**Vidya Pratishthan's**

**Kamalnayan Bajaj Institute of Engineering and Technology, Baramati.**

**(An Autonomous Institute)**

# Faculty of Science and Technology

Board of Studies

## Mechanical Engineering

Syllabus

## Double Minor with Specialization in Digital Manufacturing & Robotics

(Pattern 2023)

(w.e.f. AY: 2024-25)

## Syllabus: Double Minor with specialization in Digital Manufacturing & Robotics

## (Pattern 2023) w.e.f. AY:2024-2025

| Course Code | Courses Name | Teaching Scheme | | | Examination Scheme and Marks | | | | | | | Credits | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TH | PR | TUT | ACT | ISE | ESE | TW | PR | OR | Total | TH | PR | TUT | Total |
| ME23261 | 3D Modeling & Drafting | 2 | 2 | - | 10 | 20 | 50 | 20 | 20 | - | 120 | 2 | 1 | - | 3 |
| ME23271 | Principle of Robotics | 2 | 2 | - | 20 | 20 | 50 | 20 | 20 | - | 130 | 2 | 1 | - | 3 |
| ME23361 | Digital Manufacturing | 3 | 2 | - | 20 | 20 | 70 | 20 | 20 | - | 150 | 3 | 1 | - | 4 |
| ME23371 | Control System | 3 | 2 | - | 20 | 20 | 70 | 20 | 20 | - | 150 | 3 | 1 | - | 4 |
| ME23461 | Smart Manufacturing | 3 | 2 | - | 20 | 20 | 70 | 20 | 20 | - | 150 | 3 | 1 | - | 4 |
| **Total** | | **13** | **10** | **-** | **90** | **100** | **310** | **100** | **100** | **-** | **700** | **13** | **5** | **-** | **18** |

| Dept. Academic Coordinator | Head of Department | Dean Academic | Principal |
|---|---|---|---|
| Mr. S. C. Mahadik | Dr. M. S. Lande | Dr. S. M. Bhosle | Dr. R. S. Bichkar |

Head
Department of Mechanical Engineering
VPKBIET Baramati - 413133

VPKBIET BARAMATI
Affiliated to S.P.P.U. Pune Id No. / PU / PN / Engg. / 152 / 2000
PUNE (MS.)

| ME23261:- 3D Modeling & Drafting | | |
|---|---|---|
| **Teaching Scheme:** | **Credits:03** | **Examination Scheme:** |
| **TH: 02 Hrs/Week** | **Theory : 02**<br>**Practical : 01** | **Course Activity: - 10 Marks** |
| | | **In-Semester Exam: 20 Marks** |
| | | **End-Semester Exam: 50 Marks** |
| **PR: 02 Hrs/Week** | | **PR Exam: - 20 Marks** |
| | | **Term-Work: 20 Marks** |

**Prerequisites:** Engineering Graphics.

**Objectives:**

1. Familiarize students with the interface and basic tools of solid modeling software (e.g., SolidWorks, AutoCAD and CATIA).
2. Enable students to create detailed 3D models of mechanical parts from technical drawings.
3. Teach students to assemble individual parts into a complete mechanical assembly.
4. Introduce students to advanced modeling techniques such as surfacing.

**Course Outcomes:**

The students will be able to learn:

**CO1:** Demonstrate the ability to use solid modeling software to create accurate 3D models of mechanical components.

**CO2:** Interpret and convert technical drawings into 3D models for engineering applications.

**CO3:** Apply principles of geometric modeling to develop detailed parts and assemblies

**CO4:** Utilize advanced features and tools of solid modeling software to enhance and optimize designs.

**Course Contents**

| **Unit-1: Introduction** | **[06 Hrs.]** |
|---|---|
| Introduction – the evolution of CAD, the importance of CAD in the light of allied technologies, Product Life Cycle, CAD tools in the design process of Product Cycle, Computer-Aided Design - Features, requirements, and applications 3D Modeling approach - Types of Geometric models - extrusions, axisymmetric, 3D objects, the difference between wireframe, surface & solid modeling. | |

| **Unit-2: Curves and Surfaces** | **[06 Hrs.]** |
|---|---|
| Methods of defining Point, Line and Circle, Curve representation - Cartesian and Parametric space, Analytical and Synthetic curves, Parametric equation of line, circle, ellipse.<br>Synthetic Curves - Hermit Cubic Spline, Bezier, B-Spline Curve,<br>Surfaces: Surface representation, Types of Surfaces, Bezier, B-Spline, NURBS Surface, Coons patch surface, Surface Modeling. | |
| **Unit-3: Solid Modeling and Assembly** | **[06 Hrs.]** |
| Introduction, Geometry, and Topology, Solid entities, Solid representation, Fundamentals of Solid modeling, Boundary representation (B-Rep), Constructive Solid Geometry (CSG), Sweep representation, Analytical solid modeling, Parametric solid modeling, feature-based modeling, Introduction to Assembly Modeling, Assemblies (Top-down and Bottom-up approach). | |
| **Unit-4: Geometric Transformation** | **[06 Hrs.]** |
| Introduction, Geometric Transformations, Translation, Scaling, Rotation, Reflection/Mirror, Shear, Homogeneous Transformation, Inverse Transformation, Concatenated Transformation (limited to 2D objects with maximum 3 points only), Coordinate systems - Model (MCS), Working (WCS), Screen (SCS) coordinate system, Mapping of coordinate systems. | |

**Text Books**:


1. Zeid, I and Sivasubramania, R., (2009), "CAD/CAM : Theory and Practice", 2nd edition, McGraw Hill Education, ISBN-13: 978-0070151345
2. Rao, P. N., (2017), "CAD/CAM: Principles and Applications", 3rd edition, McGraw Hill Education, ISBN-13: 978-0070681934.


**Reference Books:**


1. Ostrowsky, O., Engineering Drawing with CAD Applications, ELBS, 1995

2. Vukašinovic, Nikola and Duhovnik, Jože, (2019), "Advanced CAD Modeling: Explicit, Parametric, Free-Form CAD and Re-engineering", Springer, ISBN-13: 978-3030023980

3. Hearn, D. D. and Baker, M. P., (2013), "Computer Graphics with OpenGL", 4th edition, Pearson Education India, ISBN-13: 978-9332518711

4. Bucalo, Joe and Bucalo, Neil, (2007), "Customizing SolidWorks for Greater Productivity", Sheet Metal Guy, LLC, ISBN-13: 978-0979566608

5. Programming Manuals of Softwares.

**Guidelines for Lab /TW Assessment (All Practical's are compulsory)**

1. **Introduction to Solid Modeling Software:**
    a. Familiarization with the software interface.
    b. Basic commands and tools.
    c. Creating simple geometric shapes.
2. **Creating 3D Models from Technical Drawings:**
    a. Converting 2D sketches into 3D models.
    b. Applying dimensions and constraints.
    c. Editing and modifying models.
3. **Assembly Modeling:**
    a. Importing and assembling individual parts.
    b. Applying mates and constraints.
    c. Checking for interferences and alignments.
4. **Advanced Modeling Techniques:**
    a. Introduction to surfacing and creating simple shapes.
5. **Technical Drawing and Documentation:**
    a. Generating 2D technical drawings from 3D models.
    b. Adding annotations, dimensions, and tolerances.

**Guidelines for Activity:**

**Mini Project:** Applying all learned techniques to design a mechanical component or assembly.

| ME23271:- Principle of Robotics | | |
|---|---|---|
| **Teaching Scheme:** | **Credits:03** | **Examination Scheme:** |
| **TH: 02 Hrs/Week** | **Theory : 02**<br>**Practical : 01** | **Course Activity: 20 Marks** |
| | | **In-Semester Exam: 20 Marks** |
| | | **End-Semester Exam: 50 Marks** |
| **PR: 02 Hrs/Week** | | **PR Exam: 20 Marks** |
| | | **Term-Work: 20 Marks** |

**Prerequisites:** Engineering Physics, Engineering Mathematics, Basics of Electrical Engineering, Basics of Electronics Engineering & Engineering Graphics.

**Objectives:**

1. To introduce various types of Robots and the functional elements of Robotics.
2. To impart knowledge of robot drive systems & educate on various sensors used in Robotic automation.
3. To introduce various types of end effectors.
4. To impart knowledge of basics of Robot Programming and robotic Applications

**Course Outcomes:**

The students will be able to learn:

**CO1:** UNDERSTAND basic concepts of robotics.

**CO2:** SELECT appropriate drive & sensors for Robotic applications.

**CO3:** To COMPARE and SELECT robot end effectors as per application.

**CO4:** To know about the fundamentals of robot programming and applications.

**Course Contents**

| **Unit-1: Fundamentals of Robotics** | **[07 Hrs.]** |
|---|---|
| Historical development of Robotics, Definitions of Industrial Robot, Type and Classification of Robots, Asimov‘s laws 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. | |

| **Unit-2: Robot Drive Systems & Sensors** | **[08 Hrs.]** |
|---|---|

**Drive Systems** :- Pneumatic Drives, Hydraulic Drives, Mechanical Drives, Electrical Drives-D.C. Servo Motors, Stepper Motors, A.C. Servo Motors, BLDC-Salient Features, Applications and Comparison of all these Drives, Micro actuators, selection of drive, Power transmission systems for robot, Motion conversion (Gearbox -Planetary, Harmonic, Cycloidal gearbox), VFD.

**Sensors:-** Transducers and sensors, Sensors in robotics, Principles and applications of the following types of sensors- Proximity Sensors, Photoelectric Sensors, Position sensors – Piezoelectric Sensor, LVDT, Resolvers, Encoders – Absolute and Incremental: - Optical, Magnetic, Capacitive, pneumatic Position Sensors, Range Sensors- Range Finders, Laser Range Meters, Touch Sensors, Force and torque sensors.

| **Unit-3: End Effectors** | **[07 Hrs.]** |
|---|---|

Grippers, Mechanical Grippers, Pneumatic and Hydraulic- Grippers, Magnetic Grippers, Vacuum Grippers; Two Fingered and Three Fingered Grippers; Internal Grippers and External Grippers; Advance Grippers- Adaptive grippers, Soft Robotics Grippers, Tactile Sensor Grippers; Various process tools as end effectors; Robot end effectors interface, Active and passive compliance, Selection and Design Considerations.

| **Unit-4: Fundamentals of Robot Programming and Applications** | **[08 Hrs.]** |
|---|---|

Introduction to Robotic Programming, On-line and off-line programming, programming examples. Various Teaching Methods, Survey of Robot Level Programming Languages with manufacture, Various Textual Robot Languages, Typical Programming Examples such as Palletizing, Job Loading & unloading, Welding, Press Work Etc. Robots in manufacturing and non-manufacturing applications, a robot-based manufacturing system, Robot controllers types & specification.

**Text Books**:


1. Groover, M.P. Weiss, M. Nagel, R.N. & Odrey, N.G., Ashish Dutta, Industrial Robotics, Technology, Programming & Applications, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw Hill.
3. Groover M.P.-Automation, production systems and computer integrated manufacturing Prentice Hall of India.
4. M.P. Grover, “Automation, Production Systems and Computer Integrated

Manufacturing"- Pearson Education.

**Reference Books:**

1. S B Niku, Introduction to Robotics, Analysis, Control, Applications, 2nd Edition, Wiley Publication, 2015.
2. Mikell P. Groover, Automation, Production Systems & Computer Integrated Manufacturing, PHI Learning Pvt. Ltd. , New Delhi, ISBN:987-81-203-3418-2, 2012.
3. John Craig, Introduction to Robotics, Mechanics and Control, 3rd Edition, Pearson Education, 2009.
4. R K Mittal & I. J. Nagrath, Robotics and Control, McGraw Hill Publication, 2015.
5. Mike Wilson, Implementation of Robotic Systems, ISBN: 978-0-124-04733-4.

**E study material: NPTEL Course on Robotics:**

1. https://onlinecourses.nptel.ac.in/noc19_me74/preview
2. https://onlinecourses.nptel.ac.in/noc20_de11/preview

**Guidelines for Lab /TW Assessment (All Practical's are compulsory)**

The student shall perform practicals from following list:

1. Study on selection of Actuators and related hardware such as DC motor, Servo motor, Stepper Motor, Motor drivers based on application.
2. Study on selection of Sensors such as IR sensors, Proximity Sensor, Ultrasonic Sensor, White line sensor, Temperature Sensor, Touch sensor, Tilt Sensor, Accelerometer, Gyroscopic Sensor etc. based on given application.
3. Simulation of target teaching on RoboDk for Scara & Articulated Robot.
4. Simulation of target teaching for curve surface on RoboDk.
5. Simulation of Spherical robot on RoboDk for pick and place aplication.
6. Simulation of SCARA robot on RoboDk.
7. Simulation of a simple robotic system for material handling systems on RoboDk.
8. Case study on selection & simulation of the appropriate robot system for given manufacturing and non- manufacturing applications.

**Guidelines for Activity:**

1. Activity on video based quizzes on unit 1 to 4.
2. One robot programming exercise for any one industrial application.
3. Industrial/ CoE visit - Report preparation based on the visit.

<table>
<tr><th colspan="3">ME23361- DIGITAL MANUFACTURING</th></tr>
<tr><th>Teaching Scheme:</th><th>Credits:04</th><th>Examination Scheme:</th></tr>
<tr><td rowspan="2">TH: 3 Hrs/Week</td><td rowspan="4">Theory : 03<br>Practical : 01</td><td>Course Activity: 20 Marks</td></tr>
<tr><td>In-Semester Exam: 20 Marks</td></tr>
<tr><td rowspan="2">Pr: 2 Hrs/Week</td><td>End-Semester Exam: 70 Marks</td></tr>
<tr><td>PR Exam: - 20 Marks</td></tr>
<tr><td></td><td>Term-Work: 20 Marks</td></tr>
</table>

This course provides an in-depth understanding of digital manufacturing systems, integrating traditional manufacturing processes with modern digital technologies. It covers the principles, techniques, and applications of digital manufacturing, including Industry 4.0 concepts, smart manufacturing, and the use of digital twins. The course emphasizes the role of digitalization in enhancing productivity, quality, and sustainability in manufacturing.

**Prerequisites:** Basic knowledge of manufacturing processes, Familiarity with computer-aided design (CAD) tools

**Course Objectives:**

- To understand the fundamentals of digital manufacturing systems.
- To explore the technologies and tools used in digital manufacturing.
- To analyze the impact of digitalization on manufacturing processes.
- To apply digital twins and simulation concepts to manufacturing applications.
- To identify smart manufacturing solutions for the industry.
- To design a digital manufacturing project by integrating digital manufacturing tools.

**Course Outcomes:** The students will be able to learn:

**CO1:** Explain the principles and components of digital manufacturing systems.
**CO2:** Utilize digital tools and technologies for manufacturing applications.
**CO3:** Analyze manufacturing data to improve processes and product quality.
**CO4:** Implement digital twins and simulation techniques to applications.
**CO5:** Understanding the smart manufacturing solutions in various industrial contexts.
**CO6:** Integrate digital manufacturing tools for manufacturing projects.

## Course Contents

| | |
|---|---|
| **Unit-1: Introduction to Digital Manufacturing** | **[6 Hrs.]** |
| Definition and evolution of digital manufacturing, Key concepts and terminology, Differences between traditional and digital manufacturing, Overview of Industry 4.0 | |
| **Unit-2: Digital Manufacturing Technologies** | **[6 Hrs.]** |
| Additive Manufacturing (3D Printing), Computer Numerical Control (CNC) Machines, Robotics and Automation, Internet of Things (IoT) in Manufacturing, Cyber-Physical Systems | |
| **Unit-3: Data Analytics in Manufacturing** | **[6 Hrs.]** |
| Importance of data in manufacturing, Data collection and management, Big Data Analytics, Predictive Maintenance, Case studies on data-driven manufacturing | |
| **Unit-4: Digital Twins and Simulation** | **[6 Hrs.]** |
| Concept of Digital Twins, Applications of Digital Twins in manufacturing, Simulation techniques and tools,Virtual commissioning of manufacturing systems | |
| **Unit-5: Smart Manufacturing Systems** | **[6 Hrs.]** |
| Characteristics of smart manufacturing, Smart factories and their components, Real-time monitoring and control, Role of AI and Machine Learning in smart manufacturing | |
| **Unit-6: Integration and Implementation** | **[6 Hrs.]** |
| Integration of digital technologies in existing systems, Challenges and solutions in digital manufacturing implementation, Case studies of successful digital manufacturing projects, Future trends and developments. | |
| **Text Books:**<br>1. Groover, M. P. – Automation, Production Systems, and Computer-Integrated Manufacturing (Pearson)<br>2. Tönshoff, H.K., & Denkena, B. – Digital Manufacturing (Springer)<br>3. Tao, F., Cheng, Y., & Zhang, M. – Digital Twin Driven Smart Manufacturing (Elsevier)<br>4. Alasdair Gilchrist – Industry 4.0: The Industrial Internet of Things | |
| **Reference Books:** | |

1.Tien-Chien Chang – Digital Manufacturing: In Design and Production

2. Michael Grieves – Digital Twin: Manufacturing Excellence through Virtual Factory Replication

3. Jay Lee, Behrad Bagheri, & Hung-An Kao – A Cyber-Physical Systems Approach to Smart Manufacturing

4. Sharma, R. & Kundra, T. K. – Introduction to Digital Manufacturing (McGraw-Hill)

5. Kuehn, W. – Digital Factory: Integration of Simulation & Virtual Reality (Springer)

6. Zhang, X. & Tao, F. – Smart Manufacturing: Concepts and Methods (Elsevier)

**Related NPTEL/Swayam Courses:**

1. Automation in Manufacturing (IIT Kanpur)

2. Computer Integrated Manufacturing (IIT Roorkee)

**List of Practicals:**

**ANY EIGHT experiments to be conducted during the course.**

1. 3D Printing Basics: Print simple geometric shapes to understand machine setup, material loading, and basic operation.

2. CNC Machining Introduction: Create a basic part using CNC milling or turning with simple tool paths.

3. Laser Cutting and Engraving: Design and cut/engrave basic shapes or patterns on various materials like wood or acrylic.

4. Basic Robotics Programming: Program a robotic arm to perform simple pick-and-place operations.

5. Simulation of Manufacturing Processes: Use simulation software (e.g., Arena or Simul8) to model a basic production line.

6. IoT in Manufacturing: Set up a simple IoT device to monitor environmental conditions (temperature, humidity) in a manufacturing setup.

7. Digital Twin Creation: Create a digital model of a simple physical object using CAD software and link it to real-time data.

8. Predictive Maintenance: Analyze sensor data to predict and schedule maintenance for a piece of equipment.

9. Virtual Reality (VR) in Manufacturing: Explore a virtual factory setup using basic VR tools and software.

10. Data Analytics for Manufacturing: Use basic statistical tools to analyze production data and identify trends or anomalies.

**Guidelines for Lab /TW Assessment**

i) **TW**: Assignment on each unit

ii) **PR**: Practical Performance or Oral exam will be conducted to evaluate Practicals.

<table>
<tr><th colspan="3">ME23371- CONTROL SYSTEMS</th></tr>
<tr><td>Teaching Scheme:</td><td>Credits:04</td><td>Examination Scheme:</td></tr>
<tr><td rowspan="2">TH: 3 Hrs/Week</td><td rowspan="4">Theory : 03<br>Practical : 01</td><td>Course Activity: 20 Marks</td></tr>
<tr><td>In-Semester Exam: 20 Marks</td></tr>
<tr><td rowspan="2">Pr: 2 Hrs/Week</td><td>End-Semester Exam: 70 Marks</td></tr>
<tr><td>PR Exam: - 20 Marks</td></tr>
<tr><td></td><td>Term-Work: 20 Marks</td></tr>
</table>

This introductory course on Control Systems is designed for providing a comprehensive foundation in the principles and applications of control systems. The course covers essential topics including system modeling, time and frequency domain analysis, and basic controller design. Additionally, the course introduces Programmable Logic Controllers (PLCs), equipping students with the knowledge to implement control systems in industrial settings.

**Prerequisites:**

**Basic Mathematics**: Knowledge of algebra, calculus, and differential equations.

**Basic Physics**: Understanding fundamental concepts in mechanics and electromagnetism.

**Introduction to Electrical Circuits/Mechanical Systems**: Basic understanding of electrical circuits (for Electrical Engineering students) or mechanical systems (for Mechanical Engineering students).

**Course Objectives:**

1. **Understand Control Systems Fundamentals**: Introduce students to basic control system concepts, terminology, and components.
2. **Model Dynamic Systems**: To develop mathematical models for simple dynamic systems.
3. **Analyze System Behavior**: To analyze the behavior of control systems in both time and frequency domains.
4. **Design Basic Controllers**: To design and implement basic controllers such as PID controllers.
5. **Apply PLCs in Control Systems**: Introduce students to the use of Programmable Logic Controllers (PLCs) in industrial control applications.
6. **Simulate and Apply Control Systems**: Provide practical experience in simulating control systems and applying concepts to real-world scenarios.

**Course Outcomes:** The students will be able to learn:

**CO1: Modeling Proficiency**: Students will be able to create and manipulate mathematical models for basic dynamic systems.

**CO2: Analysis Skills**: Students will use time-domain and frequency-domain methods to analyze system performance and stability.

**CO3: Controller Design**: Students will design and tune basic controllers to meet performance specifications.

**CO4: PLCs Knowledge**: Students will understand the basic principles and applications of PLCs in control systems.

**CO5: Simulation Expertise**: Students will use simulation tools to visualize and test control system behavior.

**CO6: Real-World Application**: Students will apply control system concepts to solve practical engineering problems.

## Course Contents

| | |
|---|---|
| **Unit-1: Introduction to Control Systems** | **[6 Hrs.]** |
| Basic Definitions and Concepts, Open-Loop and Closed-Loop Systems, Control System Components: Sensors, Controllers, Actuators, Feedback Mechanisms and Stability | |
| **Unit-2: Mathematical Modeling of Systems** | **[6 Hrs.]** |
| Transfer Functions and Block Diagrams, Modeling Electrical and Mechanical Systems, Signal Flow Graphs, Laplace Transform and Inverse Transform. | |
| **Unit-3: Time-Domain Analysis** | **[6 Hrs.]** |
| Time Response of First-Order Systems, Time Response of Second-Order Systems, Performance Metrics: Rise Time, Settling Time, Overshoot, Stability Analysis using Routh-Hurwitz Criterion. | |
| **Unit-4: Frequency-Domain Analysis** | **[6 Hrs.]** |
| Bode Plot Construction and Interpretation, Frequency Response of Systems, Gain and Phase Margins, Nyquist Criterion and Stability Analysis. | |
| **Unit-5: Controller Design** | **[6 Hrs.]** |
| Introduction to PID Controllers, Tuning PID Controllers: Methods and Examples, Design of Lead and Lag Compensators, Root Locus Technique | |

| **Unit-6: Programmable Logic Controllers (PLCs)** | **[6 Hrs.]** |
|---|---|

Introduction to PLCs: Components and Operation, PLC Programming Basics: Ladder Logic and Function Blocks, Applications of PLCs in Control Systems, Hands-On PLC Programming and Simulation.

**Text Books:**

1. "Control Systems Engineering" by Norman S. Nise
2. "Feedback Control of Dynamic Systems" by Gene Franklin, J. Da Powell, and Michael Workman
3. "Modern Control Engineering" by Ogata Katsuhiko
4. "Programmable Logic Controllers: Principles and Applications" by John W. Webb and Ronald A. Reis

**Reference Books:**

1. "Control Systems: Principles and Design" by George Ellis
2. "Automatic Control Systems" by Benjamin C. Kuo
3. "Introduction to Control Systems" by K. Ogata
4. "Fundamentals of Control Systems" by M. Gopal
5. "PLC Programming for Industrial Automation" by Kevin Collins

**List of Experiments:**

1. Time Response of First-Order Systems: Analyze RC circuit responses.
2. Time Response of Second-Order Systems: Study a mass-spring-damper system's response.
3. Frequency Response Analysis: Construct and interpret Bode plots for simple systems.
4. PID Controller Tuning: Implement and tune PID controllers using simulation software.
5. Root Locus Analysis: Design and analyze controllers using the root locus method.
6. System Simulation: Use MATLAB/Simulink for simulating control systems.
7. Lead and Lag Compensator Design: Design and simulate compensators to improve system performance.
8. Basic PLC Programming: Program and simulate basic PLC functions using ladder logic.
9. PLCs in Control Systems: Implement a PLC-based control system for a simple process.
10. Stability Analysis: Evaluate the stability of systems using time-domain and frequency-domain techniques.

**Web References**

1. MIT OpenCourseWare - Feedback Systems Introduction to Control Systems
2. Control Systems Toolbox - MathWorks MATLAB Control System Toolbox
3. Coursera - Introduction to Control Systems Control Systems Course
4. NPTEL - Introduction to Control Systems NPTEL Control Systems
5. Control System Design - TutorialsPoint Control System Design Basics
6. PLC Basics - PLCdev PLC Programming Basics
7. Control Theory - Wikipedia Control Theory Overview

**NPTEL Courses related to the subject:**

- "Introduction to Control Systems" by Prof. K. S. Rajasekaran, IIT Kharagpur
- "Control Systems: Principles and Applications" by Prof. Sudhakar Yedla, IIT Hyderabad
- "Programmable Logic Controllers" by Prof. S. K. Gupta, IIT Kharagpur

| ME23461- SMART MANUFACTURING | | |
|---|---|---|
| **Teaching Scheme:** | **Credits:04** | **Examination Scheme:** |
| **TH: 3 Hrs/Week** | **Theory : 03**<br>**Practical : 01** | **Course Activity: 20 Marks** |
| | | **In-Semester Exam: 20 Marks** |
| | | **End-Semester Exam: 70 Marks** |
| **Pr: 2 Hrs/Week** | | **PR Exam: - 20 Marks** |
| | | **Term-Work: 20 Marks** |

**Prerequisites:** Knowledge of earlier studied subjects like Solid Modeling, Material and manufacturing and Digital manufacturing.

**Objectives:**

1. Understand and realize the need of Computerized Manufacturing and factory automation.

2. Learn to integrate hardware and software elements for Computerized Manufacturing

3. Generate and Integrate CNC program for appropriate manufacturing techniques.

4. Learn to integrate processes planning, quality and MRP with computers.

5. Know about flexible, cellular manufacturing and group technology.

**Course Outcomes:**

On completion of the course the learner will be able to;

**CO1. EXPLAIN** Computerized Manufacturing and factory automation.

**CO2. UNDERSTAND** the integration of hardware and software elements for Computerized Manufacturing

**CO3. APPLY** CNC program for appropriate manufacturing techniques.

**CO4. ANALYZE** processes planning, quality and MRP integrated with computers.

**CO5. INTERPRET** flexible, cellular manufacturing and group technology.

| **Unit-1: Introduction to CIM** | **[06 Hrs.]** |
|---|---|
| Need of CIM, Introduction, Evolution of CIM,CIM Hardware and software, Role of CIM System, Definition of CIM, automation and types of automation, Reasons for automation, Types of Production, Functions in Manufacturing, CIM wheel, Computerized element of CIM, Advantages of CIM. | |
| **Unit- 2: Data Integration:** | **[06 Hrs.]** |
| CAD-CAM Integration, Product development through CIM, Design Activities in a networked environment, Networking in a manufacturing company, hardware elements of networking. CIM Database, Database requirements of CIM, Database management, Database Models, EDM, Product Data Management (PDM), Product life cycle Management(PLM) | |
| **Unit-3: Computer Aided Manufacturing (CAM)** | **[06 Hrs.]** |
| Introduction to Computer Aided Manufacturing (CAM), Coordinate system, Working principal of CNC Lathe, Turning Centers, Milling Machine, Machining Centers. Steps in developing CNC part program, Tool and geometric compensations, CNC Lathe and Mill simple part programming. | |
| **Unit-4: Computer Aided Process Planning and Quality Control** | **[06 Hrs.]** |
| Process Planning: Computer Aided Process Planning (CAPP), Benefits of CAPP, Material Requirement Planning, Capacity Planning, Manufacturing Resource Planning (MRP) - & Enterprise Resource Planning (ERP), Computer Aided Production Scheduling, Control Systems: Shop Floor Control, Inventory Control, Computer Aided Inspection and Quality Control. | |
| **Unit-5: Cellular Manufacturing** | **[06 Hrs.]** |
| Group Technology (GT), Part Families – Parts Classification and coding – Simple Problems in Opitz Part Coding system – Production flow Analysis – Cellular Manufacturing – Composite part concept – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems. | |
| **Unit - 6: Flexible Manufacturing System (FMS) And Automated Guided Vehicle System (AGVS)** | **[06 Hrs.]** |
| Types of Flexibility - FMS – FMS Components – FMS Application & Benefits – FMS Planning and Control– Quantitative analysis in FMS – Simple Problems. Automated Guided Vehicle System | |

(AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety

**Books and other resources**

**Text Books:**

1. Automation, Production system & Computer Integrated manufacturing, M. P. Groover PersonIndia, 2007 2nd edition.

2. Principles of Computer Integrated Manufacturing, S. Kant Vajpayee, Prentice Hall India

**References Books:**

1. Chang, T.C. and Wysk, R.A., 1997. Computer-aided manufacturing. Prentice Hall PTR

2. Xu, X., 2009. Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control. Information Science Reference.

3. Weatherall, A., 2013. Computer integrated manufacturing: from fundamentals to implementation. Butterworth-Heinemann.

4. Nanua Singh, Systems Approach to Computer Integrated Design and Manufacturing, John Wiley Publications.

5. Harrington J, Computer Integrated Manufacturing Krieger Publications 1979.

6. Zeid, CAD/CAM, Tata McGraw Hill. 7. Jha, N.K. "Handbook of Flexible Manufacturing Systems ", Academic Press Inc., 1991.

**NPTEL Link:**

1. https://youtube.com/playlist?list=PLFW6lRTa1g808_CfYhZKdv2eXplAQiAwS

2.https://nptel.ac.in/courses/112104289

3.https://www.youtube.com/watch?v=_zr4__3Rz0c

**Link for Virtual Lab: -** http://vlabs.iitkgp.ac.in/cim/#

**Guidelines for Laboratory Conduction**

1. Practical/Tutorial must be conducted in FOUR batches per division only.

2. Minimum 08 numbers of Experiments/Assignments shall be completed.

3. Experiments shall be conducted following 'Case Based Methodology'

4. Open source software, simulation tools may be used wherever required.

**Term Work**

The student shall complete the following activity as a Term Work:

1. Modelling of Mechanical Component using any 3D CAD software, Preparing CNC part program using any CAM software, and execute it on CNC Turning.

2. Modelling of Mechanical Component using any 3D CAD software, Preparing CNC part program using any CAM software, and execute it on CNC Milling.

3. Generate Bill of Material (BOM) from Assembly and other data using CAD Software.

4. Prepare Computer Aided Process Plan for selected part using variant type of CAPP Software.

5. Use MRP (Material Resource Planning) Software for CIM and Assembly.

6. Generate Part Family Code for a machine components using OPITZ Method

7. Study FMS system from Video clip and identify various elements of FMS and its controlling by computer.

8. Modeling and Simulation of Computer Integrated Manufacturing System. (VLab IIT, Kharagpur OR comparable sources)

9. Machine vision based quality control. (VLab IIT, Kharagpur OR comparable sources)

10.Remote Monitoring and Operation of a Computer Integrated Manufacturing System. (VLab IIT, Kharagpur OR comparable sources)