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| **KERALA TECHNOLOGICAL UNIVERSITY**  http://ktu.edu.in/images/logo_final.png  **SCHEME AND SYLLABUS**  **FOR**  **M. Tech. DEGREE PROGRAMME**  **IN**  **MECHANICAL ENGINEERING**  **WITH SPECIALIZATION**  **COMPUTER INTEGRATED MANUFACTURING**  **CLUSTER 05 (ERNAKULAM II)**  **KERALA TECHNOLOGICAL UNIVERSITY CET Campus, Thiruvananthapuram Kerala, India -695016**  **(2015 ADMISSION ONWARDS)** |

**KERALA TECHNOLOGICAL UNIVERSITY**

**SCHEME AND SYLLABUS FOR M. Tech. DEGREE PROGRAMME**

**Branch: MECHANICAL ENGINEERING**

**Specialization: Computer Integrated Manufacturing**

**Semester 1 (Credits: 21)**

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| Exam Slot | Course No: | Name | L- T - P | Internal  Marks | End Semester Exam | | Credits |
| Marks | Duration (hrs) |
| A | 05ME 6301 | Advanced Engineering Materials and Processing | 3-1-0 | 40 | 60 | 3 | 4 |
| B | 05ME 6303 | Computer Aided Process Planning and Control | 3-1-0 | 40 | 60 | 3 | 4 |
| C | 05ME 6305 | Computer Aided Design in Manufacturing | 3-1-0 | 40 | 60 | 3 | 4 |
| D | 05ME 6307 | Automation and Control Systems | 3-0-0 | 40 | 60 | 3 | 3 |
| E | 05ME 631X | Elective-I | 3-0-0 | 40 | 60 | 3 | 3 |
|  | 05ME 6377 | Research Methodology | 0-2-0 | 100 | 0 | 0 | 2 |
|  | 05ME 6391 | Computer Integrated Manufacturing Laboratory – I | 0-0-2 | 100 | 0 | 0 | 1 |

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Elective I

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| 05ME 6311 | Metrology and Computer Aided Inspection |
| 05ME 6313 | Quality Engineering and Management |
| 05ME 6315 | Rapid Prototyping |

Semester 2 (Credits: 21)

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| Exam Slot | Course No: | Name | L- T - P | Internal  Marks | End Semester Exam | | Credits |
| Marks | Duration (hrs) |
| A | 05ME 6302 | Computer Aided Manufacturing | 3-1-0 | 40 | 60 | 3 | 4 |
| B | 05ME 6304 | Industrial Automation | 3-0-0 | 40 | 60 | 3 | 3 |
| C | 05ME 6306 | Flexible Manufacturing Systems | 3-0-0 | 40 | 60 | 3 | 3 |
| D | 05ME 632X | Elective-II | 3-0-0 | 40 | 60 | 3 | 3 |
| E | 05ME 633X | Elective-III | 3-0-0 | 40 | 60 | 3 | 3 |
|  | 05ME 6366 | Seminar-I |  | 100 | 0 | 0 | 2 |
|  | 05ME 6388 | Mini Project | 0-0-4 | 100 | 0 | 0 | 2 |
|  | 05ME 6392 | Computer Integrated Manufacturing Laboratory - II | 0-0-2 | 100 | 0 | 0 | 1 |

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Elective II

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| 05ME 6322 | Supply Chain Management |
| 05ME 6324 | Composite Material Technology |
| 05ME 6326 | Simulation of Manufacturing Systems |

Elective III

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| 05ME 6332 | Industrial Robotics |
| 05ME 6334 | Precision and Micromachining |
| 05ME 6336 | Micro and Nano Manufacturing |

Semester 3 (Credits: 14)

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| A | 05ME 734X | Elective-IV | 3-0-0 | 40 | 60 | 3 | 3 |
| B | 05ME 735X | Elective-V | 3-0-0 | 40 | 60 | 3 | 3 |
|  | 05ME 7367 | Seminar-II | 0-0-2 | 100 | 0 | 0 | 2 |
|  | 05ME 7387 | Project (Phase 1) | 0-0-12 | 50 | 0 | 0 | 6 |

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Elective IV

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| 05ME 7341 | Production Scheduling |
| 05ME 7343 | Design for manufacturing and Assembly |
| 05ME 7345 | Lean Manufacturing |

Elective V

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| 05ME7351 | Sustainable Manufacturing |
| 05ME7353 | Finite Element Method |
| 05ME7355 | Artificial Intelligence |

**Semester 4 (Credits: 12)**

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| Exam Slot | Course No: | Name | L- T - P | Internal  Marks | End Semester Exam | Credits |
|  | 05ME 7388 | Project (Phase 2) | 0-0-21 | 70 | 30 | 12 |

**12**

**Total: 68**

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6301** | | **ADVANCED ENGINEERING MATERIALS AND PROCESSING** | 4-0-0-4 | 2015 | |
| **COURSE OBJECTIVES**   1. To analyze the structure and properties of intermatallics, maraging steel and super alloys. 2. To enable students to be more aware of the properties of advanced engineering materials such as composites and biomaterials and select the materials for various applications.   **COURSE OUTCOMES**  Upon completion of this course work, students should be   1. Familiar with a selection of advanced engineering materials and related processing techniques. 2. Aware of the scientific and technological aspects of these materials and processes. 3. Able to integrate the scientific and engineering principles underlying the four major elements: structure, properties, processing and performance related to material systems appropriate to the field. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Atomic structure, crystallography, imperfections, modes of plastic deformation, Frank and Read source, need of alloying, The Iron–Iron Carbide (Fe–Fe3C) phase diagram, heat treatment, strengthening mechanisms (Review only)  Intermetallics: property prediction, phase diagrams, Electron (or Hume - Rothery) compounds and Laves phase, AB2 structures.  Maraging steel: History of maraging steel development - reaction in austenite - reaction in martensite - austenite to martensite transformation – effect of aging time - effects of maraging with cobalt, cobalt free, molybdenum and other alloying elements - variation of mechanical properties: yield strength, hardness and fatigue - effect of precipitate size - fracture toughness and weldability, hardness variation in welded zone - manufacturing steps of rings- applications - special advantages and limitations - comparison of production sequence with high tensile steel.  High temperature super alloys: Characteristics of high-temperature materials- instances of superalloy component failures, gas turbine engine requirement- selection of materials for high-temperature applications,Larson–Miller approach for creep performance – justification for Nickel as a high-temperature material | | | | 9 |
| **II** | Physical metallurgy of nickel and its alloys: Composition–microstructure relationships in nickel alloys, FCC, gamma prime, gamma double prime phase, TCP phases, carbide and boride phases, grain-boundary carbides - Defects in Ni and its alloys - vacancies, shockley partial dislocations, superdislocations, stacking fault and antiphase boundary.  Strengthening effects in nickel alloys: strengthening by particles of the gamma prime phase, temperature dependence of strengthening, yielding effect in gamma prime alloys - creep behavior of nickel alloys: nickel and creep strengthening in nickel alloys by solid-solution strengthening and precipitation hardening.  Molybdenum: Ferromolybdenum -production of molybdenum – properties - effect of molybdenum alloying on hot strength, corrosion resistance, and toughness – applications - TZM,  TZC.  Niobium: Production of niobium - niobium alloys - niobium in steel making Ni alloys characteristics and applications  Biomaterials: - Requirements for biomaterials-Dental materials: Cavity fillers etc -The structure of bone and bone fracture-Replacement joints-Reconstructive surgery-Biomaterials for heart repair Modern physical metallurgy and materials engineering. | | | | 9 |
| **III** | Titanium: Basic Properties, Crystal Structure, Elastic Properties, Deformation Modes - binary phase diagram classification based on alloying elements-Basic Hardening Mechanisms: Alpha Phase, Beta Phase - Sponge Production- effect of forging temperature and forging pressure - closed die forgings - pickling of titanium - scrap recycling - closed die forging - problems in machining Titanium - shear bands - Heat treatment and microstructure obtainable - welding of titanium and defects.  Detailed discussions on Vacuum induction melting (VIM) - Conditions for freckle formation -  - Vacuum arc remelting (VAR), Control, and structure developed, melt-related defects -electroslagremelting (ESR), electrode quality melt-related defects - triple melting, super alloy cleanliness.  Ceramics: AX, AmXp, AmBmXp type crystal structures – imperfections in ceramics, stoichiometric defect reactions – stress strain behavior – applications. | | | | 10 |
| **IV** | Composites: Introduction to composites, constituent materials and reinforcing fibers -properties and characteristics glass, carbon, aramid, ceramic, silicon carbide, boron fibers - discontinuous and continuous reinforcements for metal-matrix composites -metallic matrices: aluminum alloys; low-density, high-modulus alloys; high-temperature aluminum; titanium alloys - ceramic matrices - carbon matrices - interfaces and interphases - interphase thermodynamics -surface modification strategies - interphase effects on fiber-matrix adhesion - interphase and fiber-matrix adhesion effects on composite mechanical properties | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Callister William. D., “Material science and engineering”, John Wiley. 2. Westbrook J. H., “Intermetallic compounds”, John Wiley. 3. American Society for Metals, “Source book of Maraging Steels”. 4. Richard K. Wilson (Editor), “Maraging steels - recent development and applications”, TMS Publication. 5. Roger C. Reed, “The Superalloys Fundamentals and Applications”, Cambridge university press. 6. Matthew J. Donachie, Stephen J. Donachie, Superalloys, “A Technical Guide”, ASM International. 7. Krishnan K Chawla, “Composite Materials: Science and Engineering”, Springer. 8. ASM hand book volume 21 -composites 9. Thermodynamics & Heat transfer, YunusCengel. | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6303** | | **COMPUTER AIDED PROCESS PLANNING AND CONTROL** | 4-0-0-4 | 2015 | |
| **COURSE OBJECTIVES**  Upon completion of this course the student will be able to   1. Understand what is process planning and CAPP, know the various steps involved in CAPP, classify the various methods of CAPP, and understand the feature recognition in CAPP. 2. Understand the components of manufacturing systems. 3. Understand various process planning systems and implementation of various intelligent systems in CAPP.   **COURSE OUTCOMES**   1. Fundamental understanding of computer aided process planning systems. 2. Understanding the structures, basic components of manufacturing systems. 3. Understanding fundamental of intelligent systems in CAPP. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **INTRODUCTION:**  The role of Process Planning in Manufacturing Cycle - Process Planning and Production Planning – Technology and Methods,Process Planning and Design, Concurrent Engineering, Aggregate Production Planning-Production planning defined -Short-term production planning -Multiple-objective production planning, Product mix analysis, Lot-size analysis - MRP and machine loading, Long-term production planning, Production forecasting. Production Scheduling - Scope of production scheduling operations . | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **PART DESIGN REPRESENTATION:**  Technical Drawings, Geometric Tolerances, Tolerancing in Production, Process Capability and Process selection,Experience-Based Planning, Components of a manufacturing system, Group Technology, Parts Classification and Coding, Features of Parts Classification and Coding Systems, OPITZ system, MICLASS system, Production Flow Analysis, Cellular Manufacturing, Application Considerations in Group Technology, | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **COMPUTER AIDED PROCESS PLANNING SYSTEMS:**  Computer-Aided Process Planning, Retrieval CAPP Systems, Generative CAPP Systems, Structure of a Process Planning Software, Operation of a Typical Computer Aided Process Planning Software, Implementation Considerations of a Process planning system, Process Planning Systems, CAM-I CAPP, MIPLAN and MULTICAPP, Scope and problems of process planning - Process design, Operation design. Optimum routing analysis, Line balancing - Layout Planning and Design. Scope and problems of layout planning - Systematic layout planning (SLP) | | | | 10 |
| **IV** | **INTELLIGENT PROCESS PLANNING:**  Intelligent Manufacturing and Manufacturing Intelligence, Computational Intelligence, Artificial Neural Networks, Evolutionary Computation, Group Technology in Intelligent Manufacturing, Intelligent Process Planning: Intelligent CAPP, Application of GA to Computer-Aided Process Planning, The Implementation of ANN in CAPP System, The Use of Case-Based Reasoning in CAPP, Multi-Agent-Based CAPP. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Gideon Halevi, “Process and Operation Planning” Revised Edition of The Principles of Process Planning: A Logical Approach, Kluwer Academic Publishers, 2003. 2. Groover M. P, “Automation, production systems and computer integrated manufacturing”, Prentice Hall India (P) Ltd., 2002. 3. Radhakrishnan P., Subramanyan S., Raju V., “CAD/CAM/CIM”, 3rd edition, New Age International, 2008. 4. Sadhu Singh, “Computer Aided Design and Manufacturing”, 5th edition, khanna publishers, 2010. 5. Rao P. N., “CAD/CAM: Principles and Applications”, Tata McGraw Hill, 2004. 6. Zude Zhou, Huaiqing Wang, Ping Lou, “Manufacturing Intelligence for Industrial Engineering: Methods for System Self-Organization, Learning, and Adaptation”, Engineering Science Reference, 2010. 7. A. K Gupta, S. K. Arora, “Industrial automation and robotics”, Laxmi Publications, 2009. 8. R. Panneerselvam, “ Production and Operations management”, Prentice-Hall Of India Pvt. Limited, 2006 | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6305** | | **COMPUTER AIDED DESIGN IN MANUFACTURING** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To provide an overview of the CAD systems 2. To discuss computer graphics and graphics transformations involved in CAD. 3. To introduce the concepts of geometric modeling and parameter design. 4. To provide an introduction to Finite Element Analysis.   **COURSE OUTCOMES**   1. Understand the use of computer graphics and geometric modelling techniques in CAD. 2. Understand the use of Finite Element Analysis in CAD applications. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Overview of CAD systems: Conventional and computer aided design processes – advantages and disadvantage – CAD hardware and software – analytical and graphics packages – networking of CAD systems.  Computer graphics and graphics transformation: Image processing – transport of graphics data – graphic standards – display and viewing – transformations – customizing graphics softwares. | | | | 9 |
| **II** | Geometric modeling: Wire frame, surface and solid modeling – applications and advantages –Boolean operations – half-spaces – filleting of edges of solids – boundary representations – constructive solid geometry – sweep representation | | | | 9 |
| **III** | Parametric design and object representation: Types of co-ordinate system – parametric design – definition and advantages – parametric representation of analytic and synthetic curves – parametric representation of surfaces and solids – manipulations.  Mechanical assembly – mass property calculation. | | | | 10 |
| **IV** | Introduction to finite element analysis: Basic steps in finite element problems formulation – element type and characteristics – element shapes – co-ordinate systems – 1D link elements and beam elements – shape functions – stiffness matrices – direct stiffness method – 2 D elements – axisymmetric elements – plane stress problem – higher order elements. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| REFERENCES:  1. New man &Sproull, Principles of interactive graphics, McGraw Hill. 2. C. S. Krishnamoorthy and S. Rajeev, Computer aided design, Narosa Publishing House, 1991 3. Ibrahim Zeid, CAD/CAM theory and practice, McGraw Hill Inc, 1991 4. Vera B. Anand, Computer graphics and geometric modelling for engineers, John Wiley & Sons Inc., 1993 5. Sandhu Singh, Computer aided design and manufacturing, Khanna Publishers, 1998 6. User’s Manuals for Ansys, Adams, Pro/Engineer, Cadds 5 and Autocadsoftwares. 7. R. D. Cook, Concepts and applications of finite element analysis 8. Daryl L. Logan, A first course in the finite element method 9. David V. Hutton, Fundamentals of finite element analysis 10. David F. Rogers and J. Alan Adams, Mathematical elements for computer graphics, Second Edition, McGraw Hill, 1990 | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6307** | | **AUTOMATION AND CONTROL SYSTEMS** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**  Upon completion of this course the student will be able to accomplish the following Competencies   1. Explain the General function of Industrial Automation, list basic Devices in Automated systems. 2. Students will understand the automation strategies in manufacturing plants. 3. Identify Safety in Industrial Automation, and types of industrial sensors   **COURSE OUTCOMES**   1. Fundamental understanding of dynamical behavior of processes and systems, advanced automation function. 2. Understanding the structures, basic components and terminology of control systems, the difference between open-loop and closed-loop control. 3. Understanding fundamentals of automated assembly lines. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| I | **Automation: Introduction to automation: definition, types of automation, strategies merits and criticism – manufacturing plants and operations – automation strategies – basic elements of automated system – advanced automation functions – levels of automations – automated production lines – economic and social issues .** | | | | 9 |
| **II** | **Production automation: Industrial control systems – process layout for automation –discrete manufacturing industries – continuous and discrete control systems – overview of computer process control – fundamentals of automated assembly, parts feeding devices – production flow analysis: general terminology and analysis, analysis of transfer lines without storage, partial automation.** | | | | 9 |
| **III** | **Hardware Components for Automation and Process Control:** Sensors-Actuators-Electric Motors, Other types of actuators-Analog to digital convertors-Digital to analog Convertors-Input/output devices for discrete data- Contact input/output interfaces, Pulse counters and generators. | | | | 10 |
| **IV** | **Control systems:** Servomechanisms – digital computer control – controller components – hydraulic systems – pneumatic systems – stepper motor-transfer functions – block diagram algebra-– signal flow graphs-Feedback and non-feedback systems . | | | | 8 |
| **REFERENCES:**   1. Groover M. P, “Automation, production systems and computer integrated manufacturing”, Prentice Hall India (P) Ltd., 2002 2. **Gopal M., “Control systems principles and design”, TMH, New Delhi** 3. **Nagrath I. J. and Gopal M., “Control system engineering”, New Age International, New Delhi** 4. **Shinsky, “Process control system”, PHI, 2000** 5. **Troitskey A., “Principles of automation and automated production”, Mir Publishers, 1976** | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6311** | | **METROLOGY AND COMPUTER AIDED INSPECTION** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To familiarize the basic concepts of metrology, use of statistics in metrology and types of errors in precision measurements. 2. To acquaint the students with the metrology of gears and methods of measurement in testing of machine tools and measurement of gears. 3. To discuss Computer Aided Inspection (CAI) techniques.   **COURSE OUTCOMES**  Upon completion of this course work, students should have:   1. Have up to date knowledge about Metrology and Inspection and their applications in industries. 2. Understand the role of computers in metrology. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Type of errors:-catastrophic errors, alignment errors, combined sine and cosine errors, alignment of spherical end gauges; optical principles of projector, microscope, telescope, collimator, autocollimator and optical flat etc ; errors due to ambient conditions and errors due to elastic deformation; effects of supports; scale, reading, measuring errors; compound errors.  Mathematical concepts in metrology: - statistical concepts, limiting mean, range, variance and standard deviation, normal distribution, confidence interval and limits, precision and accuracy, statistical analysis of measurement data and control chart techniques.  Pneumatic comparators: - general design features, air gauge circuits, air gauge tooling, amplification selection, air gauge mastering, automatic gauging for inspection, machine control and assembly. | | | | 9 |
| **II** | Measurement of gears:-involute curve, involute function, standard proportions, helical gears, under cutting in gear teeth and addendum modification, dual flank test, single flank test -tooth thickness measurement:-tooth thickness at a pitch line, constant chord, base tangent method, measurement of over rollers - gear pitch measurement: - tooth to pitch measurement, cumulative pitch error measurement – testing involute form – allowable errors in spur gear. | | | | 9 |
| **III** | Machine tool testing:- lathe tests:- spindle axis parallel to bed, cross slide perpendicular to spindle axis, accuracy of pitch of lead screw etc – milling machine tests:- table surface parallel to guide ways, centre tee-slot parallel to table movement and square with spindle axis, cross travel of table parallel to spindle axis etc – radial drill tests:- saddle and arm movements parallel to base plate, spindle and feed movement square with base plate, other machines and methods – testing of measuring instruments:- plate square testing, angle between centre lines of holes, spines, gear tooth measurement, testing of try square, checking micrometer measuring faces, calibration of micrometer screw, checking of an autocollimator, optical square, calibration of polygon and circular table. | | | | 10 |
| **IV** | Laser metrology – applications of lasers in precision measurements - Co-ordinate measuring machine – contact and non-contact cmm – causes of errors – accuracy specifications – contact and non-contact probes - Calibration of CMM – measuring scales – Moiré fringes in linear grating – advantages and applications of CMM - Machine vision system – image formation – binary and grayscale image – image histogram – histogram operations – pixel point processing and pixel group processing – image sharpening and smoothing – edge detection and enhancement. | | | | 8 |
| **REFERENCES:**   1. ASME, Hand book of industrial metrology 2. Hume, “Metrology”, McDonald 3. Robert J. Hocken, Paulo H. Pereira, “Coordinate measuring machines and systems”, Second Edition, [CRC](https://books.google.co.in/url?id=TGzLBQAAQBAJ&pg=PA140&q=http://www.crcpress.com&linkid=1&usg=AFQjCNG9sb7YhmU3fNfZ2en-vuWw5jeLKQ&source=gbs_pub_info_r) 4. Sharp, “Metrology”, ELBS 5. Taher, “Metrology”, ELBS   Ted Busch, “Fundamentals of dimensional metrology”, Third Edition, Delmar Publishers | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6313** | | **QUALITY ENGINEERING AND MANAGEMENT** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To introduce the philosophy and core values of quality management. 2. To develop an understanding of quality management principles, frameworks, tools and techniques for effective real life applications in industry 3. To study different methods for improving quality.   **COURSE OUTCOMES**  Upon successful completion of the module students will be able to:   1. Develop an understanding on quality management philosophies and frameworks 2. Develop in-depth knowledge on various tools and techniques of quality management 3. Learn the applications of quality tools and techniques in both manufacturing and service industry | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
|  | Quality: Defining quality – philosophies of quality ‘gurus’- dimensions of quality - measures of quality – cost of quality – direct costs & indirect costs – ‘defectives’ and its significance - traditional model and emerging model of ‘cost-of-quality.’  Continuous process improvement: PDSA cycle – problem solving methodology | | | | 9 |
| **II** | Statistical process control: Statistical tools - control charts and use of probability distributions, process capability.  Acceptance sampling: Lot-by-lot acceptance sampling by attributes – fundamental concepts, statistical aspects: operating characteristic curve, producer’s risk and consumer’s risk, AQL, LQ, AOQ, ASN, ATI – sampling plan design. | | | | 9 |
| **III** | Taguchi methods: Loss functions – signal-to-noise ratio - process optimization and robust product design using orthogonal arrays,parametric and tolerance design.  Quality function deployment: Concept - house of quality – QFD process. | | | | 10 |
| **IV** | Total quality management (TQM): Definition - basic concepts – strategies.  Six sigma methodology: Basic concepts – DMAIC problem solving technique.  Quality system and standards: An overview of ISO 9000 and ISO 14000 series of standards | | | | 8 |
| **REFERENCES:**   1. Dale H. Besterfield, “Quality control”, Person Education, New Delhi, 2006. 2. Dale H. Besterfield, Carol Besterfield, Glen H. Besterfield& Mary Besterfield, “Total quality management”, Person Education, New Delhi, 2008. 3. R. Subburaj, “ISO 9000: Path to TQM”, Allied Publishers Limited, New Delhi, 1997 4. Bank J., “The essence of total quality management”, Prentice Hall 5. Dale B. G., “Managing quality”, Prentice Hall 6. A.V. Feigenbaum, “Total quality control”, McGraw Hill 7. G. L. Taguchi and Syed et. al., “Quality engineering production systems”, McGraw Hill 8. Zaidi, “SPC - concepts, methodology and tools”, Prentice Hall 9. Perry L Johnson, “ISO 9000”, McGraw Hill | | | | | |
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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6315** | | **RAPID PROTOTYPING** | 1-1-0-2 | 2015 | |
| **COURSE OBJECTIVES:**  This subject provides students with   1. An understanding of the various rapid prototyping and rapid tooling technologies; 2. The knowledge to select appropriate technologies for product development purposes. 3. Students will study topics fundamental to rapid prototyping and automated fabrication, including the generation of suitable CAD models, current rapid prototyping fabrication technologies, their underlying material science, the use of secondary processing, and the impact of these technologies on society.   **COURSE OUTCOMES:**  Upon completion of the subject, students should be able to   1. Apply the basic principles of rapid prototyping (RP) and rapid tooling (RT), technologies to product development; 2. Decipher the limitations of RP and RT technologies for product development; 3. Realise the application of RP and RT technologies for product development. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| I | Importance of being rapid – Roles of the Prototype-Process chain-data processing for rapid prototype (RP): CAD model preparation and data interfacing for RP –Classification of rapid Prototyping Systems- stereo lithography (SL): Principle, SL process, photo polymerization of SL resins. Rapid freeze prototyping- Solid Ground Curing-advantage ,disadvantage and applications. | | | | 9 |
| **II** | Selective laser sintering (SLS): principle, indirect and direct SLS, - selective laser cladding (SLC) – Laser engineered net shaping (LENS), Electron beam melting (EBM), 3D printing and desktop processes.-advantage, disadvantage and applications. | | | | 9 |
| **III** | Fused deposition modeling (FDM) –– laminated object manufacturing-Multi jet modeling (MJM) - Shape Deposition Manufacturing –advantage, disadvantage and applications -vacuum casting. | | | | 10 |
| **IV** | Rapid tooling (RT): Classification of RT –Direct and indirect RT-Soft and Hard Tooling – applications of RP: - heterogeneous objects, MEMS and other small objects, medicine and art. | | | | 8 |
| **REFERENCES:**   1. PatrikVenuvinod, Weiyuyin Ma, “Rapid prototyping”, Kluwer Academic Publishers 2. T. A. Grimm & Associates, “Users guide to rapid prototyping”, Society of Manufacturing Engineers (SME) 3. Frank W. Liou, “Rapid prototyping & engineering applications”, CRC Press 4. Ali K. Kamarani, “Rapid Prototyping theory & practice”, Manufacturing System Engineering Series, Springer Verlag 5. J. A. McDonalds, C. J. Ryall, “Rapid prototyping - case book”, Wiley Eastern 6. C. E. Bocking, AEW Rennie, “Rapid & virtual prototyping and applications”, Wiley Eastern | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6377** | | **RESEARCH METHODOLOGY** | 0-0-2-1 | 2015 | |
| **COURSE OBJECTIVES**   1. To generate awareness about the importance, types and stages of research. 2. To introduce the methods for data collection, analysis, interpretation and presentation of the results.   **COURSE OUTCOMES**  The students will be able to understand   1. The significance of different types of research and its various stages 2. The different methods of data collection 3. Different methods for analyzing data and interpreting the results. 4. The proper way of reporting and presenting the outcome. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Research: Meaning & objectives – types of research - identification, selection and formulation of research problem - research design - review of literature. Data collection & presentation: Primary & secondary data - collection methods. Basic statistical measures: Measures of central tendency, variation and skewness. | | | | 9 |
| **II** | Probability:Definition – discrete and continuous probability distributions: binomial, poison, uniform, exponential and normal distributions. Sampling technique: Sampling methods, sampling distribution of mean, variance and proportion, confidence interval estimation, determination of sample size. | | | | 9 |
| **III** | Testing of hypothesis: Fundamentals of hypothesis testing – procedure of hypothesis testing - testing of mean, proportion and variance: one-tailed and two-tailed tests – chi-square test for checking independence of categorized data - goodness of fit test. Test for correlation and regression. | | | | 10 |
| **IV** | Non - parametric tests: One sample tests - sign test, chi-square test, Kolmogorov-Smirnov test, run test for randomness – two sample tests: sign test, median test, Mann-Whitney U test – K-samples tests: median tests, Kruskal-Wallis test. Interpretation and report writing: Meaning of interpretation, techniques of interpretations - types of report, layout of research report. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Panneerselvam, R., “Research methodology”, Prentice Hall of India, New Delhi, 2011 2. Kothary, C. R., “Research methodology: methods and techniques”, New Age International, New Delhi, 2008 3. Goddard, W. and Melville, S., “Research methodology – an introduction”, Juta& Co. Ltd., Lansdowne, 2007 4. Miller and Freund, “Probability and statistics for engineers”, Prentice Hall of India Private Limited, New Delhi | | | | | |
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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05ME 6391** | **COMPUTER INTEGRATED MANUFACTURING LABORATORY I** | 3-0-0-0 | 2015 |
| **COURSE OBJECTIVES**   * To train students in various computer aided modelling techniques using CAD softwares. * To mould students to be an expert in the field of finite element analysis and also able to undertake problem identification, formulation and solution. * To assist and support the design, manufacture and testing of products and components for design oriented projects. * To emphasize the applications of DOE in the field of computer integrated manufacturing.   **List of Exercises / Experiments**   1. 3D solid modeling and assembly using any parametric software. 2. Synthesis of simple mechanisms using any parametric software. 3. Finite Element Analysis (FEA) :-  * Pre-processing (solid modeling, meshing, analysis setup)solver and * post processing (graphical display and report)   (Exercises include Simple Beam, Plane Stress, Strain, ax-symmetric, 3D Solids).   1. Manufacturing system simulation using software. 2. Design of experiments and analysis of data using software like SPSS, MiniTabetc   (Analysis of mean and ANOVA Application of software)  **COURSE OUTCOME:**   * The students shall be able to model 3-D CAD renderings. * Students shall be able to apply FEA for solving problems in various areas. * The students should have the ability to conduct design of experiments and execute the same to an appropriate professional standard. | | | |
| **REFERENCES:**   1. Arbor text, PTC Authorized training manual (PL-830A-01), PTC University, Parametric Training Corporation, 2010. 2. K J bathe, Finite Element Procedures, Prentice Hall, 2007. 3. Abaqus 6.13, Documentation, DassaultSystèms, 2013. 4. Jacob Fish, Ted Belytschko, A First Course in Finite Elements (Paperback), Wiley, 2007. 5. Douglas C. Montgomery, Design and Analysis of Experiments: International Student Version (English) 8th Edition, Wiley. | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6302** | | **COMPUTER AIDED MANUFACTURING** | 4-0-0-4 | 2015 | |
| **COURSE OBJECTIVES**  After the successful completion of this course, students will   1. gain a basic understanding of computer numerical control (CNC) machining processes and operations using a combination of G-codes, milling and turning equipment 2. be able to create drawings using commercial solid modeling CAD software 3. be able to program NC codes manually 4. be able to generate NC codes using commercial CAM package 5. have known the current status of CAD/CAM systems in industry   **COURSE OUTCOMES**  Upon completion of the subject, students should be able to   1. Demonstrate a basic understanding of  machining fundamentals including speed and feed calculations, tooling systems, and work-holding systems for CNC milling and turning equipment 2. Demonstrate a basic understanding of numerical controlled (NC) programming strategies 3. Demonstrate an ability to set-up, program, and operate CNC milling and turning equipment and to generate NC code using G-codes to machine parts to specifications. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **Introduction and design features of CNC machines:** Working principles of typical CNC lathes, turning centre, machining centre, CNC grinders, CNC gear cutting machines, wire cut EDM, turret punch press, CNC press brakes etc. Selection of CNC machine tools. Structure, drive kinematics, gear box, main drive, feed drive, selection of timing belts and pulleys, spindle bearings arrangement and installation. Re-circulating ball screws, linear motion guide ways, tool magazines, ATC, APC, chip conveyors, tool turrets, pneumatic and hydraulic control systems. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Control systems and interfacing:** Open loop and closed loop systems, microprocessor based CNC systems, block diagram of a typical CNC system, description of hardware and software interpolation systems, standard and optional features of a CNC control system, comparison of different control systems. Feedback devices with a CNC system, spindle encoder. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Part programming of a CNC lathe:** Process planning, tooling,preset and qualified tools, typical tools for turning and machining centers. Axes definition, machine and work piece datum, turret datum, absolute and incremental programming, tape codes , ISO and EIA codes, G and M functions, tool offset information, soft jaws, tool nose radius compensation, long turning cycle, facing cycle, constant cutting velocity, threading cycle, peck drilling cycle, part programming examples. | | | | 10 |
| **IV** | **Manual part programming of a machining centre:** Co-ordinate systems, cutter diameter compensation, fixed cycles, drilling cycle, tapping cycle, boring cycle, fine boring cycle, back boring cycle, area clearance programs, macros, parametric programming, part programming examples. CAD/CAM based NC programming, features of typical CAM packages. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. James Madison, “CNC machining hand book”, Industrial Press Inc., 1996 2. Steve Krar, Arthur Gill, “CNC technology and programming”, McGraw-Hill, 1990 3. Berry Leathan - Jones, “Introduction to computer numerical control”, Pitman, London, 1987 4. Hans B. Kief, T. Fredericx Waters, “Computer numerical control”, MacMillan / McGraw-Hill, 1992 5. Bernard Hodgers, “CNC part programming work book”, City and Guids / Macmillan, 1994. 6. David Gribbs, “An introduction to CNC machining”, Cassell, 1987 7. Sadasivan, T. A. and Sarathy, D., “Cutting tools for productive machining”, Widia (India) Ltd., 1999 8. Radhakrishnan, P., “Computer numerical control machines”, New Central Book Agency, 1992 9. Peter Smid, “CNC programming hand book”, Industrial Press Inc., 2000 | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6304** | | **INDUSTRIAL AUTOMATION** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**  This course Provides comprehensive introduction to fluid power including both hydraulics and pneumatics.  **COURSE OUTCOMES**  On completion of this course the students will be able to acquire knowledge of the applications of fluid power in various engineering fields work with PLC and understand its application in industry. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **HYDRAULIC SYSTEMS**  Introduction to fluid power system - Hydraulic fluids - functions, types, properties, selection and application.  Construction, operation, characteristics and graphical symbols of hydraulic components- pumps, actuators/motors, valves, switches filters, seals, fittings and other accessories | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **PNEUMATIC SYSTEMS**  Introduction to pneumatic system - Construction, operation, characteristics and symbols of pneumatic components. Air treatment - principles and components. Sensors- types - Characteristics and applications - Introduction to fluidics and MPL. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **HYDRAULIC AND PNEUMATIC CIRCUITS:**Reciprocating circuits, pressure dependant circuits, speed control circuits, pilot operated circuits, simple sequencing circuits, synchronizing circuits, circuits using accumulator, time delay circuits, logic circuits, cascading circuits, feedback control circuits. | | | | 10 |
| **IV** | **PROGRAMMABLE LOGIC CONTROLLER**  Development of hydraulic / pneumatic circuits applied to machine tools, presses, material handling systems, automotive systems - packaging industries manufacturing automation.  Programmable logic controller-Basic PLC structure, Input / Output processing- Ladder programming. Instruction lists- Latching and internal relays, sequencing, Timers and counters, Shift registers, Master and Jump Control. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES**   1. Anthony Esposito, Fluid Power with applications, Prentice Hall International, 1997 2. Majumdar S. R., Oil Hydraulics, Tata McGraw Hill, 2002 3. W. bolton, Mechatronics, Pearson education Publication 4. Werner Deppert / Kurt Stoll, Pneumatic Application, Vogel verlag, 1986 5. John Pippenger, Tyler Hicks, Industrial Hydraulics, McGraw Hill International Edition, 1980 6. Andrew Parr, Hydraulics and pneumatics, Jaico Publishing House, 2003 7. FESTO, Fundamentals of Pneumatics, Vol I, II and III 8. Hehn Anton, H., Fluid Power Trouble Shooting, Marcel Dekker Inc., NewYork, 1984 9. Thomson, Introduction to Fluid power, Prentcie Hall, 2004 | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6306** | | **FLEXIBLE MANUFACTURING SYSTEMS** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To provide an understanding of the concepts of flexible manufacturing systems, their components and operational decisions required for controlling such systems. 2. To specify the types of quantitative analysis that may be used with regard to FMS. 3. To study the fundamental concepts and programming of a Programmable Logic Controller (PLC).   **COURSE OUTCOMES**  Upon completion of this course work, students should be able to:   1. Perform modeling, design and simulation of flexible manufacturing systems. 2. Gain insight about the research areas related to FMS and real-time shop floor control. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Introduction to FMS: Definition of FMS – types and configuration concepts – types of flexibility. Functions of FMS host computer – FMS host and area controller function distribution.  Development and implementation of FMS: Planning phases – integration – system configuration – FMS layouts – simulation – FMS project development steps. Project management – equipment development – host system development – planning - hardware and software development. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Pioneering integrated systems – different flexible systems: molins, chalmersetc – different pallets and fixtures for prismatic and turned parts – prismatic parts machines.  Planning and scheduling of FMS: Quantitative Analysis of FMS – Bottleneck Model – Terminology and symbols, FMS Operational parameters, System performance measures –Extended Bottleneck model- Sizing the FMS - problems. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | Distributed numerical control: DNC system – communication between DNC computer and machine control unit – hierarchical processing of data in DNC system – features of DNC system specific to FMS.  Automated material handling: Functions - types – quantitative analysis of material handling equipments. Design of conveyors and AGV systems.  Automated storage: Storage system performance – AS/RS – carousel storage system – WIP storage – interfacing handling and storage with manufacturing. | | | | 10 |
| **IV** | Programmable logic controllers in FMS: Role of PLCs in Manufacturing and Assembly operations in a CIM environment – PLC Input instructions, Outputs. PLC Timer and Counter functions – Creating relay logic diagrams and screen patterns for various operations in FMS from their process control descriptions.  Data base in FMS: Manufacturing data systems and data flow-CAD and CAM considerations for FMS – data base systems.  Design of automated assembly systems - FMS case studies in aerospace machining, sheet metal fabrication applications - Toyota production system - The Rover LM-500 FMS – The HNH (HattersleyMewmanHender) FMS etc. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Parrish D. J., “Flexible manufacturing”, Butterworth – Heinemann Ltd, 1990 2. Groover M. P., “Automation, production systems and computer integrated manufacturing”, Prentice Hall India (P) Ltd., 2002 3. Shivanand H. K., Benal M. M and Koti V, “Flexible manufacturing system”, New Age International (P) Limited. Publishers, 2006 4. Kusiak A., “Intelligent manufacturing systems”, Prentice Hall, Englewood Cliffs, NJ, 1990 5. Joseph Talavage and Roger G. Hannan, Flexible Manufacturing Systems in practice, Marcel Dekker, Inc. New York, 1988. 6. Considine D. M. &Considine G. D., “Standard handbook of industrial automation”, Chapman and Hall, London, 1986 7. Viswanadhan N. and Narahari Y., “Performance modeling of automated manufacturing systems”, Prentice Hall India (P) Ltd., 1992 8. John W. Webb and Ronald A. Reis “Programmable Logic Controllers”, Prentice Hall India (P) Ltd., 2006. 9. Ranky P. G., “The design and operation of FMS”, IFS Pub, U. K, 1998 | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6322** | | **SUPPLY CHAIN MANAGEMENT** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To introduce the major elements of supply chain and the need for supply chain management. 2. To study the role of forecasting and inventory management in supply chain. 3. To discuss sourcing, transportation and logistics decisions in supply chain management.   **COURSE OUTCOMES**   1. Students will be able to understand how supply chain strategy can provide a competitive edge for organizations 2. Students will learn about the importance of supply chain management and how to apply decision making techniques in an integrated supply chain environment. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Introduction to supply chain management: Supply chain basics, decision phases in supply chain, supply chain flows, supply chain efficiency and responsiveness, supply chain integration, process view of a supply chain, uncertainties in supply chain, key issues in supply chain management, drivers of supply chain performance. Supply chain coordination, bullwhip effect, developing relationships in the supply chain, resolving conflicts in supply chain relationships, role of information technology in supply chain | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | Demand forecasting in supply chain: Role of forecasting in supply chain, components of a forecast, forecasting methods, estimating level, trend and seasonal factors, Holt’s model, Winter’s model, measures of forecast error.  Role of aggregate planning in supply chain: Aggregate planning strategies, managing supply and demand in supply chain. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | Supply chain inventory: Role of cycle inventory in supply chain, economies of scale, lot sizing for a single product, lot sizing for multiple products, quantity discounts, trade promotions, price discrimination. Role of safety stock in supply chain, determining appropriate level of safety inventory, inventory replenishment policies, measures of product availability. | | | | 10 |
| **IV** | Sourcing decisions in supply chain: Supplier selection and contracts, design collaboration, making sourcing decisions in practice.  Transportation decisions: Role of transportation in supply chain, factors affecting transportation decisions. Routing and scheduling in transportation.  Logistics: Definition, logistics and SCM, international considerations, inbound logistics, internal logistics and outbound logistics. Reverse logistics, green supply chain. | | | | 8 |
| **END SEMESTER EXAM (ALL Modules)** | | | | | |
| **REFERENCES:**   1. Sunil Chopra and Peter Meindl, “Supply chain management - strategy planning and operation”, PHI 2. Handfield R. B., Nichols Jr. E. L., “Introduction to supply chain management”, Pearson Education 3. Raghuram R. and Rangaraj N., “Logistics and supply chain management”, Macmillan, 2001 4. Simchi-Levi, D., Kaminsky, P., and Simchi-Levi, E., “Designing & managing the supply chain: concepts, strategies & case studies.” 2nd Edition, Tata McGraw-Hill, 2003 5. Agarwal D. K., “A text book of logistics and supply chain management”, Macmillan, 2003 6. Srinivasan, G., “Quantitative models in operations and supply chain management”, PHI | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6324** | | **COMPOSITE MATERIAL TECHNOLOGY** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**   * To provide knowledge of various manufacturing methods of different composite materials, their properties, and their applications. * To understand machining characteristics of various composite materials.   **COURSE OUTCOME:**  At the end of this course the student will be able to select appropriate composite materials for specific applications. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | Introduction – Fibre reinforcements – Fabrication, properties and applications of Glass fibres, Boron fibres, Carbon fibres, Aramid fibres, Ceramic fibres – Whiskers – Comparison of fibres: particulate and whisker reinforcements – Matrix materials – Polymers, Metals, Ceramics and their properties. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Polymer matrix composites** – Processing of PMCs – Thermoset matrix composites: Hand layup, spray, filamentwinding, pultruion, resin transfer moulding, auctoclave moulding – Thermoplastic matrix composites :Film stacking, diaphragm forming, thermoplastic tape laying, Injection moulding – Interfaces in PMCs:Glass fibre/polymer interface, Aramid fibre/polymer interface – Structure, applications and mechanicalproperties of PMCs – Recycling of PMCs | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Metal matrix composites** – Types, Metallic matrices: Aluminium, Titanium, Magnesium, copper Alloys –Processingof MMCs: Solid state, Liquid state, Vapour state ,In-situ – Interface/Interphase in MMCs – Interfacialbonding in MMCs – Mechanical properties, coefficient of thermal expansion, environmental effects,moisture effects – Applications of MMCs – Recycling of MMCs. | | | | 10 |
| **IV** | **Ceramic matrix composites:** Introduction – Types – Toughening Mechanism- Processing of CMCs: Cold pressing, sintering, reaction bonding, liquid infiltration, lanxide process – In-situ chemical reaction techniques: Chemical vapour deposition, Chemical vapour impregnation, Sol-gel, C-C Composites. Interface in CMCs. Mechanical Properties and Applications of CMCs – Fatigue behaviors and S-N curves of particle and whisker reinforced CMCs – Hybrid composites – Thermal fatigue – Creep. **Machining of composites-** Traditional (turning, milling, drilling, abrasive machining) and non-traditional (abrasive waterjetmachining, electric discharge machining, ultrasonic, laser–assisted) machining of Composites. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:** Autar K. Kaw, “Mechanics of Composite Materials’’, CRC press.Chawla K.K., “Composite Materials: Science and Engineering”, Springer, New York.Jahanmir S., Ramulu, M. and Koshy, P., “Machining of Ceramics and Composites”, Marcel Dekker Inc, New York, 1999.Mallick P.K., “Fiber Reinforced Composites: Materials, Manufacturing and Design”, CRC Press, New Delhi.  1. Sheikh-Ahmad J.Y., “Machining of Polymer Composites”, Springer.  Hull D. and Clyne T.W., “An Introduction to Composite Materials”, Cambridge University Press. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6326** | | **SIMULATION OF MANUFACTURING SYSTEMS** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. Expose the students to Discrete-Event Simulation as a design and analysis tool, problem solving tool, risk analysis tool, and decision-making tool in manufacturing environment. 2. Know how to conduct a successful simulation using software such as Matlab   **COURSE OUTCOMES:**  After completing the course students should be able to:   1. understand the nature of discrete-event simulation and the types of simulation models 2. understand the broad applicability of discrete-event simulation to solve complex manufacturing systems problems 3. learn the essential steps of the simulation methodology 4. learn analytical techniques for interpreting input data and output results pertinent to simulation models 5. learn to use Simulation Software Tool to build credible valid simulation models, design and run simulation experiments, and critically evaluate decision-support simulation results 6. gain insight into system behavior by measuring the performance characteristics of proposed new manufacturing system or the impact of proposed changes for existing manufacturing system. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **System concept:** Systems and system environment, components of a system, discrete and continuous systems, systems approach to problem solving, types of system study, system analysis, system design and system postulation, system modeling, types of models.  **System simulation:** Technique of simulation, comparison of simulation and analytical methods, types of system simulation, steps in simulation study, Monte Carlo simulation.  **Concepts in discrete event simulation:** Event scheduling/time advance algorithm, modeling world views, simulation programming tasks, comparison and selection of simulation languages. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **Random number generation:** Techniques for generating random numbers, linear congruential method, test for random numbers, frequency tests, run tests, tests for autocorrelation, gap test, and Poker test.  **Random variate generation:** Inverse transformation technique, exponential, uniform, weibull, triangular, empirical-discrete and continuous distributions. Convolution method, acceptance - rejection technique.  **Input modeling for simulation:** Data collection, identifying the distribution with data, parameter estimation, goodness of fit test, Chi square, Klomogrov and Smirnov tests, selecting input model when data are not available. | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Verification and validation of simulation models:** Verification of simulation models, calibration and validation of models, face validity, validation of model assumption, validating input-output transformation, input-output validation using historical input data.  **Output analysis for a single model:** Measures of performance and their estimation, point estimation, interval estimation, output analysis for terminating simulations and steady state simulations. | | | | 10 |
| **IV** | **Simulation modeling and analysis of manufacturing systems:** Objectives, performance measures, issues in simulation of manufacturing systems, simulation software for manufacturing applications, simulation of job shop manufacturing systems, simulation modeling and analysis of single server and single queue systems, inventory systems and pert networks. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Banks, J., Carson, J. S., Nelson, B. L., and Nicol, D. M., “Discrete-event system simulation”, Third Edition, Pearson Education, Inc., 2001 2. Gordon G., “System simulation”, Prentice Hall Ltd. 1991 3. Deo, N., “System simulation with digital computer”, Prentice Hall of India, 1997 4. Askin R. G. and Standridge, C. R., “Modeling and analysis of manufacturing systems”, John Wiley & Sons, 1993. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6332** | | industrial robotics | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**   1. To be familiar with the automation and brief history of robot and applications. 2. To give the student familiarities with the kinematics of robots. 3. o give knowledge about robot end effectors and their design. 4. To learn about Robot Programming methods & Languages of robot. 5. To give knowledge about various Sensors and their applications in robots.   **COURSE OUTCOMES:**   1. Students will be equipped with the automation and importance of robotics in today and future goods production. 2. Students will be familiarized with the kinematic motions of robot. 3. Students will have good knowledge about robot end effectors and their design concepts. 4. Students will be equipped with the Programming methods & various Languages of robots. 5. Students will be equipped with the principles of various Sensors and their applications in   Robots. | | | | | |
| MODULE | COURSE CONTENT (36 hrs) | | | | HRS |
| **I** | **Fundamental concepts of Robotics**  History, present status and future trends, robotics and automation, laws of robotics, robot definition, robotics systems and robot anatomy, specification of robots. Resolution, repeatability and accuracy of a manipulator. | | | | 9 |
| **INTERNAL TEST 1 (Module 1)** | | | | | |
| **II** | **ROBOT DRIVE MECHANISMS**  Power transmission systems and control robot drive mechanisms, mechanical transmission method, rotary-to-rotary motion conversion, rotary-to-linear motion conversion, end effectors- types, gripping problem, remote-centered compliance devices - control of actuators in robotic mechanisms. Sensors for robotic applications: devices - non-optical-position sensors - optical position sensors - velocity sensors - proximity sensors: - contact and non-contact type - touch and slip sensors - force and torque sensors - AI and robotics | | | | 9 |
| **INTERNAL TEST 2 (Module 2)** | | | | | |
| **III** | **Computer Vision for Robotics Systems**  Robot vision systems - imaging components - image representation - hardware aspects - picture coding - object recognition and categorization - visual inspection - software considerations - applications - commercial - robotic vision systems.  **Computer Considerations for Robotic Systems:** Computer architecture for robots, hardware, computational elements in robotic applications - robot programming - sample programs - path planning - robot's computer system. | | | | 10 |
| **IV** | **Transformations, applications:**  Homogeneous co-ordinates, co-ordinate reference frames, homogeneous transformations for the manipulator, the forward and inverse problem of manipulator kinematics, motion generation, manipulator dynamics, Jacobian in terms of D. H. matrices controller architecture. Robot programming of commercial robots - robot design and process specifications - motor selection in the design of a robotic joint - robot cell layouts - economic and social aspects of robotics, Capabilities of robots-robotics applications - obstacle avoidance - robotics in India - the future of robotics. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. S.K Saha, “Introduction to Robotics”, McGraw Hill Education, 2008 2. Mikell P Groover, Mitchell Weiss, Roger N Nagel, Nicholas G Odrey, “Industrial Robotics”, McGraw Hill Book Co, NY, 2008. 3. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill Book Co., 2004. 4. Fu KS, Gomaler R C and Lee C S G., "Robotics: Control Sensing, Vision, Intelligence", McGraw Hill Book Co., 1987. 5. Shuman Y No, "Handbook of Industrial Robotics", John Wiley and Sons, New York, 1985. | | | | | |
| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6334** | | precision and micromachining | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To discuss the principles of micromachining. 2. To introduce the basic concepts in laser beam machining. 3. To study the various advanced finishing processes and their applications.   **COURSE OUTCOMES**  On successful completion of this course, students will be able to:   1. Gain an insight into the various aspects of laser beam machining. 2. Have a good understanding of the theories of cutting and chip formation in micro and nano engineering. 3. Acquire knowledge in the mechanism of material removal and machinability of materials in advanced finishing processes. | | | | | |
| MODULE |  | | | | HRS |
| **I** | Laser beam machining: Lasers basics - integration of laser system for cutting operation - principles of laser material removal – detailed discussion on process analysis, absorbed laser power at the cut front, exothermic heat in reactive laser cutting - characteristics of cut front, temperature at cut front, melt film thickness, melt flow velocity, mobility of cut front- characteristics of cut surface, striation, thermal dynamic instability, hydrodynamic instability - heat-affected zone - processing parameters, cutting speed, laser beam, polarization of beam, wavelength of laser beam, pulsed laser beam etc, gas nozzle etc - workpiece aspects for laser beam machining, workpiece thickness, workpiece materials. | | | | 9 |
| **II** | Mechanical micromachining: microfluidic systems - theory of micromachining; micromilling force analysis, initial chip curl modeling, burr formation in micromachining - micromachining tool design - high speed air turbine spindles- mechanical design of high-speed rotors, basic geometry of the rotor, rotor with fillet surfaces. | | | | 9 |
| **III** | Nanomachining: Introduction, nanometric machining, theoretical basis of nanomachining, cutting force and energy, cutting temperature, chip formation and surface generation, minimum undeformed chip thickness, critical cutting edge radius, properties of workpiece materials, comparison of nanometric machining and conventional machining- implementation - single point diamond turning. | | | | 10 |
| **IV** | Advanced finishing processes (AFPs), abrasive flow machining (AFM), magnetic abrasive finishing (MAF), elastic emission machining (EEM), ion beam machining (IBM), microhoning , superfinishing and chemical mechanical polishing (CMP). Micromachining by photonic beams- excimer laser- model construction of laser dragging, numerical simulation of dragged profile. Micromanufacturing for document security: Optically variable device - ODV foil microstructures- generic OVD microstructures- nano CODES. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Paulo Davim J, “Nontraditional machining processes”, ISBN 978-1-4471-5179-1, Springer-Verlag, London, 2013. 2. Hong Hocheng and Hung-Yin Tsai, “Advanced analysis of nontraditional machining”, Springer. 3. NitaigourPremchandMahalik, “Micromanufacturing and nanotechnology” 4. Joseph McGeough, “Micromachining of engineering materials mechanical engineering”, ISBN: 0-8247-0644-7. 5. M. Kahrizi, “Micromachining techniquess for fabrication of micro, nano structures”. 6. Mark J. Jackson, “Micro and nanomanufacturing”, Springer. | | | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 6336** | | **MICRO AND NANO MANUFATURING** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To discuss the various manufacturing processes of MEMS and semiconductor devices. 2. To study size-effects and material/interface behaviour at the micro-/nano scale. 3. To study the structure, properties and applications of carbon based nanostructures.   **COURSE OUTCOMES**   1. A good understanding of the fundamentals associated with manufacturing at the micro and nano scale. 2. In depth knowledge of micro and nano structures and their processing methods and techniques. | | | | | |
| MODULE |  | | | | HRS |
| **I** | Characterizing etching processes in bulk micromachining - microfabrication of MEMS and semiconductor devices -basics of microfabrication, integrated circuit fabrication etc - crystallography and its effects, silicon as substrate and structural material, stress and strain, - crystal plane effects on etching, wet etching process, reaction phenomena, anisotropic etching, isotropic etch curves, masking for anisotropic etchants, etching control, fusion bonding of silicon on an insulator, deep reactive ion etching, fabrication of a cantilever probe, manufacture, microprocessors etc and applications- problems with etching in bulk micromachining. | | | | 9 |
| **II** | Photolithography: Principle of the soft lithography and applications -principle of microcontact printing and applications - characterizing the surface micromachining process, isolation layer, sacrificial layer, structural material, selective etching – properties, stress, stress measurement, stiction - wafer bonding: anodic and fusion, bonding. Micro and nanotechnology: Applications for space micropropulsion - subsystems and devices for miniaturised spacecraftsmicropropulsion: microbolomete, micro FEEP, integrated cold-gas microthruster, microturbogas, pyrotechnic actuator and microvalveetc - propulsion systems: solid propellant, ADCS etc. | | | | 9 |
| **III** | Carbon nanotube production and applications: Basis of nanotechnology - structure and properties of carbon nanotubes- production of carbon nanotube: chemical vapour deposition, arc discharge, laser ablation, mechanisms of growth, purification of carbon nanotube – applications: electrical transport of carbon nanotubes for FET, Computers, nanodevices for biomedical, X-ray equipment, nanomechanic actuator and artificial muscles, fuel cells, membrane electrode assembly, mechanical and electrical reinforcement of bipolar plates, hydrogen storage etc. | | | | 10 |
| **IV** | Carbon based nanostructures: - Structure of carbon nanotubes, Y-shaped, double helical, bamboo, hierarchical morphology - structure of fullerenes - structure of carbon nanoballsstructure of carbon nanofibers - porous carbon - properties of carbon nanostructures – synthesis - 15 potential applications of nanostructures - composite materials - nanotechnology for fuel cell applications: nanoparticles in heterogeneous catalysis, O2 electroreduction reaction on carbonsupportedPt catalysts, carbon nanotubes as catalyst supports. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. NitaigourPremchandMahalik, “Micromanufacturing and nanotechnology”, Springer. 2. M. Kahrizi, “Micromachining techniquess for fabrication of micro, nano structures”. 3. Mark J. Jackson, “Micro and nanomanufacturing”, Springer 4. Jeremy Ramsden, “Micro &nano technologies”, Elsevier. | | | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05ME 6366** | **SEMINAR I** | 0-0-2-2 | 2015 |
| Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses being undergone in the second semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student’s paper, presentation and his/her participation in the seminar. | | | |

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| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05ME 6388** | **MINI PROJECT** | 0-0-2-2 | 2015 |
| The mini project is designed to develop practical ability and knowledge about practical tools/techniques in order to solve the actual problems related to the industry, academic institutions or similar area. Students can take up any application level/system level project pertaining to a relevant domain. Projects can be chosen either from the list provided by the faculty or in the field of interest of the student. For external projects, students should obtain prior permission after submitting the details to the guide and synopsis of the work. The project guide should have a minimum qualification of ME/M.Tech in relevant field of work. At the end of each phase, presentation and demonstration of the project should be conducted, which will be evaluated by a panel of examiners. A detailed project report duly approved by the guide in the prescribed format should be submitted by the student for final evaluation. Publishing the work in Conference Proceedings/ Journals with National/ International status with the consent of the guide will carry an additional weightage in the review process. | | | |
| COURSE CODE | COURSE NAME | L-T-P-C | YEAR |
| **05ME 6392** | **COMPUTER INTEGRATED MANUFACTURING LABORATORY II** | 0-0-2-1 | 2015 |
| **COURSE OBJECTIVES:**   * To provide high quality laboratory experience for post graduate students in areas of manufacturing automation and computer assisted and computer controlled manufacturing. * To familiarize students with the interdisciplinary nature of the course and embellish their experience in the field of instrumentation. * To equip students with the current tools for design & manufacturing. * To expertise students in the field of reverse engineering and PLC programming.   **List of Exercises / Experiments**   1. Programming of CNC lathe using software. 2. Programming of machining centre using software. 3. Automation using pneumatics 4. Automation using power hydraulics 5. Automation using PLCs for pneumatic control 6. Study of process control simulator. 7. PLC programming and implementation. 8. Transducer interface with PC. 9. Stepper motor and servo motor interface with PC. 10. Process capability evaluation based on inspection data.   **COURSE OUTCOME:**  Students who successfully complete this course will have enhanced knowledge in computer integrated manufacturing systems and better understanding of various aspects of CAM systems. They will know to use modern technologies in their academic and future life. | | | |
| **REFERENCES:**   1. Arbor text, PTC Authorized Training Manual (pl-830a-01), PTC University, Parametric Training Corporation, 2010. 2. L.A. Bryan, Programmable Controllers Theory and Implementation, second edition, Industrial Text Publication. 3. Kevin Otto, Product Design: Techniques in Reverse Engineering and New Product Development (english) 1st Edition, Pearson. 4. Bruno Siciliano, OussamaKhatib, Springer Handbook of Robotics, Springer, 2008. 5. Margolis, Arduino Cookbook, Oreilly, 2012. | | | |

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| COURSE CODE | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7341** | | **PRODUCTION SCHEDULING** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES**   1. To introduce theory and algorithms for scheduling several tasks over time 2. To provide an understanding of measures of performance, single machine scheduling and flowshop scheduling 3. To study line balancing algorithms and project scheduling techniques   **COURSE OUTCOMES**  Students should be able to:   1. Apply the concepts of sequencing and scheduling on the factory floor 2. Have knowledge about the fundamental research topics in the field of production scheduling | | | | | |
| MODULE |  | | | | HRS |
| **I** | Introduction to scheduling – objectives in scheduling - processing characteristics and constraints – performance measures. Single machine scheduling – sequencing theorems - SPT rule to minimize mean flow time, EDD rule to maximum lateness – branch and bound technique to minimize mean tardiness – assignment model. Parallel processors – minimization of makespan, mean weighted flowtime - McNaughton’s algorithm, heuristic procedures. | | | | 9 |
| **II** | Flow shop scheduling – Extension of Johnsons’s rule for 3 machine problem – branch and bound technique – Palmer’s heuristic. Job shop scheduling – introduction to dispatching rules – SPT, FCFS, MWKR, MOPNR, LWKR, RANDOM – two jobs and m machines scheduling - Giffler and Thomson algorithm. | | | | 9 |
| **III** | Mass production management - basic idea of assembly line balancing - optimization of number of stations with given production rate - minimization of cycle time with fixed number of stations.  Line balancing algorithms – largest candidate rule, Kilbridge and Wester, rank positional weight method, COMSOAL. | | | | 10 |
| **IV** | Project scheduling – project network – AOA and AON - Gantt chart – critical path scheduling – probabilistic method for project scheduling – deployment of resources – activity time/cost trade-off analysis, resource leveling and resource allocation. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. R. Paneerselvam, “Production and operations management”, Prentice-Hall, New Delhi, 2005 2. Roberta S. Russell and Bernard W. Taylor III, “Operations management”, Pearson Education, Delhi, 2003 3. Kenneth R. Baker, “Introduction to sequencing and scheduling”, John Wiley and Sons, 1974 4. Michael Pinedoo, “Scheduling: theory, algorithms and systems”, Prentice Hall, New Delhi, 1995. 5. Wild, R., “Mass production management”, John Wiley and Sons, New York. | | | | | |

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| 05ME 7343 | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7343** | | **DESIGN FOR MANUFACTURING AND ASSEMBLY** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:-**   1. To introduce the concept and application for design for manufacturing and assembly to practicing designers and manufacturing engineers as well as design students 2. To discuss various fundamentals of assembly and design recommendations for product development 3. The student will be able to reduce a company's production costs by analyzing and eliminating the factors that greatly affect the time, cost, and quality of manufacturing, assembly and service processes. 4. Utilize effective analysis, brainstorming, and trade-off techniques for redesigning assemblies and subassemblies.   **COURSE OUTCOMES:-**   1. Understanding various types of materials, its classification, suitable materials for product design and various methods of material selection, various mechanical properties of material. 2. Understanding various casting design, machining design, designing of formed . | | | | | |
| MODULE |  | | | | HRS |
| **I** | **Process capability and tolerances:** Process capability, mean, process capability metrics, Cp, Cpk, cost aspects, feature tolerances, geometric tolerances - ISO standards - surface finish, review of relationship between attainable tolerance grades and different machining and sheet metal processes. Cumulative effect of tolerances - worst case method, root sum square method, dimensions following truncated normal distributions, Monte Carlo Simulation.  **Selective assembly:** Interchangeable past manufacture and selective assembly, deciding the number of groups - Model-I: Group tolerances of mating parts equal; Model-II: total and group tolerances of shaft equal. Control of axial play - introducing secondary machining operations, laminated shims, examples. | | | | 9 |
| **II** | **Datum systems and fixture design:** Degrees of freedom, grouped datum systems - different types, two and three mutually perpendicular grouped datum planes; grouped datum system with spigot and recess, pin and hole; grouped datum system with spigot and recess pair and tongue - slot pair - computation of translational and rotational accuracy, geometric analysis and applications.  **True position theory:** Comparison between co-ordinate and convention method of feature location, tolerancing and true position tolerancing, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, functional gauges, paper layout gauging, compound assembly, examples. | | | | 9 |
| **III** | **Form design of castings, weldments and sheet metal components:** Redesign of castings based on parting line considerations, minimising core requirements, redesigning cast members using weldments, form design aspects of sheet metal components.  **Tolerance charting technique:** Operation sequence for typical shaft type of components. Preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples. | | | | 10 |
| **IV** | **Redesign for manufacture:** Design features to facilitate machining: datum features - functional and manufacturing. Component design - machining considerations, redesign for manufacture, examples.  **DFMA tools:** Computer aided DFMA, Poke Yoka principles, axiomatic design method, quality function deployment, design for six sigma, lean manufacturing, waste identification and elimination, value stream mapping, sensor interface for fool-proof system design. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Harry Peck, “Designing for manufacture”, Pitman Publications, 1983 2. Matousek, “Engineering design - a systematic approach”, Blackie and Son Ltd., London, 1974 3. Micheal Wader, “Lean tools: a pocket guide to implementing lean practices”, Productivity and Quality Publishing Pvt Ltd., 2002 4. Spotts M. F., “Dimensioning and tolerance for quantity production”, Prentice Hall Inc., 1983 5. Oliver R. Wade, “Tolerance control in design and manufacturing”, Industrial Press Inc., New York, 1967 6. James G. Bralla, “Hand book of product design for manufacturing”, McGraw Hill, 1983 7. Trucks H. E., “Design for economic production”, Society of Manufacturing Engineers, Michigan, Second Edition, 1987 8. Poka - Yoke, “Improving product quality by preventing defects”, Productivity Press, 1992 9. Basem Said El-Haik, “Axiomatic quality”, John Wiley and Sons, 2005 | | | | | |

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| 05ME 7343 | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7345** | | **LEAN MANUFACTURING** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**  Upon completion of this course the student will be able   1. To design a globally competitive manufacturing organisation using lean manufacturing principles. 2. To develop the skills to implement lean manufacturing in industry and manage the change process to achieve continuous improvement of efficiency and productivity.   **COURSE OUTCOMES:**  After successful completion of this course the students will   1. Identify and understand the key requirements and concepts in lean manufacturing and to initiate a continuous improvement change program in a manufacturing organization 2. Apply the tools in lean manufacturing to analyse a manufacturing system and plan for its improvements. 3. Manage the manufacturing system to achieve six sigma quality and sustainability. | | | | | |
| MODULE |  | | | | HRS |
| **I** | **Lean manufacturing:** Basics, principles & elements  **Small-lot production:** Lot-size basics; lot sizing; lot-size reduction; facilitating small lot size.  **Setup-Time reduction:** Setup reduction methodology; techniques for setup-reduction; setup reduction projects. | | | | 9 |
| **II** | **Pull production systems:** Pull systems and push systems; conditions for pull production systems; how to achieve pull production; mechanisms for signal and control.  **Workcells and cellular manufacturing:** Cell layout and capacity measures; design of workcells; worker assignment; implementation issues. | | | | 9 |
| **III** | **Scheduling for smooth flow:** Production leveling; level scheduling in pull production; master production scheduling.  **Synchronising and balancing process:** Synchronisation; bottleneck scheduling; balancing; adapting to schedule changes | | | | 10 |
| **IV** | **Planning and control in pull production:** Centralised planning and control system; decentralised planning and control system; adapting MRP-based production planning and control system to pull production  **Maintaining and improving equipment:** Equipment maintenance; equipment effectiveness; total productive maintenance. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Harold J. Steudel and Paul Desruelle, “Manufacturing in the nineties – how to become a lean, world - class competitor”, Van Norstrand Reinhold, New York, 1992 2. John Nicholas, “Competitive manufacturing management - continuos improvement, lean production, and customer-focused qualities”, McGraw Hill International Edition, 1998 3. Ronald G. Askin& Jeffrey B. Goldberg, “Design and analysis of lean production systems”, John Wiley & Sons, 2003 | | | | | |

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| 05ME 7343 | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7351** | | **SUSTAINABLE MANUFACTURING** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**  To introduce students to the realm of sustainable engineering and inculcate in them the modern trends and challenges in the area of manufacturing related to the concepts of sustainability and environmental problems related to manufacturing, green engineering, etc.  **COURSE OUTCOMES:**   1. The importance of sustainable engineering will be thoroughly understood by students on the completion of the syllabus. 2. As the members of engineering community, students will be motivated to think about sustainability in various stages of manufacturing and their responsibility levels in the conservation of environment are expected to be enhanced, while achieving the organizational goals. | | | | | |
| MODULE |  | | | | HRS |
| **I** | **SUSTAINABLE MANUFACTURING AND EMS:** Sustainable Manufacturing –Evolution of Sustainable Manufacturing - Product Design for Sustainability – introduction to ISO 14000 series standards - Concepts of ISO 14001 - requirements of ISO 14001 – Environmental Management System – frame work and benefits - Environmentally Conscious Manufacturing. | | | | 9 |
| **II** | **GREEN MANUFACTURING**: Drivers of green production within business - Role of green production in competitive strategy - Motivations and Barriers to Green Manufacturing - Strategies for Green Manufacturing -Zero Emission Strategy - Environmental Impact of Manufacturing - The Development of Eco Labelling Schemes – guiding principles. | | | | 9 |
| **III** | **RECYCLING & LIFE CYCLE ASSESSMENT:** Industrial Ecology - key concepts - System Tools to Support Industrial Ecology –Life Cycle Design Methods-Life Cycle Assessment (LCA)– components and use – planning for LCA- Reclamation and Recycling of steel - postconsumer and pre consumer recycled material. | | | | 10 |
| **IV** | **ENVIRONMENTAL ATTRIBUTES OF MANUFACTURING:** Environment process characterization- Manufacturing process inventory- input & outputs of casting, plastic processing, machining operations, forming operations, surface treatment and joining. Environmentally responsible manufacturing –general techniques.  Environmental Footprint Analysis - Carbon and water footprint analysis -need to reducethe carbon footprint of manufacturing operations –Value stream mapping-Application of Value Stream Mapping to Eliminate Waste. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Madu, C.N., “Handbook of Environmentally Conscious Manufacturing”, Kluwer Academic Publisher, 2001. 2. Gupta, S.M. and Lambert, A.J.D., “Environment Conscious Manufacturing”, CRC Press, 2008. 3. Swamidass, P.M., “Encyclopedia of Production and Manufacturing Management”, Kluwer Academic Publisher, 2000. 4. Kutz, M.,” Environmentally Conscious Mechanical Design”, John Wiley & Sons, 2007. 5. Davim, J.P., “Sustainable Manufacturing”, John Wiley & Sons, 2010. 6. Green manufacturing fundamentals and application, edited by David A. Dornfeld, springer publication, (2012) | | | | | |

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| 05ME 7343 | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7353** | | **FINITE ELEMENT METHOD** | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**  Upon completion of this course the student will be able to accomplish the following competencies   1. To provide the fundamental concepts of the theory of the finite element method. 2. To enable the students to formulate the design problems into FEM. 3. To introduce basic aspects of finite element technology, including domain discretization, polynomial interpolation, application of boundary conditions, assembly of global arrays, and solution of the resulting algebraic systems. 4. Develop finite element formulation of engineering problems from a variety of application area including stress, heat transfer and vibration analysis   **COURSE OUTCOMES:**  On completion of this course the student will   1. Understanding the fundamental theory of the FEA method; 2. Develop the ability to generate the governing FE equations for systems governed by partial differential equations; 3. Understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements; and 4. Understand the application and use of the FE method for heat transfer problems. | | | | | |
| MODULE |  | | | | HRS |
| **I** | Basic concepts of FEM – a general procedure for finite element analysis, brief history of finite element method, linear spring as a finite element, elastic bar, spar/link/truss element. Strain energy, Castigliano’s first theorem, minimum potential energy. | | | | 9 |
| **II** | Truss structures: The direct stiffness method – Nodal equilibrium equation, element transformation and direct assembly of global stiffness matrix, boundary conditions, constraint forces, element strain and stress, three dimensional trusses.  Flexure - elements – elementary beam theory, flexure element, flexure element stiffness matrix and element load vector, work equivalence for distributed loads, flexure element with axial loading. | | | | 9 |
| **III** | Method of weighted residuals – introduction, method of weighted residuals, the Galerikin finite element method, application of Galerikin’s method to structural elements - spar element, beam element.  Interpolation function for general element formation – compatibility and completeness requirements, polynomial forms- one dimensional elements, triangular elements, rectangular elements, three dimensional elements, isoperimetric formulations, axisymmetric elements, numerical integration: Gaussian quadrature. | | | | 10 |
| **IV** | Applications in solid mechanics – plane stress, plane strain – rectangular element, isoparametric formulation of plane quadrilateral element, axisymmetric stress analysis, general three dimensional stress – finite clement formulations, strain and stress computations, practical considerations. Torsion – boundary condition, torque. Introduction to FEM software. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. David V Hutton, “Fundamentals of finite element analysis”, McGraw Hill 2. Daryl L. Logan, “First course in finite element method”, Cengage Learning, Singapore. 3. J. N. Reddy, “An introduction to the finite element method”, McGraw Hill 4. C. Zienkiwiez, “The finite element method”, McGraw Hill, New York. 5. K. H. Huebner, “The finite element method of engineers”, John Wiley & Sons, New York.   L. J. Segerlind, “Applied finite element analysis”, John Wily & Sons, New York. | | | | | |

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| 05ME 7343 | | COURSE NAME | L-T-P-C | YEAR | |
| **05ME 7355** | | ARTIFICIAL INTELLIGENCE | 3-0-0-3 | 2015 | |
| **COURSE OBJECTIVES:**   1. To introduce the fundamental concepts of artificial intelligence; 2. To equip students with the knowledge and skills in logic programming; 3. To explore the different paradigms in knowledge representation and reasoning; 4. To understand the contemporary techniques in machine learning; 5. To evaluate the effectiveness of hybridization of different artificial intelligence techniques.   **COURSE OUTCOMES:**  After completing the course students should be able to:   1. Understand the history, development and various applications of artificial intelligence; 2. Familiarize with propositional and predicate logic and their roles in logic programming; 3. Learn the knowledge representation and reasoning techniques in rule-based systems, case-based systems, and model-based systems; 4. Appreciate how uncertainty is being tackled in the knowledge representation and reasoning process, in particular, techniques based on probability theory and possibility theory ; 5. Master the skills and techniques in machine learning, such as decision tree induction, artificial neural networks, and genetic algorithm;   Apply and integrate various artificial intelligence techniques in intelligent system development as well as understand the importance of maintaining intelligent systems. | | | | | |
| MODULE |  | | | | HRS |
| **I** | **Human and machine intelligence:** Concepts of fifth generation computing, programming in AI environment, developing artificial intelligence system, natural language processing, neural networks.  **Introduction to fuzzy logic:** Basic concepts in fuzzy set theory – operations of fuzzy sets – fuzzy relational equations – propositional, predicate logic – inference – fuzzy logic principles – fuzzy inference – fuzzy rule based systems – fuzzification and defuzzification – types. | | | | 9 |
| **II** | **Fuzzy logic applications:** Fuzzy logic controllers – principles – various industrial applications of fuzzy logic control – adaptive fuzzy systems – fuzzy decision making – fuzzy classification – fuzzy pattern recognition – image processing applications – fuzzy optimization.  **Introduction to artificial neural networks:** Fundamentals of neural networks – neural network architectures – learning methods – taxonomy of neural network architectures – standard back propagation algorithms – selection of various parameters – variations. | | | | 9 |
| **III** | Associative memory – exponential bidirectional associative memory – adaptive resonance theory – introduction – adaptive resonance theory 1 – adaptive resonance theory 2 – applications – Kohenself organizing maps – counter propagation networks – industrial applications.  **Expert system development:** Definition, choice of domain, collection of knowledge base, selection of inference mechanism, case studies of expert system development in design and manufacturing. | | | | 10 |
| **IV** | **Industrial application of AI and expert systems:** Robotic vision systems, image processing techniques, application to object recognition and inspection, automatic speech recognition.  **Recent advances:** Fundamentals of genetic algorithms – hybrid systems – meta heuristic techniques like simulated annealing,tabu search, ant colony optimization, perpetual self organizing, artificial immune systems – applications in design and manufacturing. | | | | 8 |
| **END SEMESTER EXAM (All Modules)** | | | | | |
| **REFERENCES:**   1. Robert Levine et al, “A comprehensive guide to AI and expert systems”, McGraw Hill Inc, 1986 2. Henry C. Mishkoff, “Understanding AI”, BPB Publication, New Delhi, 1986 3. Peter Jackson, “Introduction to expert systems”, First Indian Reprint, 2000, Addison Wesley 4. Stuart Russell and Peter Norvig, “Artificial intelligence: a modern approach”, Prentice Hall, 1995 5. Elaine Rich et al., “Artificial intelligence”, McGraw Hill, 1995 6. Winston P H, “Artificial intelligence”, Addison Wesley, Massachusetts, Third Edition, 1992 | | | | | |

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| 05ME 7343 | COURSE NAME | L-T-P-C | YEAR |
| **05ME 7367** | SEMINAR II | 0-0-2-2 | 2015 |
| Each student shall prepare a seminar paper on any topic of interest related to the core/elective courses being undergone in the second semester of the M. Tech. programme. He/she shall get the paper approved by the Programme Coordinator/Faculty Members in the concerned area of specialization and shall present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student’s paper, presentation and his/her participation in the seminar. . | | | |

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| 05ME 7343 | COURSE NAME | L-T-P-C | YEAR |
| **05ME 7387** | PROJECT PHASE I | 0-0-8-6 | 2015 |
| The project (phase I) shall consist of research work done by the candidate or a comprehensive and critical review of any recent development in the subject of specialization or a detailed report of project work consisting of experimentation/numerical work, design and or development work that the candidate has executed.  In phase I of the project it is expected that the student should decide a topic of thesis, which is useful in the field or practical life. It is expected that students should refer national and international journals, proceedings of national and international seminars. Emphasis should be given to the introduction to the topic, literature review, and scope of the proposed work along with some preliminary work/experimentation carried out on the thesis topic.  Student should submit phase I project report in two copies covering the content discussed above and highlighting the features of work to be carried out in part I of the project. Student should follow standard practice of thesis writing.  The candidate will deliver a talk on the topic and the assessment will be made on the basic of the term work and talks there on by a panel of internal examiners one of which will be the internal guide. These examiners should give suggestions in writing to the student to be incorporated in project work phase II. | | | |

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| 05ME 7343 | COURSE NAME | L-T-P-C | YEAR |
| **05ME 7388** | PROJECT PHASE II | 0-0-21-12 | 2015 |
| In the fourth semester the student has continue project work and after successfully finishing the work, he / she has to submit a detailed bounded thesis report. The work carried out should lead to a publication in a National / International Journal or Conference. They should have submitted the paper before M. Tech. evaluation and specific weightage should be given to accepted papers in reputed journals or conferences. | | | |