**ANNA UNIVERSITY, CHENNAI**
**UNIVERSITY DEPARTMENTS**
**REGULATIONS – 2023**
**CHOICE BASED CREDIT SYSTEM**
**M.E. COMPUTER INTEGRATED MANUFACTURING**

**THE VISION OF THE DEPARTMENT OF MANUFACTURING ENGINEERING:**

To be an outstanding department where students can gain acumen to be brewed them such that they unswervingly meet the needs of the society.

**THE MISSION OF THE DEPARTMENT OF MANUFACTURING ENGINEERING:**

- To foster the growth of its members and develop them in new vistas promoting them to their fullest cognition.
- To be nationally recognized as the leader of Manufacturing Engineering in education and research.
- Bring augmentation to the Department, College and University.
- Discern the potential of its members.
- Have its members vivaciously conscripted nationally by employees and graduate programs.
- To evoke new ideas in the minds of its members and infuse nascent technology to modern era of manufacturing.

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**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

I. To train students to independently carry out research / investigations, prepare technical report/ documents and development work to solve practical problems.
II. To train students to demonstrate mastery in the area of computer integrated manufacturing at a higher level.
III. To train students to pursue professional career in manufacturing industries/educational institutions/research & development organisations as well as in allied fields and excel as an individual and also as a team player in multidisciplinary environments.
IV. To train students to provide solutions to industrial/research problems considering economic, environmental and social contexts for sustainable development.

**PROGRAMME OUTCOMES (POs):**

The programme outcomes of the Computer Integrated Manufacturing Postgraduate students are given below:

PO1: An ability to independently carry out research /investigation and development work to solve practical problems
PO2: An 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 programme.
PO4: Ability to apply inter-disciplinary knowledge in various functional areas of Computer Integrated Manufacturing and will be familiar with engineering hardware/software and equipments as practiced in manufacturing industries to formulate and solve real time problems.
PO5: Identify and apply automation and use the latest technology in continuous improvement of manufacturing systems and processes with the integration of design system.
PO6: Motivated to have out-of-the-box thinking in becoming entrepreneurs/start-ups by developing new manufacturing systems and assessing the feasibility of technical, financial, research initiatives, and social perspectives.

**PEO / PO Mapping:**

| PROGRAMME EDUCATIONAL OBJECTIVES | PROGRAMME OUTCOMES | | | | | |
|---|---|---|---|---|---|---|
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
| I | 3 | 3 | 3 | 3 | 2 | 3 |
| II | 3 | 3 | 1 | 3 | 2 | 2 |
| III | 1 | 1 | 3 | 3 | 1 | 3 |
| IV | 3 | 1 | 3 | 3 | 1 | 3 |

1,2,3, -, scale against the correlation PO's with PEO's



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## PROGRAM ARTICULATION MATRIX

| | | Course Name | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|---|---|
| I Year | Semester 1 | Statistical Methods for Engineers | 3 | 1 | 1 | 1 | 1 | 1 |
| | | Research Methodology and IPR | 3 | 3 | 1 | 3 | 3 | 3 |
| | | Computer Applications in Design | 2 | 1 | 3 | 3 | 3 | 3 |
| | | Computer Aided Manufacturing | 3 | 2 | 3 | 3 | 3 | 3 |
| | | Solid Freeform Manufacturing | 3 | 2 | 2 | 2 | 3 | 2 |
| | | Professional Elective - I | | | | | | |
| | | Computer Aided Manufacturing Laboratory | 3 | 2 | 2 | 3 | 2 | 2 |
| | Semester 2 | Advanced Metrology | 3 | 1 | 2 | 3 | 3 | 3 |
| | | Manufacturing Planning and Control Systems | 3 | 1 | 3 | 3 | 3 | 3 |
| | | Advances in Manufacturing Technology | 3 | 2 | 3 | 3 | 3 | 3 |
| | | Professional Elective II | | | | | | |
| | | Professional Elective III | | | | | | |
| | | Advanced Manufacturing Technology Laboratory | 3 | 3 | 2 | 3 | 3 | 3 |
| II Year | Semester 3 | Professional Elective IV | | | | | | |
| | | Professional Elective V | | | | | | |
| | | Professional Elective VI | | | | | | |
| | | In Plant Training / Internship | 2 | 3 | 2 | 3 | 3 | 3 |
| | | Project Work - I | 3 | 3 | 2 | 3 | 3 | 3 |
| | Semester 4 | Project Work - II | 3 | 3 | 2 | 3 | 3 | 3 |



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**CHOICE BASED CREDIT SYSTEM**
**M.E. COMPUTER INTEGRATED MANUFACTURING**
**CURRICULUM AND SYLLABI FOR SEMESTERS I TO IV**

**SEMESTER I**

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | MA3161 | Statistical Methods for Engineers | FC | 4 | 0 | 0 | 4 | 4 |
| 2. | CI3101 | Computer Applications in Design | PCC | 3 | 0 | 4 | 7 | 5 |
| 3. | CI3102 | Computer Aided Manufacturing | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | CI3151 | Solid Freeform Manufacturing | PCC | 3 | 0 | 0 | 3 | 3 |
| 5. | | Professional Elective - I | PEC | 3 | 0 | 0 | 3 | 3 |
| 6. | RM3151 | Research Methodology and IPR | RMC | 2 | 1 | 0 | 3 | 3 |
| **PRACTICAL** | | | | | | | | |
| 7. | CI3111 | Computer Aided Manufacturing Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **18** | **1** | **8** | **27** | **23** |

**SEMESTER II**

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | CI3201 | Advanced Metrology | PCC | 3 | 0 | 4 | 7 | 5 |
| 2. | CI3202 | Manufacturing Planning and Control Systems | PCC | 3 | 0 | 0 | 3 | 3 |
| 3. | CI3203 | Advances in Manufacturing Technology | PCC | 3 | 0 | 0 | 3 | 3 |
| 4. | | Professional Elective II | PEC | 3 | 0 | 0 | 3 | 3 |
| 5. | | Professional Elective III | PEC | 3 | 0 | 0 | 3 | 3 |
| **PRACTICAL** | | | | | | | | |
| 6. | CI3211 | Advanced Manufacturing Technology Laboratory | PCC | 0 | 0 | 4 | 4 | 2 |
| | | | **TOTAL** | **15** | **0** | **8** | **23** | **19** |

## SEMESTER III

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **THEORY** | | | | | | | | |
| 1. | | Professional Elective IV | PEC | 3 | 0 | 0 | 3 | 3 |
| 2. | | Professional Elective V | PEC | 3 | 0 | 0 | 3 | 3 |
| 3. | | Professional Elective VI | PEC | 3 | 0 | 0 | 3 | 3 |
| **PRACTICAL** | | | | | | | | |
| 4. | CI3311 | In Plant Training / Internship* | EEC | 0 | 0 | 4 | 4 | 2 |
| 5. | CI3312 | Project Work - I | EEC | 0 | 0 | 12 | 12 | 6 |
| | | | **TOTAL** | **9** | **0** | **16** | **25** | **17** |

* During Second Semester holidays

## SEMESTER IV

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS |
|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | |
| **PRACTICAL** | | | | | | | | |
| 1. | CI3411 | Project Work - II | EEC | 0 | 0 | 24 | 24 | 12 |
| | | | **TOTAL** | **0** | **0** | **24** | **24** | **12** |

**TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE = 71**



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## FOUNDATION COURSES (FC)

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C | Semester |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | MA3161 | Statistical Methods for Engineers | FC | 4 | 4 | 0 | 0 | 4 | I |

## PROGRAM CORE COURSES (PCC)

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C | Semester |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | CI3101 | Computer Applications in Design | PCC | 7 | 3 | 0 | 4 | 5 | I |
| **2.** | CI3102 | Computer Aided Manufacturing | PCC | 3 | 3 | 0 | 0 | 3 | I |
| **3.** | CI3151 | Solid Freeform Manufacturing | PCC | 3 | 3 | 0 | 0 | 3 | I |
| **5.** | CI3111 | Computer Aided Manufacturing Laboratory | PCC | 4 | 0 | 0 | 4 | 2 | I |
| **6.** | CI3201 | Advanced Metrology | PCC | 7 | 3 | 0 | 4 | 5 | II |
| **7.** | CI3202 | Manufacturing Planning and Control Systems | PCC | 3 | 3 | 0 | 0 | 3 | II |
| **8.** | CI3203 | Advances in Manufacturing Technology | PCC | 3 | 3 | 0 | 0 | 3 | II |
| **10.** | CI3211 | Advanced Manufacturing Technology Laboratory | PCC | 4 | 0 | 0 | 4 | 2 | II |
| | | | | | **TOTAL CREDITS** | | | **26** | |



## RESEARCH METHODOLOGY AND IPR COURSES (RMC)

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C | Semester |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | RM3151 | Research Methodology and IPR | RMC | 3 | 2 | 1 | 0 | 3 | I |
| | | | | | | | **TOTAL CREDITS** | **3** | |

## PROFESSIONAL ELECTIVES COURSES (PEC)

| SL. NO. | COURSE CODE | COURSE TITLE | CATEGORY | PERIODS PER WEEK | | | TOTAL CONTACT PERIODS | CREDITS | Semester |
|---|---|---|---|---|---|---|---|---|---|
| | | | | L | T | P | | | |
| 1. | CI3051 | Advances in Welding and Casting Technology | PEC | 3 | 0 | 0 | 3 | 3 | I |
| 2. | CI3001 | Theory of Metal Cutting | PEC | 3 | 0 | 0 | 3 | 3 | I |
| 3. | CI3002 | Product Innovation and Development | PEC | 3 | 0 | 0 | 3 | 3 | I |
| 4. | CI3003 | Electronics Packaging | PEC | 3 | 0 | 0 | 3 | 3 | I |
| 5. | IL3056 | Advanced Optimization Techniques | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 6. | CI3052 | Design for Manufacturing and Assembly | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 7. | CI3053 | Micro and Nano Manufacturing | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 8. | CI3004 | Finite Element Analysis in Manufacturing Engineering | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 9. | CI3005 | Precision Engineering | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 10. | CI3054 | System Simulation for Manufacturing Engineers | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 11. | CI3006 | Competitive Manufacturing Systems | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 12. | CI3007 | Applied Materials Engineering | PEC | 3 | 0 | 0 | 3 | 3 | II |
| 13. | CI3008 | Design for Additive Manufacturing | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 14. | IL3251 | Supply Chain Systems and Management | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 15. | QE3251 | Lean Six Sigma | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 16. | CI3009 | Enterprise Resource Planning | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 17. | IL3054 | Industrial Automation and Robotics | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 18. | CI3010 | Sustainable Manufacturing | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 19. | CI3011 | Sensors for Manufacturing and Condition Monitoring | PEC | 3 | 0 | 0 | 3 | 3 | III |
| 20. | MN3052 | Mechatronics in Manufacturing | PEC | 3 | 0 | 0 | 3 | 3 | III |



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## EMPLOYABILITY ENHANCEMENT COURSES (EEC)

| S. No | COURSE CODE | COURSE TITLE | CATEGORY | CONTACT PERIODS | L | T | P | C | Semester |
|---|---|---|---|---|---|---|---|---|---|
| **1.** | CI3311 | In Plant Training / Internship | EEC | 4 | 0 | 0 | 4 | 2 | III |
| **2.** | CI3312 | Project Work - I | EEC | 12 | 0 | 0 | 12 | 6 | III |
| **3.** | CI3411 | Project Work - II | EEC | 24 | 0 | 0 | 24 | 12 | IV |

### SUMMARY

| | M.E. COMPUTER INTEGRATED MANUFACTURING | | | | | |
|---|---|---|---|---|---|---|
| | SUBJECT AREA | CREDITS PER SEMESTER | | | | CREDITS TOTAL |
| | | I | II | III | IV | |
| **1.** | **FC** | **4** | **-** | **-** | **-** | **4** |
| **2.** | **PCC** | **13** | **13** | **-** | **-** | **26** |
| **3.** | **PEC** | **3** | **6** | **9** | **-** | **18** |
| **4.** | **RMC** | **3** | **-** | **-** | **-** | **3** |
| **5.** | **EEC** | **-** | **-** | **8** | **12** | **20** |
| **7.** | **TOTAL CREDITS** | **23** | **19** | **17** | **12** | **71** |

**MA3161 STATISTICAL METHODS FOR ENGINEERS L T P C**
**4 0 0 4**

**OBJECTIVES:**

- To enable them to estimate the value of the parameters involved in the specific distribution from a possible continuum of alternatives.
- To give an idea of testing the statistical hypothesis claimed based on a set of data points using suitable test statistics which follows standard sampling distributions.
- To establish a relationship that make it possible to predict one or more variable in terms of others using correlation and regression analysis.
- To introduce the various experimental designs and their corresponding analysis of variance which play vital role in many real time scenarios.
- To impart knowledge of handling random vectors which represent random variables in multi-dimensional space.

**UNIT I ESTIMATION THEORY 12**

Estimators: Unbiasedness, Consistency, Efficiency and Sufficiency–Maximum Likelihood Estimation – Method of moments.

**UNIT II TESTING OF HYPOTHESIS 12**

Tests based on Normal, *t*, $\chi^2$ and *F* distributions for testing of means, variance and proportions – Analysis of *r x c* tables – Goodness of fit.

**UNIT III CORRELATION AND REGRESSION 12**

Multiple and Partial Correlation - Method of Least Squares- Plane of Regression - Properties of Residuals - Coefficient of Multiple Correlation - Coefficient of Partial Correlation - Multiple Correlation with total and partial correlations - Regression and Partial correlations in terms of lower order coefficients.

**UNIT IV DESIGN OF EXPERIMENTS 12**

Analysis of variance – One-way and two-way classifications – Completely randomized design – Randomized block design – Latin square design.

**UNIT V MULTIVARIATE ANALYSIS 12**

Random vectors and Matrices – Mean vectors and Covariance matrices – Multivariate Normal density and its properties – Principal components: Population principal components – Principal components from standardized variables.

**TOTAL: 60 PERIODS**

**OUTCOMES:**

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

**CO1** Obtain the value of the point estimators using the method of moments and method of maximum Likelihood.

**CO2** Use various test statistics in hypothesis testing for mean and variances of large and small samples.

**CO3** Determine the regression line using the method of least square and also to calculate the partial and multiple correlation coefficient for the given set of data points.

**CO4** Test the hypothesis for several means using one way, two way or three way classifications.

**CO5** Get exposure to the principal component analysis of random vectors and matrices.

**REFERENCES:**


1. Devore, J.L., “Probability and Statistics for Engineering and the Sciences”, Thomson and Duxbury, Singapore, 6th Edition, Boston, 2004.
2. Gupta, S.C., and Kapoor, V.K., “Fundamentals of Mathematical Statistics”, Sultan Chand and Sons, Eleventh Edition, Reprint, New Delhi, 2019.
3. Johnson, R. A. and Gupta, C. B., “Miller & Freund’s Probability and Statistics for Engineers”, Pearson Education, Asia, Eighth Edition, New Delhi, 2015.
4. Johnson, R.A., and Wichern, D.W., “Applied Multivariate Statistical Analysis”, Pearson Education, Sixth Edition, New Delhi, 2013.
5. Spiegel, M.R. and Stephens, L.J.,” Schaum’s outlines on Statistics”, Tata McGraw-Hill, 6th Edition, New York, 2018.


**CO-PO Mapping:**

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



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| CI3101 | COMPUTER APPLICATIONS IN DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 4 | 5 |

**OBJECTIVES:**

- To understand fundamental concepts of computer graphics and its tools in a genericframework, geometric models using curves, surfaces and solids.
- To provide clear understanding of CAD systems for 3D modeling and viewing.
- To create strong skills of assembly modeling and prepare the student to be an effective userof a standards in CAD system.

**UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9**

Graphic display, Line and circle drawing algorithms - Filled area primitives, attributes to output primitives - Two Dimensional Geometric transformations, Viewing and clipping – Coordinate Transformations – Three dimensional transformations.

**UNIT II CURVES AND SURFACES MODELLING 9**

Curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations. Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – Synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface- surface manipulations.

**UNIT III NURBS AND SOLID MODELING 9**

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations - constructive solid Geometry - comparison of representations - user interface for solid modeling.

**UNIT IV VISUAL REALISM 9**

Hidden Line removal, Hidden Surface removal, – Hidden Solid Removal algorithms - Shading – Coloring. Animation - Conventional, Computer animation, Engineering animation - types and techniques.

**UNIT V ASSEMBLY OF PARTS AND PRODUCT LIFE CYCLE MANAGEMENT 9**

Mass properties, assembly modeling, Product Data Exchange – Geometric tolerances, Tolerance practice in drafting and manufacturing – Tolerance modeling, analysis and synthesis – Managing product life cycle



**LECTURE : 45 PERIODS**

**LIST OF EXPERIMENTS:**

**CAD MODULE**

1. Sketching and Part modelling (Solid modelling, Surface modelling, Feature manipulation) of mechanical components using CAD software package.
2. Assembly (Constraints, Exploded Views, Interference check) and Drafting (Layouts, Geometric Dimensions &Tolerance Standards, Sectional Views, & Detailing) of mechanical components using CAD software package.
3. Working with CAD Data Exchange formats: IGES, PDES, PARASOLID, DXF and STL.
4. Study and exercise on freeform modelling.
5. Reverse engineering the given product/component and convert the data into 3D model.
6. Exercise on. STL file Preparation, Slicing, Support Structure Generation & Build setup Preparation.

**CAE MODULE**

7. Finite Element Analysis (FEA) using Pre-processing (solid modelling, meshing, analysis setup) and post processing (graphical display and report) with CAE software package
8. Finite Element Analysis (FEA) for plastic deformation using nonlinear material models with CAE software package

**LAB : 60 PERIODS**

**LIST OF ITEMS (Hardware/Software) REQUIRED:**

1. Computers 24 Nos.
2. CAD software Package
3. Open source CAD software for Additive Manufacturing
4. CAE Software package

**TOTAL: 105 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Solve 2D and 3D transformations of geometric models.
CO 2: Formulate the curve and surface model to CAD system.
CO 3: Formulate the NURBS and solid model to CAD system.
CO 4: Create visual realism of the geometric models.
CO 5: Perform assembly modeling and tolerance practices

**CO - PO MAPPING :**

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



**REFERENCES:**


1. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2nd Edition, 2006
2. David Rogers, James Alan Adams “Mathematical Elements for Computer Graphics” 2nd Edition, Tata McGraw-Hill edition.2002
3. Boothroyd, G, “Assembly Automation and Product Design” Marcel Dekker, New York, 1991.
4. Chitale A.K and Gupta R.C “ Product design and manufacturing “ PHI learning private limited, 6th Edition, 2015.
5. Donald D Hearn and M. Pauline Baker “Computer Graphics C Version”, Prentice Hall, Inc., 2nd Edition, 1996.
6. William M Newman and Robert F.Sproull “Principles of Interactive Computer Graphics”, Mc Graw Hill Book Co. 1stEdition, 2001

| CI3102 | COMPUTER AIDED MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To introduce the evolution of CAD, CAM, CIM, engineering product specification and interpreting geometric specifications.
- To train the candidates on the integration of Computer Aided Design and Computer Aided Manufacturing and to introduce with the implementation of CAD and CAM in manufacturing process
- To impart knowledge on manual part program and generation of CNC part program using Computer Aided Manufacturing packages and to introduce the importance of Internet of Things in Computer Aided Manufacturing..

**UNIT I INTRODUCTION TO CAM 9**

Introduction CAD, CAM, CAE, CIM, system configuration for CAM including hardware and software, evolution of product realization, historical development, engineering product specification. Geometric Tolerancing – ASME, ISO and DIN standards, interpreting geometric specifications, multiple part features and datum.

**UNIT II CAD AND CAM INTEGRATION 9**

Introduction - Networking - Techniques, components, interface cards, network standards, Graphics standards - Graphical kernel system, Data exchange format - IGES and STEP. Integration of CAD and CAM in CNC turning center, machining center.
Process planning, Computer Aided Process Planning (CAPP), Product life cycle management (PLM), Enterprise resource planning (ERP).

**UNIT III CNC MACHINES 9**

CNC Machine building, structural details, guide ways –Friction, Anti friction and other types of guide ways, elements used to convert the rotary motion to a linear motion – Screw and nut, recirculating ball screw, spindle assembly, torque transmission elements – gears, timing belts, flexible couplings, Bearings, Spindle drives and feed drives, Linear Motors- open loop and closed loop control, Axis measuring system, grating, linear scale, encoder, laser interferrometer - Axes & Spindle Cooling System - Through Coolant & Shower Coolant - Integral Spindle With HSK & Big Plus Spindle - Double Ball Screws - Grease Lubricating System - Probing For Zero Offsets and First Off Inspection - Tool Breakage Detecting System - In Process Gauging System, ATC, APC.

**UNIT IV PROGRAMMING OF CNC MACHINES 9**

Structure of CNC program, Coordinate system, G & M codes, cutter radius compensation, tool nose radius compensation, tool wear compensation, canned cycles, mirroring features, Manual part programming for CNC turning, machining center, macro programming, wire electric discharge machining, abrasive water jet cutting machine, bulk and sheet metal forming, generation of CNC program using CAM softwares.

**UNIT V IOT IN CAM 9**

Introduction, overview of IOT enabled manufacturing system, Real-time and multi-source manufacturing information sensing system, IOT enabled smart assembly station, cloud computing based manufacturing resources configuration method, Real-time key production performances analysis method, Real-time information driven production scheduling system.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Recognize the importance of CAD, CAM, CIM, Engineering product specification and interpreting geometric specifications.

CO 2: Improve knowledge on the integration of CAD and CAM.

CO 3: Exhibit competency in manual part program and generation of CNC part program using CAM packages.

CO 4: Describe the implementation of CAD and CAM in manufacturing processes

CO 5: Explain applications of IOT in computer aided manufacturing

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Radhakrishnan P., “Computer Numerical Control ", New Central Book Agency, India,1992.
2. Nee Y.C., Soh K. Ong, Yun G. Wang., “Computer Applications in Near Net-Shape Operations”, Springer, United Kingdom, 2012.
3. Yingfeng Zhang and Fei Tao, “Optimization of Manufacturing Systems Using the Internet of Things” Academic Press, United Kingdom, 2017.
4. Chang T.C., Wysk, R.A. and Wang.H.P., “Computer Aided Manufacturing”, Pearson Prentice Hall, India ,2009, ISBN: 978-0131429192.
5. HMT,“Mechatronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2005.
6. Rao P.N., “CAD/CAM”, 3rd Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2010, ISBN-13: 978-0070681934

| CI3151 | SOLID FREEFORM MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To gain knowledge on evolution of Solid Freeform Manufacturing (SFM) and the importance of DfAM in improving the quality.
- To acquaint with various SFM Technologies and hybrid processes, along with their material science and applications in different fields.

**UNIT I INTRODUCTION 9**

Introduction to solid freeform manufacturing (SFM) - Need- SFM evolution, Distinction between SFM & CNC machining- Development of SFM systems — Hierarchical structure of SFM - SFM process chain — Classification. SFM Supply chain - Economics aspect: Strategic aspect- Operative aspect

**UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DfAM) 9**

Concepts and Objectives- General Guidelines for DfAM - DfAM tools, Requirements of DfAM methods, - Additive Manufacturing (AM) Unique Capabilities –Design Consideration in AM- Part Consolidation – Computational tools for design analysis- Topology Optimization - Lightweight Structures – Generative design- DfAM for Part Quality Improvement - CAD Modeling - Model Reconstruction - Data Processing for AM - Data Formats: STL, AMF,PLY, VRML- Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation.

**UNIT III VAT POLYMERIZATION, MATERIAL EXTRUSION & SHEET LAMINATION TECHNOLOGIES 9**

Vat polymerization: Stereolithography Apparatus (SLA): Principles — Photo Polymerization of SL Resins - Pre Build Process — Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Capabilities - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process – Capabilities and Applications. Continuous Liquid Interface Production (CLIP)- Materials - Process - Capabilities and Applications. Material extrusion: Fused deposition Modeling (FDM): Working Principles - Process - Materials – Capabilities and Applications. Design Rules for FDM. Sheet lamination processes: Laminated Object Manufacturing (LOM): Working Principles - Process – Materials- Capabilities- Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters –Capabilities- Applications. Case Studies.

**UNIT IV POWDER BED FUSION, BINDER JETTING, MATERIAL JETTING & DIRECT ENERGY DEPOSITION TECHNOLOGIES 9**

Powder Bed Fusion: Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure -Materials - Surface Deviation and Accuracy – Capabilities- Applications. Multi-jet Fusion Principles – Processes - Materials — Capabilities and Applications. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles — Processes — Materials — Capabilities - Limitations and Applications. Binder Jetting: Three dimensional Printing (3DP): Principles - Process - Physics of 3DP - Process — Materials - Capabilities - Limitations - Applications. Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Capabilities and Application. Direct Energy Deposition: Laser Engineered Net Shaping (LENS): Processes- Materials- Capabilities - Limitations and Applications. Hybrid Additive Manufacturing – Need - Principles - Part Quality and Process Efficiency. Wire Arc Additive Manufacturing (WAAM) Processes- Materials- Capabilities - Limitations and Applications. Case Studies.

**UNIT V MATERIALS AND APPLICATIONS OF SFM 9**

Materials science for SFM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship. Application of SFM in Automotive-Aerospace-Bio Medical-Bio printing- Food Printing- Electronics printing — Rapid Tooling - Building printing.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Explore the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain

CO 2: Recognize the importance of DfAM in improving the quality of fabricated parts and understand the guidelines of DfAM

CO 3: Acquire knowledge on principles and applications of vat polymerization, material extrusion and sheet lamination processes with case studies.

CO 4: Acquire knowledge on principles of powder bed fusion, jetting, direct energy deposition and hybrid processes

CO 5: Understand the properties and characteristics of materials used in SFM/AM and explore the applications in various fields.

**CO - PO MAPPING :**

| CO | PO | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| 2 | 3 | 3 | 2 | 2 | 2 | 3 |
| 3 | 3 | 2 | 3 | 3 | 3 | 2 |
| 4 | 3 | 3 | 2 | 3 | 3 | 2 |
| 5 | 3 | 2 | 3 | 2 | 3 | 3 |
| Avg | 2.6 | 2.4 | 2.4 | 2.2 | 2.6 | 2.4 |

**REFERENCES:**


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3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
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**RM3151 RESEARCH METHODOLOGY AND IPR L T P C**
**2 1 0 3**

**OBJECTIVES:**

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

**UNIT I RESEARCH PROBLEM FORMULATION 9**

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

**UNIT II RESEARCH DESIGN AND DATA COLLECTION 9**

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

**UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9**

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

**UNIT IV INTELLECTUAL PROPERTY RIGHTS 9**

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

**UNIT V PATENTS 9**

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES**

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

**REFERENCES:**


1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
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| CI3111 | COMPUTER AIDED MANUFACTURING LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**OBJECTIVES:**

- To familiarize students with manual CNC part programming and part programs using CAM packages for milling and turning machines.
- To train students with dimensional and geometric measurements for machined features using video measuring system and coordinate measuring machine.
- To get hands on knowledge on programming logic controller - ladder programming, robot programming and Material requirements planning.

**LIST OF EXPERIMENTS:**

1. Programming and simulation for various operations using canned cycle for CNC turning Centre.
2. Programming and simulation for machining of internal surfaces in CNC turning Centre
3. Programming and simulation for profile milling operations
4. Programming and simulation for circular and rectangular pocket milling
5. Programming and simulation using canned cycle for CNC Milling such as peck drilling and tapping cycle
6. CNC code generation using CAM software packages – Milling
7. CNC code generation using CAM software packages – Turning
8. Dimensional and geometric measurement of machined features using VMS and CMM
9. PLC ladder logic programming.
10. Robot programming for Material handling applications.
11. Study on RDBMS and its application in problems like inventory control MRP.
12. Design and fabrication of a component using extrusion based additive manufacturing.

**TOTAL: 60 PERIODS**

**LIST OF ITEMS (Hardware/Software) REQUIRED:**

1. Computers 30
2. CAM Software for 3 axis machining or more
3. CNC Production type turning or Machining center
4. Video Measuring System
5. Coordinate Measuring Machine
6. Surface Roughness tester
7. 5 -axis Robot
8. Programmable Logic Controller with ladder logic programming software
9. RDMBS Package with relevant modules like Inventory Control and MRP
10. 3D Printer

**COURSE OUTCOMES:**

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

CO 1:Exhibit competency in manual CNC part programming for milling and turning machines

CO 2: Demonstrate generation of part programs using CAM packages for milling and turning Machines and geometric measurements of machined features using CMM

CO 3: Demonstrate PLC ladder and robot programming and appreciate the application RDBMS in MRP

**CO - PO MAPPING :**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 3 | 3 |
| CO3 | 3 | 2 | 2 | 3 | 3 | 3 |

| CI3201 | ADVANCED METROLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 4 | 5 |

**OBJECTIVES:**

- To teach the students about the concepts of metrology.
- To train the students in the field of surface roughness measurement, form measurements and interferometry.
- To introduce some fundamental principles of CAI, Laser metrology, Image processing on Machine vision.

**UNIT I CONCEPTS OF METROLOGY 9**

Introduction - Terminologies - Standards of measurement - Interchangeability - Selective assembly - Accuracy and Precision – Calibration of instruments – Errors in measurements – Limits – Fits - Tolerances – Process capabilities - Laboratory accreditation, Basics of dimensional metrology and Form metrology – Form, Fits, functions, Clean room - Maintenance and handling of metrology equipment's - Standard practices of inspection rooms – Linear and Angular measurements – Comparators.

**UNIT II MEASUREMENT OF SURFACE ROUGHNESS 9**

Introduction – Types of Surface Texture - Surface Roughness Measurement Methods - Roughness parameters, bearing area parameters, Contact and Non-Contact type roughness measuring instruments, 3D Surface Roughness Measurement - Nano Level Surface Roughness Measurement – Instruments: Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM), Scanning and Transmission Electron Microscope(STEM), Atomic Force Microscopy(AFM).

**UNIT III INTERFEROMETRY AND FORM MEASUREMENTS 9**

Introduction - Principles of Interferometry - Optical flats in assessing surface contours - Interferometers – Measurement and Calibration - Laser Interferometry - Engineering applications of interferometry - Form measurements - flatness, straightness, roundness, cylindricity.

**UNIT IV COMPUTER AIDED INSPECTION AND LASER METROLOGY 9**

Introduction – Computer Aided Inspection Techniques - Tool Makers Microscope – Coordinate Measuring Machines - Advantages, limitations – Applications – Advanced Laser gauging techniques – Lasers in precision Measurements – Laser Scanners for Reverse Engineering - In-process inspection -Industrial case studies. DIC (digital image correlation), Perceived quality.

**UNIT V MACHINE VISION AND IMAGE PROCESSING 9**

Introduction - Machine vision – Overview - Computer imaging systems, Applications of Machine vision- Advantages and limitations-Image Analysis, Preprocessing, Human Vision System, Image model, Image enhancement, gray scale models, histogram models, Image Transforms - Applications of image processing -Advantages and limitations and Case studies.

**LECTURE : 45 PERIODS**

**LIST OF EXPERIMENTS:**

1. Calibration of comparators using slip gauges
2. Assessment of gauge surfaces using optical flats
3. Measurement of Surface roughness of specimens using contact method
4. Non-contact surface roughness measurement of specimens
5. Counting of fringes produced by Michelson's interferometer
6. Measurement of dimensional features using machine vision system
7. Study exercises on clean room behaviour
8. Roundness and cylindricity measurement of components

9. Study on flatness measurement of surface using autocollimator
10. Measurement of dimensional features of a specimen - Contact type using CMM.

**LAB: 60 PERIODS**

**TOTAL: 105 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Explain the fundamental concepts of measurement, standards, calibration, maintenance of laboratory facilities and handling of metrological equipments

CO 2: Explain roughness and its applications in manufacturing research, learn the important concepts, principles and applications related to interferometry.

CO 3: Discuss the use of interferometry related sophisticated measurement and inspection facilities.

CO 4: Execute the concepts of Computer aided inspection technologies for industrial Situations, design and develop new inspection techniques.

CO 5: Describe the importance of image processing techniques and the possibilities of developing new heuristics for image processing related to metrology.

**CO - PO MAPPING:**

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

**REFERENCES:**


1. "ASTE Handbook of Industries Metrology", Prentice Hall of India Ltd., India,1992.
2. Bewoor A.K. and Kulkarni V.A.,"Metrology and Measurement", Tata McGraw-Hill, India, 2009.
3. Galyer F.W. and Shotbolt C.R., "Metrology for engineers", ELBS, Germany, 1990.
4. Jain R.K., "Engineering Metrology", Khanna Publishers, India, 2008.
5. Smith G.T., "Industrial Metrology", Springer, United States, 2002.

| CI3202 | MANUFACTURING PLANNING AND CONTROL SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To introduce students with Current Trends in Manufacturing Planning and Control System
- To be familiarized with the functions of automated shop floor control and Computerized Process Monitoring.

**UNIT I MANUFACTURING PLANNING AND CONTROL AND FORECASTING 9**

Introduction: Production Planning and Control-Limitations with Traditional Production Planning and Control-Need and Evolution of Manufacturing Planning and Control (MPC) System -Basic framework - Demand Management in MPC System- Forecasting**:** Time Horizon, Design of Forecasting Systems - Developing the Forecast Logic– Qualitative methods: Delphi Technique, Market Research, Quantitative methods -Time Series - Moving Averages, Exponential Smoothing - Regression- Measure of Forecast Accuracy- Numerical Problems.

**UNIT II AGGREGATE PRODUCTION PLANNING 9**

Introduction-Need for Aggregate production planning (APP) - Alternatives for Managing Demand- Reservation of Capacity, Influencing Demand - Alternatives for Managing Supply - Inventory based Capacity Adjustment, Capacity Augmentation, Basic Strategies - Level, Chase, Mixed - Numerical Problems - APP Methods - Heuristic Methods, Optimal Methods.

**UNIT III RESOURCE PLANNING 9**

Open-loop control systems: Basic definitions – items and BOMs- Order models of control-Basic reorder point theory- ROP limitations- Use of safety stock- EOQ theory-Material requirements planning (MRP) Closed-loop MRP: Closed-loop control-Mechanism for closed-loop control- Manufacturing resource planning-Development of ERP from MRPII-Master production scheduling: Reasons to master schedule-MPS stability-MPS mechanics-Two level MPS techniques-Management aspects of MPS-Finite and infinite capacity planning: Limitations of MRPII-Infinite vs finite capacity scheduling -Schedule optimization -Sequencing - Short interval scheduling -Problems of finite capacity scheduling -Feedback and work to lists - Rough-cut capacity planning- Optimized production technology- OPT principles - OPT scheduling logic- Case study- Just-in-time: Japanese manufacturing practice – Kanban- ERP extensions to support Kanban- Pre-requisites for Kanban- Influence of JIT-JIT and purchasing

**UNIT IV SHOP FLOOR CONTROL 9**

Shop Floor Control - Functions - Shop Floor Control System - Order Release - Order Scheduling - Order Progress - Operation Scheduling-Priority Rules for Job Sequencing - The Factory Data Collection System - Online and Offline Data Collection Systems - Case studies.

**UNIT V PROCESS MONITORING AND CONTROL 9**

Computer Process Monitoring: Data Logging Systems - Data Acquisition Systems - Multilevel Scanning - Computer Control: Computer-Process Interfacing - Manufacturing Process Data - System Interpretation of Process Data - Interface Hardware Devices - Digital Input / Output Processing Interrupt system - Control Programming - Computer Process Control - Structural Model of a Manufacturing Process - Process Control Strategies-Case studies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Gain Knowledge on activities of Manufacturing Planning and Control System and to select suitable Forecasting technique

CO 2: Managing supply and demand.

CO 3:Perceive Inventory management and Resource Requirements.

CO 4: Evaluate the functions of Shop Floor Control and associated systems.

CO 5: Choose Computer Process Monitoring, Computer Process Interfacing and Process Control Strategies.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Groover M. and Zimmers E., “CAD/CAM: Computer-Aided Design and Manufacturing”, Prentice Hall., India, Reprint 2013, ISBN-13: 978-0131101302.
2. David K. Harrison, David J. Petty, “Systems for Planning and Control in Manufacturing-Systems and management for competitive manufacture”First Edition 2002, Newnes, ISBN 0 7506 49771
3. Mahadevan B., "Operations Management: Theory and practice", Pearson., India, 2015, ISBN- 13: 978-9332547520.
4. Mahapatra P.B., “Computer-Aided Production Management”, Prentice-Hall, India, 2004, ISBN- 13: 978-8120317420.
5. Nanua Singh, "System Approach to Computer Integrated Design and Manufacturing", Wiley India Edition, Reprint 2011, ISBN-13: 978-0471585176.
6. Thomas E. Vollmann, William Lee Berry, David Clay Whybark and Robert Jacobs F., “Manufacturing Planning and Control Systems for Supply Chain Management”, McGraw Hill., United States, 2014, ISBN: 9789339205331.

| CI3203 | ADVANCES IN MANUFACTURING TECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To analyze and compare different unconventional machining processes, precision machining processes and modern metal forming processes.
- To formulate smart manufacturing systems
- To implement the concepts of AI and ML in Manufacturing

**UNIT I UNCONVENTIONAL MACHINING 9**

Introduction – Electrical discharge machining – Micro electrical discharge machining - Wire electrical discharge machining – Micro wire electrical discharge machining - Electro chemical machining – Micro electro chemical machining – Abrasive water jet machining – Micro abrasive water jet machining – Laser assisted machining – Cryogenic machining – Hybrid machining processes

**UNIT II PRECISION MACHINING 9**

Introduction – Ultra precision grinding – Electrolytic in process dressing – Chemical mechanical polishing – Diamond turn machining – High speed machining – Magneto rheological finishing processes.

**UNIT III MODERN METAL FORMING 9**

Introduction – Orbital forging – Isothermal forging – Rubber pad forming –Incremental forming – Fine blanking – Powder forming: Powder rolling, Powder extrusion – High speed extrusion.

**UNIT IV INDUSTRY 5.0 9**

Introduction – Industry 5.0 – Smart manufacturing: Smart design, smart machining, smart monitoring, smart control, smart scheduling – Internet of Things – Industrial Internet of Things – Cyber physical systems – Machine to Machine communication –Cloud computing – Digital twin – Case studies.

**UNIT V DATA ANALYTICS, MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE 9**

Data Analytics – Introduction to Machine Learning and deep learning, Supervised and unsupervised algorithms – Applications of machine learning algorithms – Introduction to artificial intelligence and Artificial Neural Network in manufacturing – Case studies using chatGPT.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Differentiate unconventional machining processes
CO 2: Apply different precision machining techniques.
CO 3: Apply modern metal forming processes.
CO 4: Demonstrate the Industry 5.0 concepts.
CO 5: Apply artificial intelligence and machine learning concepts

**CO - PO MAPPING :**

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

**REFERENCES:**


1. M. Adithan, “Unconventional Machining Processes”, Atlantic, New Delhi, 2021.
2. Jain V.K., “Introduction to Micromachining”, Narosa, New Delhi, 2018.
3. Balasubramaniam R. and Ramagoplan V.S and Sathyan Subbiah, “Diamond Turn Machining”, CRC Press, USA, 2018.
4. Venkatesh V. C. and SudinIzman, “Precision Engineering”, Tata McGraw-Hill, New Delhi, 2007.
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6. Uthayan Elangovan, “Industry 5.0: The future of the Industrial Economy”, CRC Press, USA, 2021.
7. Zsolt Nagy, “Artificial Intelligence and Machine Learning Fundamentals”, Packt Publishing Ltd, UK, 2018
8. Solanki, Kumar and Nayyar, “Emerging Trends and Applications of Machine Learning”, IGI Global, USA, 2019.
9. Khim Phuc Tran, “Artificial Intelligence for smart manufacturing”, Springer, Switzerland, 2023.

| CI3211 | ADVANCED MANUFACTURING TECHNOLOGY LABORATORY | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**OBJECTIVES:**

- To familiarize the students with manual part program and generation of program using CAM package.
- To gain knowledge in robot programming, traditional and nontraditional micro machining processes, and fabrication of composite materials.
- To familiarize the students with additive manufacturing processes.

**LIST OF EXPERIMENTS:**

1. Generation of CNC part programs and machining components for 5 axis CNC machining center.
2. Machining using CNC wire EDM.
3. Thin film multilayer coating using PVD coating equipment.
4. Machining using Abrasive water jet machine.
5. Micro machining – micro turning, micro drilling & micro milling
6. Nontraditional micro machining – Electro Chemical Micro Machining (EMM)
7. Manufacturing of Polymer based composites using Resin Transfer Moulding Machine (RTM)
8. Fabrication of metal matrix composite using stir casting setup
9. Topology optimisation and fabrication of components using additive manufacturing process
10. Fabrication of components using different tool path strategies with material extrusion additive manufacturing process.
11. Optimisation of build time and support structure for vat photo polymerisation additive manufacturing process.
12. 5 Axis CNC Machining of aerospace alloys.

**TOTAL: 60 PERIODS**



**COURSE OUTCOMES:**

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

CO1:Demonstrate manual part program and to generate CNC program using CAM packages

CO2: Compare traditional and nontraditional micro machining processes and perform composite material fabrication.

CO3: Build parts using different additive manufacturing process.

**CO - PO MAPPING :**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 3 |

| CI3311 | INPLANT TRAINING / INTERNSHIP | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 4 | 2 |

**OBJECTIVES:**

- To familiarize students with real life situations in industrial organizations.
- To accelerate the learning process.
- To train the students to apply their gained knowledge in an Industrial organization.
- To expose students with best working practices and with ethical values.
- To inculcate integrity, responsibility, and self-confidence in student's mind.

**DURATION:** The students have to undergo practical Inplant Training / Internship for four weeks (During Second Semester holidays) in recognized industrial establishments/educational institutions / research and development organizations under the guidance of a faculty member. Periodically they have to communicate to the guide about the progress in the industry. At the end of the training, they have to submit a project report with following information:

1. Profile of the Industry
2. Product range
3. Organization structure
4. Plant layout
5. Processes/Machines/Equipment/devices
6. Personnel welfare schemes
7. Details of the training undergone
8. Learning points.

The presentation of the above will be carried out during third semester.

**COURSE OUTCOMES:**

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

CO 1: Describe structure of the Industrial organization.
CO 2: Realize the various functions of management.
CO 3: Understanding of groups and group dynamics.
CO 4: Describe the industrial culture.
CO 5: Develop skills to read, write and comprehend.

**CO - PO MAPPING :**

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

**CI3312** **PROJECT WORK - I**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 12 | 6 |

**OBJECTIVES:**

- To identify industrial problem and solve them.
- To develop good written and oral communication skills and leadership skills.
- To train the students in preparing the project reports and to face reviews.
- To develop the ability to solve a specific Industrial problem.
- To accelerate the learning process.

**EVALUATION:**

- Project work evaluation is based on Regulations of Credit System University Departments - Postgraduate programmes of Anna University

**TOTAL: 180 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Apply the knowledge gained from theoretical and practical courses in solving problems.
CO 2: Recognize the importance of literature review.
CO 3: Realize the importance of solving problems using literature review.
CO 4: Recognize the modern concepts in technology and design.
CO 5: Develop skills to read, write and comprehend.

**CO - PO MAPPING :**

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



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

| CI3411 | PROJECT WORK - II | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 24 | 16 |

**OBJECTIVES:**

- To produce factual results of their applied research idea in the Manufacturing Engineering.
- To improve research and development activities.
- To develop technical competency to provide solutions for problems.
- To accelerate the learning process.
- To develop good communication skills.

**EVALUATION:**

- Project work evaluation is based on Regulations of Credit System University Departments - Postgraduate programmes of Anna University

**TOTAL: 360 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Apply the knowledge gained from theoretical and practical courses in solving problems.
CO 2: Demonstrate a strong working knowledge of ethics and professional responsibility.
CO 3: Demonstrate effective organizational leadership and change skills.
CO 4: Realize the importance of solving problems using literature review.
CO 5: Develop skills to read, write and comprehend.

**CO - PO MAPPING :**

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

| CI3051 | ADVANCES IN WELDING AND CASTING TECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To impart knowledge on welding Metallurgy, Design and Special welding processes.
- To elaborate gating system design and casting metallurgy and to provide knowledge on Special casting processes.
- To familiarize the students with automation and environmental aspects and standards.

**UNIT I WELDING DESIGN 9**

Heat Flow in Welding: Welding Thermal Cycle (WTC)- Effect of WTC and Cooling Rate in Welding- Cooling Rate- Peak Temperature and Solidification Rate- - Residual Stress-Residual Stress -Design of Weld Joints: Introduction to Design of Weld Joints- Types of Joints and Welds- Edge Preparation- Design for Static and Fatigue Loading- Fatigue Fracture of Weld Joints-- Fatigue Fracture of Weld Joints.- Understanding Weldability-Reactions in Weldment- Failure Analysis and Prevention Testing of Welding joints -– Case Studies.

**UNIT II SPECIAL WELDING PROCESSES 9**

Micro joining And Nano joining, Wire Bonding; Fundamentals and Types of Laser Welding Including Hybrid Processes, Laser Properties; Stud Welding And Mechanical Fasteners; Magnetically Impelled Arc Welding; Advanced Gas Tungsten Arc Welding; Flux Cored Arc Welding; Electron Beam Welding; Cold Pressure Welding; Ultrasonic Welding; Explosive Welding; Diffusion Bonding; Friction Stir Welding; Electromagnetic Pulse Welding; High Velocity Projectile Impact Welding-Under water welding-Diffusion bonding.

**UNIT III CASTING DESIGN AND SOLIDIFICATION 9**

Introduction - - Pattern allowances- Introduction of gating design-Types of gate-Pouring time calculation-Aspiration effects in gating system-Problem solving on gating design-Solidification analysis-Risering methods-Shape factor-Feeding & Chills effect-Problem related to riser design- Design of thin and unequal sections - mechanism of solidification - Rapid solidification processing (RSP) - Melt spinning -Roll quenching - Vibratory solidification -Splat cooling - Thixoforming – Rheocasting - Single crystal growing- Casting defects, inspection, diagnosis and rectification – Case studies

**UNIT IV SPECIAL CASTING PROCESSES 9**

Evaporative Pattern Casting Process and full mould process – Vaccum sealed moulding - vacuum casting - Magnetic Moulding - Squeeze Casting-types – Mega Casting-Plaster mould casting - Ceramic mould casting.

**UNIT V AUTOMATION ENVIRONMENTAL ASPECTS, SPECIFICATION AND STANDARDS 9**

Fundamentals of Foundry automation-: Sand Plant, Material Handling, Mould and Core Making- Pollution control, energy and waste management in foundries. Fundamentals of welding automation - Principles of robotic welding- Welding robots, Positioners and Manipulators - Welding sensors and data acquisition Arc sensing-, Weld Seam Tracking-Vision system- Microprocessor based control - Effects of welding fumes on environment. Codes, Specifications and Standards: American Society of Mechanical Engineers (ASME), American Petroleum Institute, American Society for Testing Materials (ASTM).

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Use design knowledge to overcome defects in welding

CO 2: Select suitable welding process for the given applications.

CO 3: Use design knowledge to produce quality casting.

CO 4: Select suitable casting process for the given applications.

CO 5: Implement automation principles with environment consciousness techniques in welding and casting plants and learn to follow standards.

**CO - PO MAPPING :**

| Mapping of COs with POs | | | | | | | |
|---|---|---|---|---|---|---|---|
| PO / CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | COs Average |
| CO1 | 3 | 1 | 3 | 3 | 3 | 3 | 2.7 |
| CO2 | 3 | 1 | 3 | 3 | 3 | 3 | 2.7 |
| CO3 | 3 | 1 | 3 | 3 | 3 | 3 | 2.7 |
| CO4 | 3 | 1 | 3 | 3 | 3 | 3 | 2.7 |
| CO5 | 3 | 1 | 3 | 3 | 3 | 3 | 2.7 |
| POs Average | 3.0 | 1.0 | 3.0 | 3.0 | 3.0 | 3.0 | |
| 1 – Slight, 2 – Moderate, 3 - Substantial | | | | | | | |

**REFERENCES:**


1. American Welding Society," Welding Handbook", Volume 110th Edition, 2019.
2. Dieter Radaj, "Design and Analysis of Fatigue Resistant Welded Structures", Woodhead Publishing, United Kingdom, 1990, ISBN: 978-1855730045.
3. John Campbell, "Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design", 2nd edition, Butterworth-Heinemann., United Kingdom, 2015, ISBN: 978-1856178099.
4. Mahi Sahoo and Sam Sahu, "Principles of Metal Casting", McGraw-Hill Education, United States, 3rd Edition, 2017, ISBN: 9339218167.
5. Robert B. Tuttle, "Foundry Engineering: The Metallurgy and Design of Castings", Create Space Independent Publishing Platform, Amazon, 2012, ISBN: 9781478157434.
6. Ramesh Singh, "Applied Welding Engineering: Processes, Codes and Standards", First Edition, Elsevier, 2012, ISBN: 978-0-12-391916-8.

| CI3001 | THEORY OF METAL CUTTING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To learn tool nomenclature, mechanics of metal cutting and forces in metal cutting
- To know the thermal aspects in machining, tool materials, tool life and wear mechanisms

**UNIT I TOOL NOMENCLATURE 9**

Single point tool-significance of the various angles provided and nose radius- American, German CIRP and orthogonal system of tool nomenclature, System of tool nomenclature and its conversion, nomenclature of drills, milling cutters and broaches- grinding wheels, Need for chip breakers.

**UNIT II MECHANICS OF METAL CUTTING 9**

Mechanisms of formation of chips-types of chips and the conditions conducive for the formation of each type, built- up edge and its effects, Orthogonal Vs Oblique cutting - - Merchant's circle diagram- Force and velocity relationship, shear plane angle, Energy considerations in machining - Ernst Merchant's theory of shear angle relationship-original assumptions and modifications made, Chip formation mechanism in micro and nanomachining.

**UNIT III FORCES IN MACHINING 9**

Forces in turning, drilling, milling and grinding, conventional Vs climb milling-mean and maximum cross sectional areas of chip in milling-specific cutting pressure-specific horse power-requirements of tool dynamometers-construction and principle of operation of tool dynamometers for turning, drilling and milling, Analysis of cutting forces and process optimization – a case study, Monitoring and controlling of process parameters – A case study using AI and ML.

**UNIT IV THERMAL ASPECTS IN MACHINING 9**

Sources of heat generation in machining-temperature measurement techniques in machining, Temperature distribution, Zones, measurement -Latest trends in cutting tool temperature measurement. Functions of cutting fluid-characteristics of cutting fluid-types, modes of applications, additives-application of cutting fluids- dry machining, Minimum Quantity Lubrication (MQL) machining.

**UNIT V TOOL MATERIALS, TOOL WEAR AND TOOL LIFE 9**

Requirements of tool materials- advances in tool materials- Selection of cutting tool - Latest trends in Cutting tool coating, HSS, coated HSS, carbides and coated carbides, ceramic, cold pressed, hot pressed, ceramic composites, CBN, PCD, properties, advantages and limitations-ISO-specifications for inserts and tool holders, tool wear, type mechanisms, tool life, machinability, economics of machining, chatter in machining.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Understanding various tool geometries of single point and multi-point cutting tools based on different tool reference systems and apply for tool and cutter grinding.

CO 2: Analytically predict the force, velocity relationship and study their effects on chip formation mechanism during orthogonal and oblique cutting.

CO 3: Evaluation of cutting forces generated during various machining operations by selecting suitable cutting force and power sensors.

CO 4: Determine the tool temperature by selecting suitable temperature sensors and demonstrate means of reducing heat generation by appropriate cooling strategies.

CO 5: Select suitable cutting tool materials to efficiently apply for different tool/work combinations to optimize machining performance.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Shaw M. C., “Metal cutting principles”, Oxford, Clarendon Press, 2004. ISBN13: 9780195142068.
2. Bhattacharya A. “Metal Cutting Theory and Practice”, New Central Book Agency (p) Ltd., Calcutta, 1984.
3. Venkataesh V.C and Chandrasekaran. H, “Experimental Techniques in Metal Cutting”, Prentice Hall of India, 1982.
4. Xing Sheng Li & Low.I.M., Editors, “Advanced ceramic tools for machining Applications”, I TRANSTECH PUBLICATIONS, 1994.
5. Kuppuswamy. G., “Principles of Metal Cutting”, Universities Press, 1996.
6. Juneja B.L and Sekhon G.S., “Fundamentals of Metal cutting and Machine Tools”, New Age International (P) Ltd., 2nd edition, 2012.

| CI3002 | PRODUCT INNOVATION AND DEVELOPMENT | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- Gain knowledge of innovation in Product design & development and brief overview of development of new products through conceptualization, design, and testing phases.
- Connect diverse aspects of product development to manufacturing and industrial design. Interpret the fundamental concept of Rapid Prototyping.
- Develop products that are suitable for the demands of society.

**UNIT I PRODUCT DEVELOPMENT AND CONCEPT SELECTION 9**

Product development process – Product development organizations- Identifying the customer needs – Establishing the product specifications – concept generation – Concept scoring-testing and selection. Trends in innovation concepts.

**UNIT II PRODUCT ARCHITECTURE 9**

Product architecture – Implication of the architecture – Establishing the architecture – Related system level design issues- Modular product- Case studies

**UNIT III INDUSTRIAL AND MANUFACTURING DESIGN 9**

Need for industrial design – Impact of industrial design – Industrial design process. Assessing the quality of industrial design- Human Engineering consideration -Estimate the manufacturing cost – Reduce the component cost – Reduce the assembly cost – Reduce the support cost – Impact of DFM decisions on other factors - Case studies

**UNIT IV PROTOTYPING AND ECONOMIC ANALYSIS 9**

Principles of prototyping – Planning for prototypes – Rapid Prototyping - Elements of economic analysis – Base case financial model – Sensitivity analysis – Influence of the quantitative factors.

**UNIT V MANAGING PRODUCT DEVELOPMENT PROJECTS 9**

Sequential, parallel and coupled tasks - Baseline project planning – Project Budget- Project execution – Project evaluation- patents- patent search-patent laws-International code for patents.



**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Understand the basic concept of product development

CO 2: Design and develop new products in a systematic using the studied tools and techniques.

CO 3: To associate various aspects of product development with industrial design and manufacturing.

CO 4: To understand the fundamental concept of Rapid Prototyping.

CO 5: To be able to design products which are suitable for the needs of the society.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Gevirtz C, Developing New products with TQM, McGraw – Hill International editions,1994.
2. Jamnia A, Introduction to Product Design and Development for Engineers, Taylor and Francis Group, 2018.
3. RosenthalS, Effective product design and development, Irwin 1992.
4. Ulrich K, Eppinger S, Product Design and Development, McGraw- Hill International Fifth Editions, 2012.

| CI3003 | ELECTRONICS PACKAGING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To impart the knowledge in electronic packaging technology

**UNIT I INTRODUCTION TO ELECTRONICS MANUFACTURING 9**

History, definition, wafer preparation by growing, machining, and polishing, diffusion, microlithography, etching and cleaning, Printed Circuit Boards, types- single sided, double sided, multi-layer and flexible printed circuit board, design, materials, manufacturing, inspection. Electronic packaging – Through Hole Technology (THT) and Surface Mount Technology (SMT).

**UNIT II COMPONENTS AND PACKAGING 9**

Through-hole components – axial, radial, multi leaded, odd form. Surface mount components- active, passive. Interconnections - chip to lead interconnection, die bonding, wire bonding, TAB, Flip chip, chip on board, multi-chip module, direct chip array module, leaded, leadless, area array and embedded packaging, miniaturization and trends.

**UNIT III SURFACE MOUNT TECHNOLOGY 9**

SMT Equipment and Material Handling Systems, Handling of Components and Assemblies - Moisture Sensitivity and ESD, Safety and Precautions Needed, IPC and Other Standards, Stencil Printing Process, solder paste storage and handling, stencils and squeegees, process parameters, quality control - Component Placement, Equipment Type, Chip shooter, IC placer, Flexibility, Accuracy of Placement, Throughput, reflow soldering, adhesive, under fill and encapsulation process, applications, storage and handling, process & parameters.

**UNIT IV SOLDERING AND CLEANING 9**

Soldering theory, effect of elemental constituents on wetting, microstructure and soldering, solder paste technology – fluxing reactions, flux chemistry, solder powder, solder paste composition and manufacturing, solder paste rheology, Wave soldering. Adhesive and solder paste application. solder system variables. soldering temperature profile. Reflow soldering - profile generation and control, soldering quality and defects. Thermal aspects- Post solder cleaning and selection. Measurement of cleanliness levels.

**UNIT V INSPECTION, TEST AND REWORK FOR PCB 9**

Inspection Techniques, Equipment and Principle – AOI, X-ray. Testing of assemblies, In-circuit testing (ICT), functional testing, stencil printing process- defects corrective action, component placement process - defects & corrective action, Reflow Soldering Process- defects & corrective action, underfill and encapsulation Process- defects & corrective action, Testing of assemblies, In-circuit testing (ICT), functional testing, concept of yield, Rework and Repair, tools, rework criteria and process, Design for - Manufacturability, Assembly, Reworkability, Testing, Reliability and Environment. Design for reliability, Life cycle, RRR-Disposal, Failure Modes and Mechanisms, Reliability Metrology and Analysis, Accelerated Degradation Modeling, Environmental Stress Screening.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Realize wafer preparation and PCB fabrication.

CO 2: Elaborate on through hole and surface mount technology components.

CO 3: Improve knowledge on surface mount technology.

CO 4: Discuss the steps involved in soldering post solder cleaning and its importance in PCB Manufacturing.

CO 5: Locate the required inspections, testing and repair methods used in PCB.

**CO - PO MAPPING :**

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

**REFERENCES:**


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3. Seraphim, D., Lasky, R.C. and Che-Yu Li, “Principles of Electronic Packaging” Mcgraw Hill, 1989.
4. Strauss, R.,“ SMT Soldering Handbook”, Newnes Elsevier , 1998
5. Zant, P.V., “ Microchip Fabrication – a practical guide to semiconductor processing ”McGraw Hill, 2000
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**IL3056 ADVANCED OPTIMIZATION TECHNIQUES L T P C**

**3 0 0 3**

**COURSEOBJECTIVES:**

1. To impart knowledge to model and solve Integer programming problems.
2. To model and solve problems using dynamic programming.
3. To solve single- and multiple-variable unconstrained and constrained nonlinear.
4. To solve non-linear problem using KKT condition, quadratic programming and separable programming.
5. To apply meta heuristics for solving engineering problems

**UNIT I INTEGER PROGRAMMING AND GOAL PROGRAMMING 9**

Branch and Bound technique –cutting plane algorithm method - Traveling Salesman Problem - Branch and Bound Algorithms for TSP - Heuristics for TSP. Goal programming – Goal programming formulation - Goal programming algorithms – The weights method – Pre-emptive method

**UNIT II DYNAMIC PROGRAMMING 9**

Characteristics of Dynamic Programming Problems - Deterministic Dynamic Programming - Forward and Backward recursive recursion – selected dynamic programming application – investment model – inventory model – replacement model –reliability model – stage coach problem.

**UNIT III NONLINEAR PROGRAMMING I 9**

Types of Nonlinear Programming Problems - One-Variable Unconstrained Optimization - Multivariable Unconstrained Optimization

**UNIT IV NONLINEAR PROGRAMMING II 9**

Lagrangian multiplier - Karush-Kuhn-Tucker (KKT) Conditions for Constrained Optimization - Quadratic Programming - Separable Programming - Convex Programming – Non-convex Programming

**UNIT V META-HEURISTICS 9**

Combinatorial optimization- NP Hard- Classification of Meta-Heuristic algorithms- Genetic Algorithm- Ant Colony Optimization- Simulated Annealing- Case studies

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

**CO1.** Solve integer programming problems using appropriate methods
**CO2.** Solve various dynamic programming problems.
**CO3.** Apply methods to solve nonlinear unconstrained problems
**CO4.** Apply methods to solve nonlinear constrained problems.
**CO5.** Identify, apply and solve suitable meta-heuristic technique to solve engineering optimization problems.

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1. Hamdy A Taha, “Operations Research – An Introduction”, Pearson, 2017.
2. Philips, Ravindran and Solberg, “Operations Research principles and practices”, John Wiley, 2007
3. Ronald L Rardin, “Optimisation in Operations Research”, Pearson, 2018
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**CO’s - PO’s & PSO’s MAPPING**

| CO | PO’s | | | PSO’s | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 |
| CO1 | 2 | 3 | 3 | 2 | - | - |
| CO2 | 2 | 3 | 3 | 2 | - | 3 |
| CO3 | 2 | 3 | 3 | - | 3 | - |
| CO4 | 2 | 3 | 3 | - | 3 | 2 |
| CO5 | 2 | 3 | 3 | - | - | 3 |
| AVG | 2 | 3 | 3 | 2 | 3 | 2.6 |



Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**CI3052 DESIGN FOR MANUFACTURING AND ASSEMBLY**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To teach manufacturing issues that must be considered in the mechanical engineering design process.
- To Discuss on tools and methods to facilitate development of manufacturable mechanical designs.
- To make the students to Understand the importance of Assembly, Reliability and Quality for improving design process approach.

**UNIT I INTRODUCTION 9**

DFMA: overview –Product Design- Process-Design -Process overview: Conceptual and configuration design of products and assemblies, criteria and concepts in design, Introduction to limits, fits and Tolerances Dimensional management & tolerance analysis: GD & T, Datum features, stockup Analysis-Need Identification and Problem Definition- Concept Generation and Evaluation-Embodiment Design.

**UNIT II SELECTION OF MATERIALS AND SHAPES 9**

Overview of engineering materials -standards for materials selection - -Physical and Mechanical Properties of Engineering Materials- Selection of Materials-Case Studies - Selection of Shapes-Co-Selection of Materials and Shapes- Effect of composition, processing and structure on material Properties-Case-Studies.

**UNIT III SELECTION OF MANUFACTURING PROCESSES 9**

Review of Manufacturing Processes- The concept of manufacturability- Limitations of manufacturing -Design for Casting- Various Casting process, Defects in casting and its remedial measure, recommendation for achieving good quality casting Design -Design for Bulk Deformation Processes-Design for Sheet Metal Forming Processes-Design for Machining- Advantages and disadvantages and design guide line of parts for machining. Design for Powder Metallurgy-Design for Polymer Processing-Co-selection of Materials and Processes-Case Studies Design of jigs and fixtures Mathematical modeling and Finite Element Analysis-Simulation -Rapid prototyping

**UNIT IV DESIGN FOR ASSEMBLY 9**

Review of Assembly Processes- Design for Welding- Defects in welding, methods for rectification -Design for Brazing and Soldering: Design recommendation for brazing and soldering for good quality joints - Design for Adhesive Bonding-Design for Joining of Polymers

**UNIT V DESIGN FOR RELIABILITY AND QUALITY 9**

Reliability theory and design for-Failure Mode and Effect Analysis- Design for Heat Treatment-Case Studies-Design for corrosion resistance, Design for wear Resistance-Design for Quality-Approach to Robust Design-Design for Optimization Design for safety Design for environment

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Understand how to formulate the need analysis leading to definition of the design problem and to convert design problem leading to embodiment design.

CO 2: Identify the suitability of materials application and manufacturing considerations

CO 3: Select manufacturing process and to consider design as per the process adopted for the design problem.

CO 4: Apply the principles of assembly to minimize the assembly time.

CO 5: Analyze and apply the concept of reliability and quality in the product design process.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Geoffrey Boothroyd, Peter Dewhurst, and Winston A. Knight, “Product Design, for Manufacture, and Assembly”, 3rd Edition, CRC Press., United States,2011, ISBN 9781420089271.
2. Peck H., “Designing for manufacture”, Sir Isaac Pitman & Sons Ltd., United States 1973.
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7. M. F. Ashby and K. Johnson, Materials and Design - the art and science of material selection in product design, Butterworth Heinemann, 2003.

**CI3053 MICRO AND NANO MANUFACTURING**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To introduce Meso, Micro and Nano manufacturing and their respective applications.
- To familiarize the students with diamond, turn machining, advanced micro machining and nano finishing methods.
- To familiarize the students with synthesis of nanomaterials and types of characterization techniques to be used.

**UNIT I INTRODUCTION 9**

Introduction to Meso, Micro and Nano manufacturing, Miniaturization and applications, classification- subtractive, additive, mass containing processes, Theory of micromachining, micro turning, micro drilling, micro milling- Micro stereo lithography - micro forming, micro moulding, micro casting- micro joining, Applications of Micro and Nano products in IT and telecommunications, Automotive, Medicine.

**UNIT II DIAMOND TURNING 9**

Diamond turn machining-need, classification, components, material removal mechanisms, Tooling for diamond turning, Process parameters and optimization - Molecular Dynamic simulation to study nanoscale cutting-tool path strategies in surface generations- symmetric, asymmetric and freeform, applications of DTM products.

**UNIT III ADVANCED MACHINING / FINISHING PROCESSES 9**

Introduction to mechanical and beam energy based micro machining processes- Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining, Pulsed water drop micromachining, Micro/ Nano finishing processes- Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Hybrid micro/nano machining – Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic In Process Dressing Grinding.

**UNIT IV SYNTHESIS OF NANOMATERIALS 9**

Introduction to nano materials, Methods of production of Nanoparticles, Sol-gel synthesis, Inert gas condensation, High energy Ball milling, Plasma synthesis, Electro deposition and other techniques. Synthesis of Carbon Nanotubes – Solid carbon source based production techniques, Gaseous carbon source based production techniques – Diamond Like Carbon coating. Nano wires.

**UNIT V CHARACTERISATION TECHNIQUES 9**

Metrology for micro machined components -Optical Microscopy, White Light Interferometry, Molecular Measuring Machine, Micro CMM- Atomic Force Microscopy.
Scanning Probe Microscopy (SPM) – Scanning Electron Microscope, Transmission Electron Microscope, Scanning Thermal Microscopy, Tribological characteristics -Micro abrasion wear - 3D surface roughness measurement- Nano indentation- Ellipsometric Analysis.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Recognize the importance of Meso, Micro and Nano manufacturing and their respective applications.
CO 2: Elaborate on Diamond turn machining process
CO 3: Describe the advanced micro machining and nano finishing methods.
CO 4: Acquire knowledge on synthesis of nanomaterials
CO 5: Identify the type of characterization techniques to be used.

**CO - PO MAPPING :**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| **CO1** | **3** | **3** | **3** | **2** | **2** | **1** |
| **CO2** | **3** | **3** | **3** | **2** | **3** | **3** |
| **CO3** | **3** | **3** | **3** | **2** | **3** | **3** |
| **CO4** | **3** | **3** | **3** | **2** | **2** | **1** |
| **CO5** | **3** | **3** | **3** | **2** | **2** | **2** |

**REFERENCES:**


1. Jain, V.K, “Micro manufacturing Processes”, by CRC Press, ISBN: 9781439852903, 2013.
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| | | L | T | P | C |
|---|---|---|---|---|---|
| **CI3004** | **FINITE ELEMENT ANALYSIS IN MANUFACTURING ENGINEERING** | **3** | **0** | **0** | **3** |

**OBJECTIVES:**

- To equip students with fundamentals of finite element analysis of manufacturing processes
- To develop finite element model for various manufacturing processes.
- To effectively use the FEA tools for solving problems in Manufacturing Engineering R&D

**UNIT I ELASTIC AND PLASTIC RELATIONS AND ISOTROPIC MATERIAL** **9**

Elastic stress strain relations - Elastic stress-strain relations for small deformations - Classical Theory of Plasticity - Criteria for Initial Yielding of Isotropic Materials - Incremental Strain and Strain Rate Measures - Plastic Stress-Strain and Stress-Strain Relations for Isotropic Materials, Objective Stress Rate and Objective Incremental Stress Tensors, Unloading Criterion.

**UNIT II PLASTICITY OF FINITE DEFORMATION AND ANISOTROPIC MATERIALS** **9**

Kinematics of Finite Deformation and Rotation - Constitutive Equation for Eulerian Formulation, Updated Lagrangian Formulation, - Anisotropic Initial Yield Criteria- Elastic-Plastic Incremental Stress-Strain - Stress-Strain Rate Relations for Anisotropic Materials.

**UNIT III EULERIAN FORMULATION OF METAL FORMING PROCESSES** **9**

Formulation of Plane-Strain metal forming processes- Formulation of axisymmetric metal forming processes-, Formulation of three-dimensional metal forming processes, incorporation of anisotropy- elasto-plastic formulation.

**UNIT IV UPDATED LAGRANGIAN FORMULATION OF METAL FORMING PROCESSES** **9**

Application of Finite Element Method to Updated Lagrangian Formulation- Modeling of Axisymmetric Open Die Forging by Updated Lagrangian Finite Element Method- Modeling of Deep Drawing of Cylindrical Cups by Updated Lagrangian Finite Element Method.

**UNIT V FINITE ELEMENT MODELING OF ORTHOGONAL MACHINING PROCESS** **9**

Domain - Governing Equations and Boundary Conditions for Eulerian Formulation, - Approximations for Velocity Components and Pressure- Application of boundary condition, solution procedure

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Develop the fundamental elastic and plastic equation used in finite element modeling of manufacturing processes

CO 2: Develop equation for plasticity of finite deformation and anisotropic

CO 3: Develop Eulerian formulation of metal forming processes

CO 4: Develop updated Lagrangian formulation of metal forming processes.

CO 5: Develop finite element modeling of orthogonal machining process

**CO - PO MAPPING :**

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

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1. Prakash M. Dixit and Uday S. Dixit, “Modelling metal forming and machining processes” Springer, 2008.
2. Henry Valberg, “Applied Metal Forming: Including FEM Analysis Hardcover”, Cambridge University Press; 1st edition, 2010.
3. Kobayashi S., Soo-IK-Oh and Alton T., “Metal forming and the Finite Element Methods”, Oxford University Press, 1989.
4. Paulo Davim J., “Finite Element Method in Manufacturing Processes”, ISTE Ltd.; 1st edition, 2011.
5. Cook R.D. and Malkus, D.S., “Concepts and Applications of Finite Elements Analysis”, Wiley, 4th edition, 2007.
6. Reddy J.N., “An Introduction to the Finite Element Method”, McGraw Hill, 3rd edition 2017.

| CI3005 | PRECISION ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To know about the need for precision engineering with its application and to understand the importance of the materials.
- To impart the knowledge about the reasons for the errors and their remedies.

**UNIT I INTRODUCTION 9**

Accuracy and Precision– Need for high precision –concept of accuracy - tolerance and fits system – Hole and shaft system – accuracy of manufacturing processes – types of fits – Selective assembly.

**UNIT II MATERIALS FOR PRECISION ENGINEERING 9**

Diamond - types-single crystal - PCD - Natural-synthetic CBN - Ceramics - coated metals and non-metals - High performance polymer –Graphene- alloys - refractory metals: cutting tools – performance - components of instruments - Jewels - self Lubrication - smart materials - properties - testing – applications.

**UNIT III ERRORS: CAUSES AND REMEDIES 9**

Static stiffness - influence on machining accuracy - over all stiffness in a machine/instrument - errors due to variation of cutting forces - clamping forces - errors due to compliance while machining. Inaccuracy due to thermal effects: Heat sources and dissipation - Geometry of thermal deformation – Influence of forced is statics dimensional wear of elements - instruments; Machining tools and their influence on accuracy- error due to clamping and setting location.

**UNIT IV PRECISION MACHINING 9**

Precision grinding: IC chip manufacturing- ELID process - aspherical surface generation Grinding wheel- Designer and selection of grinding wheel -High-speed grinding -High-speed milling -Micro machining - Diamond turning-MEMS - micro finishing process - surface roughness measures - concept and non-concept method - comparison of features with machining process. Near net shape manufacturing.

**UNIT V PRECISION MACHINE ELEMENTS 9**

Introduction- guide ways- Drive systems; rolling element bearings - Principles, construction, classification, application etc., - Lubricated sliding bearings - construction - Principles etc., - Hydrostatics bearings-types - aerostatic bearings - linear drive motors – cryogenically cooled Motors-Integral spindles- magnetic bearings - applications - limitations - advantages.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Understand the need of precision engineering and its application.

CO 2: Discuss process knowledge to use the light material / superior material as per the raising demands.

CO 3: Discuss the advanced precision machining processes.

CO 4: Explain the various errors, its causes and remedies to overcome these.

CO 5: Describe elements used in precision machine tool.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. James D. and Meadow, S., “Geometric Dimensioning and Tolerancing”, Marcel Dekker Inc.,1995.
2. Juliar W.Gardner, and Vijay K. Varadan, “Micro Sensors, MEMS and Smart Devices”, John Wiley and Sons, 2001.
3. Murthy R.L., “Precision Engineering in Manufacturing”, New age International Publications, New Delhi, First edition 1996; Reprint 2005.
4. Paulo Davim "Microfabrication and Precision Engineering: Research and Development", Woodhead publishing, 2017.
5. Venkatesh V.C. and Sudin I., “Precision engineering”, Tata McGraw Hill Co., New Delhi, 2007.

| CI3054 | SYSTEM SIMULATION FOR MANUFACTURING ENGINEERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To teach the concept of system simulation and their importance in industries and the various techniques used for generating the random numbers.
- To discuss about the generation techniques and the use of the random numbers in simulation, tests, validity, verification, models of simulation and analysis.
- To train the students to solve the real time problems in the discrete systems by using a simulation software.

**UNIT I PREAMBLE TO SYSTEM SIMULATION 9**

Systems, general systems theory, Functions/Relationship, concept of simulation, Stochastic activities, Types of Models, Principles used in Modeling, simulation as a decision-making tool, types of simulation, Important measures of performance, Advantages and disadvantages of simulation, Steps in simulation model building.

**UNIT II RANDOM NUMBERS 9**

Methods of generating random numbers, Desirable attributes of random numbers, manual methods, computerized methods, Pseudo random numbers and random variates, discrete and continuous random probability distributions, tests for random numbers, Need for testing random numbers, Application of random numbers in simulation models

**UNIT III DESIGN OF SIMULATION 9**

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation, validation. Monte Carlo method of simulation, Manual simulation techniques

**UNIT IV SIMULATION SOFTWARE AND DATA HANDLING 9**

Study and selection of simulation languages, Animation based Simulation packages, Selection of Simulation language / package, Use of any one of the simulation software for simulation model building, programmable blocks, Creation of database, Data handling and reporting, terminating conditions, Interpretation of results using statistical analysis

**UNIT V ADVANCED HEURISTICS AND AREAS OF APPLICATION 9**

Ear deaf Analysis - Development of simulation models for Manufacturing and production systems, inventory optimization techniques, Advanced Sequencing and Scheduling problems, queuing systems - Problems,

Heuristics for scheduling - Single pass heuristics, multipass heuristics, Evolutionary Optimization techniques - Genetic algorithm, Ant Colony algorithm, Particle Swarm optimization - Case studies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Discuss various types of systems and identify different elements of a system to build simulation models and to use them.

CO 2: Generate, test and use random numbers in different ways.

CO 3: Explain various steps in building simulation models and how to run them for effective analysis of real life scenarios and obtain superior results.
CO 4: Develop capabilities of taking up consultancy projects and completing them successfully.
CO 5: Describe various cases in system simulation and its approaches

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Banks J., Nelson B.L., Nicol D.M and Shahabudeen. P, “Discrete event system simulation”, 4th edition Prentice Hall, India, 2005.
2. R. Pannerselvam and P. Senthilkumar, ‘System Simulation, Modelling and languages, PHI Learning Pvt, Ltd, 2013
3. Law A.M. and Kelton W.D., “Simulation Modeling and Analysis”, 2nd edition, McGraw Hill Inc. (2015), New York.
4. Geoffrey Gordon, "System Simulation", second edition, Prentice Hall, India, 2005.
5. Shannon R.E., “systems simulation – The art and Science”, Prentice Hall, 1975.
6. Hardbound by Altaf Q. H. Badar, ‘Evolutionary Optimization Algorithms’ 1st Edition 2021 , CRC Press

| CI3006 | COMPETITIVE MANUFACTURING SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To expose students on the areas of competitive environment, the best manufacturing practices in the world.

**UNIT I MANUFACTURING IN A COMPETITIVE ENVIRONMENT 9**

Introduction – Competitiveness - Cost, Time, Quality, Flexibility - Product flexibility, Operation flexibility, Capacity flexibility - Automation of Manufacturing Process - Numerical Control - Adaptive Control - Material Handling and Movement - Industrial Robots - Sensor Technology - Flexible Fixtures - Design for Assembly, Disassembly and Service – Product Lifecycle Management

**UNIT II COMPETITIVE MANUFACTURING FOR PRODUCT DESIGN 9**

Product Design for Global Markets- Product policies in a global environment- Factors affecting the choice of a product policy. Concurrent Engineering-Background-implementation-Concurrent engineering teams- Sequential and overlapped product development activities-benefits- information exchange- supporting infrastructure for implementation. Mass customization- Customization issues- Mass production issues- Types of mass customization-Classification of mass customized production (MCP) systems-- Factors that influence an MCP System-Case studies.

**UNIT III GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS 9**

Part Families - Classification and Coding - Production Flow Analysis - Machine Cell Design – Benefits - Components of Flexible Manufacturing Systems (FMS) - Computer Control and Functions - Planning, Scheduling and Control of FMS - Knowledge Based Scheduling.

**UNIT IV SIMULATION OF FLEXIBLE MANUFACTURING SYSTEMS 9**

Introduction - Application of Simulation – Simulation Process - Stating the Project's Objective(s), Building the Abstract Model, Input Analysis, Building the Simulation Model, Model Verification, Model Validation, Output Analysis - Model of FMS - Simulation Software – Limitations-Case studies.

**UNIT V COMPUTER SOFTWARE AND DATABASE OF FLEXIBLE MANUFACTURING SYSTEMS 9**

FMS Software - Introduction, General Structure and Requirements, Functional Descriptions, Operational Overview, Types of Software Specification and Selection - Trends. Manufacturing Data Systems - Data Flow - FMS Database Systems – Computer Aided Design/Computer Aided Manufacturing Considerations - Planning for FMS Database.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Describe the areas of Competitive Environment and the best Manufacturing Practices in the World.
CO 2: Explain competitive manufacturing for product design.
CO 3: Perceive concepts of Group Technology and Flexible Manufacturing Systems.
CO 4: Acquaint with Simulation of Flexible Manufacturing Systems.
CO 5: Evaluate Computer Software and Database of Flexible Manufacturing Systems.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Chryssolouris G., "Manufacturing Systems: Theory and Practice", 2nd Edition, Springer., United States, Reprint 2010, ISBN 9780387256832.
2. Dennis P., “Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System”, 3rd edition, Routledge. United States, 2015, ISBN-13: 978-1563273568.
3. Groover M.P., “Automation, Production Systems and Computer Integrated Manufacturing", 3rd Edition, Prentice-Hall, India, 2016, ISBN-13: 978-9332572492.
4. Jha N.K., “Handbook of Flexible Manufacturing Systems ", Academic Press Inc., United States, 2012, ISBN-13: 9780323139359.
5. Nanua Singh "System Approach to Computer Integrated Design and Manufacturing", Wiley India Edition, Reprint 2011, ISBN-13: 978-0471585176.
6. Paul M. Swamidass, “Innovations in competitive manufacturing”, Springer Science+Business Media, New York, 2000, ISBN 978-1-4613-5687-5

| CI3007 | APPLIED MATERIALS ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To provide knowledge in the areas of elastic and plastic behavior of materials, and fracture behavior of materials.
- To elaborate the theories on plastic forming and applications of advanced materials.
- To study about the selection of material.

**UNIT I ELASTIC AND PLASTIC BEHAVIOUR 9**

Elastic, plastic and elastic and viscoelastic behavior-Mechanism of Elastic and Plastic deformation, Shear strength of perfect and real crystals - Deformation by slip and twinning, strengthening mechanism, solid solution, grain boundary, poly phase mixture, precipitation, particle, fiber and dispersion strengthening, work hardening.

**UNIT II FRACTURE BEHAVIOUR 9**

Fracture; types of fracture, Griffith's theory, ductile to brittle transition in steel - Fatigue of metals; strain life equation, Low and high cycle fatigue test, crack initiation and propagation mechanisms, High temperature fracture – Creep and stress rupture; High temperature alloys-Brittle-fracture problem.

**UNIT III PLASTIC FORMING OF METALS 9**

Fundamentals of metal working, mechanics of metal working, flow-stress distribution, residual stresses, temperature in metal working- Forging in plane strain, open and closed die forging - Forces and geometrical relationships in rolling, theories of cold and hot rolling, bending and stretch forming.

**UNIT IV ADVANCED MATERIALS 9**

Advanced high strength ferrous and non-ferrous alloys, properties and applications of engineering plastics, composite, and - Functionally gradient materials, Smart materials, Nano materials, Biomaterials

**UNIT V SELECTION OF MATERIALS 9**

Motivation, cost basis and service requirements - Selection for mechanical properties, Selection for surface durability - Relationship between materials processing and selection - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Develop strengthening mechanisms.
CO 2: Analyse the fracture behavior of metals and give solutions to avoid them.
CO 3: Create processing techniques for control the plastic forming.
CO 4: Use advanced materials for new product development.
CO 5: Select materials based on industrial requirements.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Dieter G.E., “Mechanical Metallurgy”, McGraw Hill education, 3rd edition, 2017.
2. Courtney T.H., “Mechanical Behaviour of Materials”, 2nd edition, McGraw Hill, 2017.
3. ASM hand book, volume 11, “Failure Analysis and Prevention”, ASM international,10thedition, 2002.
4. ASM Handbook Volume 02: “Properties and Selection: Nonferrous Alloys and Special-Purpose Materials”, ASM international,10thedition, 1990.
5. R. E. Smallman, A.H.W. Ngan, “Physical Metallurgy and Advanced Materials”
6. 7th edition, Butterworth-Heinemann, 2007
7. Crane F.A.A., Charles J.A., and Furness, J.A.G., “Selection and use of engineering Materials”, Reed Elsevier India, 2006.

| CI3008 | DESIGN FOR ADDITIVE MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- To understand the necessity and different design strategies in additive manufacturing.
- To study the various computational design techniques and tools to improve product development with additive manufacturing.
- To gain knowledge on polymer and metal AM design guidelines to leverage industrial applications.

**UNIT I INTRODUCTION TO DESIGN FOR ADDITIVE MANUFACTURING (DfAM) 9**

Introduction-Design freedom with AM-Need for Design for Additive Manufacturing (DfAM)-CAD tools vs. DfAM tools-Requirements of DfAM methods-General Guidelines for DfAM-Design to Avoid Anisotropy - Design to Minimize Print Time- Design to Minimize Post-processing- Economic of Additive Manufacturing - AM Part Standardization and Certification-Case Studies.

**UNIT II DESIGN CONSIDERATION IN ADDITIVE MANUFACTURING 9**

Part Consolidation- Design Guidelines for Part Consolidation - Opportunities for part consolidation- challenges with part consolidation. Guidelines for AM Tooling Design- Multi scale design for Additive manufacturing- Design of multi-materials and functionally graded materials- Design of cellular and lattice structures- Design of support structures- Case studies.

**UNIT III COMPUTATIONAL TOOLS FOR AM 9**

Considerations for Analysis of AM Parts- Topology Optimization -performing analysis for weight reduction Post-processing and Interpreting Results -Applications of TO -Generative design -Generative design system and implementation -Generative design opportunities for mass-customization -Case studies.

**UNIT IV DESIGN FOR POLYMER AM 9**

Anisotropy-Wall Thicknesses-Overhangs- Support Material- Accuracy- Tolerances- Layer Thickness- Resolution- Print Orientation- Warpage- over sintering- Hollowing Parts-Horizontal Bridges- Connections- Fill Style- holes- fillets- ribs- font sizes and small details- Designing for Material Extrusion- Designing for Polymer Powder Bed Fusion- Designing for Vat Photopolymerization.

**UNIT V DESIGN FOR METAL AM 9**

Powder Morphology- Powder Size Distribution- Material Characteristics- Designing to Minimize Stress Concentrations - Residual Stress - Overhangs- shrinkage- warpage and Support Material- Design Guidelines for Wall Thickness- Clearance Between Moving Parts-Vertical Slots- Circular Holes- fillets- channels- vertical Bosses- circular pins-External Screw Threads and part positioning.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO1: Gain a comprehensive understanding on design in additive manufacturing.

CO2: Acquire the ability to effectively apply design for additive manufacturing guidelines across various domains within the additive manufacturing field.

CO3: Develop the capability to optimize products and achieve optimal design outcomes.

CO4: Gain a comprehensive understanding of design guidelines for polymer additive manufacturing processes, enabling the effective utilization of these guidelines to maximize the potential applications and benefits of polymer AM technology.

CO5: Gain a comprehensive understanding of design guidelines for metal additive manufacturing processes, enabling the effective utilization of these guidelines to maximize the potential applications and benefits of Metal AM technology.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
2. The 3D Printing Handbook: Technologies, Design and Applications, Redwood, Ben, Filemon Schoffer, and Brian Garret, 3D Hubs, 2017.
3. Design for Additive Manufacturing, Martin Leary, Elsevier ,2020.
4. Design for Advanced Manufacturing: Technologies and Process, Laroux K, Gillespie, McGrawHill, 2017.
5. Additive Manufacturing Technologies, Gibson, Ian, David W. Rosen, Brent Stucker, and Mahyar Khorasani, Springer, 2021.
6. Laser-Induced Materials and Processes for Rapid Prototyping, L.Lu, J. Y. H. Fuh and Y.S. Wong, Springer, 2001.

**IL3251 SUPPLY CHAIN SYSTEMS AND MANAGEMENT L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

1. To describe the role and drivers of and supply chain management in achieving competitiveness.
2. To explain about Supply Chain Network Design.
3. To illustrate about the issues related to inventory in Supply Chain.
4. To appraise about transportation and sourcing in Supply Chain.
5. To application of Information Technology and Emerging Concepts in Supply Chain.

**UNIT I INTRODUCTION TO SUPPLY CHAIN MANAGEMENT 9**

Definition and Objective of Supply Chain, The importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process View of Supply Chains. Competitive and Supply Chain Strategies, Achieving Strategic fit, Expanding Strategic Scope. Drivers of Supply Chain Performance, Frame work for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics

**UNIT II DISTRIBUTION NETWORK DESIGN IN SUPPLY CHAIN 9**

The Role of Distribution in the Supply Chains, Factors influencing Distribution Network design, Design Options for a Distribution Network, Online sales and the Distribution network, Distribution Networks in practice. Factors influencing network design decisions, Framework for Network design decisions, The impact of uncertainty on network design, The impact of Globalization on Supply Chain networks, Risk Management in Global Supply Chains, Discounted cash flow analysis, Evaluating Network Design Decisions

**UNIT III INVENTORY IN SUPPLY CHAIN 9**

The Role of Cycle inventory in a Supply Chain, Economies of Scale to Exploit Fixed costs, Managing Multi-echelon Cycle Inventory. The Role of Safety Inventory in a Supply Chain, Determining appropriate level of Safety inventory, Impact of supply Uncertainty on Safety inventory, Impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, Managing Safety Inventory in a Multi-echelon Supply Chain, The Role of IT in inventory management.

**UNIT IV TRANSPORTATION AND SOURCING IN SUPPLY CHAIN 9**

The role of transportation in a Supply chain, Modes of transportation and their performance characteristics, Transportation infrastructure and policies, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation, The role of IT in transportation, Problems. Sourcing Decisions In A Supply Chain: The role of sourcing in a supply chain, in-house or outsource, Third-and Fourth-party logistics providers, Total cost of Ownership, Supplier selection, Auctions and Negotiations, Sharing Risk and Reward in the supply chain.

**UNIT V INFORMATION TECHNOLOGY IN SUPPLY CHAIN 9**

The role of IT in a supply chain, The supply chain IT framework, The supply chain macro processes, Lack of Supply Chain co-ordination and the Bullwhip effect, managerial levers to achieve coordination, continuous replenishment and vendor-managed inventories, collaborative planning, forecasting and replenishment (CPFR).

**TOTAL:45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

**CO1.** Understand supply chain concepts, systemic and strategic role of SCM in global competitive environment.

**CO2.** Evaluate alternative supply and distribution network structures using optimization models.

**CO3.** Develop optimal inventory policies in the supply chain context.

**CO4.** Develop optimal sourcing and Transportation decisions in the supply chain.

**CO5.** Select appropriate information technology frameworks for managing supply chain processes.

**REFERENCES:**


1. Sunil Chopra, Peter Meindl and D.V. Kalra, “Supply Chain Management: Strategy, Planning, and Operation", Pearson Education, 2016.
2. Sarika Kulkarni & Ashok Sharma, Supply Chain Management – Creating Linkages for Faster Business Turnaround, 1st Edition, TATA Mc Graw Hill, 2004.
3. David Simchi Levi, Philip Kaminsky, Edith Simchi Levi & Ravi Shankar, Designing & Managing the Supply Chain – Concepts Strategies and Case Studies, McGraw-Hill higher education, 3rd Edition, 2008.
4. Jeremy F Shapiro, Modelling the Supply Chain, 2nd Edition, Cengage Learning,2009.


**CO’s-PO’s & PSO’s MAPPING**

| CO’s | PO’s | | | PSO’s | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **1** | **2** | **3** |
| 1 | 1 | 2 | 1 | | | |
| 2 | 3 | 3 | 1 | 1 | 1 | 1 |
| 3 | 3 | 3 | 1 | 1 | 1 | 1 |
| 4 | 3 | 3 | 1 | 1 | 1 | 1 |
| 5 | 3 | 3 | 1 | 1 | 3 | 1 |
| **Avg**. | **2.6** | **3** | **1** | **1** | **1.5** | **1** |

| QE3251 | LEAN SIX SIGMA | L T P C |
|---|---|---|
| | | 3 0 0 3 |

**COURSE OBJECTIVES**

1. To understand Lean production principles, eliminate waste, and improve efficiency through case studies.
2. To learn steps for Value Stream Mapping, apply Lean metrics, and implement improvements in value streams.
3. To explore Six Sigma's relationship with Lean Manufacturing, cultural changes, quality assessment, and cost implications.
4. To gain knowledge of various Six Sigma tools and techniques for problem-solving and project management.
5. To evaluate Six Sigma quality economics, focus on continuous improvement using Lean principles, Kaizen, and 5S methodologies.

**UNIT I LEAN MANUFACTURING 9**

Evolution of Mass production, Traditional versus Mass production, Evolution of Toyota (Lean) Production System, Business Dynamics of Lean production, Principles of Lean production – Value, Value stream, Flow, Pull, Perfection- 3Ms – Muda, Mura, Muri, 7 Wastes in Manufacturing, Lean Tools to eliminate Muda - 5S, Standardised work, TPM, SMED, Jidoka – Poka Yoke, JIT, Heijunka, Kanban, One piece production, Case studies.

**UNIT II VALUE STREAM MAPPING 9**

Need for Value Stream mapping; Steps involved in Value stream mapping – Choose value stream – PQ and PR analysis, Current State map, Lean Metrics, Future State Map, Kaizen plans; Lean implementation - Cultural change, Hoshin planning; Lean in the Supply chain.

**UNIT III SIX SIGMA 9**

Six sigma - lean manufacturing and six sigma- six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments - implications of quality levels, Cost of Poor Quality (COPQ)

**UNIT IV SIX SIGMA SCOPE OF TOOLS AND TECHNIQUES 9**

Tools for definition – IPO diagram, SIPOC diagram, Flow diagram, CTQ Tree, Project Charter – Tools for measurement – Check sheets, Histograms, Run Charts, Scatter Diagrams, Cause and effect diagram, Pareto charts, Control charts, Flow process charts, Process Capability Measurement, Tools for analysis – Process Mapping, Regression analysis, RU/CS analysis, SWOT, PESTLE, Five Whys, interrelationship diagram, overall equipment effectiveness, TRIZ innovative problem solving – Tools for improvement – Affinity diagram, Normal group technique, SMED, 5S, mistake proofing, Value stream Mapping, forced field analysis – Tools for control – Gantt chart, Activity network diagram, Radar chart, PDCA cycle, Milestone tracker diagram, Earned value management.

**UNIT V EVALUATION AND CONTINUOUS IMPROVEMENT METHODS 9**

Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen – 5S

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

**CO1.** Demonstrate understanding of Lean production principles, waste identification, and efficiency improvement.

**CO2.** Apply Value Stream Mapping steps and Lean metrics to enhance organizational performance.

**CO3.** Analyze the relationship between Six Sigma and Lean Manufacturing, evaluate cultural changes, quality levels, and cost implications.

**CO4.** Acquire knowledge of Six Sigma tools and techniques for effective problem-solving and project management.

**CO5.** Evaluate Six Sigma quality economics and demonstrate commitment to continuous improvement through Lean principles, Kaizen, 5S methodologies, and customer focus.

**REFERENCES:**


1. Michael L.George, David Rownalds, Bill Kastle, What is Lean Six Sigma, McGraw – Hill 2003
2. Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill,2000
3. Fred Soleimannejed , Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004
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5. James P. Womack, Daniel T.Jones, Lean Thinking, Free Press Business, 2003


**CO's- PO's & PSO's MAPPING**

| CO's | PO's | | | PSO's | | |
|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **1** | **2** | **3** |
| **1** | - | 3 | 3 | - | - | 2 |
| **2** | - | 3 | 3 | - | - | 2 |
| **3** | 2 | 3 | 3 | - | - | 2 |
| **4** | 3 | - | 3 | 2 | 3 | 2 |
| **5** | 2 | - | 3 | 2 | 3 | 2 |
| **Avg** | **2.33** | **3** | **3** | **2** | **3** | **2** |

**1-low, 2-medium, 3-high, '-"- no correlation**

**CI3009** **ENTERPRISE RESOURCE PLANNING**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- Describe an idea about ERP and extended modules of ERP
- Extract knowledge of ERP implementation cycle and effects of ERP after its implementation
- Understanding the emerging trends on ERP

**UNIT I OVERVIEW OF ERP SYSTEMS** **9**

Overview of enterprise systems – Evolution - Risks and benefits - Fundamental technology - Issues to be consider in planning design and implementation of cross functional integrated ERP systems.

**UNIT II ERP SOLUTIONS AND FUNCTIONAL MODULES** **9**

Overview of ERP software solutions- Small, medium and large enterprise vendor solutions, BPR, and best business practices - Business process Management, Functional modules- Management Information system - Executive information system - Decision support system - Business Intelligence for ERP systems.

**UNIT III ERP IMPLEMENTATION** **9**

Planning Evaluation and selection of ERP systems - Implementation life cycle - ERP implementation- transition strategies- Methodology and Frame work- Training – Data Migration. People Organization in implementation-Case studies-Consultants, Vendors and Employees- Case studies in ERP implementation

**UNIT IV POST IMPLEMENTATION** **9**

Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors of ERP Implementation- Operation and Maintenance of an ERP system - ERP Audit-Case studies.

**UNIT V EMERGING TRENDS ON ERP** **9**

Extended ERP systems and ERP add-ons -CRM, SCM, Business analytics - Future trends in ERP systems-web enabled, Wireless technologies, cloud computing- Application development- Case studies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

CO 1: Get an idea about ERP.
CO 2: Awareness of core and extended modules of ERP
CO 3: Knowledge of ERP implementation cycle.
CO 4: Gain knowledge about effects of ERP after its implementation.
CO 5: Understand the emerging trends on ERP.

**CO - PO MAPPING :**

| | PO1 | PO2 | PO3 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|
| CO1 | 1 | 2 | 2 | 2 | 1 | 3 |
| CO2 | 1 | 3 | 2 | 2 | 1 | 3 |
| CO3 | 1 | 2 | 2 | 2 | 1 | 3 |
| CO4 | 1 | 2 | 2 | 2 | 1 | 3 |
| CO5 | 1 | 2 | 2 | 2 | 1 | 3 |

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1. Alexis Leon, “Enterprise Resource Planning”, second edition, Tata McGraw-Hill, 2008.
2. Alexis Leon, “ERP Demystified”.,Tata Mc Graw-Hill, 2000.
3. Jagan Nathan Vaman, ERP in Practice, Tata McGraw-Hill, 2008.
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5. Simha R. Magal and Jeffery Word, “Essentials of Business Process and Information System”, Wiley India, 2012
6. Vinod Kumar Garg and N.K. Venkitakrishnan, ERP- Concepts and Practice, Prentice Hall of India, 2011.

**IL3054 INDUSTRIAL AUTOMATION AND ROBOTICS L T P C**

**3 0 0 3**

**COURSE OBJECTIVES:**

1. To understand industrial automation principles and strategies.
2. To evaluate the material handling system used in the automated industries.
3. To understand the working of industrial robots and its sensors.
4. To gain knowledge in the kinematics of robotic manipulators.
5. To gain knowledge in the dynamics of robotic manipulators.

**UNIT I INTRODUCTION 9**

Definition, automation principles and strategies - scope of automation - socioeconomic consideration, low cost automation - Production concepts and automation strategies - Fixed Automation: Automated Flow lines, Methods of Work part Transport. Transfer Mechanism - Continuous transfer, intermittent transfer - Indexing mechanism Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis.

**UNIT II MATERIAL HANDLING SYSTEM 9**

Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, rail guided vehicles, conveyor systems - advanced material handling systems - automated guided vehicle systems - automated storage and retrieval systems(ASRS), Work-in-process Storage - Interfacing Handling and Storage with Manufacturing.

**UNIT III ROBOTS AND SENSORS 9**

Introduction - Definition, Classification, Robot Components, Degree of Freedom, Mobile robots, Robot Characteristics, Robot Workspace, Robot programming - Application of Robots - Various Sensors and their Classification - Use of Sensors and Sensor Based System in Robotics - Machine Vision System - Description, Sensing – Digitizing - Image Processing and Analysis and Application of Machine Vision System - Robotic Assembly Sensors and Intelligent Sensors.

**UNIT IV KINEMATICS OF ROBOTIC MANIPULATORS 9**

General Mathematical Preliminaries on Vectors & Matrices - Direct Kinematics problem - Geometry Based Direct kinematics problem - Co-ordinate and vector transformation using matrices, Rotation matrix, Inverse Transformations, Problems - Composite Rotation matrix - Homogenous Transformations - Robotic Manipulator Joint Co-Ordinate System - Euler Angle & Euler Transformations - Roll-Pitch-Yaw (RPY) Transformation - DH Representation & Displacement - Matrices for Standard Configurations - Jacobian Transformation in Robotic Manipulation - Trajectory Interpolators.

**UNIT V DYNAMICS OF ROBOTIC MANIPULATORS 9**

Definitions - Generalized Robotic Coordinates - Jacobian for a two link Manipulator - Euler Equations and The Lagrangian Equations of motion - Application of Lagrange – Euler (LE) - Dynamic Modeling of Robotic Manipulators - Velocity of Joints, Kinetic Energy (T) of Arm, Potential Energy (V) of Robotic Arm, The Lagrange L, Two Link Robotic Dynamics with Distributed Mass.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

The students will be able to

**CO1.** Describe the industrial automation principles and strategies.
**CO2.** Evaluate the material handling system for automation.
**CO3.** Distinguish between different sensors for different applications.
**CO4.** Demonstrate the Kinematics of Robotic Manipulators.
**CO5.** Demonstrate the Dynamics of Robotic Manipulators.

**REFERENCE:**


1. Ashitava Ghoshal, Robotics-Fundamental Concepts and Analysis', Oxford University Press, Sixth impression, 2010.
2. Richaerd D Klafter, Thomas Achmielewski and MickaelNegin, "Robotic Engineering – An integrated Approach" Prentice Hall India, New Delhi, 2001.
3. Deb S R and Deb S, Robotics Technology and Flexible Automation, Tata McGraw Hill Education Pvt. Ltd, 2010.
4. Mikell P Groover, "Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson Education, 2015.


**CO's - PO's & PSO's MAPPING**

| CO's | PO's | | | PSO's | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 |
| 1 | - | - | 3 | - | - | - |
| 2 | - | - | 3 | 3 | - | - |
| 3 | - | - | 2 | - | - | - |
| 4 | - | - | 2 | 2 | - | - |
| 5 | - | - | 2 | 2 | - | - |
| Avg. | - | - | 2.4 | 2.33 | - | - |

| CI3010 | SUSTAINABLE MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- Understand the concept of sustainable manufacturing and its importance in today's global context.
- Identify the environmental, economic, and social impacts of manufacturing processes and products.
- Explore sustainable manufacturing practices, tools, and strategies used in different industries.

**UNIT I ECONOMIC SUSTAINABILITY 9**

Industrial Revolution-Economic sustainability: globalization and international issues-Sustainability status - Emerging issues- Innovative products- Reconfiguration manufacturing enterprises - Competitive manufacturing strategies - Performance evaluation- Management for sustainability - Assessments of economic sustainability. Government regulations for Sustainability

**UNIT II SOCIAL AND ENVIRONMENTAL SUSTAINABILITY 9**

Social sustainability – Introduction-Work management -Human rights - Societal commitment - Customers -Business practices -Modelling and assessing social sustainability. Environmental issues pertaining to the manufacturing sector: Pollution - Use of resources -Pressure to reduce costs - Environmental management: Processes that minimize negative environmental impacts - environmental legislation and energy costs - carbon footprint: calculation, need to reduce the carbon footprint of manufacturing Operations, Carbon trading and offsetting -Modelling and assessing environmental sustainability.

**UNIT III SUSTAINABILITY PRACTICES 9**

Sustainability awareness - Measuring Industry Awareness-Drivers and barriers -Availability of sustainability indicators -Analysis of sustainability practicing -Modeling and assessment of sustainable practicing -Sustainability awareness -Sustainability drivers and barriers - Availability of sustainability indicators- Designing questionnaires- Optimizing Sustainability Indexes-Elements – Cost and time model – Government regulations for Sustainable Manufacturing.

**UNIT IV MANUFACTURING STRATEGY FOR SUSTAINABILITY 9**

Concepts of competitive strategy and manufacturing strategies and development of a strategic improvement programme - Manufacturing strategy in business success strategy formation and formulation - Structured strategy formulation - Sustainable manufacturing system design options - Approaches to strategy formulation - Realization of new strategies/system designs - Design for Environment (DfE) principles and frameworks - Life cycle assessment (LCA) for sustainable product design - Resource efficient design - Design for disassembly and recyclability.

**UNIT V TRENDS IN SUSTAINABLE OPERATIONS 9**

Principles of sustainable operations - Process analysis - Capacity management - Quality management -Inventory management - Just-In-Time systems -Circular economy principles and strategies - Product life extension and remanufacturing - Closed-loop supply chains and reverse logistics - Sustainable sourcing and procurement practices - Green logistics and transportation in supply chains - Recycling and reuse techniques for manufacturing waste - Energy-efficient technologies and practices in manufacturing - Case studies on renewable energy implementation in manufacturing – Net Zero Emission - Consumerism and sustainable well-being.

**TOTAL: 45 PERIODS**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

**COURSE OUTCOMES:**

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

CO 1: Discuss the importance of economic sustainability.
CO 2: Describe the importance of sustainable practices.
CO 3: Identify drivers and barriers for the given conditions.
CO 4: Formulate strategy in sustainable manufacturing.
CO 5: Plan for sustainable operation of industry with environmental, cost consciousness.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Davim J.P., “Sustainable Manufacturing”, John Wiley & Sons., United States, 2010, ISBN: 978-1-848-21212-1.
2. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0”, Springer International Publishing., United States, 2016, ISBN-13: 978-3319293042.
3. Kutz M., “Environmentally Conscious Mechanical Design”, John Wiley & Sons., United States, 2007, ISBN: 978-0-471-72636-
4. Seliger G., “Sustainable Manufacturing: Shaping Global Value Creation”, Springer, United States, 2012, ISBN 978-3-642-27289-9.
5. Joseph Fiksel, Design for Environment, Second Edition: A Guide to Sustainable Product Development, McGraw-Hill Education, 2018.
6. Fahimnia, B. & Bell, Michael & Hensher, David & Sarkis, Joseph. (2015). Green Logistics and Transportation: A Sustainable Supply Chain Perspective.

| CI3011 | SENSORS FOR MANUFACTURING AND CONDITION MONITORING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES:**

- Understand the fundamentals of sensors and their importance in condition monitoring.
- Learn about various types of sensors and their working principles.
- Explore the applications of sensors in monitoring the health and performance of machines and systems.

**UNIT I INTRODUCTION TO SENSORS AND CONDITION MONITORING 9**

Role of sensors in manufacturing and condition monitoring – measurement of positions, displacement, angles, mechanical, fluidic, thermal, imaging – Principles – Classification – Direct and indirect methods - Applications — Basic requirements of sensor – Signal processing and decision making - Reactive, Preventive, Predictive Maintenance.

**UNIT II SENSORS FOR WORKPIECE MONITORING 9**

Mechanical, Electrical, Electro-mechanical, Opto-electrical, Optical, Pneumatic, Capacitance, Eddy- current and Magnetic sensors – Case Studies.

**UNIT III SENSORS FOR MACHINE TOOL MONITORING 9**

Position measurements: Linear, angular and velocity sensors – Calibration of machine tools – Collision detection measurements – Structural health monitoring – Case Studies.

**UNIT IV SENSORS FOR MACHINING PROCESSES 9**

Sensors for condition monitoring: Force, torque, power, temperature, vibration, acoustic emission, tool sensors, chip control sensors – Tool Condition Monitoring Systems - Adaptive control system – Intelligent systems for machining processes – Case Studies.

**UNIT V ADVANCED SENSORS AND CONDITION MONITORING METHODS 9**

Optical and machine vision sensors – Smart/Intelligent sensors – Integrated sensors – Robot sensors – Micro-sensors – Nano-sensors – Sensor Network - IoT enabled enabled Condition Monitoring methods – Case Studies.

**TOTAL: 45 PERIODS**



**COURSE OUTCOMES:**

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

CO 1: Recognize the importance of sensors and condition monitoring in manufacturing.
CO 2: Identify suitable sensors for monitoring workpiece during machining operation.
CO 3: Identify suitable sensors for monitoring machine tool during machining operation.
CO 4: Identify suitable sensors in monitoring the machining process.
CO 5: Perceive the usage and importance of advanced sensors in manufacturing industries.

**CO - PO MAPPING :**

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

**REFERENCES:**


1. Tönshoff H.K. and Inasaki I., “Sensors in Manufacturing: Sensors Applications-Volume1”, Wiley-VCH Verlag GmbH, Weinheim, 2001, ISBN (13) :9783527295586.
2. Hesse, S., Sensors in Production Engineering, Blue Digest on Automation: Sensorics. Manufacturing, Festo AG & Company, 2001
3. Mohanty A. R., "Machinery Condition Monitoring: Principles and Practices", CRC Press, U.S.A, 2017, ISBN (13): 9781138748255.
4. Sinclair I., “Sensors and Transducers”, Elsevier, Newnes, Reprint 2012, ISBN: 9780750649322.
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| MN3052 | MECHATRONICS IN MANUFACTURING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare the students

| | |
|---|---|
| 1. | To Understand and apply the principles of mechatronics in modern manufacturing |
| 2. | To Develop proficiency in selecting and integrating sensors, transducers, drives, and actuators for mechatronic systems |
| 3. | To Design and optimize manufacturing processes using mechatronic principles and techniques |
| 4. | To Gain practical skills in programming and interfacing microcontrollers for controlling mechatronic systems |
| 5. | To Analyze and evaluate the performance of mechatronic systems in manufacturing operations for continuous improvement |

| UNIT I | INTRODUCTION TO MECHATRONICS IN MODERN MANUFACTURING | 9 |
|---|---|---|

Introduction to Process Parameters in Conventional Manufacturing – Assembly – Inspection –Transportation - Introduction to basic elements of Mechatronics Systems- Entities in Modern Manufacturing - Mechanical, Fluid, Thermal, Electrical, Electronics, Communication, Control systems and Software Integration for Manufacturing - Classification of Manufacturing based on Mechatronics – CNC based Subtractive Manufacturing –Rapid Prototyping based Additive Manufacturing- Automated Assembly Stations – Modern Quality Inspection and Transportation Systems

| UNIT II | SENSORS AND TRANSDUCERS | 9 |
|---|---|---|

Introduction – Performance Terminology – Resistive Transducers – Inductive Transducers -

Capacitance Transducers – Optical Sensors – Contact and Non-Contact Temperature Sensors – Eddy Current Sensor – Hall Effect Sensor – Piezo Electric Sensor - Ultrasonic Sensors – Proximity Sensors – Chemical and Gas Sensors - Signal Conditioning - Condition Monitoring

| UNIT III | DRIVES AND ACTUATORS | 9 |
|---|---|---|

Role of Linear and Rotary Actuators - Electrical Actuators- Servo Concepts and Stepper Motors - Fluid Power – Piezo Actuators – Solenoids - Function of Drives - Mechanical Switching Devices – Solid State drives for various actuators

| UNIT IV | MICROPROCESSORS AND MICROCONTROLLERS | 9 |
|---|---|---|

Requirement for Processor – Comparison of 8085 Microprocessor and 8051 Microcontrollers– 8051 Microcontrollers Architecture -Assembly Language Programming- Instruction Set, Addressing Modes, Basic Programming – Interfacing - Sensors, Keyboard, LED, LCD, A/D and D/A Converters, Actuators – Embedded Systems

| UNIT V | INTEGRATION OF MANUFACTURING SYSTEMS | 9 |
|---|---|---|

Design Process - Stages of Design Process – Skeletal Structure and Block Diagram of CNC Based - Vertical Machining Centre, turning centre, Water Jet Machine, Electrical Discharge Machine, Serial Manipulator, hydraulic press, 3 D printers– Coordinate Measuring Machine –Automated conveyors - Extended Transportation System – Total Integration of Manufacturing Systems for Production Automation

| TOTAL : | 45 PERIODS |
|---|---|

| **COURSE OUTCOMES:** | |
|---|---|
| Upon successful completion of the course, students should be able to | |
| **CO1** | Recall and identify key concepts in mechatronics for modern manufacturing. |
| **CO2** | Describe the principles and relationships of mechatronic system elements in manufacturing processes. |
| **CO3** | Apply knowledge of sensors, transducers, drives, and actuators to design and troubleshoot mechatronic systems. |
| **CO4** | Analyze and evaluate the performance of mechatronic components for process optimization. |
| **CO5** | Design and integrate mechatronic systems for manufacturing automation. |

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1. Bolton .W.,"Mechatronics" ,Pearson Education Limited, 5th Edition, 2011.
2. Mazidi. M.A and Mazidi .M.J., MCkinlay.R.D, "The 8051 Microcontroller and Embedded
   Systems Using Assemblyand C", Pearson India, 2nd Edition, 2008.
3. Patranabis D., "Sensor and Actuators", Prentice Hall of India Pvt Ltd., 2nd edition 2005.
4. Vijayaraghavan G.K., BalasundaramM.S , Ramachandran K.P. , Mechatronics: IntegratedMechanical Electronic Systems, Willey, 2008.
5. John P. Bentley., "Principle of Measurement systems", Pearson Prentice Hall, Fourth edition,2005.
6. K. Ogata, "Modern Controls Engineering ", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.


**Mapping of COs with POs**

| PO / CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | COs Average |
|---|---|---|---|---|---|---|---|
| CO1 | 2 | 1 | 1 | 1 | - | 1 | 1.2 |
| CO2 | 2 | 1 | 2 | 1 | 1 | 1 | 1.3 |
| CO3 | 2 | 1 | 2 | 1 | 1 | 2 | 1.5 |
| CO4 | 2 | 1 | 2 | 1 | 1 | 2 | 1.5 |
| CO5 | 2 | 1 | 2 | 1 | 1 | 2 | 1.5 |
| POs Average | 2.0 | 1.0 | 1.8 | 1.0 | 1.0 | 1.6 | |

1 – Slight, 2 – Moderate, 3 - Substantial