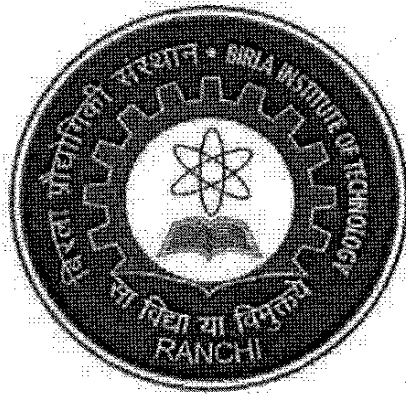


# **BIRLA INSTITUTE OF TECHNOLOGY**



## **CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM**

*(REVISED COURSE STRUCTURE – To be effective from Academic Session 2021-22)*

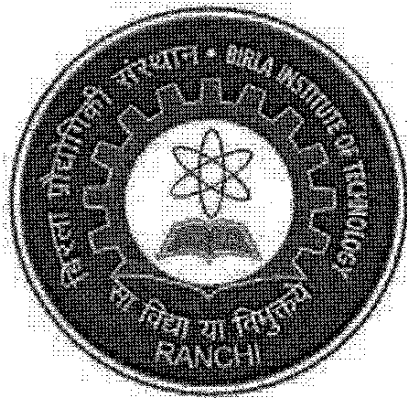
## **M.TECH IN AUTOMATED MANUFACTURING SYSTEMS**

## **PRODUCTION AND INDUSTRIAL ENGINEERING DEPARTMENT**

Introduced and approved in Meeting of Board of Studies, dated 23/04/2018  
Revised and approved in Meeting of Board of Studies, dated 21/06/2021

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# BIRLA INSTITUTE OF TECHNOLOGY



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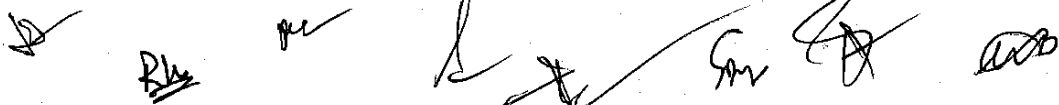
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## **INSTITUTE VISION**

- ❖ To become a Globally Recognised Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research, and technological service to the National needs.

## **INSTITUTE MISSION**

- ❖ To educate students at Under Graduate, Post Graduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- ❖ To provide excellent research and development facilities to take up Ph.D programmes and research projects.
- ❖ To develop effective teaching learning skills and state of art research potential of the faculty.
- ❖ To build national capabilities in technology, education, and research in emerging areas.
- ❖ To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

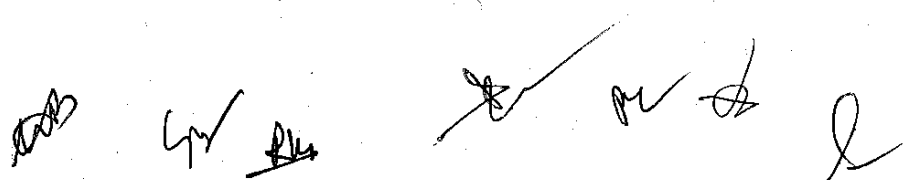


### **DEPARTMENT VISION:**

- ❖ To become a Centre of Repute striving continuously towards providing Quality Education, Research and Innovation in the field of Production and Industrial Engineering

### **DEPARTMENT MISSION**

- ❖ To provide quality education at both undergraduate and post graduate levels
- ❖ To provide opportunities and facilities for research and innovation in Production and Industrial Engineering
- ❖ To produce industry-ready graduates to meet the demands of manufacturing industries, knowledge-based software firms, supply chain and logistic firms, and R&D organizations
- ❖ To integrate skills on state-of-the-art manufacturing technology with industrial engineering and operations management
- ❖ To impart latest knowledge in the domain area to students by continuous up-gradation of curricula and faculty



## **Programme Educational Objectives (PEOs) – Automated Manufacturing Systems**

- ✓ **PEO 1:** Graduates will develop into independent researchers and academicians in the broad area of production and industrial engineering
- ✓ **PEO 2:** Graduates will demonstrate a high level of competency and problem-solving aptitude to find innovative solutions for theoretical and practical problems
- ✓ **PEO 3:** Developing a practice of continuously updating with latest knowledge and information in their relevant field of specialization
- ✓ **PEO 4:** Graduates should engage with engineering profession and understand the importance of ethics, teamwork and professionalism

## **Graduate Attributes (GAs)**

### **GA1: Scholarship of Knowledge**

Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

### **GA2: Critical Thinking**

Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

### **GA3: Problem Solving**

Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

### **GA4: Research Skill**

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

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**GA5: Usage of modern tools**

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

**GA6: Collaborative and Multidisciplinary work**

Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

**GA7: Project Management and Finance**

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

**GA8: Communication**

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

**GA9: Life-long Learning**

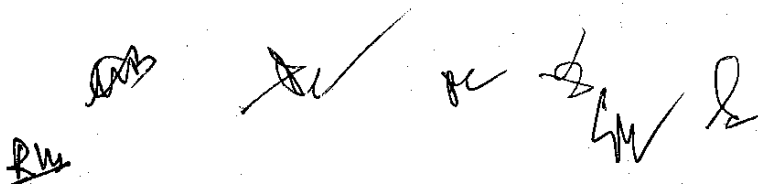
Recognise the need for and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

**GA10: Ethical Practices and Social Responsibility**

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

**GA11: Independent and Reflective Learning**

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently and learn from mistakes without depending on external feedback.



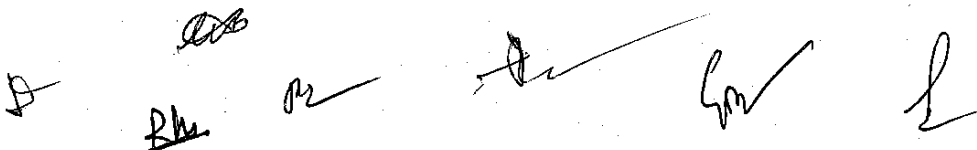
**PROGRAM OUTCOMES (POs) for M.TECH. (AUTOMATED MANUFACTURING SYSTEMS)**

**Compulsory PO**

- ✓ **PO1:** An ability to independently carry out research /investigation and development work to solve practical problems.
- ✓ **PO2:** Ability to write and present a substantial technical report/document.
- ✓ **PO3:** Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

**Optional PO (Program Specific)**

- ✓ **PO4:** Application of engineering and technological knowledge to solve a wide range of Production and Industrial problems.
- ✓ **PO5:** Developing expertise in automation related subjects both at the theory and practical level.
- ✓ **PO6:** Developing the ability and expertise in the students to apply latest data analytics tools and techniques for computing and engineering practice.



**PROGRAMME COURSE STRUCTURE**

|  |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|
| <b>BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI</b><br><b>REVISED COURSE STRUCTURE - Effective from academic session 2021-22</b><br><b>Based on CBCS &amp; OBE Model</b><br><b>Recommended scheme of study for M.Tech in AUTOMATED MANUFACTURING SYSTEMS</b> |  |  |  |  |  |  |  |
|--|--|--|--|--|--|--|--|

| SEMESTER /<br>Session of Study<br>(Recommended) | Course<br>Level     | Category<br>of Course                  | Course<br>Code                         | Courses  | Mode of delivery & credits<br><i>L-Lecture; T-Tutorial; P-<br/>Practicals</i> |                         |                         | Total<br>Credits<br>C-<br>Credits |    |
|---|---------------------|--|--|--|---|-------------------------|-------------------------|-----------------------------------|----|
|   |                     |  |  |  | L<br>(Periods/<br>week)   | T<br>(Periods/<br>week) | P<br>(Periods<br>/week) | C                                 |    |
| <b>THEORY</b>                                   |                     |  |  |  |   |                         |                         |                                   |    |
| <b>FIRST /<br/>Monsoon</b>                      | <b>Fifth</b>        | <b>Programme<br/>Core<br/>(PC)</b>     | PE 501                                 | Manufacturing Automation                         | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | PE 503                                 | Planning & Control of<br>Production<br>System    | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | PE 504                                 | Modeling and Simulation                          | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | PE 518                                 | Data Analytics                                   | 3   | 0                       | 0                       | 3                                 |    |
|   |                     | <b>Programme<br/>Elective<br/>(PE)</b> |  | Programme Elective - I                           | 3   | 0                       | 0                       | 3                                 |    |
|   | <b>LABORATORIES</b> |  |  |  |   |                         |                         |                                   |    |
|   |                     | <b>Fifth</b>                           | <b>Programme<br/>Core<br/>(PC)</b>     | PE 502   | Computer Aided<br>Manufacturing Lab   | 0                       | 0                       | 4                                 | 2  |
|   |                     |  |  | PE 505   | Manufacturing Simulation Lab  | 0                       | 0                       | 4                                 | 2  |
|   | <b>TOTAL</b>        |  |  |  |   |                         |                         |                                   | 19 |
|   | <b>THEORY</b>       |  |  |  |   |                         |                         |                                   |    |
| <b>SECOND/<br/>Spring</b>                       | <b>Fifth</b>        | <b>Programme<br/>Core<br/>(PC)</b>     | PE 510                                 | Robotics & Robot Applications                    | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | PE 511                                 | Computer Integrated<br>Manufacturing             | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | PE 512                                 | Soft Computing in<br>Manufacturing<br>Automation | 3   | 0                       | 0                       | 3                                 |    |
|   |                     |  | <b>Programme<br/>Elective<br/>(PE)</b> |  | Programme Elective - II   | 3                       | 0                       | 0                                 | 3  |
|   |                     |  |  | Programme Elective - III                         | 3   | 0                       | 0                       | 3                                 |    |
|   | <b>LABORATORIES</b> |  |  |  |   |                         |                         |                                   |    |
|   |                     | <b>Fifth</b>                           | <b>Programme<br/>Core<br/>(PC)</b>     | PE 516   | Autonomous Systems Lab  | 0                       | 0                       | 4                                 | 2  |
|   |                     |  |  | PE 517   | Computer Aided Design &<br>Drafting<br>Laboratory                             | 0                       | 0                       | 4                                 | 2  |
|   | <b>TOTAL</b>        |  |  |  |   |                         |                         |                                   | 19 |



| THIRD / Monsoon                           | Sixth | THEORY              |                                |                  |   |   |    |    |
|---|-------|---------------------|--------------------------------|------------------|---|---|----|----|
|   |       | Programme Core (PC) | PE 600                         | Thesis (Part I)  |   |   |    |    |
| Open Elective (OE)                        |       |                     | Open Elective - I / MOOC - I   | 3                | 0 | 0 | 3  |    |
|   |       |                     | Open Elective - II / MOOC - II | 3                | 0 | 0 | 3  |    |
| TOTAL                                     |       |                     |                                |                  |   |   | 14 |    |
| FOURTH / Spring                           | Sixth | Programme Core (PC) | PE650                          | Thesis (Part II) |   |   |    | 16 |
|   |       | TOTAL               |                                |                  |   |   |    |    |
| GRAND TOTAL FOR MTECH PROGRAMME (38 + 30) |       |                     |                                |                  |   |   |    | 68 |

### PROGRAM ELECTIVE COURSES

| LEVEL |                       | Course Code | Name of the PE courses                 | Prerequisites courses with code | L | T | P | C |
|-------|-----------------------|-------------|--|---------------------------------|---|---|---|---|
| FIFTH | PE - I<br>(Any one)   | PE 506      | Manufacturing Technology               | None                            | 3 | 0 | 0 | 3 |
|       |                       | PE 507      | Additive Manufacturing                 | None                            | 3 | 0 | 0 | 3 |
|       |                       | PE 508      | Operations and Supply Chain Management | None                            | 3 | 0 | 0 | 3 |
|       | PE - II<br>(Any one)  | PE 513      | Manufacturing System Design            | None                            | 3 | 0 | 0 | 3 |
|       |                       | PE 514      | Mechatronic Systems                    | None                            | 3 | 0 | 0 | 3 |
|       |                       | ME 533      | Automatic Control                      | None                            | 3 | 0 | 0 | 3 |
|       |                       | EE 573      | Embedded System and Applications       | None                            | 3 | 0 | 0 | 3 |
|       | PE - III<br>(Any one) | PE 519      | Optimization Techniques                | None                            | 3 | 0 | 0 | 3 |
|       |                       | PE 520      | Hydraulic & Pneumatic Controls         | PE 501 Manufacturing Automation | 3 | 0 | 0 | 3 |
|       |                       | PE 521      | Quality Engineering and Robust Design  | None                            | 3 | 0 | 0 | 3 |

\*\* PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS

### OPEN ELECTIVE COURSES

| LEVEL / SESSION | Code no. | Name of the OE courses  | Prerequisites courses with code | L | T | P | C |
|-----------------|----------|-------------------------|---------------------------------|---|---|---|---|
| SIXTH / (MO)    | PE 601   | Automated Manufacturing | None                            | 3 | 0 | 0 | 3 |
| SIXTH / (MO)    | PE 602   | Smart Manufacturing     | None                            | 3 | 0 | 0 | 3 |

\* OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS

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## COURSE INFORMATION SHEET

**Course code:** PE 501  
**Course title:** MANUFACTURING AUTOMATION  
**Pre-requisite(s):** None  
**Co- requisite(s):** PE 502  
**Credits:** 03 L:3 T:0 P:0  
**Class schedule per week:** 3  
**Class:** M.Tech.  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives:

This course enables the students to:

|   |  |
|---|--|
| 1 | To learn the concepts and principle of manufacturing automation  |
| 2 | To understand the various types of controls, components of automation and their practical use in manufacturing application |
| 3 | Automation Using Pneumatic Systems in various application areas  |
| 4 | Understand the Automation Using Hydraulic Systems  |
| 5 | To provide knowledge levels needed for PLC programming and operating   |

### Course Outcomes:

At the end of the course, a student should be able to:

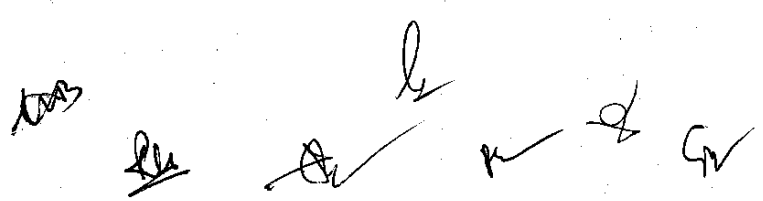
|     |  |
|-----|--|
| CO1 | Able to implement concepts of automation in machine tools and plant                                |
| CO2 | Students will understand the fundamentals of control in automation as they apply to manufacturing. |
| CO3 | Design of Pneumatic Circuit for manufacturing application  |
| CO4 | Design of Hydraulic Circuit for manufacturing application  |
| CO5 | Ability to apply PLC timers and counters for the control of industrial processes                   |

## SYLLABUS

**Module 1:** [8L]  
Fundamentals of Manufacturing; Production system facilities; Manufacturing support systems; Different types of manufacturing systems; Automation in Production Systems

**Module 2:** [8L]  
Manufacturing operations; Product, Production relationships; Production Concepts & Mathematical Models, Costs of Manufacturing Operations, Case studies

**Module 3:** [8L]  
Automation Principles & Strategies, Concept of automation; Basic elements and types of automation; flexibility, degree, levels and yardstick of automation;  
Components of Automation: Sensors, Actuators, ADC, DAC and Input/output devices.



**Module 4:****[8L]**

Industrial Control: Industrial control systems; Mechanical, Hydraulic, Pneumatic, Electrical, Electronic and hybrid systems; Concepts, features and parameters governing the selection of various components of Industrial control systems.

**Module 5:****[8L]**

PLC: Discrete Control using PLC & PLC network, Micro PLC, Programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, data Handling instructions, Sequencing Instructions, Mask Data representation.

**Books recommended:****TEXT BOOK**

1. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, New Delhi. ISBN: 0132393212. (T1)
2. Andrew Parr, "Hydraulic and Pneumatics", Butterworth-Heinemann. ISBN:0750644192. (T2)
3. Bolton. W. "Pneumatic and Hydraulic Systems" Elsevier Science & Technology Books. ISBN:0750638362. (T3)
4. N. Viswanandham, Y. Narhari "Performance Modeling of Automated Manufacturing Systems" Prentice-Hall. ISBN: 0136588247. (T4)
5. W Bolton., "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" Prentice-Hall. ISBN: 0131216333. (T5)

**REFERENCE BOOK**

1. Antony Esposito, "Fluid power with Applications" Pearson Education India. ISBN:8177585800. (R1)
2. C D Johnson, "Process Control Instrumentation Technology", Prentice Hall of India, New Delhi. ISBN: 8120309871. (R2)
3. S. R. Mujumdar, "Pneumatic system", Tata McGraw Hill. ISBN: 0074602314. (R3)

**Course Evaluation:**

Individual assignment, Theory (Quiz and End semester) examinations

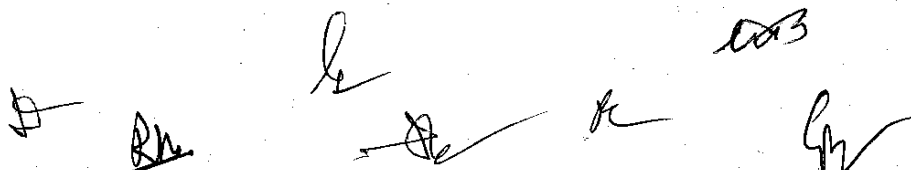
**Gaps in the syllabus (to meet Industry/Profession requirements) :**

Design of real-time industrial projects.

POs met through Gaps in the Syllabus:

**Topics beyond syllabus/Advanced topics/Design:**

POs met through Topics beyond syllabus/Advanced topics/Design:



**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery Methods**

|     |   |
|-----|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors      |
| CD2 | Assignments/Seminars  |
| CD3 | Laboratory experiments/teaching aids                        |
| CD4 | Industrial/guest lectures                                   |
| CD5 | Industrial visits/in-plant training                         |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation  |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 3   |     | 3   | 3   |     |     |
| CO2 | 3   |     | 1   | 3   |     | 2   |
| CO3 | 2   | 3   | 3   | 2   |     | 2   |
| CO4 | 3   | 2   | 2   | 3   | 2   | 3   |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   |

< 34% = 1, 34-66% = 2, > 66% = 3

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**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1,CD2, CD3           |
| CO2             | CD1, CD2, CD6          |
| CO3             | CD1, CD2, CD3,CD6,     |
| CO4             | CD1, CD2, CD3,CD6      |
| CO5             | CD1,CD2,CD3,CD6        |

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## COURSE INFORMATION SHEET

**Course code: PE 502**

**Course title: COMPUTER AIDED MANUFACTURING LAB**

**Pre-requisite(s): None**

**Co- requisite(s): PE 501**

**Credits: 02 L:0 T:0 P: 4**

**Class schedule per week: 4**

**Class: M.Tech.**

**Semester / Level: I/5**

**Branch: Production and Industrial Engineering (A.M.S)**

**Name of Teacher:**

### Course Objectives:

This course enables the students to:

|   |  |
|---|--|
| 1 | To learn the concepts and principles of Computer aided Manufacturing (CAM)   |
| 2 | To understand the various types of CAM Software's like Fanuc, Siemen's, etc. and their practical usage in manufacturing applications   |
| 3 | Understand concepts of machining for selection of appropriate machining parameters, and cutting tools for CNC milling and turning jobs |
| 4 | Develop industrial components by interpreting 3D part models/ part drawings  |
| 5 | Understand the concepts of CAM Software, CNC technology, to convert a CNC-lathe into a CNC-Milling machine and vice-versa              |

### Course Outcomes:

At the end of the course, a student should be able to:

|     |   |
|-----|---|
| CO1 | Apply the concepts of machining for selection of appropriate machining centers, machining parameters, select appropriate cutting tools for CNC milling and turning equipment, set-up, program, and operate CNC milling and turning equipment. |
| CO2 | Create and validate NC part program data using manual data input (MDI) for manufacturing of required component using CNC milling or turning applications<br>Through CAM Software's like Fanuc, Siemen's, Unimat etc.                          |
| CO3 | Produce an industrial component by interpreting 3D part model/ part drawings using Computer Aided Manufacturing technology through programming, setup, and ensuring safe operation of Computer Numerical Control (CNC) machine tools.         |
| CO4 | Apply the concepts of CNC technology to convert a CNC-lathe into a CNC-Milling machine and vice-versa and also to carry out machining using programmed part programs.   |
| CO5 | Develop prototype models by interpreting 3D part model/ part drawings   |

### List of experiments

#### Experiment No. 1

Write a manual part program for step turning operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

**Experiment No. 2**

Write a manual part program for radius cutting and taper turning operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

**Experiment No. 3**

Write a manual part program for grooving operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

**Experiment No. 4**

Write a manual part program for thread cutting operation for a given drawing. Write the program and simulate in FANUC/SIEMENS CNC lathe simulator.

**Experiment No. 5**

Convert a modular CNC-mill Unimat machine into CNC-Lathe Unimat machine and write a manual part program for step turning operation for a given drawing in Unimat CNC Lathe.

**Experiment No. 6**

Write a manual part program for taper turning operation for a given drawing in Unimat CNC Lathe.

**Experiment No. 7**

Write a manual part program for profile milling operation using linear and circular interpolation cutting for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

**Experiment No. 8**

Write a manual part program for Profile cutting with sub-program and right compensation for given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

**Experiment No. 9**

Write a manual part program for circular and rectangular pocketing for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

**Experiment No. 10**

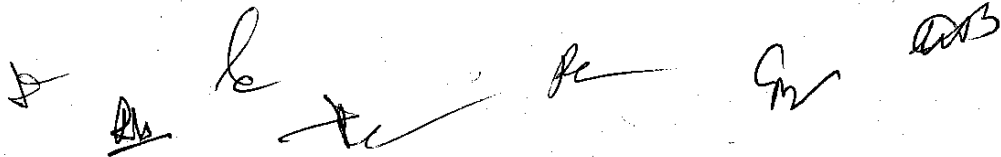
Write a manual part program for drilling operation for a given drawing. Write a program and simulate in FANUC/SIEMENS CNC milling simulator.

**Experiment No. 11**

Convert a modular CNC-lathe Unimat machine into CNC-mill Unimate machine and write a manual part program for contouring operation for a given drawing in Unimat CNC Milling.

**Experiment No. 12**

Write a manual part program for contouring operation with tool compensation right for a given drawing.



**Experiment No. 13**

To study and learn how to operate CNC milling (VMC 300) machine-Siemens controller.

**Experiment No. 14**

To machine a mill part for a given drawing on a CNC milling machine (VMC 300).

**Books recommended:****TEXT BOOK**

1. Mikell P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, New Delhi. ISBN: 0132393212. (T1)
2. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd Edition, 2004. (T2)
3. Mikell P. Grover, E. Zimmer, "Computer Aided Design and Manufacturing (CAD/CAM)", Pearson Publication, 2<sup>nd</sup> Edition, 2006. (T3)

**REFERENCE BOOK**

1. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998. (R1)
2. Radhakrishan P., Subramaniyam S., "CAD CAM and CIM", New Age International, 2002 (R2)

**Course Evaluation:****Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 60                                  |
| Semester End Examination       | 40                                  |

| Continuous Internal Assessment      | % Distribution |     |     |     |     |
|-------------------------------------|----------------|-----|-----|-----|-----|
| Day to day performance & Lab files  | 30             |     |     |     |     |
| Quiz (es)                           | 10             |     |     |     |     |
| Viva-voce                           | 20             |     |     |     |     |
| Semester End Examination            | % Distribution |     |     |     |     |
| Examination: Experiment Performance | 30             |     |     |     |     |
| Quiz                                | 10             |     |     |     |     |
| Assessment Components               | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment      |                |     |     |     |     |
| Semester End examination            |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome



**Gaps in the syllabus (to meet Industry/Profession requirements) :**

Design of real-time industrial projects.

POs met through Gaps in the Syllabus:

**Topics beyond syllabus/Advanced topics/Design:**

POs met through Topics beyond syllabus/Advanced topics/Design:

**Course Delivery Methods**

|     |   |
|-----|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors      |
| CD2 | Assignments/Seminars  |
| CD3 | Laboratory experiments/teaching aids                        |
| CD4 | Industrial/guest lectures                                   |
| CD5 | Industrial visits/in-plant training                         |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation  |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 3   | 3   | 3   | 3   | 3   | 3   |
| CO2 | 3   | 2   | 1   | 3   | 2   | 2   |
| CO3 | 2   | 3   | 3   | 2   | 3   | 2   |
| CO4 | 3   | 2   | 2   | 3   | 2   | 3   |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method  |
|-----------------|-------------------------|
| CO1             | CD1, CD3                |
| CO2             | CD1, CD3, CD7           |
| CO3             | CD1, CD3, CD7           |
| CO4             | CD1, CD3, CD6, CD7      |
| CO5             | CD1, CD2, CD3, CD6, CD7 |

Introduced and approved in Meeting of Board of Studies, dated 23/04/2018  
Revised and approved in Meeting of Board of Studies, dated 21/06/2021

*[Handwritten signatures and initials]*

## COURSE INFORMATION SHEET

**Course code: PE 503**

**Course title: PLANNING & CONTROL OF PRODUCTION SYSTEM**

**Pre-requisite(s): None**

**Co-requisite(s): None**

**Credits: 03 L:3 T:0 P:0**

**Class schedule per week: 3**

**Class: M.Tech.**

**Semester / Level: I/5**

**Branch: Production and Industrial Engineering (A.M.S.)**

**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |  |
|----|--|
| A. | To introduce to various inherent concepts of production systems, planning and control systems of Manufacturing Industry.                   |
| B. | To introduce of forecasting models, plant layout.  |
| C. | To make routine process, scheduling process and identify different strategies employed in manufacturing industries to production planning. |
| D. | To give basic concept of inventory control and its technique.  |
| E. | To give concept of Production monitoring & control   |

### Course Outcomes

After the completion of this course, students will be:

|     |  |
|-----|--|
| CO1 | Identify Various types of production systems   |
| CO2 | Understand the fundamentals of facility locations, demand forecasting.   |
| CO3 | Obtain knowledge about production planning, capacity planning.   |
| CO4 | Able to solve inventory problems and to be able to apply selected techniques for its control and management under dependent and independent circumstances. |
| CO5 | Know production monitoring and control techniques.   |

## SYLLABUS

### Module 1

[8 L]

Generalized model of a production system, decisions in the life cycle of a production system, risk analysis using decision trees, different kinds of production systems.

### Module 2

[8 L]

Mathematical models for facility location and layout, Importance of forecasting – Types of forecasting, their uses – General principles of forecasting – Forecasting techniques– qualitative methods and quantitative methods.

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**Module 3** [8 L]  
Routing, Scheduling, Loading, dispatching, Production Planning Models, Hierarchical Production Planning, Aggregate planning, Desegregation of Aggregate Plan.

**Module 4** [8 L]  
Inventory planning and control, Material Requirements Planning and Lot Sizing, manufacturing resource planning & ERP.

**Module 5** [8 L]  
Production monitoring & control, Production Control principles and techniques, performance criteria & evaluation, resource balancing, PPC in Process Industries, Planning and Control of JIT Systems.

**Books recommended:**

**TEXT BOOKS**

1. Jay H Heizer, Barry Render, Production and operations management, Prentice Hall Publication.(T1)
2. Elsayed E.A. and Boucher T. O. Analysis and Control of Production systems, Prentice Hall.(T2)
3. King J. R., Production Planning and Control, Pergamon Press, Oxford.(T3)

**REFERENCE BOOKS:**

1. Production and operations management, S. N. Chary (R1)
2. Production and Operations Management Manufacturing and Services, Nicholas J. Aquilano and Richard B. Chase (R2)
3. Quantitative Production Management, Bestwick, P.F. and Lockyer, K (R3)
4. O. R. in Production Planning, Scheduling and Inventory Control Johnson, L. A. and Momtgomery, D. C (R4)
5. Production and Inventory Management, Hax, A. C. and Candea, D.,(R5)

**Course Evaluation:**

Individual assignment, Theory (Quiz and End semester) examinations


**Gaps in the syllabus (to meet Industry/Profession requirements)**

NIL

**POs met through Gaps in the Syllabus**

**Topics beyond syllabus/Advanced topics/Design**

**POs met through Topics beyond syllabus/Advanced topics/Design**



**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 1   | 2   | 2   |     |     |     |
| CO2 | 2   | 1   | 2   | 3   |     | 3   |
| CO3 | 1   |     | 1   | 1   |     |     |
| CO4 | 2   |     | 1   | 3   |     | 2   |
| CO5 | 1   |     |     | 3   | 2   | 2   |

< 34% = 1, 34-66% = 2, > 66% = 3

*[Handwritten signatures and initials]*

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| <b>Course Outcomes</b> | <b>Course Delivery Method</b> |
|------------------------|-------------------------------|
| CO1                    | CD1, CD4                      |
| CO2                    | CD1, CD2, CD4                 |
| CO3                    | CD1, CD2, CD3, CD4            |
| CO4                    | CD1, CD2, CD3, CD4            |
| CO5                    | CD1, CD2, CD3, CD4            |

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## COURSE INFORMATION SHEET

**Course code:** PE 504  
**Course title:** MODELING AND SIMULATION  
**Pre-requisite(s):** None  
**Co-requisite(s):** PE 505  
**Credits:** 03 L:3 T:0 P:0  
**Class schedule per week:** 3  
**Class:** M.Tech  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |  |
|----|--|
| A. | To learn the concepts of modelling and simulation                                |
| B. | To understand the various types of simulation models and their practical use     |
| C. | To know about software for modelling and simulation in various application areas |
| D. | Understand the statistical aspect of simulation                                  |
| E. | To comprehend the verification and validation approaches for simulation models   |

### Course Outcomes

After the completion of this course, students will be:

|     |  |
|-----|--|
| CO1 | Develop model frameworks for discrete-event simulation                                 |
| CO2 | Apply pseudo-random number based manual simulation to discrete-events                  |
| CO3 | Construct software models for manufacturing, logistic and material handling problems   |
| CO4 | Generate random distributions of various probability distributions for queuing systems |
| CO5 | Analyse the simulation output for validation   |

## SYLLABUS

### Module 1

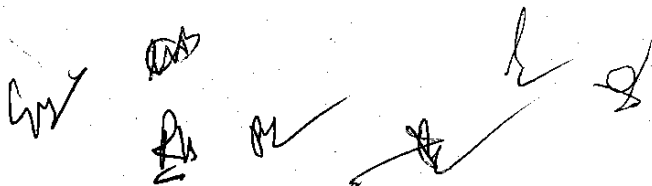
[8L]

Introduction to modeling and simulation concepts, System analysis and components, Simulation terminology, Model of a system and types of models, Discrete *verses* continuous systems, Static and Dynamic System simulation, Pros and cons of simulation

### Module 2

[8L]

Event *verses* activity, General principles of event-driven simulation, Use of Pseudo-Random numbers in simulation of queuing systems, Simulation of manufacturing systems and other examples



**Module 3****[8L]**

Simulation of manufacturing and material handling systems, Modeling downtime and failures, Case studies, Introduction to simulation software and languages for manufacturing and material handling

**Module 4****[8L]**

Statistical models in simulation, Terminology and concepts, Useful statistical models: Discrete and continuous distribution, Poisson, Uniform, Exponential and Normal distribution, Empirical distribution

**Module 5****[8L]**

Verification and validation of simulation models, Input-output validation using historical data, stochastic nature of output, Analysis of simulation results, Steady-State behavior, Output analysis and Replication method for steady-state simulation

**Books recommended:****TEXT BOOKS:**

1. Discrete-Event System Simulation by Jerry Banks, Carson and Nelson, Prentice Hall of India Pvt. Ltd. (T1)

**REFERENCE BOOKS:**

1. Simulation Modelling and Analysis by Law and Kelton, McGraw Hill, New York. (R1)
2. Introduction to simulation and SLAM II by Pritsker, John Wiley, New York. (R2)

**Course Evaluation:**

Individual assignment, Theory (Quiz and End semester) examinations

**Gaps in the syllabus (to meet Industry/Profession requirements)**

NIL

POs met through Gaps in the Syllabus

**Topics beyond syllabus/Advanced topics/Design**

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE****Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

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| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 1   | 2   | 2   |     |     |     |
| CO2 | 2   | 1   | 2   | 3   |     | 3   |
| CO3 | 1   |     | 1   | 1   |     |     |
| CO4 | 2   |     | 1   | 3   |     | 2   |
| CO5 | 1   |     |     | 3   | 2   | 2   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1, CD4               |
| CO2             | CD1, CD2, CD4          |
| CO3             | CD1, CD2, CD3, CD4     |
| CO4             | CD1, CD2, CD3, CD4     |
| CO5             | CD1, CD2, CD3, CD4     |



## COURSE INFORMATION SHEET

**Course code:** PE 505  
**Course title:** MANUFACTURING SIMULATION LAB  
**Pre-requisite(s):** None  
**Co-requisite(s):** PE 504  
**Credits:** 02 L:0 T:0 P:4  
**Class schedule per week:** 4  
**Class:** M.Tech.  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To apply the concepts of modelling and simulation to real problems        |
| B. | To develop various types of simulation models                             |
| C. | To use some software for modelling and simulation                         |
| D. | To understand the statistical aspect of simulation                        |
| E. | To apply the verification and validation approaches for simulation models |

### Course Outcomes

After the completion of this course, students will be:

|     |  |
|-----|--|
| CO1 | Able to develop models for discrete-event simulation                               |
| CO2 | Apply pseudo-random number based manual simulation to discrete-events              |
| CO3 | Develop software models for manufacturing, logistic and material handling problems |
| CO4 | Apply various probability distributions for queuing systems                        |
| CO5 | Analyse the simulation output for validation                                       |

### List of experiments

#### Experiment No. 1

Modelling & Simulation Concepts and Simulation software

**Aim:** To understand and make a list of the basic terms, concepts and software related to modelling and simulation

#### Experiment No. 2

Discrete Event Simulation (Using Random Numbers) of a Bank

**Aim:** Consider the operation of a one-teller bank where customers arrive for service in  $1 \pm 10$  minutes. The customers are served in time  $1 \pm 6$  minutes. Simulate the bank operation until twenty customers are served assuming customer 1 arrives at time 0, and compute measures of performance such as the percentage of idle time and the average waiting time per customer.

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**Experiment No. 3**

Simulation of a Robotic work cell

Aim: Simulate a robotic work cell to find the cycle time of job and production rate. Assuming a 90% efficient and 8 hours shift, find the per day production. Also give your suggestion for improving the system productivity.

**Experiment No. 4**

Simulation of a Drill press operation

Aim: Parts are machined on a drill press. They arrive at a rate of one every  $5 \pm 3$  minute and it takes  $3 \pm 2$  minute to machine them. Every  $60 \pm 60$  minutes, a rush job arrives which takes  $12 \pm 3$  minute to complete. The rush job interrupts the present job. When the regular job returns to the machine, it stays only for its remaining process time. Simulate the mean system response time for each type of part. Response time is the total time that a part spends in the system.

**Experiment No. 5**

Simulation of a Grocery shop

Aim: A small grocery has only one checkout counter. Customers arrive at this checkout counter at random in the interval of [1, 8] minutes. The service time vary from 1 to 6 minutes with the probabilities shown. Simulate the problem/system for arrival and service of 20 customers.

**Experiment No. 6**

Discrete Event Simulation (Using a GPSS<sup>®</sup> software) of a Food Store

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation

**Experiment No. 7**

Simulation of a Self-Service Cafeteria Using a GPSS<sup>®</sup> software

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation

**Experiment No. 8**

Simulation of Ambulance Dispatch

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation

**Experiment No. 9**

Simulation of Factory Maintenance

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation

**Experiment No. 10**

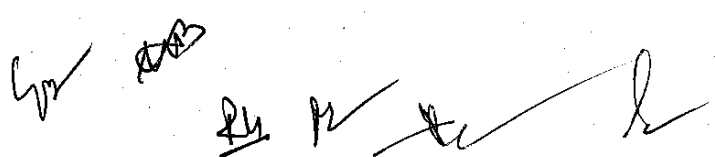
Simulation of Ships (Un)Loading Cargo at a Harbor

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation

**Experiment No. 11**

Simulation of Hospital's Emergency Room

Aim: Use aGPSS<sup>®</sup> software to construct the model for simulation



**Experiment No. 12**

Monte Carlo Simulation (Using MINITAB®)

Aim: Use MINITAB® to conduct a Monte Carlo simulation for finding the distribution of machining time in a lathe when the probability distribution for length of job, feed rate and rotational rpm are known

**Books recommended:****TEXT BOOKS:**

1. Discrete-Event System Simulation by Jerry Banks, Carson and Nelson, Prentice Hall of India Pvt. Ltd. (T1)

**REFERENCE BOOKS:**

1. Simulation Modelling and Analysis by Law and Kelton, McGraw Hill, New York. (R1)

**Course Evaluation:****Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 60                                  |
| Semester End Examination       | 40                                  |

| Continuous Internal Assessment      | % Distribution |     |     |     |     |
|-------------------------------------|----------------|-----|-----|-----|-----|
| Day to day performance & Lab files  | 30             |     |     |     |     |
| Quiz (es)                           | 10             |     |     |     |     |
| Viva-voce                           | 20             |     |     |     |     |
| Semester End Examination            | % Distribution |     |     |     |     |
| Examination: Experiment Performance | 30             |     |     |     |     |
| Quiz                                | 10             |     |     |     |     |
| Assessment Components               | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment      |                |     |     |     |     |
| Semester End examination            |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Gaps in the syllabus (to meet Industry/Profession requirements):**

1. Design of real-time industrial projects.
2. POs met through Gaps in the Syllabus:

**Topics beyond syllabus/Advanced topics/Design:**

1. POs met through Topics beyond syllabus/Advanced topics/Design:

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**Course Delivery methods**

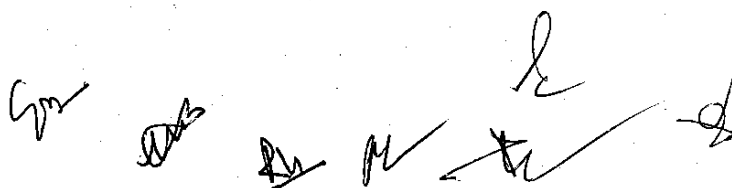
|     |   |
|-----|---|
| CD1 | Lecture by use of boards/LCD projectors |
| CD2 | Hands on training on computers          |
| CD3 | Self- learning advice                   |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome # | Program Outcomes |   |   |   |   |   |
|------------------|------------------|---|---|---|---|---|
|                  | 1                | 2 | 3 | 4 | 5 | 6 |
| 1                |                  | 2 | 1 |   | 2 |   |
| 2                |                  | 1 | 1 |   | 3 |   |
| 3                | 1                | 2 | 1 | 2 | 1 | 1 |
| 4                |                  | 1 |   |   | 2 |   |
| 5                |                  |   | 1 |   | 2 |   |

< 34% = 1, 34-66% = 2, > 66% = 3



## COURSE INFORMATION SHEET

**Course code:** PE 518  
**Course title:** Data Analytics  
**Pre-requisite(s):** None  
**Co- requisite(s):** None  
**Credits:** 03 L: 03 T: 00 P: 00  
**Class schedule per week:** 3  
**Class:** M. Tech  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |  |
|----|--|
| A. | To learn the concepts of Descriptive Statistics  |
| B. | To know the fundamentals of Analysis of variance and Hypothesis test                       |
| C. | To understand the various types of statistical approach for identifying clustering of data |
| D. | To know about supervise learning and support vector machines algorithms                    |
| E. | To understand basics of Neural network method  |

### Course Outcomes

After the completion of this course, students will be:

|     |   |
|-----|---|
| CO1 | Analysing data to convert information to useful knowledge         |
| CO2 | Designing and testing Hypothesis test and ANOVA                   |
| CO3 | Solving problems on clustering of data                            |
| CO4 | Analysing data using, Bias-Variance Dichotomy, Regression and SVM |
| CO5 | Demonstrating the Neural Network for any experimental data        |

### Syllabus

#### Module 1:

[8L]


#### Data and Statistics

Classification of data, Introduction to big data, data analytics and descriptive statistics. Central Limit Theorem, Normal distribution, distributions of the sample mean and the sample variance for a normal population, Sampling distributions (Chi-Square, t, F, z).

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**Module 2:** [8L]

**Regression Analysis**

Correlation analysis, Regression analysis, Linear and non-linear regression, Bi-variate and multi-variate regression, Logistic and robust regression, Path analysis

**Module 3:** [8L]

**Hypothesis Testing**

Introduction to Hypothesis testing, testing for Attributes, Mean of Normal Population, One-tailed and two-tailed tests, F-test and Chi-Square test. Analysis of variance ANOVA- One way and two-way classifications.

**Module 4:** [8L]

**Clustering**

Introduction, hierarchical clustering, Centroid-based clustering: K-means, Distribution-based clustering, Density-based clustering, Clustering using artificial neural network (ANN), Application examples for clustering

**Module 5:** [8L]

**Machine Learning**

Introduction to Machine Learning, supervise learning and un-supervise learning. Bias-Variance Dichotomy, Support Vector Machines, Applications of Machine learning.

**Text books:**

1. Douglas C. Montgomery "Design and analysis of experiment" Arizona state university, John wiley & sons INC.
2. Z C Holcomb "Fundamental of descriptive statistics" Routledge (Taylor and Francis).
3. S. Marshland, Machine Learning: An Algorithmic Perspective, CRC Press (Taylor and Francis), 1st edition, 2009, ISBN: 978-1420067187.
4. S. Kumar "Neural Network A classroom approach" Tata McGraw Hill Publication.

**Reference books:**

1. C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006, ISBN: 978-0387-31073-2.
2. Brain S. Everitt, "A Handbook of Statistical Analysis Using R", Second Edition, 4 LLC, 2014.
3. Dalgaard, Peter, "Introductory statistics with R", Springer Science & Business Media, 2008.
4. K. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.

Gaps in the syllabus (to meet Industry/Profession requirements)  
 POs met through Gaps in the Syllabus  
 Topics beyond syllabus/Advanced topics/Design  
 POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
 PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Course Outcomes and Program Outcomes**

| Course Outcome | Program Outcomes |     |     |     |     |     |
|----------------|------------------|-----|-----|-----|-----|-----|
|                | PO1              | PO2 | PO3 | PO4 | PO5 | PO6 |
| CO1            | 1                |     | 1   | 1   | 2   |     |
| CO2            |                  |     | 2   | 2   | 2   |     |
| CO3            | 1                |     | 2   | 3   | 3   |     |
| CO4            | 1                |     | 2   | 3   | 3   | 1   |
| CO5            | 2                | 1   | 2   | 3   | 3   |     |

<34% =1, 34-66% = 2, >66% = 3

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| Mapping between Course Outcomes and Course delivery method |  |                         |
|--|--|-------------------------|
| CD   | Course Delivery methods                                | Course Outcomes         |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2  | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3  | Seminars   | CO3, CO4, CO5           |
| CD4  | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |
| CD5  | Industrial visit                                       | CO2, CO5                |

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## COURSE INFORMATION SHEET

**Course code:** PE 506  
**Course title:** MANUFACTURING TECHNOLOGY  
**Pre-requisite(s):** None  
**Co-requisite(s):** None  
**Credits:** 03 L:3 T:0 P:0  
**Class schedule per week:** 3  
**Class:** M.Tech  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives

This course enables the students to:

|    |   |
|----|---|
| 1. | Learn the concepts of casting   |
| 2. | Understand the various types of forming methods   |
| 3. | Know about tool life, MRR, Cutting forces and surface finish in different machining process |
| 4. | Understand the concept of joining processes   |
| 5. | Realize the importance of NTM in present manufacturing scenario.                            |

### Course Outcomes

After the completion of this course, students will be able to:

|     |   |
|-----|---|
| CO1 | Classify the different types of casting process   |
| CO2 | Explain principles and process of Forging, Rolling, Extrusion, drawing and designing of die |
| CO3 | Analyse the tool life, MRR, Cutting forces and surface finish                               |
| CO4 | Categorize welding processes according to welding principle and material                    |
| CO5 | Select a proper NTM method for given component  |

## SYLLABUS

### Module 1: Introduction to manufacturing and Foundry

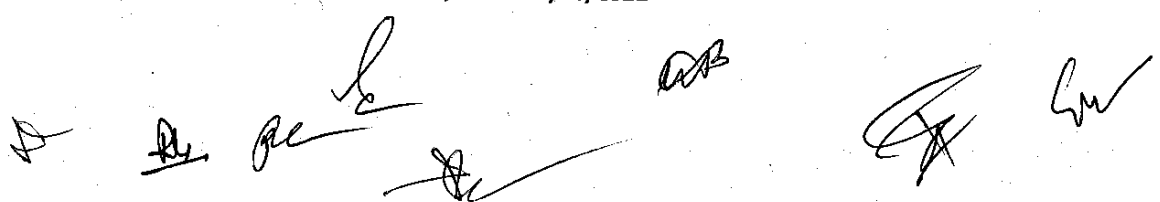
[8L]

Classification of different manufacturing processes, application areas and limitations, basic engineering materials.

**Sand casting process-** Patterns, Core; Molding Processes, Solidification Process, Melting Furnaces,

**Special casting methods** - centrifugal casting and continuous casting; Permanent mold casting; Hot chamber and cold chamber die casting; Investment casting; Shell mold casting; Plaster mold casting.

Basic design considerations in casting, Casting defects and remedies.



**Module 2: Metal forming****[8L]**

Hot and cold working. Forming operation~Forging, rolling, extrusion, drawing processes, sheet metal operations.

Powder metallurgy processing: Production of metal powders, compaction and sintering processes.

**Module 3: Metal Removal Processes****[8L]**

Classification of machining processes and machine tools. Tool's materials, different types of cutting tools, tool geometry and nomenclature of single point cutting tool, Concept of cutting speed, feed and depth of cut. single and multipoint cutting operation. Turning, Drilling, shaper, grinding, milling operations.

**Module 4: Joining processes****[8L]**

Classification of welding processes, electric arc, special welding methods: MMAW, GTAW, GMAW, GMAW-CO2 welding, submerged arc welding, electro-slag welding, electron beam welding, laser beam welding, ultrasonic welding, resistance welding, welding defects, and arc blow heat affected zone, testing of welded joints, brazing and soldering.

**Module 5: Non conventional manufacturing****[8L]**

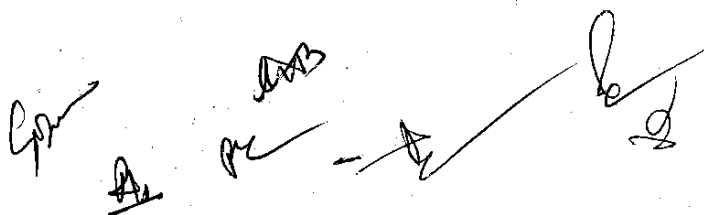
Theory and application of machining by Abrasive Jet, Water Jet, Abrasive Flow, Ultrasonic. Electrochemical Machining and grinding. Thermal energy methods of material processing by Electro-discharge, High Energy Rate Forming.

**Books recommended:****TEXT BOOKS:**

1. Kalpakjian, S. and Schmid, S. R, "Manufacturing Engineering and Technology", Pearson Education, 2000. (T1)
2. Groover, M. P., "Fundamentals of Modern Manufacturing", John Wiley and Sons Inc., 2002. (T2)
3. Rao, P. N., "Manufacturing Technology (Vol. 1&2)", Tata McGraw Hill 2009. (T3)
4. Choudhry, S.K.H., Choudhry, A.K.H., and Roy N., "Elements of Work Shop Technology", Vol I & II, Media Promoters & Publishers, 1994. (T4)

**REFERENCE BOOKS:**

1. Ghosh A., Malik A. K., "Manufacturing Science" East West Press, 2010. (R1)
2. DeGarmo, E. P, Black, J. T., Kohser, R. A. "Materials and Processes in Manufacturing", Prentice Hall of India Pvt. Limited, 1997. (R2)
3. Lindberg, R. A., "Processes and Materials of Manufacture", Prentice Hall India Limited, 1990. (R3)
4. Khanna, O.P., and Lal, M., A Text Book of Production Technology, Vol I & II, Dhanpat Rai & Sons, 1992. (R4)
5. Jain R K ., "Production Technology: Manufacturing Processes, Technology and Automation" Khanna Publication 2004. (R5)



**Course Evaluation:**

Individual assignment, Theory (Quiz and End semester) examinations

**Gaps in the syllabus (to meet Industry/Profession requirements):**

Design of real-time industrial projects.

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE****Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

**Mapping between Objectives and Outcomes**

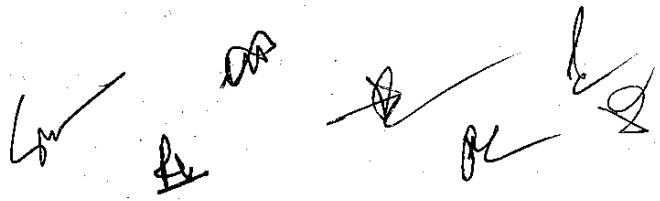
**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome # | Program Outcomes |     |     |     |     |     |
|------------------|------------------|-----|-----|-----|-----|-----|
|                  | PO1              | PO2 | PO3 | PO4 | PO5 | PO6 |
| 1                | 1                | 1   | 1   | 2   | 1   | 1   |
| 2                | 1                | 1   | 1   | 2   | 1   | 1   |
| 3                | 1                | 1   | 2   | 3   | 1   | 2   |
| 4                | 1                | 1   | 1   | 3   | 1   | 1   |
| 5                | 1                | 1   | 2   | 3   | 2   | 2   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |



## COURSE INFORMATION SHEET

**Course code:** PE 507  
**Course title:** ADDITIVE MANUFACTURING  
**Pre-requisite(s):** None  
**Co-requisite(s):** None  
**Credits:** 03 L: 03 T:00 P:00  
**Class schedule per week:** 3  
**Class:** M.Tech  
**Semester / Level:** I/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |  |
|----|--|
| A. | To exploit technology used in additive manufacturing.  |
| B. | To understand importance of additive manufacturing in advance manufacturing process.           |
| C. | To acquire knowledge, techniques and skills to select relevant additive manufacturing process. |
| C. | To explore the potential of additive manufacturing in different industrial sectors.            |
| D. | To apply 3D printing technology for additive manufacturing.                                    |

### Course Outcomes

After the completion of this course, students will be:

|     |   |
|-----|---|
| CO1 | Able to define the various process used in Additive Manufacturing   |
| CO2 | Able to analyse and select suitable process and materials used in Additive Manufacturing.                     |
| CO3 | Able to identify, analyse and solve problems related to Additive Manufacturing.                               |
| CO4 | Able to apply knowledge of additive manufacturing for various real-life applications                          |
| CO5 | Able to apply technique of CAD and reverse engineering for geometry transformation in Additive Manufacturing. |

## SYLLABUS

### Module 1

[7L]

#### Introduction

Overview, Basic principle need and advantages of additive manufacturing, Procedure of product development in additive manufacturing, Classification of additive manufacturing processes, Materials used in additive manufacturing, Challenges in Additive Manufacturing.

### Module 2

[9L]

#### Additive Manufacturing Processes

Z-Corporation 3D-printing, Stereolithography apparatus (SLA), Fused deposition modeling (FDM), Laminated Object Manufacturing (LOM), Selective deposition lamination (SDL), Ultrasonic consolidation, Selective laser sintering (SLS), Laser engineered net shaping (LENS),

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Electron beam free form fabrication (EBFFF), Electron beam melting (EBM), Plasma transferred arc additive manufacturing (PTAAM), Tungsten inert gas additive manufacturing (TIGAM), Metal inert gas additive manufacturing (MIGAM).

**Module 3** [8L]

**Additive Manufacturing Machines and Systems**

Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors. Introduction to NC/CNC/DNC machine tools, CNC programming and introduction, Hardware Interpolators, Software Interpolators, Recent developments of CNC systems for additive manufacturing.

**Module 4** [8L]

**Pre-Processing in Additive Manufacturing**

Preparation of 3D-CAD model, Reverse engineering, Reconstruction of 3D-CAD model using reverse engineering, Part orientation and support generation, STL Conversion, STL error diagnostics, Slicing and Generation of codes for tool path, Surface preparation of materials.

**Module 5** [8L]

**Post-Processing in Additive Manufacturing**

Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques, Brief information on characterization techniques used in additive manufacturing, Applications of additive manufacturing in rapid prototyping, rapid manufacturing, rapid tooling, repairing and coating.

**Future scope in Additive Manufacturing**

**Modelling and Simulation:** Thermal model to predict size of deposition such as width and height of deposition, Finite element simulation of additive process.

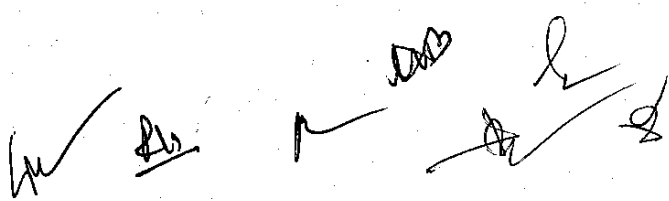
**Books recommended:**

**TEXT BOOKS:**

1. Gibson, I, Rosen, D W., and Stucker, B., Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Springer, 2010 (T1).
2. Chua C.K., Leong K.F., and Lim C.S., "Rapid prototyping: Principles and applications", Third Edition, World Scientific Publishers, 2010 (T2).
3. Chee Kai Chua, Kah Fai Leong, 3D Printing and Additive Manufacturing: Principles and Applications: Fourth Edition of Rapid Prototyping, World Scientific Publishers, 2014 (T3)
4. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003 (T4).

**Reference books:**

1. Liou L.W. and Liou F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2007 (R1).
2. Kamrani A.K. and Nasr E.A., "Rapid Prototyping: Theory and practice", Springer, 2006 (R2).



3. Mahamood R.M., Laser Metal Deposition Process of Metals, Alloys, and Composite Materials, Engineering Materials and Processes, Springer International Publishing AG 2018 (R3).
4. Ehsan Toyserkani, Amir Khajepour, Stephen F. Corbin, "Laser Cladding", CRC Press, 2004 (R3).

**Gaps in the syllabus (to meet Industry/Profession requirements)**

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

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**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome # | Program Outcomes |     |     |     |     |     |
|------------------|------------------|-----|-----|-----|-----|-----|
|                  | PO1              | PO2 | PO3 | PO4 | PO5 | PO6 |
| CO1              |                  | 2   |     | 3   | 1   |     |
| CO2              | 2                | 1   | 1   |     | 3   | 1   |
| CO3              | 1                | 3   | 2   | 3   |     | 2   |
| CO4              |                  |     | 1   | 3   | 2   | 3   |
| CO5              |                  |     | 3   | 2   | 3   | 3   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |

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## COURSE INFORMATION SHEET

**Course code: PE 508**  
**Course title: OPERATIONS AND SUPPLY CHAIN MANAGEMENT**  
**Pre-requisite(s): None**  
**Co-requisite(s): None**  
**Credits: 03 L:3 T:0 P:0**  
**Class schedule per week: 3**  
**Class: M.Tech**  
**Semester / Level: I/5**  
**Branch: Production and Industrial Engineering (A.M.S)**  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To provide the student the knowledge of strategic importance of supply chain design and planning of an organisation |
| B. | The role of inventory management and forecasting in a supply chain  |
| C. | Knowledge of facility planning and scheduling models  |
| D. | Knowledge of various distribution and transportation networks and their applications                                |
| E. | The role of sourcing, information technology, pricing and revenue management, and coordination in a supply chain.   |

### Course Outcomes

After the completion of this course, students will be:

|     |  |
|-----|--|
| CO1 | Define the goal of a supply chain and analysis the impact of supply chain decisions on the success of a firm |
| CO2 | Analyse demand forecasts and supply for both an enterprise and a supply chain                                |
| CO3 | Apply operations planning, MRP, and aggregate planning concepts  |
| CO4 | Design a supply chain network for a firm or organisation   |
| CO5 | Judge and select the best supplier for a firm or organisation  |

## SYLLABUS

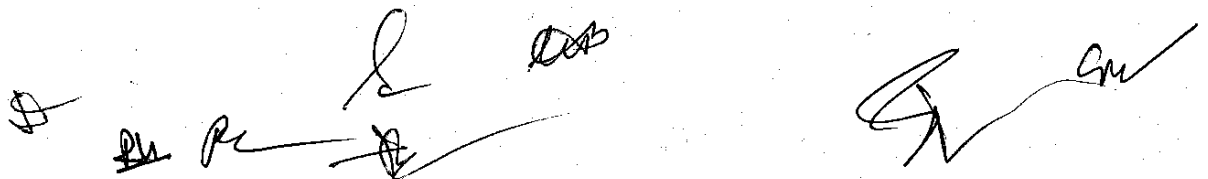
### Module 1

[8L]

Introduction to Supply Chain Management: Understanding the supply chain, Supply Chain Performance- Achieving strategic fit and scope, complexity, key issues, Supply Chain Drivers and Metrics, Centralized vs. decentralized systems

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**Module 2**

[8L]

Planning Demand and Supply in a Supply Chain: Forecasting- Need for forecasting, Quantitative methods. Inventory Management- Various costs in inventory management and need, Deterministic models and discounts, Probabilistic inventory management. Aggregate Planning- The Role of Aggregate Planning, Aggregate Planning Strategies.

**Module 3**

[8L]

Facility Planning and Scheduling models: Facility layout and location- Qualitative aspects, Quantitative models for layout decisions, Product, process fixed position, group layout, Location decisions-quantitative models. Scheduling models- Scheduling in MRP system, Sequencing rules and applications, Batch production sequencing and Scheduling.

**Module 4**

[8L]

Designing the Supply chain network: Distribution Networks– Design options for a distribution network, e-Business and the distribution network, Network design in an uncertain environment. Transportation Networks- Design options for a transportation network, Trade-offs in transportation design, Supply Chain Optimization.

**Module 5**

[8L]

Managing Cross-Functional Drivers in a Supply Chain: Sourcing Decisions- Make or buy decisions, Third- and fourth-party logistics providers, Sourcing Processes. Pricing and Revenue Management in a Supply Chain, Information Technology in a Supply Chain, Coordination in a Supply Chain.

**Books recommended:****TEXT BOOKS:**

1. Chopra, S., and Meindl, P. "Supply Chain Management, strategy, planning, and operation" 6/e – PHI, second edition, 2014. (T1)
2. Operations Management by Evans and Collier. (T2)
3. R. Panneerselvan, Production and operations Management, Prentice Hall of India, Delhi (2000). (T3)

**REFERENCE BOOKS:**

1. Christopher, "Logistics and Supply Chain Management", Pearson Education Asia, New Delhi. (R1)
2. Taylor and Brunt, "Manufacturing Operations and Supply Chain Management (The Lean Approach)", Business Press Thomson Learning, NY. (R2)
3. Arjan J. Van Weele, "Purchasing and Supply Chain Management (Analysis Planning and Practice)", Engineering, Business Press, Thomson Learning NY. (R3)
4. Shah, J. "Supply Chain Management, text and cases", Pearson Education South Asia, 2009. (R4)

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5. Donald B., "Logistic Management - The Integrated Supply Chain process", McGraw Hill. (R5)
6. Operations Management by Heizer and Render. (R6)

Gaps in the syllabus (to meet Industry/Profession requirements)- NIL

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

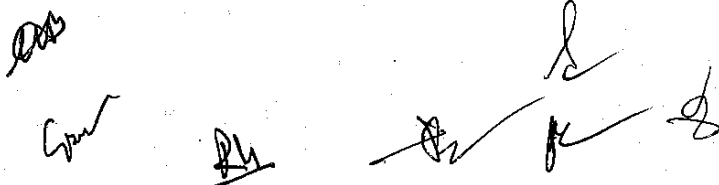
## Mapping between Objectives and Outcomes

### Mapping of Course Outcomes onto Program Outcomes

| Course Outcome # | Program Outcomes |      |      |      |      |      |
|------------------|------------------|------|------|------|------|------|
|                  | PO 1             | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
| 1                | 2                | 1    | 2    | 3    | 1    |      |
| 2                | 2                | 1    | 2    | 3    |      | 2    |
| 3                | 2                | 1    | 2    | 3    |      | 1    |
| 4                | 2                | 1    | 2    | 3    | 1    | 1    |
| 5                | 2                | 1    | 2    | 3    |      | 1    |

< 34% = 1, 34-66% = 2, > 66% = 3

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO4, CO5                |



## COURSE INFORMATION SHEET

Course code: PE 510  
Course title: ROBOTICS & ROBOT APPLICATIONS  
Pre-requisite(s): None  
Co-requisite(s): None  
Credits: 03 L:3 T:0 P:0  
Class schedule per week: 3  
Class: M.Tech  
Semester / Level: II/5  
Branch: Production and Industrial Engineering (A.M.S)  
Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To understand robot structures and their workspace                      |
| B. | To perform spatial transformations associated with rigid body motions   |
| C. | To perform forward and inverse kinematics analysis of robot manipulator |
| D. | To carry out robot dynamic analysis and trajectory planning             |
| E. | To perform programming of robots.                                       |

### Course Outcomes

After the completion of this course, students will be able to:

|     |  |
|-----|--|
| CO1 | Describe and explain the various robot classification and their characteristics. |
| CO2 | Analyse gravity force of simple robot manipulators.                              |
| CO3 | Solve forward and inverse kinematics of simple robot manipulators                |
| CO4 | Plan and generate joint trajectory for robot motion.                             |
| CO5 | Code fundamental programs for robot applications.                                |

## SYLLABUS

### Module 1

[8L]

**Introduction:** Brief history of robot technology, Basic terminologies, Robot Anatomy, Degree of Freedom, classification and characteristics, Robot selection, structure of industrial robot, Robots in Automation.

### Module 2

[8L]

**Robot End Effectors and Sensors:** Types of End Effectors, Mechanical Grippers, Gripper Force Analysis, Other Types of Grippers, Special-Purpose Grippers, Gripper Selection and Design. Robot Sensors, Different types of Robot Sensors.

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**Module 3****[8L]**

**Robot Kinematics:** Transformations and Kinematics, Vector operations - Properties of Transformation matrices and their arithmetic link and joint description -Homogeneous transformations and Manipulator – Forward solution -Inverse solution, Denavit-Hartenberg parameters, frame assignment to links, Jacobian Transformation in Robotic Manipulation

**Module 4****[8L]**

**Robot Dynamics:** Dynamics of Robotic Manipulators, Euler Equations, The Lagrangian Equations of motion. Application of Lagrange–Euler (LE), Dynamic Modeling of Robotic Manipulators. Trajectory Planning and generations, Join-Interpolated Trajectories, Cartesian Path Trajectories.

**Module 5****[8L]**

**Robot Programming and Applications:** Robot Programming, Programming Methods, Programming Languages. Robot application in Manufacturing- Material handling, Processing operations, Assembly and Inspection Operations.

**Text books:**

1. M. P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, Industrial Robotics Technology, Programming and Applications, McGraw Hill, Int. 2008.
2. Keramas, J., G., Robot Technology Fundamentals, DELMAR, Cengage learning.
3. Mittal, R., K., Robotics and Control, McGraw Hill publication, 2015.
4. K.S. Fu, R. C. Gonzalez and C.S.G. Lee, Robotics Control, Sensing, Vision and Intelligence, McGraw Hill, 2008.

**Reference books:**

1. Introduction to Robotics Analysis, Systems, Applications by Saeed B Niku PHI.
2. Fundamentals of Robotics Analysis and Control, Robert J Schilling, PHI.
3. J. J. Craig, Introduction to Robotics: Mechanics and Control, 3/e, Pearson Education, 2009
4. S. K. Saha, Introduction to Robotics, Tata McGraw Hill Education Private Limited, 2008.
5. D. Richard, Klafter, and A. Thomas, Chmielewski, Michael Negin, Robotics Engineering-An Integrated Approach, Prentice-Hall of India Pvt.Ltd., 2009.
6. A. Ghosal, Robotics Fundamental Concepts and Analysis, Oxford University Press India, 2006.
7. S. R. Deb, Robotics Technology and Flexible Automation, Tata McGraw -Hill, 2009.

**Gaps in the syllabus (to meet Industry/Profession requirements)**

**POs met through Gaps in the Syllabus**

**Topics beyond syllabus/Advanced topics/Design**

**POs met through Topics beyond syllabus/Advanced topics/Design**

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

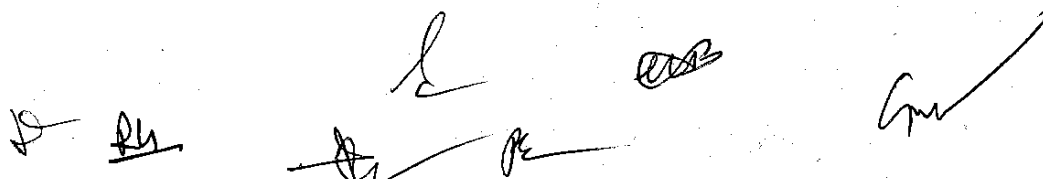
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Course Outcomes and Program Outcomes**

| Course Outcome | Program Outcomes |     |     |     |     |     |
|----------------|------------------|-----|-----|-----|-----|-----|
|                | PO1              | PO2 | PO3 | PO4 | PO5 | PO6 |
| CO1            | 1                |     | 1   | 1   | 2   |     |
| CO2            |                  |     | 2   | 2   | 2   |     |
| CO3            | 1                |     | 2   | 3   | 3   |     |
| CO4            | 1                |     | 2   | 3   | 3   | 1   |
| CO5            | 2                | 1   | 2   | 3   | 3   |     |

<34% =1, 34-66% = 2, >66% = 3



| Mapping between Course Outcomes and Course delivery method |  |                         |
|--|--|-------------------------|
| CD   | Course Delivery methods                                | Course Outcomes         |
| CD1  | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2  | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3  | Seminars   | CO3, CO4, CO5           |
| CD4  | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |
| CD5  | Industrial visit                                       | CO2, CO5                |

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## COURSE INFORMATION SHEET

Course code: PE 511

Course title: COMPUTER INTEGRATED MANUFACTURING

Pre-requisite(s): PE 503

Co-requisite(s): None

Credits: 03 L: 03 T:0 P:0

Class schedule per week: 03

Class: M.Tech

Semester / Level: II/5

Branch: Production and Industrial Engineering (A.M.S)

Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To acquire knowledge in recent advances in the CIM.   |
| B. | Design and develop CIM systems using the knowledge of mathematics, science, engineering and IT tools  |
| C. | Apply modern computational, analytical, tools and techniques to face the challenges in CIM.   |
| D. | Communicate ideas effectively with diversified groups to become lead professionals in academia and industry in advanced areas of manufacturing. |
| E. | To inculcate students with professional and ethical attitude, and an ability to relate CIM issues to broader engineering and social context.    |

### Course Outcomes:

After the completion of this course, students will be:

|    |   |
|----|---|
| 1. | Understand the effect of manufacturing automation strategies and know the basics of Computer Integrated Manufacturing (CIM)                     |
| 2. | Analyse automated flow lines and assembly systems and balance the line.   |
| 3. | Design automated material handling and storage systems for a FMS  |
| 4. | Design manufacturing cells and apply automatic inspection methods in CIM environment.   |
| 5. | Analyze the role of OSI model in the design of communication protocols and comprehend the importance of data communications in CIM environment. |

## Syllabus

### MÓDULE-I

**Manufacturing Automation:** Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation and Process Improvement, CIM, Computer based integration between various functions - manufacturing, sales, design, materials, shop floor & computer process monitoring.

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## **MODULE-II**

**Manual Assembly Lines:** Assembly Workstations and Work Transport Systems

**Automated Flow lines:** System Configurations, Work part Transfer Mechanisms, Storage Buffers, Control of Production Line, Analysis of Transfer Lines-Transfer Lines with No Internal Parts Storage, Transfer Lines with Internal Storage Buffers. The Line Balancing Problem.

## **MODULE-III**

**Flexible Manufacturing Systems:** Flexibility, Types of FMS and its Components. FMS Applications and Benefits, Machine loading problems in FMS, Production scheduling, scheduling rules, Routing and sequencing decisions.

**Automatic Material Handling and Storage systems:** Design Considerations in Material Handling, Material Transport Equipment- Automated Guided Vehicles, Design of Automated Storage/Retrieval Systems.

## **MODULE-IV**

**Cellular Manufacturing Systems:** Part Families, Parts Classification and Coding, Features of Parts Classification and Coding Systems, Opitz of Parts Classification and Coding Systems, Production Flow Analysis, Machine Cell Design, Applications of GT Quantitative analysis of Cellular Manufacturing, Grouping of parts and Machines by Rank Order Clustering, Arranging Machines in a GT Cell.

**Automated Inspection systems:** Overview of Automated Identification Methods, Bar Code Technology, Radio Frequency Identification,

## **MODULE-V**

**Computer Networks for Manufacturing**

**Introduction to Data Communications:** Data Communications, CIM data Files and report formats for data management.

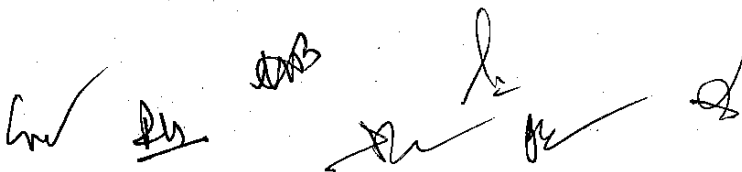
Networks, The Internet – History, Protocols and Standards. Network Models: Layered Tasks, The OSI model, Layers in the OSI model,

**Network Layer:** logical addressing and Internet Protocol, MAP/TOP,

**Physical Layer and Media:** Bandwidth Utilization, Multiplexing, Spread Spectrum, Transmission media

**Data Link Layer:** Error Detection and Correction, Data Link Control, Multiple Access, Wired LANs: Ethernet, Wireless LANs.

**Transport and Application Layer:** Process-to-Process Delivery: UDP, TCP and SCTP. Domain Name System, File Transfer.



**Books:****Text books:**

1. Groover, M.P., "Automation, Production Systems and Computer Integrated Manufacturing ",Third Edition, Prentice-Hall, 2007
2. P.N.Rao, "CAD/CAM Principle and Applications", Tata McGraw Hill Publishing Company Limited.
3. Viswanadham N. and Narahari Y., Performance Modelling of Automated Manufacturing Systems, Prentice Hall India, 1994.
4. Kumar Surender, U.Chandra,and S.C.Srivatasava, "Computer Integrated Manufacturing", Satya Prakshan Pvt. Ltd., New Delhi

**Reference books:**

1. Kamrani, A.K, Parsaei, H.R and Liles, D.H. (Eds), "Planning, design and analysis of cellular manufacturing systems", Elsevier, 1995.
2. Burbidge, J.L., "Group Technology in Engineering Industry", Mechanical Engineering pub.London, 1979.
3. Rani, S.A., " Hand Book of Cellular Manufacturing Systems", John Wiley & Sons, 1999.
4. Askin R. G. and Standridge C. R., Modelling and Analysis of Manufacturing Systems, John Wiley and Sons, 1994.
5. Ranky P. G., Flexible Manufacturing Cells and Systems in CIM, CIM Ware Ltd., Guildford, Surrey, England, 1990.
6. B. Scholz and Reiter, C.I.M.Interfaces, Chapman Hall, 1992.
7. D. Bedworth et al., Computer Integrated Design and Manufacturing, McGraw Hill, 1991.

**Gaps in the syllabus (to meet Industry/Profession requirements)**

NIL

**POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design****COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE****Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |
|--------------------------------|----------------|
| 3 Quizzes                      | 30 % (3 × 10%) |
| Assignment (s)                 | 10             |
| Seminar before a committee     | 10             |

| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous Internal Assessment |     |     |     |     |     |
| Semester End Examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|----------------|-----|-----|-----|-----|-----|-----|
| CO1            | 3   | 1   | 2   | 3   |     |     |
| CO2            | 3   |     | 1   | 3   | 2   | 3   |
| CO3            | 3   | 1   | 2   | 3   |     | 2   |
| CO4            | 3   | 2   |     | 3   | 3   | 2   |
| CO5            | 3   | 3   |     | 3   |     | 1   |

<34% =1, 34-66% = 2, >66% = 3

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |
| CD5                       | Industrial visit                                       | CO1, CO4, CO5           |

## COURSE INFORMATION SHEET

Course code: PE 512

Course title: **SOFT COMPUTING IN MANUFACTURING AUTOMATION**

Pre-requisite(s): PE 501

Co-requisite(s): None

Credits: 03 L:3 T: P:

Class schedule per week: 03

Class: M.Tech

Semester / Level: II/5

Branch: Production and Industrial Engineering (AMS)

Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To differentiate soft computing tools from hard computation                         |
| B. | To learn ANN, Fuzzy Logic and GA and their capabilities to solve complex problems   |
| C. | To apply Artificial Neural Network and its various learning/training algorithms     |
| D. | To learn fuzzy sets, their operations and apply fuzzy rule base to complex problems |
| E. | To understand various hybrid soft computing applications                            |

### Course Outcomes

After the completion of this course, students can

|     |  |
|-----|--|
| CO1 | Distinguish controllers based hard and soft computing tools          |
| CO2 | Apply ANN tools for optimization, prediction and search applications |
| CO3 | Apply fuzzy logic tools to inference systems                         |
| CO4 | Apply genetic algorithm for optimization and search                  |
| CO5 | Develop hybrid soft computing tools using ANN, fuzzy and GA          |

## Syllabus

### Module 1

[8L]

Introduction to soft computing and comparison with hard computation, capabilities of soft computing tools, practical applications of soft computing.

### Module 2

[8L]

Basic concepts of Artificial Neural Networks (ANN), Single layer and Multi-layer perceptron, Learning Processes, Fundamentals of back propagation neural networks (BPNN), Learning and tuning parameters. Applications of ANN in manufacturing and automation.

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**Module 3****[8L]**

Basic concepts Fuzzy Logic (FL), Fuzzy sets and their operations. Fuzzy memberships and relations, Fuzzification and defuzzification methods, Fuzzy rule generation, Applications of FL in manufacturing and automation.

**Module 4****[8L]**

Genetic Algorithms: An Overview, Introduction to fundamentals of techniques and applications of genetic algorithms, Selection, fitness function, Cross over, Mutation, Reproduction. GA in problem solving, Implementation of GA. Application of GA in optimization and search

**Module 5****[8L]**

Hybridization of soft computing tools, Types of hybridization, Fundamentals of hybrid systems like Neuro-Fuzzy, Neuro-Genetic and Fuzzy Genetic hybrids

**Text books:**

1. Neural Network, Fuzzy logic and Genetic Algorithm: Synthesis and Applications – S.Rajasekaran, G.A and Vijayalakshmi Pai.

**Reference books:**

1. Fuzzy Logic- Intelligence control and information – Jhon Yen and Reza Langar, Pearson Education
2. Neural Network A Comprehensive Foundation- Simon Haykin, Person Education
3. Genetic Algorithms in Search, Optimization and Machine Learning- D.E. Goldberg, Addison-Wesley, 1989.
4. Fuzzy logic with engineering applications - Ross, T. J, 1997, McGraw-Hill, New York.

**Gaps in the syllabus (to meet Industry/Profession requirements)**

NIL

**POs met through Gaps in the Syllabus****Topics beyond syllabus/Advanced topics/Design****POs met through Topics beyond syllabus/Advanced topics/Design**

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |
|--------------------------------|----------------|
| 3 Quizzes                      | 30 % (3 × 10%) |
| Assignment (s)                 | 10             |
| Seminar before a committee     | 10             |

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| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous Internal Assessment |     |     |     |     |     |
| Semester End Examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Objectives and Outcomes**

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 |
|-----|-----|-----|-----|-----|-----|
| CO1 | 1   | 2   |     | 2   | 2   |
| CO2 | 1   |     | 3   |     | 2   |
| CO3 | 1   | 2   | 3   | 2   |     |
| CO4 | 2   |     |     |     | 2   |
| CO5 | 1   | 2   | 3   |     | 2   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1,CD2,CD3, CD4       |
| CO2             | CD1,CD2                |
| CO3             | CD1, CD2,CD3           |
| CO4             | CD1,CD2                |
| CO5             | CD1,CD2,CD3, CD4       |

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## COURSE INFORMATION SHEET

**Course code:** PE 513  
**Course title:** MANUFACTURING SYSTEM DESIGN  
**Pre-requisite(s):** None  
**Co- requisite(s):** None  
**Credits:** 3    **L:**03    **T:** 00    **P:** 00  
**Class schedule per week:** 3  
**Class:** M. Tech  
**Semester / Level:** II/5  
**Branch:** Production and Industrial Engineering (AMS)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To learn the concepts of manufacturing systems                      |
| B. | To know the fundamentals of design system, components and processes |
| C. | To estimate optimizing parameters of product                        |
| D. | To redesign the manufacturing systems                               |
| E. | To understand the optimization techniques in Manufacturing          |

### Course Outcomes

After the completion of this course, students will be able to:

|     |   |
|-----|---|
| CO1 | Evaluate the manufacturing systems and its components                 |
| CO2 | Design the manufacturing system according to need.                    |
| CO3 | Analyze the optimization parameter for particular product             |
| CO4 | Redesign manufacturing system   |
| CO5 | Solve problems on optimization and designing of manufacturing system. |

## Syllabus

### Module 1

[8L]

Introduction of manufacturing systems; Elements of manufacturing systems and their interaction; Recent Manufacturing strategies; Dynamics of manufacturing systems; Performance evaluation of manufacturing systems.

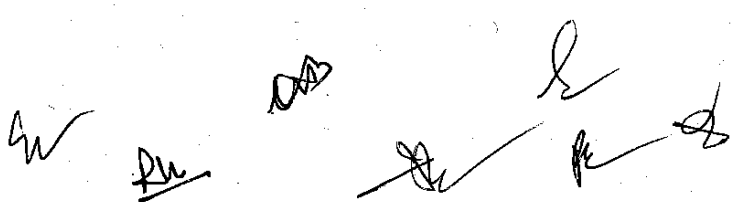
### Module 2

[8L]

Design requirements of manufacturing system, Architecture and methodologies of manufacturing system, Framework of Manufacturing Systems, performance measurement and tools of Manufacturing Systems.

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**Module 3****[8L]**

Design of Information system for manufacturing, Parts oriented production information system  
Development of Knowledge Based manufacturing system. Production control strategies, the  
importance of Optimization in manufacturing.

**Module 4****[8L]**

Redesign Methodology, case study of system redesign; Miltenburg's manufacturing system  
worksheet. System element used for system redesign. Sensitivity analysis of stochastic  
parameters.

**Module 5****[8L]**

Concept of artificial intelligence and its application for optimization. Human centered  
manufacturing system; Role of Manufacturing systems in Industry; Social system for  
manufacturing system

**Text books:**

1. Robert E Stein, "Re-Engineering the Manufacturing System" Marcel, Dekker
2. Product Design & Development - Karl. T. Ulrich and Steven D. Eppinger – TMH, Delhi
3. Ulrich Rembold, Christan Blume, Ruediger Dillmann, "Computer Integrated Manufacturing  
Technology and Systems", Marcel, Dekker.
4. Introduction of work study - ILO, Geneva - Universal Publishing Corporation, Bombay.
5. Motion and Time Study - Ralph M. Bannes - John Wiley & Sons
6. Work Study and Ergonomics - H.S. Shan – Dhanpat Rai & Sons

**Reference books:**

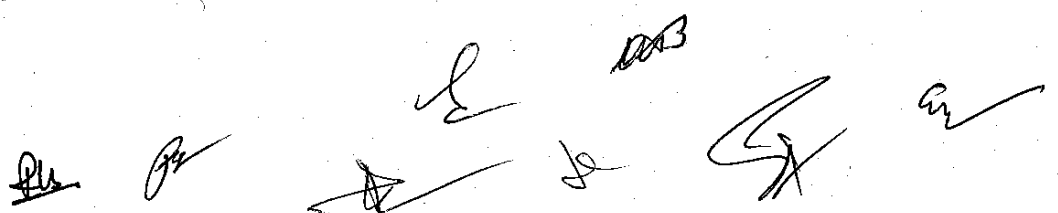
1. David O' Sullivan, "Manufacturing System Redesign- Creating the Integrated Manufacturing  
Environment", PTR Prentice Hall
2. Gideon Malevi, "Restructuring the Manufacturing Process Applying the Matrix Method",  
APICS.
3. Peter Bernus, Laszlo Nemes & Theodore J. Williams, "Architectures for Enterprise  
Integration", Chapman & Hall.

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:



**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous Internal Assessment |                |     |     |     |     |
| Semester End Examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 2   | 1   |     | 2   | 1   |     |
| CO2 | 2   | 1   |     |     | 2   | 2   |
| CO3 | 3   | 2   | 2   | 2   | 1   |     |
| CO4 | 3   | 2   | 3   | 3   | 1   | 3   |
| CO5 | 1   | 2   |     |     | 3   |     |

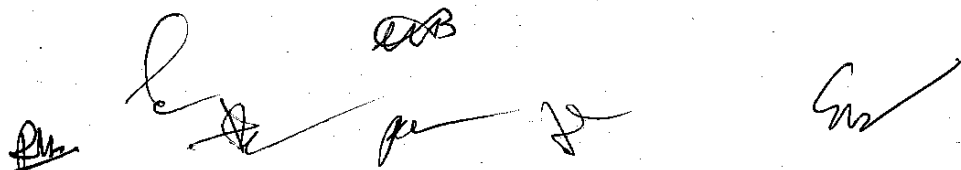
< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| <b>Mapping between CO and CD</b> |  |                         |
|----------------------------------|--|-------------------------|
| <b>CD</b>                        | <b>Course Delivery methods</b>                         | <b>Course Outcomes</b>  |
| CD1                              | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                              | Tutorials/Assignments                                  | CO2, CO3, CO4           |
| CD3                              | Seminars   | CO4, CO5                |
| CD4                              | Self- learning advice using internets                  | CO1, CO2, CO3, CO4, CO5 |
| CD5                              | Industrial visit                                       | CO3, CO5                |

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## COURSE INFORMATION SHEET

**Course code:** PE 514  
**Course title:** MECHATRONICS SYSTEMS  
**Pre-requisite(s):** None  
**Co- requisite(s):** None  
**Credits:** 03    **L:** 3    **T:** 0    **P:** 0  
**Class schedule per week:** 3  
**Class:** M.Tech  
**Semester / Level:** II/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives:

This course enables the students to:

|    |  |
|----|--|
| A. | Understand the concepts of Mechatronics systems and its Applications |
| B. | Study various types of Sensors, Actuators & Transducers              |
| C. | Gain knowledge on Hydraulic and Pneumatic systems                    |
| D. | Gain Knowledge on Data Acquisition systems                           |
| E. | Understand the types of Modelling & Simulation Techniques            |

### Course Outcomes:

At the end of the course, a student should be able to:

|     |  |
|-----|--|
| CO1 | Comprehend mechatronic systems, measurement system and control systems             |
| CO2 | Select appropriate sensors and transducers for mechatronic applications            |
| CO3 | Design hydraulic and pneumatic systems for machine tool automation                 |
| CO4 | Develop Signal Conditioning and Data Acquisition systems                           |
| CO5 | Model and Simulate Different types of Mechanical, Electrical & Electronics Systems |

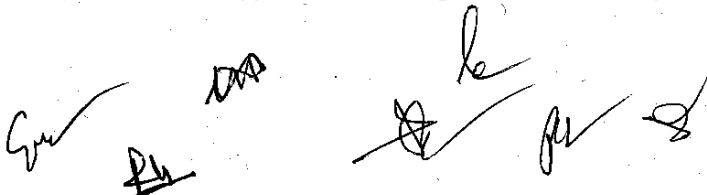
## SYLLABUS

### **Module 1: Introduction to Mechatronics** [8L]

Introduction to mechatronic systems, measurement system, control systems; Microprocessors and their applications, PLC system, examples of mechatronic system.

### **Module 2: Sensors and Transducers** [8L]

Performance parameters of transducers, photoelectric transducers, flow transducers, optical transducers; Sensors specifications, Different types of sensors, application of sensors, Actuators and its types.



**Module 3: Hydraulic and Pneumatic systems**

[8L]

Hydraulic system, pressure-flow-direction control valves, servo, logic valves. Hydraulic circuit of machine tools; Pneumatic system, Pressure-flow-direction control valves, Pneumatic component symbols, Pneumatic circuit of machine tools

**Module 4: Signal Conditioning**

[8L]

Signal conditioning, Filtering digital signals, Multiplexers, Data acquisition, Signal processing, Pulse modulation, Data presentation systems

**Module 5: Modelling and Simulation of systems**

[8L]

Mechanical, Electrical, Hydraulic and Thermal systems, Dynamic response of system, Mathematical models, Transfer function and frequency response, Closed loop controllers, Simulation and techniques of simulation

**Books recommended:**

**Text Books:**

1. Mechatronics 3/e, W, Bolton (Addison Wesley, ISBN 981-235-874-9.
2. Mechatronics (G. K. Vijayaraghavan, K. P. Ramachandran, M. S. Balasundaram), Wiley Publication
3. Mechatronics System Design 2nd Edition (Devdas Shetty), Cengage Learning

**Reference Books**

1. Introduction to Mechatronics and Measurement Systems, David G. Alciatore, McGraw Hill Publications
2. Mechatronics: A Foundation Course 1st Edition, Clarence W. de Silva, CRC Press.

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

**POs met through Gaps in the Syllabus:**

Topics beyond syllabus/Advanced topics/Design:

POs met through Topics beyond syllabus/Advanced topics/Design:

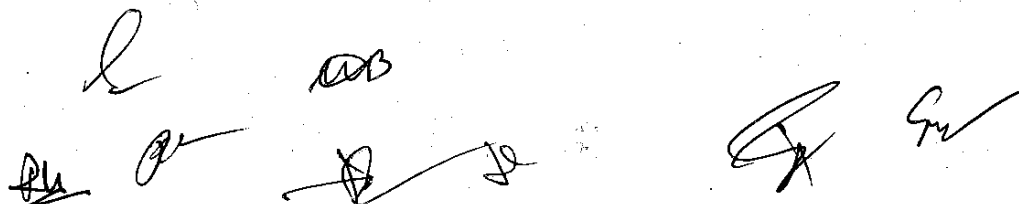
**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

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| Continuous Internal Assessment | % Distribution |
|--------------------------------|----------------|
| 3 Quizzes                      | 30 % (3 × 10%) |
| Assignment (s)                 | 10             |
| Seminar before a committee     | 10             |

| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous Internal Assessment |     |     |     |     |     |
| Semester End Examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 3   |     | 3   | 3   |     |     |
| CO2 | 2   |     | 1   | 2   |     | 3   |
| CO3 | 3   | 3   | 3   | 3   |     | 2   |
| CO4 | 2   | 2   | 2   | 2   | 2   | 3   |
| CO5 | 3   | 3   | 3   | 3   | 3   | 2   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1,CD2, CD3           |
| CO2             | CD1, CD2, CD6          |
| CO3             | CD1, CD2, CD3,CD6,     |
| CO4             | CD1, CD2, CD3,CD6      |
| CO5             | CD1,CD2,CD3,CD6        |

## COURSE INFORMATION SHEET

Course code: PE 516  
Course title: AUTONOMOUS SYSTEMS LAB  
Pre-requisite(s): None  
Co-requisite(s): None  
Credits: 02 L: 0 T: 0 P: 4  
Class schedule per week: 4  
Class: M.Tech.  
Semester / Level: II/5  
Branch: Production and Industrial Engineering (AMS)  
Name of Teachers:

### Course Objectives:

This course enables the students to:

|   |   |
|---|---|
| 1 | Comprehend a real-time concepts of Manufacturing Autonomous systems                                       |
| 2 | Be acquainted with standard Autonomous systems and create application programs for different applications |
| 3 | Give a hands-on experience of industrial applications and integrate with PLC                              |
| 4 | Identify real scenario for the kinematic parameters and troubleshoot a given autonomous system            |
| 5 | Develop simple robot simulations using MATLAB for controlling the robot positions                         |

### Course Outcomes:

At the end of the course, students should be able to:

|     |  |
|-----|--|
| CO1 | Develop a basic manufacturing autonomous systems   |
| CO2 | Create programs for different autonomous applications (Robots and AS/RS)                     |
| CO3 | Design and create pneumatic and electro-pneumatic circuits using PLC                         |
| CO4 | Analyze the kinematic and dynamic parameters of a standard robot                             |
| CO5 | Simulate a given autonomous system using virtual tools like MATLAB and interpret the results |

### List of experiments

#### Experiment No. 1

Basic components and applications of Autonomous systems

#### Experiment No. 2

Simulation and study the functional details of the various components of the ARISTO robots

#### Experiment No. 3

Simulation and Writing a program for PTP operation in ARISTO robot software

#### Experiment No. 4

Robot Workspace Calibration

#### Experiment No. 5

Simulation and Writing a program for repeatability through ARISTO robot software

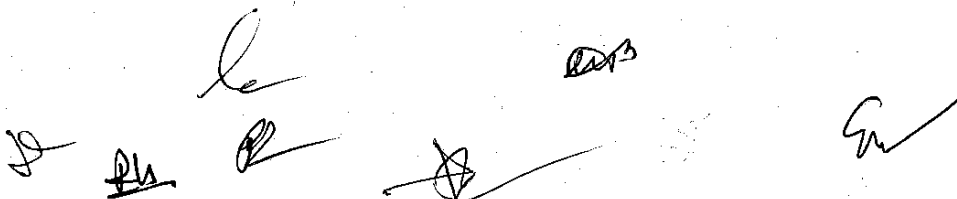
#### Experiment No. 6

Simulation and Writing a program for circle and spline command through ARISTO robot

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Software

**Experiment No. 7**

Simulation and study the functional details of the various components of the Automated storage & Retrieval System (AS/RS)

**Experiment No. 8**

Simulation and Writing a program for rack to conveyor and conveyor to rack through AS/RS software

**Experiment No. 9**

Introduction to PLC and Ladder Logic Programming

**Experiment No. 10**

Programming PLC for Pick and Place Tasks

**Experiment No. 11**

Programming using MATLAB to perform Autonomous Simulations

**Experiment No. 12**

Simulate a Robot in MATLAB and control its position

**Books recommended:**

**TEXT BOOK**

4. Mikell P. Grover, E. Zimmer, "Computer Aided Design and Manufacturing (CAD/CAM)", Pearson Publication, 2<sup>nd</sup> Edition, 2006. (T1)
5. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2<sup>nd</sup> Edition, 2004. (T2)

**REFERENCE BOOK**

3. Radhakrishnan P., Subramaniam S., "CAD CAM and CIM", New Age International, 2002 (R1)
4. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998 (R2)

**Course Evaluation:**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 60                                  |
| Semester End Examination       | 40                                  |

| Continuous Internal Assessment      | % Distribution |
|-------------------------------------|----------------|
| Day to day performance & Lab files  | 30             |
| Quiz (es)                           | 10             |
| Viva-voce                           | 20             |
| Semester End Examination            | % Distribution |
| Examination: Experiment Performance | 30             |
| Quiz                                | 10             |



| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous internal assessment |     |     |     |     |     |
| Semester End examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

Design of real-time Industrial projects.  
POs met through Gaps in the Syllabus:

**Topics beyond syllabus/Advanced topics/Design:**

Design optimization for industrial projects, Fractional order controller  
POs met through Topics beyond syllabus/Advanced topics/Design:

**Course Delivery Methods**

|     |   |
|-----|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors      |
| CD2 | Assignments/Seminars  |
| CD3 | Laboratory experiments/teaching aids                        |
| CD4 | Industrial/guest lectures                                   |
| CD5 | Industrial visits/in-plant training                         |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation  |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 |     | 2   | 1   | 2   | 2   |     |
| CO2 | 1   | 2   | 1   | 2   | 3   |     |
| CO3 | 2   | 1   | 3   | 2   | 3   | 2   |
| CO4 |     | 2   | 2   | 3   | 3   |     |
| CO5 | 1   | 1   | 1   | 3   | 1   | 1   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method  |
|-----------------|-------------------------|
| CO1             | CD1, CD3                |
| CO2             | CD1, CD3, CD7           |
| CO3             | CD1, CD3, CD7           |
| CO4             | CD1, CD3, CD6, CD7      |
| CO5             | CD1, CD2, CD3, CD6, CD7 |

## COURSE INFORMATION SHEET

Course code: PE 517

Course title: COMPUTER AIDED DESIGN AND DRAFTING LAB

Pre-requisite(s): None

Co-requisite(s): None

Credits: 02 L: 0 T: 0 P: 4

Class schedule per week: 4

Class: M.Tech.

Semester / Level: II/5

Branch: Production and Industrial Engineering (AMS)

Name of Teacher:

### Course Objectives:

This course enables the students to:

|   |   |
|---|---|
| 1 | Learn the concepts and principles of Computer aided Design & Drafting (CADD)  |
| 2 | Understand the various types of CAD Software's like CATIA V5, Unigraphics NX etc.   |
| 3 | Understand concepts of designing and drafting of various manufacturing components.  |
| 4 | Understand the concepts of parametric 3D part modelling/Assembly  |
| 5 | Understand the concepts of CAD Software, Design & Assemble various parts of Manufacturing with focus on Industrial Applications |

### Course Outcomes:

At the end of the course, a student should be able to:

|     |  |
|-----|--|
| CO1 | Apply the concepts of concepts of designing using 3D modeling software   |
| CO2 | Create Designs of various real-world Industrial components by using mechanical design Software's like CATIA, Unigraphics, etc. |
| CO3 | Produce models of an industrial component by interpreting 3D part drawings using Computer Aided Design, Drafting software.     |
| CO4 | Apply the concepts of CAD Drawings and Assemble various components of Manufacturing with focus on Industrial Applications      |
| CO5 | Will be able to generate part/assembly drawings.   |

### List of experiments

#### Experiment No. 1

Introduction to Basics of Computer Aided Design. Sketcher, Drafting & 3D Modeling.

#### Experiment No. 2

Exercise on Padding, Pocketing & Revolving.

#### Experiment No. 3

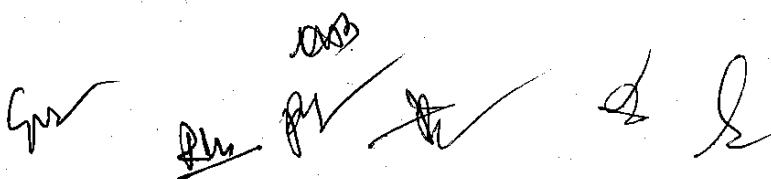
Exercise on Nut, Bolt & Threads

#### Experiment No. 4

Exercise on Chamfer, Fillets, Mirror & Offset

#### Experiment No. 5

Exercise on Hole & Patterns



- Experiment No. 6**  
Exercise on Ribs & Shell
- Experiment No. 7**  
Exercise on Sweep
- Experiment No. 8**  
Exercise on Blend
- Experiment No. 9**  
Exercise on Datum plane & Axis
- Experiment No. 10**  
Exercise on Assembly-I: Foot-step Bearing
- Experiment No. 11**  
Exercise on Assembly-II: Plumber-Block
- Experiment No. 12**  
Exercise on Assembly-III: Bench-Vice assembly

**Books recommended:**

**TEXT BOOK**

1. Rao, P.N. "CAD/CAM: Principles and Applications", McGraw Hill Publication, 2nd Edition, 2004. (T1)
2. Mikell P. Grover, E. Zimmer, "Computer Aided Design and Manufacturing (CAD/CAM)", Pearson Publication, 2<sup>nd</sup> Edition, 2006. (T2)

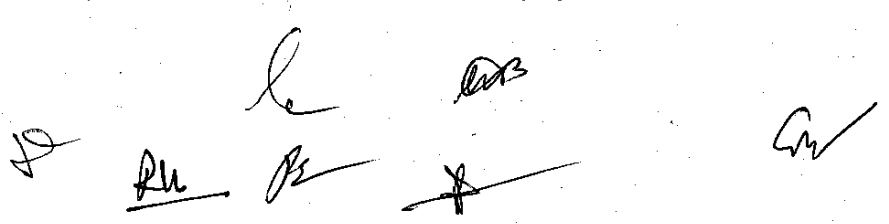
**REFERENCE BOOK**

1. David Bedworth, "Computer Integrated Design and Manufacturing" Tata McGraw Hill, New Delhi, 1998. (R1)
2. Radhakrishan P., Subramaniyam S., "CAD CAM and CIM", New Age International, 2002 (R2)

**Course Evaluation:**

**Direct Assessment**

| Assessment Tool                       | % Contribution during CO Assessment |            |            |            |            |
|---------------------------------------|-------------------------------------|------------|------------|------------|------------|
| Continuous Internal Assessment        | 60                                  |            |            |            |            |
| Semester End Examination              | 40                                  |            |            |            |            |
| <b>Continuous Internal Assessment</b> | <b>% Distribution</b>               |            |            |            |            |
| Day to day performance & Lab files    | 30                                  |            |            |            |            |
| Quiz (es)                             | 10                                  |            |            |            |            |
| Viva-voce                             | 20                                  |            |            |            |            |
| <b>Semester End Examination</b>       | <b>% Distribution</b>               |            |            |            |            |
| Examination: Experiment Performance   | 30                                  |            |            |            |            |
| Quiz                                  | 10                                  |            |            |            |            |
| <b>Assessment Components</b>          | <b>CO1</b>                          | <b>CO2</b> | <b>CO3</b> | <b>CO4</b> | <b>CO5</b> |
| Continuous internal assessment        |                                     |            |            |            |            |
| Semester End examination              |                                     |            |            |            |            |



**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Gaps in the syllabus (to meet Industry/Profession requirements) :**

Design of real-time Industrial projects.

POs met through Gaps in the Syllabus:

**Topics beyond syllabus/Advanced topics/Design:**

Design optimization for industrial projects, Fractional order controller

POs met through Topics beyond syllabus/Advanced topics/Design:

**Course Delivery Methods**

|     |   |
|-----|---|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors      |
| CD2 | Assignments/Seminars  |
| CD3 | Laboratory experiments/teaching aids                        |
| CD4 | Industrial/guest lectures                                   |
| CD5 | Industrial visits/in-plant training                         |
| CD6 | Self- learning such as use of NPTEL materials and internets |
| CD7 | Simulation  |

**Mapping between Objectives and Outcomes****Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 2   |     | 3   | 3   | 3   |     |
| CO2 | 1   | 2   | 1   | 3   | 2   | 1   |
| CO3 | 2   | 1   | 3   | 2   | 3   | 2   |
| CO4 | 2   | 2   | 2   | 3   | 2   | 1   |
| CO5 | 1   | 2   | 3   | 3   | 3   | 2   |

&lt; 34% = 1, 34-66% = 2, &gt; 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1, CD3               |
| CO2             | CD1, CD3, CD7          |
| CO3             | CD1, CD3, CD7          |
| CO4             | CD1, CD3, CD6, CD7     |
| CO5             | CD1, CD2, CD3, CD6     |

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## COURSE INFORMATION SHEET

Course code: PE 519

Course title: OPTIMIZATION TECHNIQUES

Pre-requisite(s): None

Co-requisite(s): None

Credits: 03 L: 03 T:0 P:0

Class schedule per week: 03

Class: M.Tech

Semester / Level: II/5

Branch: Production and Industrial Engineering (A.M.S)

Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To Impart knowledge to students in recent advances in the Optimization Techniques in Manufacturing and research related professions |
| B. | Formulate more complex problems, and apply implementations of selected algorithms to solve these problems                           |
| C. | Introduction to optimization techniques using both linear and non-linear programming.   |
| D. | Apply search, satisfaction, optimization and learning algorithms to real world problems.  |
| E. | Evaluate analytically the limitations of these algorithms, and assess tradeoffs between these algorithms                            |

### Course Outcomes:

After the completion of this course, students will be:

|    |  |
|----|--|
| 1. | To cover various optimization techniques and their applications                              |
| 2. | To explain the optimization of linear systems using simplex method                           |
| 3. | Understanding optimization of non-linear problems using quadratic and Direct Search Methods. |
| 4. | Cast engineering minima/maxima problems into optimization framework.                         |
| 5. | To solve sequential systems like scheduling using dynamic programming                        |

## SYLLABUS

### Module 1:

[8L]

#### Introduction to Optimization

Introduction, Development, Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems

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**Module 2:** [8L]

**Classical Optimization Techniques**

Introduction, Single Variable Optimization, Multivariable Optimization with no constraints, Multi variable Optimization with Inequality Constraints

**Module 3:** [8L]

**Linear Programming**

Optimization of linear systems: Introduction, Definition & theories; simplex method; initial feasible basics; Duality and sensitivity analysis.

**Module 4:** [8L]

**Optimization of Non-linear systems**

Introduction, Separable programming; Quadratic programming: programming: gradient methods, Direct Search methods.

**Module 5:** [8L]

**Optimization using meta-heuristics**

Introduction to meta-heuristics like Simulated Annealing, tabu search, ACO, PSO, Immune systems and hybrid systems

**Books recommended:**

**TEXT BOOKS:**

1. Hamady A Taha, "Operation Research", Pearson Education [T1]
2. 2.Rao S.S., Engineering Optimization - Theory and Practice, John Wiley & Sons, New York, 903 pp, 1996 .[T2]

**REFERENCE BOOKS:**

1. An introduction to Optimization by Edwin P K Chong, Stainslaw Zak [R1]
2. Nonlinear Programming by Dimitri Bertsekas [R2]

**Gaps in the syllabus (to meet Industry/Profession requirements)**

**POs met through Gaps in the Syllabus**

**Topics beyond syllabus/Advanced topics/Design**

**POs met through Topics beyond syllabus/Advanced topics/Design**

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|----------------|-----|-----|-----|-----|-----|-----|
| 1              | 3   | 1   | 2   | 3   |     |     |
| 2              | 3   |     | 1   | 3   | 2   | 3   |
| 3              | 3   | 1   | 2   | 3   |     | 2   |
| 4              | 3   | 2   |     | 3   | 3   | 2   |
| 5              | 3   | 3   |     | 3   |     | 1   |

< 34% = 1, 34-66% = 2, > 66% = 3

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |

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## COURSE INFORMATION SHEET

**Course code:** PE 520  
**Course title:** HYDRAULIC AND PNEUMATIC CONTROLS  
**Pre-requisite(s):** PE 501  
**Co- requisite(s):** None  
**Credits:** 03 L: 3 T: 0 P: 0  
**Class schedule per week:** 3  
**Class:** M.Tech.  
**Semester / Level:** II/5  
**Branch:** Production and Industrial Engineering (A.M.S)  
**Name of Teacher:**

### Course Objectives:

This course enables the students to:

|    |   |
|----|---|
| A. | To understand the concepts of Power Hydraulics and its applications |
| B. | To study various controls valves                                    |
| C. | To gain knowledge on Hydraulic actuators and Servo valves           |
| D. | To Design Hydraulic circuits  |
| E. | To understand the types of Pneumatics and its applications          |

### Course Outcomes:

At the end of the course, a student should be able to:

|     |  |
|-----|--|
| CO1 | Recognise the Importance of Hydraulics and Pneumatics Controls |
| CO2 | Explore the control of various types of valves                 |
| CO3 | Handle real-life projects in various organizations             |
| CO4 | Design Hydraulic circuits                                      |
| CO5 | Perform the maintenance of hydraulic systems and fluids        |

## SYLLABUS

### Module 1:

[8L]

#### Introduction

Power hydraulics & its applications, Hydraulic symbols,  
Positive displacement Pumps: Gear, Vane, Piston and other special types of pumps.

### Module 2:

[8L]

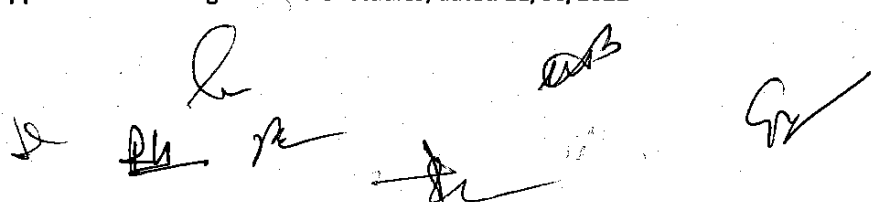
#### Control valves

Pressure Control: relief valve, Unloaded valve, Pressure reducing valve, Counter balance valve, sequence valve, Flow Control: Meter in Meter out, Bleed off, Pressure and Temperature, compensated flow control valve, Direction Control: Check valve, Open centre, closed centre, Tandem centre and others, Cartridge valves, Flow forces on valve spools.

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**Module 3:** [8L]

**Hydraulic actuators**

Linear and rotary, Design of Hydraulic actuators, Accessories in hydraulic systems: Accumulator, Air-breathe valve, Pressure switches etc. Hydraulic power packs.  
Servo valves: Torque motor, electro-hydraulic Servo valves: Types and principles of operations.

**Module 4:** [8L]

**Design of Hydraulic circuits and its application**

Regeneration, Pre-fill, Twin Pump and others. Maintenance of hydraulic systems and working fluid:

**Module 5:** [8L]

**Pneumatics**

Air Filter, Lubricators and Regulators, Pneumatic control elements: Air Cylinders and their Design, Pneumatic safety circuits, Pneumatic Logic control.

**Books recommended:**

**TEXT BOOK**

1. H.E. Merritt, "Hydraulic Control Systems", John Wiley & Sons, New York. (T1)
2. D. Mc Cloy and H. R. Martin, "Control of Fluid Power, Analysis, Design and Control", John Wiley & Sons. (T2)

**REFERENCE BOOKS:**

1. Andrew Parr, Hydraulics and Pneumatics, Jaico Publishers. (R1)
2. Esposito, Fluid Power by Esposito, Pearson Education. (R2)

**Gaps in the syllabus (to meet Industry/Profession requirements)**

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |
|--------------------------------|----------------|
| 3 Quizzes                      | 30 % (3 × 10%) |
| Assignment (s)                 | 10             |
| Seminar before a committee     | 10             |

| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous internal assessment |     |     |     |     |     |
| Semester End examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping between Objectives and Outcomes**

**Mapping of Course Outcomes onto Program Outcomes**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|-----|-----|-----|-----|-----|-----|-----|
| CO1 | 3   |     | 3   | 3   |     |     |
| CO2 | 2   |     | 1   | 2   |     | 3   |
| CO3 | 3   | 3   | 3   | 3   |     | 2   |
| CO4 | 3   | 2   | 2   | 3   | 2   | 3   |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   |

< 34% = 1, 34-66% = 2, > 66% = 3

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Course Outcomes | Course Delivery Method |
|-----------------|------------------------|
| CO1             | CD1,CD2, CD3           |
| CO2             | CD1, CD2, CD6          |
| CO3             | CD1, CD2, CD3,CD6,     |
| CO4             | CD1, CD2, CD3,CD6      |
| CO5             | CD1,CD2,CD3,CD6        |

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## COURSE INFORMATION SHEET

Course code: PE 521

Course title: QUALITY ENGINEERING AND ROBUST DESIGN

Pre-requisite(s): None

Co- requisite(s): None

Credits: 03 L:3 T:0 P:0

Class schedule per week: 3

Class: M.Tech

Semester / Level: II/5

Branch: Production and Industrial Engineering (AMS)

Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To know the fundamentals of quality and quality control charts                                |
| B. | To learn the techniques of acceptance sampling, process measurement and control               |
| C. | To find root cause identification and corrective action                                       |
| D. | To learn Design of Experiments (DOE), Analysis of Variance (ANOVA), and Factorial Experiments |
| E. | To Know about robust design and Six Sigma   |

### Course Outcomes

After the completion of this course, students will be able to:

|     |   |
|-----|---|
| CO1 | Develop control charts for variables and attributes                       |
| CO2 | Design acceptance sampling plans  |
| CO3 | Analysis the root cause and develop the Quality Function Deployment (QFD) |
| CO4 | Explain the practical implications of design of experiments               |
| CO5 | Apply Taguchi techniques to conduct experiments for robust design         |

## Syllabus

### Module 1:

[8L]

#### Introduction

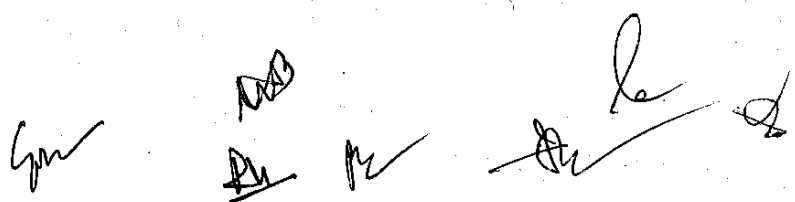
Quality Planning, Analysis & Control, Control charts for attributes and variables, cumulative sum and exponentially weighted moving average control charts, process capability.

### Module 2:

[8L]

#### Sampling Procedures & Measurement Techniques:

acceptance sampling for attributes, sampling plan, Dodge-Romig sampling, Acceptance sampling by variables. Inspection principles and strategies, Online and off line methods of inspection.



**Module 3:****[8L]****Root Cause Identification and Corrective Action**

Seven Basic and Advanced Quality Control Tools-Affinity Diagram, Inter-Relationship diagram, Tree Diagram, Matrix Diagram, Activity Network Diagram, Prioritization Matrices, Process Decision Program Chart. Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA).

**Module 4:****[8L]****The Design of Experiments**

Introductions and DOE process steps; orthogonal array selection and utilization. Analysis and Interpretation Methods for Experiments, Analysis of Variance (ANOVA), Confirmation Experiments, Factorial Experiments.

**Module 5:****[8L]****Robust Design**

Application and Benefit of Robust Design, off line and online quality control, quality loss function, Taguchi Technique, S/N Analysis, Quality in Design and manufacturing, basic concept of six sigma, DMAIC.

**Books:****Text books:**

1. Montgomery, D.C. "Design and Analysis of Experiments", John Wiley and Sons, 5th Edition, 2002.
2. Montgomery, D.C. "Introduction to statistical Quality control" John Wiley & Sons, Inc
3. Mitra, A., "Fundamentals of Quality Control and Improvement", Pearson Education Asia, First Edition (2004)

**Reference books:**

1. Ross, P. J., "Taguchi Techniques for Quality Engineering", McGraw-Hill Professional.
2. Bagchi, T. P., "Taguchi Methods Explained: Practical steps to Robust Design" Prentice-Hall of India.
3. Hicks, C. R. "Fundamental concepts in the Design of Experiments", Holt, Rinehart and Winston, 2000.
4. Grant E L and Leavenworth R S, "Statistical Quality Control", McGraw Hill, Sixth Edition (2000).
5. Hansen Bertrand L and Ghare Prabhakar M, "Quality Control and Applications" Prentice Hall of India Pvt. Ltd., First Edition (1993).

**Gaps in the syllabus (to meet Industry/Profession requirements) - NIL**

**POs met through Gaps in the Syllabus**

**Topics beyond syllabus/Advanced topics/Design**

**POs met through Topics beyond syllabus/Advanced topics/Design**

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**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**Mapping of Course Outcomes onto Program Outcomes**

| Course Outcome # | Program Outcomes |   |   |   |   |   |
|------------------|------------------|---|---|---|---|---|
|                  | 1                | 2 | 3 | 4 | 5 | 6 |
| 1                |                  | √ |   |   |   |   |
| 2                | √                | √ |   |   |   |   |
| 3                | √                | √ | √ | √ |   |   |
| 4                | √                | √ |   | √ |   |   |
| 5                | √                | √ |   | √ |   |   |

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |

## COURSE INFORMATION SHEET

**Course code:** PE 601  
**Course title:** AUTOMATED MANUFACTURING  
**Pre-requisite(s):** None  
**Co- requisite(s):** None  
**Credits:** 03 L:3 T:0 P:0  
**Class schedule per week:** 3  
**Class:** M.Tech  
**Semester / Level:** III/6  
**Branch:** ALL (Open Elective)  
**Name of Teacher:**

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | Understand the concept of automation and manufacturing systems                      |
| B. | Write basic part programme for NC machine   |
| C. | Knowledge about various components of automation like sensors, actuators, PLC       |
| D. | To utilize material handling equipment like AGV, AS/RS, in manufacturing situations |
| E. | To identify the role of robotics in automated manufacturing systems                 |

### Course Outcomes

After the completion of this course, students will be:

|     |  |
|-----|--|
| CO1 | Explain the principles and strategies of automation in different manufacturing systems |
| CO2 | Demonstrate program for NC machining using part programming                            |
| CO3 | Interpret different types of controller  |
| CO4 | Analyze different types of material handling systems                                   |
| CO5 | Apply fundamentals of Robotics, CIMS and FMS in designing manufacturing systems        |

## SYLLABUS

### Module 1 Introduction to Automation

[8L]

Basic Elements of an Automated Systems, Advanced Automation Functions, Levels of automation, Automation Principles & Strategies, concept of automation; types of automation; flexibility, degree, level and yardstick of automation; Components of automation, Introduction to NC/CNC/DNC

### Module 2 CNC Part Programming

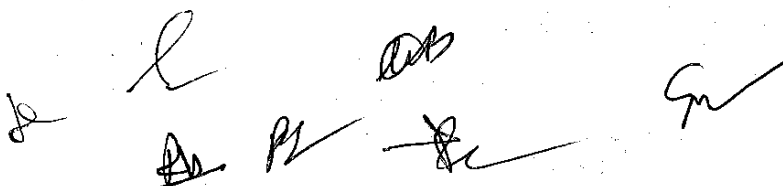
[8L]

Axes identification, coordinate system, movements and interpolation with other axis, Application of rotary axis, Manual programming for CNC turning and Milling– offline, Programming formats, Tool offsets, Type of compensations and cutting parameters, Introduction to G codes and M codes for CNC Turning and Milling, single and multipass canned cycle in turning, drilling canned cycles in milling, sub programming.

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**Module 3 Controller****[8L]**

Industrial Control Systems, Mechanical, Electrical, Hydraulic, Pneumatic, Electronic and Hybrid systems. Concepts features & parameters governing the Selection of various components Necessary for Building the elements.

Introduction to Programmable logical controller (PLC): Discrete Control using PLC & PLC network, Introduction, Micro PLC, programming a PLC, Logic Functions, input & output Modules, PLC Processors, PLC Instructors, Documenting a PLC System, Timer & counter Instructions, Comparison & data Handling instructions, Sequencing Instructions, Mask Data representation.

**Module 4 Automated material handling and quality control****[8L]**

Types of equipment, functions, analysis, conveyor systems, automated guided vehicle systems (AGVs), guidance, routing and control, Automated Storage and Retrieval systems (AS/RS), Components, Controls and applications, Integration of automated material handling and storage systems to manufacturing environment. Introduction to CMM, Non-Contact Inspection Method

**Module 5 Robotics CIM and FMS****[8L]**

Introduction, Fundamentals of robot technology, Robot applications in manufacturing, Robot programming Methods - Robot programming languages and ROS.

Elements of CIM, Different modules and information flow, CIM planning & implementation process, requirements of CIM, Computerized production activities, Computerized integrated quality concept.

Definition & concept, flexible automation & productivity, components of FMS, Different types of FMS, Design problem of FMS, Technology required for FMS system. Their function & programming in FMS.

**Books recommended:****TEXT BOOKS:**

1. Groover M.P., Automation, "Production Systems and Computer Integrated Manufacturing :3 edition PHI,2009 (T1).
2. Asfahl C. R., "Robots and Manufacturing Automation" John Wiley & Sons, 1992 (T2).
3. Viswanandham N., "Performance modeling of automated Manufacturing Systems", PHI, 1992 (T3).
4. Viswanathan,N., and Narahari,Y., "Performance Modeling and Automated Manufacturing Systems", Prentice Hall of India Pvt. Ltd., 2000 (T4).

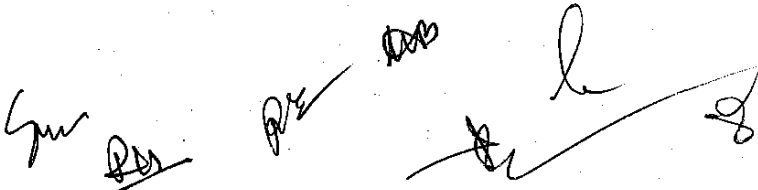
**REFERENCE BOOKS:**

1. Deb S. R., "Robotics Technology & Flexible Automation" Tata McGraw Hill, 2001 (R1).
2. Thomas R. Kurfess, "Robotics and Automation Handbook" 1 ed., CRC Press 2005 (R2).

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3. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 1997 (R3).
4. Bolton, W., "Mechatronics: A Multidisciplinary Approach" 4<sup>th</sup> ed., Pearson 2008 (R4).

**Gaps in the syllabus (to meet Industry/Profession requirements)**

NIL

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |     |     |     |     |
|--------------------------------|----------------|-----|-----|-----|-----|
| 3 Quizzes                      | 30 % (3 × 10%) |     |     |     |     |
| Assignment (s)                 | 10             |     |     |     |     |
| Seminar before a committee     | 10             |     |     |     |     |
| Assessment Components          | CO1            | CO2 | CO3 | CO4 | CO5 |
| Continuous internal assessment |                |     |     |     |     |
| Semester End examination       |                |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

**Course Delivery methods**

|     |  |
|-----|--|
| CD1 | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2 | Tutorials/Assignments                                  |
| CD3 | Seminars   |
| CD4 | Self- learning advice using internets                  |

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Handwritten signatures of faculty members, including names like 'S', 'R', 'P', 'A', 'G', and 'S'.

## Mapping between Objectives and Outcomes

### Mapping of Course Outcomes onto Program Outcomes

| Course Outcome # | Program Outcomes |   |   |   |   |   |
|------------------|------------------|---|---|---|---|---|
|                  | 1                | 2 | 3 | 4 | 5 | 6 |
| 1                | 1                | 1 | 1 | 2 | 2 | 1 |
| 2                | 1                | 1 | 1 | 3 | 3 | 1 |
| 3                | 1                | 1 | 1 | 3 | 2 | 1 |
| 4                | 1                | 1 | 2 | 3 | 3 | 1 |
| 5                | 1                | 1 | 2 | 3 | 3 | 2 |

< 34% = 1, 34-66% = 2, > 66% = 3

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3, CO4, CO5      |
| CD3                       | Seminars   | CO3, CO4, CO5           |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |

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## COURSE INFORMATION SHEET

Course code: PE 602  
Course title: SMART MANUFACTURING  
Pre-requisite(s): None  
Co-requisite(s): None  
Credits: 03 L:3 T:0 P:0  
Class schedule per week: 3  
Class: M, Tech  
Semester / Level: III/6  
Branch: ALL (Open Elective)  
Name of Teacher:

### Course Objectives

This course enables the students:

|    |   |
|----|---|
| A. | To learn the concepts of CAD/CAM, CIMS and smart manufacturing            |
| B. | To understand the various types of robots and their applications          |
| C. | To gain knowledge about different types material handling systems         |
| D. | To comprehend the concepts of agile and E- manufacturing system           |
| E. | To realise the importance of Industry 4.0 through industrial case studies |

### Course Outcomes

After the completion of this course, students will be able to:

|     |  |
|-----|--|
| CO1 | Classify automated Manufacturing Systems, CAD/CAM and CIMS and smart manufacturing.                              |
| CO2 | Identify and select different types of robots based on their applications  |
| CO3 | Develop basic design criteria for AGVs and AS/RS systems   |
| CO4 | Define the concepts of E-manufacturing, IT based supply chain, Cloud based manufacturing and Agile manufacturing |
| CO5 | Comprehend the concepts of Industry 4.0 and IoT in manufacturing systems   |

### Syllabus

#### Module 1:

##### Introduction to Smart Manufacturing

[8L]

Automated Manufacturing Systems, Computerized Manufacturing Support Systems, CAD/ CAM and CIMS, Need for Automation, Process Improvement, Computer based integration between various functions - manufacturing, design, materials

#### Module 2:

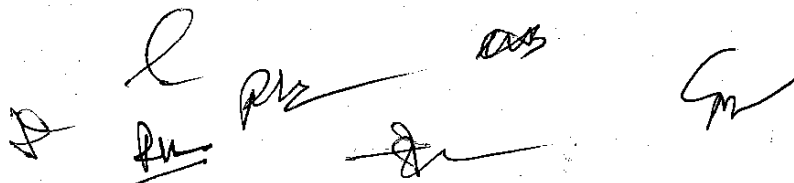
##### Introduction to Robotics

[8L]

Introduction of robot technology, Basic Terminologies, Classification, and characteristics, Physical configuration, Structure of industrial robots and its Applications. Case Studies.

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**Module 3:**

**Automated material handling**

[8L]

Introduction of material handling systems, Conveyor systems, Automated Guided Vehicle systems (AGVs): guidance, routing, control and design, Automated Storage and Retrieval systems (AS/RS): Components, Controls and applications. Integration of automated material handling and storage systems.

**Module 4:**

**E- MANUFACTURING .**

[8L]

Introduction of Agent based manufacturing, Information technology based Supply chain, and cloud based Manufacturing, Concept of agile manufacturing and E-manufacturing.

**Module 5:**

**Industry 4.0**

[8L]

Evaluation of industries, Introduction to Industry 4.0, Challenges in industry 4.0, Impact of Industry 4.0, Case studies on industry 4.0, Introduction to Internet of Things (IoT) and its applications, Smart supply chain and Case studies.

**Books:**

**Text books:**

1. Bahga and V. Madiseti, Internet of Things, A hands-on approach, Create Space Independent Publishing Platform, 1st edition, 2014, ISBN: 978-0996025515
2. A. Bahga and V. Madiseti, Cloud Computing, A hands-on approach, Create Space Independent Publishing Platform, 1st edition, 2013, ISBN: 978-1494435141
3. M. Skilton and F. Hovsepian, The 4th Industrial Revolution: Responding to the Impact of Artificial Intelligence on Business, Springer Nature, 2017, ISBN: 978-3-319-62479-2
4. M. P. Grover "Automation, Production Systems and Computer-Integrated Manufacturing" Pearson Education, 4<sup>th</sup> Edition, 2016, ISBN: 978-0133499612
5. M. P. Grover, Mitchell Weis, Roger, N. Nagel, Nicholas and G. Odrey, Industrial Robotics Technology, Programming and Applications, McGraw Hill, 2<sup>nd</sup> Edition, 2017 ISBN: 978-1259006210

**Reference books:**

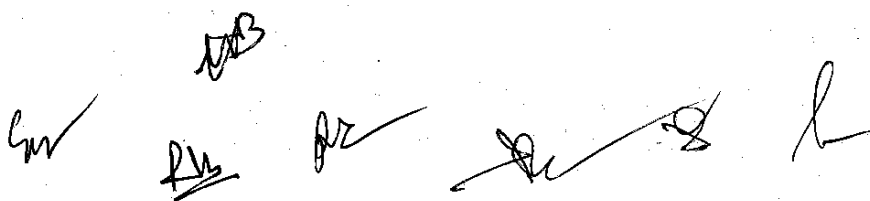
1. Gilchirst, Industry 4.0: The Industrial Internet of Things, Apress (Springer), 1<sup>st</sup> Edition, 2016, ISBN: 978-1-4842-2046-7
2. S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cyber manufacturing Systems, Springer, 1st edition, 2017, ISBN: 978-3319425580
3. T. Erl, Z. Mahmood, and R. Puttini, Cloud Computing: Concepts, Technology & Architecture, Prentice Hall, 1st edition, 2013, ISBN: 978-0133387520.
4. N. Viswanandham, Y. Narhari "Performance Modeling of Automated Manufacturing Systems" Prentice-Hall, 1<sup>st</sup> Edition, 1994, ISBN: 978-8120308701
5. S. K. Saha, Introduction to Robotics, Tata Mcgraw Hill Education Private Limited, 2<sup>nd</sup> Edition, ISBN: 978-9332902800

**Gaps in the syllabus (to meet Industry/Profession requirements)**

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POs met through Gaps in the Syllabus  
 Topics beyond syllabus/Advanced topics/Design  
 POs met through Topics beyond syllabus/Advanced topics/Design

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION  
 PROCEDURE**

**Direct Assessment**

| Assessment Tool                | % Contribution during CO Assessment |
|--------------------------------|-------------------------------------|
| Continuous Internal Assessment | 50                                  |
| Semester End Examination       | 50                                  |

| Continuous Internal Assessment | % Distribution |
|--------------------------------|----------------|
| 3 Quizzes                      | 30 % (3 × 10%) |
| Assignment (s)                 | 10             |
| Seminar before a committee     | 10             |

| Assessment Components          | CO1 | CO2 | CO3 | CO4 | CO5 |
|--------------------------------|-----|-----|-----|-----|-----|
| Continuous Internal Assessment |     |     |     |     |     |
| Semester End Examination       |     |     |     |     |     |

**Indirect Assessment –**

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

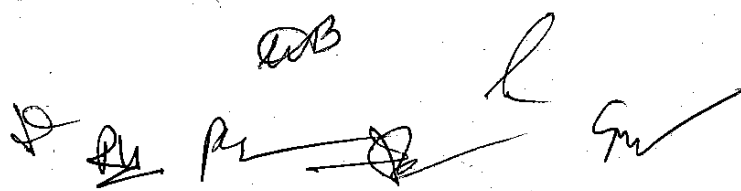
| Course Delivery methods |  |
|-------------------------|--|
| CD1                     | Lecture by use of boards/LCD projectors/OHP projectors |
| CD2                     | Tutorials/Assignments                                  |
| CD3                     | Seminars   |
| CD4                     | Self- learning advice using internets                  |
| CD5                     | Industrial visit                                       |

**MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES**

| Course Outcome # | Program Outcomes |     |     |     |     |     |
|------------------|------------------|-----|-----|-----|-----|-----|
|                  | PO1              | PO2 | PO3 | PO4 | PO5 | PO6 |
| CO1              | 1                | 1   | 1   | 2   | 2   | 1   |
| CO2              | 1                | 1   | 1   | 2   | 3   |     |
| CO3              | 1                | 1   | 2   | 3   | 3   | 1   |
| CO4              | 1                | 1   | 1   | 3   | 2   | 1   |
| CO5              | 1                | 2   | 1   | 3   | 3   | 1   |

< 34% = 1, 34-66% = 2, > 66% = 3

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**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD**

| Mapping between CO and CD |  |                         |
|---------------------------|--|-------------------------|
| CD                        | Course Delivery methods                                | Course Outcomes         |
| CD1                       | Lecture by use of boards/LCD projectors/OHP projectors | CO1, CO2, CO3, CO4, CO5 |
| CD2                       | Tutorials/Assignments                                  | CO2, CO3                |
| CD3                       | Seminars   | CO4, CO5                |
| CD4                       | Self- learning advice using internets                  | CO2, CO3, CO4, CO5      |
| CD5                       | Industrial visit                                       | CO1, CO4, CO5           |

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