO CHAVAN COLLEGE OF ENGINEERING**
**(An Autonomous Institution affiliated to R T M Nagpur University Nagpur)**
**Accredited by NAAC (1st Cycle) with 'A' Grade (Score 3.25 on 4 Point Scale)**
**Wanadongri, Hingna Road, Nagpur-441110**

## Department of Mechanical Engineering
## (Honors in AIR)

# B.E. Honors in Advanced Industrial Robotics
# SoE & Syllabus 2021-22

# B.E Honors in Advanced Industrial Robotics
## Information Brochure of Honor Program

1. Title of Program: **ADVANCED INDUSTRIAL ROBOTICS**
2. Type of Program : **Honor**
3. Department offering the program: **Mechanical Engineering**
4. Industry / Association / Collaboration: NO
5. Department/s eligible to opt for the program:

   **(The program can be opted only by the students Mechanical Engineering Department.)**

6. General information about courses in program:

   Advanced robotics systems are ready to transform industrial operations. Compared with conventional robots, advanced robots have superior perception, integrability, adaptability, and mobility. These improvements permit faster setup, commissioning, and reconfiguration, as well as more efficient and stable operations. The cost of this sophisticated equipment will decline as prices for sensors and computing power decrease, and as software increasingly replaces hardware as the primary driver of functionality. Taken together, these improvements mean that advanced robots will be able to perform many tasks more economically than the previous generation of automated systems.

   Producers are now deploying advanced robotics as an essential element of advanced automation that enables the self-controlled factory of the future. Enhancing plant structures and processes with digital technologies can increase productivity and flexibility in both the factory and the supply chain, enabling producers to rapidly adjust to changing customer needs.) A BCG analysis found that using advanced robots can reduce conversion costs by up to 15%, and combining advanced robotics with other technologies, process enhancements, and structural layout changes can yield savings of up to 40%.

7. Advance knowledge or research orientation of Program:

   The status quo of industrial robots mainly discusses the application technologies involved in the research of robots at the current stage, which effectively demonstrates the relevant applications of industrial robots in the field of smart manufacturing. However, the development of the application technology of industrial robots has not received enough attention. This is also the main reason that causes the disconnection between the design and manufacturing of industrial robots and the application requirements. This not only limits the popularity of industrial robots to a great extent, but also limits the large-scale and vigorous development of the industrial robot industry itself. The course aims at some actual conditions of the existing industrial robots in manufacturing automation applications, and systematically summarizes and

analyzes the future research direction and strategic thinking of industrial robots. Effectively grasping the relevant principles and implementing research and development of related technologies

8. Employability potential of program:
The impact of robots on employment and trade is a highly discussed topic in the academic and public debates. Particularly, there are concerns that automation may threat jobs in emerging countries given the erosion of the labour cost advantage. We provide evidence on the effects of robots on worldwide employment, including emerging economies. To instrument the use of robots, we introduce an index of technical progress, defined as the ability of robots to carry out different tasks. Robots turn out to have a statistically significant negative impact on worldwide employment. While it is small in developed countries, for emerging economies it amounts to -14% between 2005 and 2014. This course offer 100% chance to acquire the position in Industry.

9. Departmental Steering committee: For proper publicity / conduct of program

| SN | Name of the Faculty Member | Post | Designation | e-mail ID | Contact Number |
|---|---|---|---|---|---|
| 1 | Dr. S. S. Chaudhari | Chairman | HOD | hod_me@ycce.edu | 9545531727 |
| 2 | Dr.J.P.Giri | Member | Associate Professor | jayantpgiri@gmail.com | 9822929871 |
| 3 | Prof.A.P.Edlabadkar | Member | Assistant Professor | ajinkyae@gmail.com | 9764478622 |
| 4 | Prof.A.R.Narkhede | Member | Assistant Professor | alok.narkhede@gmail.com | 7666767483 |

10. Departmental coordinator

| SN | Name of the Faculty Member | Post | Designation | e-mail ID | Contact Number |
|---|---|---|---|---|---|
| 1 | Prof.A.R.Narkhede | Member | Assistant Professor | alok.narkhede@gmail.com | 7666767483 |

## Scheme of Examinations

## B.E. Honors in Advanced Industrial Robotics

| SN | Sem | Sub. Code | Subject | T/P | Contact Hours | | | | Credits | % Weightage | | | ESE Duration Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L | T | P | Hrs | | MSEs* | TA** | ESE | |
| 1 | 5 | MEH101 | Introduction to Robotics | T | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 2 | 5 | MEH102 | Robot Kinematics and Dynamics | T | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 3 | 5 | MEH103 | Robot Kinematics and Dynamics LAB | P | 0 | 0 | 2 | 2 | 1 | - | 60 | 40 | 3 |
| 4 | 6 | MEH111 | Robot Control Programming | T | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 5 | 6 | MEH112 | Robot Control Programming LAB | P | 0 | 0 | 2 | 2 | 1 | - | 60 | 40 | 3 |
| 6 | 6 | MEH113 | Robot Applications | T | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 7 | 7 | MEH121 | Industrial Robotics | T | 3 | 0 | 0 | 3 | 3 | 30 | 30 | 40 | 3 |
| 8 | 7 | MEH122 | Industrial Robotics LAB | P | 0 | 0 | 2 | 2 | 1 | - | 60 | 40 | 3 |
| **TOTAL** | | | | | **15** | **0** | **6** | **21** | **18** | | | | |

**MSEs* = Three MSEs of 15 Marks each will conducted and marks of better 2 of these 3 MSEs will be considered for Continuous Assessment**

**TA ** = for Theory : 20 marks on lecture quizzes, 8 marks on assignments, 2 marks on class performance**
**TA** = for Practical : MSPA will be 15 marks each**

## V Semester

| MEH101 | Introduction to Robotics | | | L=3 | T=0 | P=0 | Credits= 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Tota | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs. |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| • To be familiar with the automation and brief history of robot and applications.<br>• To give knowledge about various Sensors and their applications in robots | 1. Demonstrate the knowledge of Robots and their applications<br>2. Understand the Robot Configuration<br>3. Understand the effectiveness Automation<br>4. Demonstrate the knowledge of Automated Inspection and Testing |

**Unit 1** **[7 hrs]**

**FUNDAMENTALS OF ROBOT**

Robot – Definition – Robot anatomy – Co-ordinate systems, work envelope, types and classification – Specifications – Pitch, yaw, roll, joint notations, speed of motion and pay load – Robot parts and their functions – Need for robots – Different applications.

**Unit 2** **[8 hrs]**

**ROBOT DRIVE SYSTEMS**

Pneumatic drives – Hydraulic drives – Mechanical drives – Electrical drives – D.C. servo motors, stepper motor and A.C. servo motors – Salient features, applications and comparison of all these drives.

**END EFFECTORS**

End effectors – Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers – Two fingered and three fingered grippers – Internal grippers and external grippers – Selection and design considerations.

**Unit 3** **[8 hrs]**

**SENSORS**

Requirements of a sensor, principles and applications of the following types of sensors – Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors) – Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters) – Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors) – Touch sensors (Binary sensors, Analog sensors) – Wrist Sensors – Compliance Sensors – Slip Sensors.

**Unit 4** **[7 hrs]**

**Automation Introduction:** Definition, automation principles and strategies, scope of automation, socio-economic consideration, low-cost automation, basic elements of advanced functions, Information processing in manufacturing industry, Production concepts and automation strategies.

**Fixed Automation:** Automated Flow lines, Methods of Work part Transport, Transfer Mechanism – Continuous transfer, intermittent transfer, Indexing mechanism, Operator-Paced Free Transfer Machine, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines without Storage, Partial Automation, Automated Flow Lines with Storage Buffers.

**Unit 5** **[8 hrs]**

**Materials Handling:** The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems.

**Automated Storage Systems:** Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.

**Unit 6** **[7 hrs]**

**Automated Inspection and Testing:** Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other
Contact Inspection Methods, Machine Vision, Other optical Inspection Methods.
Modelling Automated Manufacturing Systems: Role of Performance Modelling, Performance Measures, Performance Modelling Tools: Simulation Models, Analytical Models.

**Text Books:**

1. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, Industrial Robotics: Technology, Programming and Applications, 2 nd Edition, Tata McGraw Hill, 2012.
2. Roland Siegwart, Illah R. Nourbakhsh, an d Davide Scaramuzza, "Introduction to Autonomous Mobile Robots, 2 nd Edition, PHI, 2011

**Reference Books:**

1. S.P. SukhatMT, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. C. S. Solanki, Solar Photovoltaic's: FundaMTntal Applications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

## V Semester

| MEH102 | Robot Kinematics and Dynamics | | | L=3 | T=0 | P=0 | Credits= 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Tota | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs. |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| To impart basic detail knowledge of Robot Kinematics and Dynamics to the learner. | 1. Perform kinematic analysis, synthesis of mechanisms.<br>2. Perform forward and inverse kinematics of robots<br>3. Apply design procedure for mechanical grippers depending upon their types and mechanism<br>4. Design of robot manipulators based on dynamic analysis |

**Unit 1** **[7 hrs]**

**ROBOT KINEMATICS**

Manipulator Kinematics Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, solvability, algebraic and geometrical methods,

**Unit 2** **[7 hrs]**

Velocities and Static forces in manipulators Motion of the manipulator links, Jacobians, singularities, static forces, Jacobian in force domain.

**Unit 3** **[8 hrs]**

**Manipulator Dynamics** Iterative Newton-Euler dynamic formulation, structure of the manipulator dynamic equations, introduction to the Lagrangian formulation and generalized D'Alembert's equations of motion,

**Unit 4** **[8 hrs]**

Trajectory Generation Considerations in path description and generation, joint space schemes, paths with via points, Cartesian space schemes, geometrical problems with Cartesian paths

**Unit 5** **[10 hrs]**

Configuration spaces of mobile vehicles and manipulators, Geometric modelling and sensor-based map building. Path planning and obstacle avoidance. Object manipulation and grasping. Design of user interfaces and simulation. Algorithms for assembly and biological aspects of motion and intelligence.

**Unit 6** **[5 hrs]**

Advanced techniques of kinematics and dynamics of mechanical systems. Parallel actuated and closed loop manipulators. Redundant manipulators. Mobile robots and path planning. Complaint motion and grasping. Any other relevant topic.

**Text Books:**

[T1] Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.

[T2] Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999. Reference Books:

[R1] S.R. Deb, "Robotics Technology and flexible automation", Tata McGraw-Hill Education., 2009.

[R2] Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.

[R3] Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.

[R4] P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.

[R5] Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.

[R6] Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987

[R7] Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985

## V Semester

| MEM103 | Lab.: Robot Kinematics and Dynamics | | | L= 0 | T = 0 | P = 1 | Credits = 1 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme<br>*Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | -- | -- | -- | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| To impart basic detail knowledge of Robot Kinematics and Dynamics to the learner. | 1. Perform kinematic analysis, synthesis of mechanisms.<br>2. Perform forward and inverse kinematics of robots<br>3. Apply design procedure for mechanical grippers depending upon their types and mechanism<br>4. Design of robot manipulators based on dynamic analysis |

**List of Practical's:**

(1) Assignment on introduction to robot configuration

(2) Demonstration of robot with 2 dof, 3 dof, 4 dof etc.

(3) Two assignments on programming the robot for applications in val ii

(4) Two programming exercises for forward kinematics in robots using simulation software

(5) Two programming exercises for inverse kinematics in robots using simulation software

(6) Two case studies of applications in industry

(7) Two programming exercises for welding operation through robcad

(8) Two programming exercises for pick-and-place operation through robcad

## VI Semester

| **MEH111** | **Robot Control and Programming** | | | **L=3** | **T=0** | **P=0** | **Credits= 3** |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Tota | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs. |
| **Prerequisites** | | | | | | | |

| **Objective** | **Course Outcome** |
|---|---|
| To impart basic detail knowledge of Robot Control and Programming. | 1. Explain robot programming methods on<br>**2.** Understand the components of robot programming<br>**3.** Develop simple Programmes to simulate robot movements<br>4. Develop robot Programmes for specific application |

**Unit 1** **[7 hrs]**

**Manipulator Control:** Introduction to closed loop control, second order linear systems and their control, control law partitioning, trajectory-following control, modeling and control of a single joint.

**Unit 2** **[8 hrs]**

**Introduction to non-linear control**, non-linear and time-varying systems, the control problem of manipulators, practical considerations, present industrial robot control systems, introduction to force control, brief introduction to robot actuators, need for sensors and vision system in the working and control of a robot,

**Unit 3** **[8 hrs]**

**ROBOT PROGRAMMING**

Programming: Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines, RAIL and VAL II programming languages VAL programming – Motion commands – Sensor commands – End effecter commands – Simple programs.

**Unit 4** **[7 hrs]**

**MACHINE VISION**

Camera, frame grabber, sensing and digitizing image data – Signal conversion – Image Storage – Lighting techniques – Image processing and analysis – Data reduction – Segmentation – Feature extraction – Object recognition – Other algorithms – Applications – Inspection, identification, visual serving and navigation.

**Unit 5** **[8 hrs]**

**IMPLEMENTATION**

\RGV – AGV – Implementation of robots in industries – Various steps - Safety considerations for robot operations.

**Unit 6** **[7 hrs]**

**Machine Learning in Robotics**

Imitation Learning, Self-Supervised Learning, Assistive and Medical Technologies, Multi-Agent Learning

**Text Books:**

[T1] Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.

[T2] Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999.Reference Books:

[R1] S.R. Deb, "Robotics Technology and flexible automation", Tata McGraw-Hill Education., 2009.

[R2] Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.

[R3] Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.

[R4] P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.

[R5] Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.

[R6] Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987

[R7] Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985

## VI Semester

| MEM112 | Lab- Robot Control and Programming | | | L= 0 | T = 0 | P = 1 | Credits = 1 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme<br>*Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | -- | -- | -- | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| To impart basic detail knowledge of Robot Control and Programming. | 1. Explain robot programming methods on<br>**2.** Understand the components of robot programming<br>**3.** Develop simple Programmes to simulate robot movements<br>4. Develop robot Programmes for specific application |

**List of Practical's:**

1. Programming on VAL Language
2. Programming on VAL-II Language
3. Programming on RAPID Language
4. Programming on AML Language
5. Programming the robot for pick and place operation using any robot
6. Robot Programming for Colour identification/shape identification/path tracking
7. Industrial visit and its report on industrial applications of robots

## VI Semester

| MEH113 | Robot Applications | | | L=3 | T=0 | P=0 | Credits= 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Tota | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs. |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| • Gain knowledge of Robotics and it's application. | 1. Understand the working methodology of robotics and automation.<br>2. Write the program for robot for various applications.<br>3. Understand the Robot Application in Mechanical Industry<br>4. Understand the robotics programming and simulation |

**Unit 1** **[7 hrs]**

Robot Applications :-

- Assembly ,deployment strategy ,analysis , programming interface

**Unit 2** **[8 hrs]**

Robot Applications :-

- Welding ,deployment strategy ,analysis , programming interface

**Unit 3** **[8 hrs]**

Robot Applications :-

- Material Handling ,deployment strategy ,analysis , programming interface ,Simulation

**Unit 4** **[7 hrs]**

Robot Applications :-

- Processing , deployment strategy ,analysis , programming interface ,Simulation

**Unit 5** **[8 hrs]**

Robot Applications :-

- Mechanical Cutting, Grinding, Deburring and Polishing.

**Unit 6** **[7 hrs]**

Robot Applications :-
- Gluing, Adhesive Sealing and Spraying Materials

**Text Books:**

[T1] Mikell P Groover, Nicholas G Odrey, Mitchel Weiss, Roger N Nagel, Ashish Dutta, "Industrial Robotics, Technology programming and Applications", McGraw Hill, 2012.

[T2] Craig. J. J. "Introduction to Robotics- mechanics and control", Addison- Wesley, 1999. Reference Books:

[R1] S.R. Deb, "Robotics Technology and flexible automation", Tata McGraw-Hill Education., 2009.

[R2] Richard D. Klafter, Thomas .A, ChriElewski, Michael Negin, "Robotics Engineering an Integrated Approach", PHI Learning., 2009.

[R3] Francis N. Nagy, Andras Siegler, "Engineering foundation of Robotics", Prentice Hall Inc., 1987.

[R4] P.A. Janaki Raman, "Robotics and Image Processing an Introduction", Tata McGraw Hill Publishing company Ltd., 1995.

[R5] Carl D. Crane and Joseph Duffy, "Kinematic Analysis of Robot manipulators", Cambridge University press, 2008.

[R6] Fu. K. S., Gonzalez. R. C. & Lee C.S.G., "Robotics control, sensing, vision and intelligence", McGraw Hill Book co, 1987

[R7] Ray Asfahl. C., "Robots and Manufacturing Automation", John Wiley & Sons Inc.,1985

### VII Semester

| MEH121 | Industrial Robotics | | | L=3 | T=0 | P=0 | Credits= 3 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme *Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Tota | ESE Duration |
| | 15 | 15 | 15 | 30 | 40 | 100 | 3 Hrs. |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| • Gain knowledge of Robotics and Industrial automation.<br>• | On completion of course students will<br>• have knowledge of Robotics, automation, robotics motion, sensors and control, machine vision, robotic programming and roles of robots in industry<br>• Understand the working methodology of robotics and automation, motion and control, machine vision and programming, application of robots in industry.<br>• write the program for robot for various application |

**Unit 1** **[7 hrs]**

**FUNDAMENTALS OF ROBOT**

Robot – Definition – Robot anatomy – Co-ordinate systems, work envelope, types and classification – Specifications – Pitch, yaw, roll, joint notations, speed of motion and pay load – Robot parts and their functions – Need for robots – Different applications..

**Unit 2** **[8 hrs]**

**ROBOT DRIVE SYSTEMS**

Pneumatic drives – Hydraulic drives – Mechanical drives – Electrical drives – D.C. servo motors, stepper motor and A.C. servo motors – Salient features, applications and comparison of all these drives.

**END EFFECTORS**

End effectors – Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers – Two fingered and three fingered grippers – Internal grippers and external grippers – Selection and design considerations.

**Unit 3** **[8 hrs]**

**SENSORS**

Requirements of a sensor, principles and applications of the following types of sensors – Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors) – Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters) – Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors) – Touch sensors (Binary sensors, Analog sensors) – Wrist Sensors – Compliance Sensors – Slip Sensors.

**Unit 4** **[7 hrs]**

**MACHINE VISION**

Camera, frame grabber, sensing and digitizing image data – Signal conversion – Image Storage – Lighting techniques – Image processing and analysis – Data reduction – Segmentation – Feature extraction – Object recognition – Other algorithms – Applications – Inspection, identification, visual serving and navigation.

**Unit 5** **[8 hrs]**

**ROBOT KINEMATICS**

Forward kinematics – Inverse kinematics – Differences: Forward kinematics and Reverse kinematics of manipulators with two and three degrees of freedom (In 2 dimensional), four degrees of freedom (In 3 dimensional) – Deviations and problems

**Unit 6** **[7 hrs]**

**ROBOT PROGRAMMING**

Teach pendant programming – Lead through programming – Robot programming languages – VAL programming – Motion commands – Sensor commands – End effecter commands – Simple programs.

**IMPLEMENTATION**

RGV – AGV – Implementation of robots in industries – Various steps - Safety considerations for robot operations.

**Text Books:**

1. Mikell P. Groover, Mitchel Weiss, Roger N. Nagel, Nicholas G. Odrey and Ashish Dutta, Industrial Robotics: Technology, Programming and Applications, 2 nd Edition, Tata McGraw Hill, 2012.
2. Roland Siegwart, Illah R. Nourbakhsh, an d Davide Scaramuzza, "Introduction to Autonomous Mobile Robots, 2 nd Edition, PHI, 2011

**Reference Books:**

1. S.P. SukhatMT, Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. C. S. Solanki, Solar Photovoltaic's: FundaMTntal Applications and Technologies, Prentice Hall of India, 2009.
3. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.

## VII Semester

| MEH122 | Lab. : Industrial Robotics | | | L= 0 | T = 0 | P = 1 | Credits = 1 |
|---|---|---|---|---|---|---|---|
| Evaluation Scheme<br>*Best Two out of three MSE's would be considered | MSE-I* | MSE-II* | MSE-III* | TA | ESE | Total | ESE Duration |
| | -- | -- | -- | 60 | 40 | 100 | 3 Hrs |
| **Prerequisites** | | | | | | | |

| Objective | Course Outcome |
|---|---|
| ain knowledge of Robotics and Industrial automation. | On completion of course students will<br>• have knowledge of Robotics, automation, robotics motion, sensors and control, machine vision, robotic programming and roles of robots in industry<br>• Understand the working methodology of robotics and automation, motion and control, machine vision and programming, application of robots in industry.<br>• write the program for robot for various application |

**List of the practical's.**

1. Study components of a real **robot** and its DH parameters.
2. Forward kinematics and validate using a software (Robo Analyser or any other free software tool).
3. Inverse kinematics of the real **robot** and validation using any software.
4. Use of open-source computer vision programming tool open CV.
5. Image Processing using open CV.
6. Image processing for color/shape detection.
7. Positioning and orientation of Robotic Arm
8. Control experiment using available hardware and software.
9. Integration of assorted sensors, Micro-controllers and ROS in Robotic arm.