Haldia Institute of Technology
(An Autonomous Institution Under MaulanaAbulKalam Azad University Of Technology, West Bengal)
Syllabus for M. Tech in Mechanical Engineering

Curriculum Structure
Semester -I

THEORY							
Sl. No.	Course Code	Subject Name	L	T	P	Total	Credit
1	MM(ME) 101	Advanced Engg. Math	4	0	0	4	4
2	MMT 101	Operational Management	4	0	0	4	4
3	MMT 102	Principles of Machining Process	4	0	0	4	4
4	MMT 103	Computer Graphics & CAE	4	0	0	4	4
5	MMT 104	Elective I	4	0	0	4	4
	Total Theory					**20**	**20**
PRACTICAL							
1	MMT 191	Machining Technology Lab	0	0	4	4	2
2	MMT 192	CAD/CAM Lab	0	0	4	4	2
3	MMT 181	Seminar I	0	2	0	2	1
	Total of Practical					**10**	**5**
	Total of Semester					**30**	**25**

Elective I

MMT 104A- Hydraulics & Pneumatics
MMT 104B- Ergonomics & Work System Design
MMT 104C- Statistical Process Control
MMT 104D- Industrial and Systems Engineering

Semester -II

THEORY							
Sl. No.	Course Code	Subject Name	L	T	P	Total	Credit
1	MMT 201	Numerical Control of Machine Tools	4	0	0	4	4
2	MMT 202	Non-traditional & Modern Machining	4	0	0	4	4
3	MMT 203	Robotics	4	0	0	4	4
4	MMT 204	Elective II	4	0	0	4	4
5	MMT 205	Elective III	4	0	0	4	4
	Total Theory					**20**	**20**
PRACTICAL							
1	MMT 291	Robotics & Mechatronics Lab	0	0	4	4	2
2	MMT 281	Seminar II	0	2	0	2	1
	Total of Practical					**6**	**3**
	Total of Semester					**26**	**23**

Elective II

MMT 204A-Reverse Engineering And Rapid Prototyping
MMT 204B-Mechatronics
MMT 204C-Agent Based Holonic Manufacturing Systems
MMT 204D-Cyber Physical Production Systems

Elective III

MMT 205A- Reliability

MMT 205B- Quality Function Deployment
MMT 205C- Business Process Reengineering

Semester -III

Sessional							
1	MMT 381	Pre-submission Defense of Dissertation	0	0	0	0	4
2	MMT 382	Dissertation Progress	0	0	24	24	18
	Total of Semester					**24**	**22**

Semester -IV

Sessional							
1	MMT 481	Dissertation (Completion)	0	0	24	24	18
2	MMT 482	Post-submission Defense of Dissertation	0	0	0	0	6
3	MMT 483	Comprehensive Exam(Viva-Voce)	0	0	0	0	4
	Total of Semester					**24**	**28**
Total							**98**

Subject Code: MM(ME) 101	
Subject Name: Advanced Engineering Mathematics	**Semester:**First
L-T-P:4-0-0	**Credit:**4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

This course aims at introducing important mathematical techniques useful for materials engineers and scientists. It is specifically designed towards students not familiar with mathematical thinking and oriented mostly on hands-on manipulations and calculus. The class covers basic mathematical methods for engineers including: differentiation and integration, Taylor's expansion, linear systems resolution and matrix formalism, partial differential equations, Laplace, Fourier and Legendre transforms, statistics and probability.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Statistics:** Elements of statistics ; frequency distribution ; concept of mean , median, mode ; and different types of distribution ; Standard derivation and variance ; curve fitting by least square method; Correlation and Regression ; Testing of hypothesis ; Basic types of factorial design and Analyses of Variance.	20
2	**Matrix Operation:** Matrix Operations; Eigen value and Eigen vector by iterative methods; Diagonalisation of a square matrix.	8
3	Laplace Transform, Fourier Transform; Fourier Integral and Their Applications.	6
4	**Numerical Methods:** Interpolation by Polynomials ; Error Analysis ; Solution of system of linear equation by Gauss – Seidel iterative methods ; Newton Rap son methods ; Numerical integration by Gauss – quadrature ; Solution of ordinary differential equation by Rayleigh – Ritz method.	14
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Evaluate different mathematical tools and techniques used in electrical engineering.
2. Apply appropriate scientific and mathematical theories and laws to solve engineering problems.
3. Demonstrate theoretical knowledge to use in the modern communication systems.
4. Apply statistical theories to solve engineering problems.

LearningResources:

1. Advanced Engineering Mathematics, by Erwin Kreyszig, Wiley.

Subject Code: MMT 101	
Subject Name: Operational Management	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

This course aims to improve students understanding of the concepts, principles, problems, and practices of operations management.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Introduction to Operational Management and Processes:** Management perspective and control approach to management, Basic management functions and managerial skills, Operations Strategy, Process and Technologies, HR in Operations Management, Concept of productivity and its analysis, Quality aspects in Production and Services.	5
2	**Facility planning:** Product and process selection, Facilities locations: Factors influencing selection of locations, Quantitative analysis in facility location: Weight method, Weight cum rating method, Composite measure method, Locational break-even analysis, Median model, Gravity model, Bridgeman's. Dimensional analysis. Plant layout: Product layout, Process Layout, G.T based layout.	5
3	**Production planning and control:** Different types of production systems: Mass, Batch, Job, Project and continuous.	5
4	**Forecasting:** Need and importance of Forecasting, Forecasting Techniques: Delphi Method, Simple and Moving average, Exponential Smoothing, Correlation and Regression Analysis, Karl Pearson's Correlation, MAD, Tracking Signal.	5
5	**Planning & Scheduling:** Different types of Planning: Long-term, Aggregate, short-term, Master Production Schedule, Rough cut capacity planning, Detail scheduling, Machine loading and sequencing: Johnson's rule and GANTT chart, Assembly line balancing: Line efficiency, balance delay, smoothing index, Different techniques of balancing.	6
6	**Materials Management:** Concept of inventory and its importance, Types of inventory, Saw – Tooth model, Computation of EOQ: Deterministic and Probabilistic models, Selective inventories. MRP –I and MRP – II, JIT.	5
7	**Supply Chains:** Evolution of Supply chain and its definition, Push pull view of supply chain, Cycle View of supply chain, Supply chain drivers, Factors affecting the supply chain performance, Efficient	5

	supply chain and responsive supply chain and its strategic fit, Bullwhip effect of supply chain, Merits and demerits of supply chain.	
8	**Project Management:** Concept of project and network analysis and network diagram, Computation of project completion time (Forward pass and backward pass), CPM, Computation of float, Difference between PERT and CPM, Probabilistic time estimates, probability of project completion by a target date, Project crushing.	6
9	**Queuing Model:** Waiting line problem and its application, Characteristic of the Queue and the service facilities, Poisson arrival and Exponential service distribution, Traffic intensity, Computation of Waiting time, number of customers in the system, decision problems in queuing.	6
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Develop an understanding of and an appreciation for the production and operations managementfunction in any organization.
2. Understand the importance of productivity and competitiveness to both organizations and nations and importance of an effective production and operations strategy to anorganization.
3. To understand the various production and operations design decisions and how they relate to theoverall strategies of organizations.
4. Obtain an understanding of quality management practice in organizations and how total qualitymanagement and six-sigma facilitate organizational effectiveness.
5. To understand the relationship of the various planning practices of capacity planning, aggregateplanning, project planning and scheduling and the roles of inventories and basics of managing inventories in various demandsettings.
6. To understand contemporary operations and manufacturing organizational approaches and thesupply-chain management activities and the renewed importance of this aspect of organizationalstrategy.

Learning Resources:

1. Essentials of Management by Koontz &Weihrich, TMH.
2. Modern Production / Operations Management by E.S. Buffa and R.K. Sarin, John Wiley & Sons.
3. Quantitative techniques in Management by N. D. Vohra, Tata McGraw Hill.
4. Production Planning and Inventory Control by Narasimhan, McLeavey, Billington, PHI.
5. Production and Operation Management by Muhlemann, Oakland and Lockyer, Mcmillian India Ltd.
6. An Introduction to Management science by Anderson, Sweeny and Williams, Thomson South west.

7. Logistic and supply chain management by Martin Chirstopher, Pearson Education.
8. Supply Chain Management by Chopra and Meindl, Pearson Education, 3rd Ed.,. 2007

Subject Code: MMT 102	
Subject Name: Principles of Machining Process	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

1. To identify the classification of unconventional machining processes.
2. To understand the principle, mechanism of metal removal of various machining processes.
3. To understand the applications of different processes.
4. To study the various process parameters and their effect on the component machined on various machining processes.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Classification of Manufacturing Process:** Importance and perspective of machining process, Schematic Representation of machining system, Different types of motions to generate different shapes.	5
2	**Mechanics of chip formation:** Orthogonal and oblique cutting**,** shear plane and shear strain, Computation of chip reduction coefficient, Velocity triangle, different process variables, actual feed and actual depth of cut, Different types of chips, computation of MRR for different processes.	5
3	**Cutting tool geometry:** ASA, ORS and NRS systems, conversion from one system to others, Cutting tool Nomenclature	5
4	**Cutting force:** Theoretical **a**nalysis of cutting force, Merchant circle diagram, Theory of Ernst and Merchant 1st and 2nd Model, Theory of Lee and Shaffer model, Ploughing force and size effect, Dynamometry, Friction in metal cutting, Cutting energy and power in metal cutting.	5
5	**Cutting tool materials:** Properties, different types of cutting tool materials e.g. HSS, Carbides, Coated carbides, ceramics, Cermets, PCBN and Diamonds and other advanced cutting tool materials, ISO specification of modern throw away inserts.	4
6	**Temperatures in metal cutting:** Heat generation and temperature distribution in metal cutting (Primary and secondary zone), Measurement of cutting temperature, Effect of process variables and tool geometry in temperature rise.	5
7	**Cutting fluid and surface roughness:** Need for cutting fluid, characteristics of an efficient lubricant, Different applications: flood, jet, mist and Z-Z cooling, Cutting fluid maintenance and its disposal, Concept of dry cutting.	5
8	**Surface roughness:** Theoretical computation of surface roughness, Measurement of surface roughness, Modification of tool geometries for improved surface finish, Effect of process variables on surface roughness.	4

9	**Tool wear, Tool life and machinability:** Causes and mechanism of wear, Types of wear: Crater wear and flank wear, Tool life criteria, Effect of built-up-edges and tool geometries on wear, Concept of tool life, Taylor's tool life equation, Effect of process variables on tool life, Concept of machinability and machinability rating, Variables affecting machinability.	5
10	**Abrasive processes:** Grinding, Chip removal in grinding, Cutting force in grinding, Types of abrasive and specification of grinding wheel, Effect of variables on grinding performance. Types of abrasive machining and finishing processes: honing, lapping, super finishing and buffing.	5
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Summarize the needs and classification of unconventional machining process.
2. Understand the various input and output parameters that influence in the performance.
3. Explain the working principle of energy based machining process.
4. Compare the merits, demerits and applications of unconventional machining process.
5. Identify the electric discharge machining and wire cut electric discharge machining process.
6. Select the material and tool with respect to the process.

Learning Resources:

1. Metal Cutting Theory & Practice by A. Bhattacharya, New Central Book Agency Pvt. Ltd. Fundamentals of machining and machine tools by Boothroyd, G. and Knight, W. A. (2006), 3rd Edition, CRC Press, Taylor and Francis Group.
2. Metal Cutting Principles, Shaw by M. C. (2005), 2nd Edition, New York: Oxford University Press.
3. Principles of Engineering Manufacture, Black, S. C., Chiles, V., Lissaman A. J. and Martin, S.J.
4. (2004) 3rd Edition, New Delhi: Viva Books Pvt. Ltd.
5. Fundamentals of Machining Processes, H. El-Hofy (2007), CRC Press, Taylor and Francis Group.
6. Production Technology by HMT, McGraw-Hill, India.

Subject Code: MMT 103	
Subject Name: Computer Graphics & CAE	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

Exposure to CAD tools for use in mechanical engineering design conceptualization, geometric modelling, communication, analysis and optimization, further use in CAD, CAM, CAE. Impart knowledge related to principles, methods and techniques of 3D modelling in parametric CAD software. Undertake project works in use of CAD geometric modelingsoftwar for design analysis, evaluation and optimization of mass properties, static-stresses, thermal deformations, etc. using professional software. To provide an experiential learning environment, while applying CAD, CAE tools to design of simple parts, assemblies, mechanisms and structures.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Graphics System:** Hardware, Types of systems, Input/Output devices, Workstations, Raster scan display, Workstations and peripherals, graphics standards.	5
2	**Geometric modeling:** Types and mathematical representation of lines & curves: DDA – Algorithm, Algorithm for various conic sections.	5
3	**Transformations:** 2-d and 3-D transformations, Projections, Viewing and clipping, Hidden surface removal, Windowing, Segmentation, Trimming, Integration, Projection and Transformations engineering applications.	8
4	**Surface Modeling:** Types and mathematical representation of curves and surfaces: Parametric description of analytic and synthetic curves, Curve and Surface Design, Composite Curves and Splines, Composite Surfaces.	7
5	**Solids Modeling**: Half spaces, Boundary representation (B-Rep), Constructive Solid Modeling (CSG), sweep representation, Solid modeling based application.	7
6	**Finite Element Analysis:** Basic concept of the finite element method, comparison with finite difference method; Variational methods: calculus of variation, the Rayleigh-Ritz and Galerkin methods; Finite Element analysis of 1-D problems: formulation by different approaches (direct, potential energy and Galerkin); Derivation of elemental equations and their assembly, solution and its post processing.	10
7	**CAM:** Stock boundary definition and Generation of machining paths from CAD Database. Cutter paths for Numerical Control, CAD-CAM interface.	6
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Explain the basics of geometric modeling and computer graphics.
2. Explain the theory behind the finite-element method (FEM) and to provide insight into thepractical aspects of FEM.
3. Develop skills in the design and analysis of practical engineering problems through theintegration of geometric modeling, FEM, and computer graphics.
4. Underscore the importance of validating the results obtained from numerical models.
5. Use parametric 3D CAD software tools in the correct manner for making geometric part models, assemblies and automated drawings of mechanical components and assemblies.
6. Evaluate design, analyze and optimize using commercial CAD, CAE software as black box for required mass properties/ stress, deflection / temperature distribution etc. under realistic loading and constraining conditions.

Learning Resources:

1. Computer Graphics by D. Hearn & M. P. Baker, PHI
2. Principles of Interactive Computer Graphics by W. M. Newman & R. F. Sproull, McGrawHill.
3. Procedural Elements for Computer Graphics by D.F. Rogers, Tata McGraw-Hill.
4. Computational Geometry for Design and Manufacture, by I. D. Faux and M. J. Pratt, EllisHorwood, Chichester, 1979.
5. CAD/CAM by I. Zeid, Tata McGraw-Hill.
6. An Introduction to the Finite Element Method by J.N.Reddy, McGrawHill, NewYork.
7. The Finite Element Method by O. C. Zienkiewicz and R.L.Taylor, 3rd ed. McGraw-Hill.
8. Introduction to Finite elements in Engineering by Chandrupatla&Belegundu, PHI.

Subject Code: MMT 104A	
Subject Name: Hydraulics & Pneumatics	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

This course aims to study of fluid power technology using fluids or compressed air as the transfer media. Complete hydraulic and pneumatic systems are studied including power sources, reservoirs, pumps, compressors, lines, valves and actuators. Students will learn troubleshooting strategies to identify, localize and correct malfunctions. Preventative maintenance and safety issues will also be discussed.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Introduction:** Power hydraulics & its applications, Hydraulic symbols.	5
2	**Positive displacement Pumps:** Gear, Vane, Piston and other special types of pumps.	5
3	**Control valves:** Pressure Control: relief valve, Unloader valve, Pressure reducing valve, Counter balance valve, sequence valve, Flow Control: Meter in Meter out, Bleed off, Pressure and Temperature compensated flow control valve, Direction Control: Check valve, 2/3 position, ¾ position, Open centre, closed centre, Tandem centre and others, Cartridge valves, Flow forces on valve spools and valve design.	10
4	**Hydraulic actuators:** Linear (S/T, D/T, Cushion) and rotary, Design of Hydraulic actuators, Accessories in hydraulic systems: Accumulator, Air-breathe valve, Pressure switches etc. Hydraulic power packs.	8
5	**Servo valves:** Torque motor, electro-hydraulic Servo valves: Types and principles of operations.	6
6	**Design of Hydraulic circuits and its application:** Regeneration, Pre-fill, Twin Pump and others.	5
7	**Maintenance of hydraulic systems and working fluid, Pneumatics:** Air Filter, Lubricators and Regulators, Pneumatic control elements: Air Cylinders and their Design, Pneumatic safety circuits, Pneumatic Logic control.	9
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Understand hazards of hydraulic and pneumatic circuits and be able to work safely.
2. Understand the concepts of fluid statics and dynamics as applied to commercial and industrial control.

3. Recognize standard schematic symbols for common fluid power components.
4. Understand and troubleshoot basic fluid power, electro-hydraulic, and electro-pneumatic circuits using schematic diagrams.
5. Understand the operation, application, and maintenance of common fluid power components such as pumps, compressors, valves, cylinders, motors, rotary actuators, accumulators, pipe, hose, and fittings.
6. Find component application data online and select components from manufacturer's catalogs.

Learning Resources:

1. Hydraulic Control Systems by H.E. Merritt, Wiley New York.
2. Fluid Power by Esposito, Peaerson Education
3. Hydraulics and Pneumatics by Andrew Parr, Jaico Publishers.

Subject Code: MMT 104B	
Subject Name: Ergonomics & Work System Design	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

Production Ergonomics and Work Design (PEWD) is an engineering discipline concerned with supporting the safe, sustainable, healthy, effective and economic utilization of human resources in industrial work facilities. The course relates engineering improvements to productivity factors in industrial operations and introduces human requirements and capacities during work, covering individual, physiological, biomechanical, work-environmental and social aspects.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Work Study Fundamentals**: Productivity and Work Study, Definitions, Scope, and History of Work Study, Tools of productivity, Productivity index, Kinds of productivity Measurements, Causes of low productivity and techniques of their elimination, technical Methods to improve productivity.	10
2	**Analysis of Work Content:** Management techniques to reduce work content Method Study: Process Analysis, Process and Activity Charts, Operation Analysis, Basic procedure, Micro Motion Study, Principles of Motion Economy.	8
3	**Work Measurement:** Purposes and uses, Basic procedure, Techniques – Work Sampling, Stop-Watch Time Study, Rating and Allowances, Setting Standard Times for Jobs, Standard Data, Predetermined Time Standards.	7
4	**Ergonomics:** Fundamental Concepts, Issues in Work system Design, Measuring Work by Physiological means, Muscle Physiology, Muscle Metabolism, Work Posture, Fatigue Measurement and Evaluation, Work rest cycles, Applied anthropometry and work space design, Biomechanics of Human Motion, Sensorimotor responses.	8
5	**Environmental Factors and Work Systems:** Characteristics of Illumination, colour cone, Measurement of llumination parameters, effect of glare on Human eyes, Effect stress on Human Health and performance, thermoregulation, Physiological effects of noise and vibration, Measurements of Noise level parameters.	9
6	**Job Evaluation:** Basic concepts, Objective and Subjective methods, Compensation Schemes, Relationship of Work Study to Incentive Schemes, Wage Incentive Plans.	6
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Explain why human factors issues must be considered when designing industrial work
2. Identify harmful work conditions on the basis of theory and methods
3. Discuss different work environment parameters' effect on ergonomics
4. Select and apply a proper method to study and quantify human physical workload in an observed situation
5. Select appropriate hand tools for improving ergonomics and productivity in manual assembly
6. Explain and justify recommendations and limit values for mental and social working conditions, in the long and short term

Learning Resources:

1. Human factors in engineering and Design by Sanders and McCormick, McGraw Hill.
2. Ergonomics (Man in his working environment) by Murrell, Chapman and Hall.
3. Ergonomics at work by d.J.Oborne, Wiley and sons.
4. A guide to Ergonomics of Manufacturing by Martin Helander, East - West and Taylor Francis.
5. Introduction to work study by ILO Geneva, Oxford and IBH.
6. Work Study and Ergonomics by Sharma and Sharma, S. K. Kataria and sons.

Subject Code: MMT 104C	
Subject Name: Statistical Process Control	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

1. To understand the purpose and function of statistical quality control.
2. To understand the differences between attributes and variables.
3. To become familiar with basic methods of statistical process control.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Introduction:** History Of Statistical Process Control, Quality And Quality Management Techniques, Basic Principles Of Statistical Quality Control.	7
2	**Basic principles of Statistics:** Basic Statistics and Types of Distributions (Normal, Exponential, Binomial, And Poisson's Distributions).	5
3	**Control chart for variables:** Different types of control charts, Preparation of control charts for variables (*X*, *R* charts and s chart).	6
4	**Some adaptation of control charts for variables:** Group Control Chart, Moving Average, Moving Range, Difference Control Charts and Cumulative Sum Control Charts.	8
5	**Control chart for attributes:** Control charts for attributes (p-and n.p-chart, c-chart, u-chart, U-chart).	5
6	**Process and measurement system capability analysis:** Process Capability Analysis, Method of Calculating Process capability, Process Capability Index.	6
7	**Some aspects of Specification and Tolerances:** Purpose of specification, effect of Careless setting of specification limits, setting of Realistic Tolerances, Statistical tolerancing, Statistical Theorem.	7
8	**Acceptance sampling:** Sampling techniques, Lot formation, Sampling Methods, OC Curve.	4
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Understand SPC fundamentals and the importance of reducing variation
2. Implement control charting in order to assess process stability
3. Interpret control chart signals and implement appropriate reaction plans
4. Determine appropriate sampling plans and sample sizes
5. Assess process capability training (for normal and non-normal data)

6. Apply charting techniques for short production runs, charting methods where multiple sources of variation may exist (e.g. multiple cavities, filling heads) and Virtual SPC training for naturally trending data (e.g. due to tool wear)

Learning Resources:

1. Introduction to Statistical Quality Control by Douglas C. Montogomery, Wiely Pub, U.K.
2. Statistical Quality Control by E. L. Grant, Tata McGraw Hill.
3. Statistical Quality control by M. Mahajan, DhanpatRai& Co.
4. Quality Planning and Analysis by Juran, Tata McGraw Hill**.**

Subject Code: MMT 104D	
Subject Name: Industrial and Systems Engineering	**Semester:** First
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester**=12 minimum

Course Objective

- To understand the scope and importance of Industrial and Systems engineering in manufacturing industries
- To understand the different types of production systems and strategies to classify and to be acquainted with the KPIs of production systems
- To understand the different aspects of industrial engineering and apply the underlying procedures for performance improvement of the production systems with a focus on ergonomics
- To develop the knowledge of PPC considering its role, objectives and techniques involved to execute varieties of activities under its banner
- To understand the relevance and importance of systems engineering in manufacturing industries
- To understand the importance of reliability and maintenance of plant and machinery for improving the system performance by reducing failure
- To understand the role of different quality control techniques used in production units

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Introduction** Definition, objectives and scope of Industrial Engineering, Production systems and their classifications: Mass, batch, job, continuous, flow; Strategies to connect sales with production: MTS, MTO, ATO, ETO; Production system's KPIs, Productivity: different types and metrics for measurements, Reasons and remedy for poor productivity	5
2	**Job analysis and Work Measurement** Work System Design: Role of work study in improving productivity, Taylor's scientific management, Gilbreth's contributions; method study, Therbligs, SIMO chart, Cycle graph and Chrono cycle graph, micro-motion study, principles of motion economy; work measurement - stop watch time study, Performance rating and rating factor,work sampling, standard time, PMTS; Ergonomics: Design of workplace layout, ergonomics in automated systems,Anthropometric data and its application in ergonomic design, Job evaluation, merit rating, incentive schemes, and wage administration	8
3	**Production Planning and Control (PPC)** PPC: Activities, objective and functions; Routing, Aggregate planning, and scheduling,rough cut capacity planning, production scheduling,	10

	job shop scheduling problems, sequencing problems: Johnson's rule, priority rules for scheduling, Integrated process planning and scheduling, Gantt chart, machine loading anddispatching.MRP & MRP II, Dynamic and distributed scheduling; approaches to distributed scheduling.	
4	**System Engineering** Introduction, applications of system engineering, system concept, system analysis and approach, techniques in system analysis. Planning and decision making: types of planning; Decision Making: principles of decision making, steps, and types: decision making under certainty, under risk, under uncertainty,decision making tools; Value engineering and value analysis: Concepts, methodology and applications.	9
5	**Reliability and Maintenance** Reliability, availability and maintainability; distribution of failure and repair times; determination of MTBF and MTTR, system reliability determination; Maintenance management and its objectives, Various types of Maintenance Planning, House Keeping, 5S concepts, Concept of Total productive maintenance (TPM).	8
6	**Quality Engineering** Concept of Quality, different aspects of quality, dimensions of quality, evolution of quality techniques. Statistical quality control: specification limits, control limits, process capability, process control and control charts for both attributes and variable data, acceptance sampling. Concept of TQM, ISO: 9000, Quality control and assurance.	8
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. **explain** the scope and importance of Industrial and Systems engineering in revamping the productivity and efficiency of manufacturing industries in an economical way
2. **classify** and **compare** different production systems based on business philosophy and strategy, **evaluate** the productivity from different perspectives, and **suggest** for improvement
3. **formulate** appropriate course of actions for improving the efficiency of production systems, **develop** standard time for different processes and operations, and **recommend** different wage and incentive plans
4. **Identify** scope of PPC system and **execute** various activities using different scientific and mathematical techniques
5. **Recommend** importance of system engineering and **undertake** various functions under its purview for the benefit of the relevant industries
6. **Apply** different techniques for improving reliability of plant and machinery, **adopt** and **practice** the most suitable approach to quality control & assurance, and **recommend** and **implement** different maintenance measures for reducing failure of machinery and equipment

Learning Resources:

1. Industrial Engineering and Management by O. P. Khanna, DhanpatRai Publication.
2. Industrial Engineering and Managementby Dr. Ravi Shankar, Galgotia Publications.
3. Production and Operations Management by R. Panneerselvam, Prentice-Hall of India.
4. Quality control by Dale H. Besterfield, Pearson International edition.

Subject Code:MMT 191	
Subject Name:	**Semester:** First
L-T-P:0-0-4	**Credit:**2
Contact Per Week-4P	**Contact Week / Semester=**12 minimum

Course Objectives:

1. To enhance the students' understanding of machine tools, cutting forces, EDM, robot programming etc. by hand on practices in laboratory.
2. To develop the understanding of measurement on coordinate measuring machine, surface roughness tester etc in laboratory by practical applications

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	Computation of Shear Plane angle (β), Chip reduction co-efficient ( ),	8
2	Computation of Metal Removal Rate (MRR) and Total machining time (Tm/c) in turning.	4
3	Dynamometry	4
4	Surface Finish in Machining	4
5	Multi response Optimization by RSM in turning	4
6	Determination of Taylor's tool life equation.	4
7	Grinding of a Cylindrical Pin to a attain close Dimensional Tolerance & Improved Surface Finish	4

8	To study the electric discharge machine and the effect of different EDM parameters on material removalrate and tool wear rate.	8
9	To study the effect of different EDM parameters on surface roughness of a machined sample.	8
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Decide best suitable parameters in machining.
2. Understand the effect of machining parameters on the output.
3. Select suitable machining processes for the specific object manufacturing.

Learning Resources:

1. Manufacturing Technology, Volume 1 and 2 By P. N. Rao
2. Nontraditional Manufacturing Processes by Gary F. Benedict

Subject Code:MMT 192	
Subject Name:CAD/CAM Lab	**Semester:** First
L-T-P:0-0-4	**Credit:**2
Contact Per Week-4P	**Contact Week / Semester=**12 minimum

Course Objectives:

Students should be able to examine interactive computer graphics and its use in designing computer control of manufacturing processes, computer-integrated production control, automated inspections, and flexible manufacturing systems. They also discuss the implementation of turnkey CAD/CAM systems.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	2D and 3D modelling and assembly modelling using modelling packages using AutoCAD, Auto Desk Mechanical desktop.	8
2	2D and 3D modelling and assembly modelling using modelling packages using Pro-Engineer,CREO	8

3	2D and 3D modelling and assembly modelling using modelling packages using SOLID WORKS	8
4	Features and selection of CNC turning and milling centers. Practice in part programming and operation of CNC turning machines, subroutine techniques and use of cycles. Practice in part programming and operating a machining center, tool panning and selection of sequences of operations, tool setting on machine, practice in APT based NC programming.	12
5	Surface generation, Tool selection, NC code generation and Tool path simulation for turning and milling operations using CAM packages like CATIA, Gibbs CAM, Master CAM.	12
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

4. Analyse and design real world componentsImplement control charting in order to assess process stability
5. Understand basics of Computer Graphics for development of CAD models
6. Develop different types of surfaces with the help of different curves
7. Suggest whether the given component is safe or not for the applied loading conditions Select suitable manufacturing method for different mechanical components using CAMsoftware.
8. Design, Analyse and Manufacture of different components usingdifferent CAD, CAM, and CAE software's.

Learning Resources:

1. CAD/CAM : Computer-Aided Design and Manufacturing 1st Edition (English, Paperback, E. Zimmers, M. Groover)
2. CAD/CAM: Principles and Applicationsby P N Rao
3. CAD/CAM : Theory and Practiceby Ibrahim Zeid, R Sivasubramanian

Subject Code:MMT 201	
Subject Name: Numerical Control of Machine Tools	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

This course introduces the concepts and capabilities of computer numerical control machine tools. Topics include setup, operation, and basic applications. Upon completion, students should be able to explain operator safety, machine protection, data input, program preparation, and program storage.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Fundamentals of Numerical Control:** Introduction to numerical control, Classification of NC/CNC machines and axis nomenclature, PTP and Continuous Contouring, Absolute and Incremental Programming, Difference between NC and CNC, Different types of software's in CNC.	5
2	**Control system fundamentals:** feedback, transfer function, system stability. Open Loop and Closed Loop control: Servo Mechanism, Position and Velocity feedback.	4
3	**Engineering Analysis of NC/CNC systems:** Computations of total number of pulses and pulse frequency in Open Loop and Closed Loop control, Precision in NC/CNC: Resolution, Accuracy and Repeatability. Interpolation in NC and CNC: Linear and Circular, Tolerance Analysis: Inward, Outward and Secantial.	8
4	**System components:** Machine Control Unit (MCU), Transducers, Actuators.	3
5	**Design considerations of NC/CNC machine tools:** Re-circulating ball screw, lost motions in NC systems, Turning Centers and Machining Centers.	6
6	**Part Programming:** Manual programming: Different G codes and M codes, Stock Removal Cycle, Canned Cycles. Computer assisted Part Programming. Tool path generation from CAD models, CNC Toolings.	7
7	**Process optimization:** Online condition monitoring in CNC, Adaptive control: ACC, ACO & GA.	5
8	**DNC:** Direct and Distributed Numerical Control, Merits of DNC, Concept of BTR, Data Multiplexing.	5
9	**Economic analysis of NC/CNC:** Various cost elements of CNC, Break-Even analysis, ROI and other techniques.	5
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Understand the basic procedures and concepts of programming, set up and operation of a CNC Machining Center.
2. Identify and understand the basic programming codes.

3. Create geometry and toolpaths from the specifications on a blueprint for simple parts usingmastercam programming software.
4. Identify and define the functions of the CNC machine control.
5. Set up the CNC machining center for manufacturing simple parts
6. Manufacture simple parts on the CNC machining center.

Learning Resources:

1. Computer Control of Manufacturing Systems by Y. Koren, McGraw-Hill
2. Numerical Control and Computer Aided manufacturing by R. S. Pressman & J. E. Williams, John Wiley & Sons
3. Computational Geometry for Design and Manufacture, by I. D. Faux and M. J. Pratt, Ellis Horwood, Chichester, 1979.
4. Numerical Control in Manufacturing by F. W. Wilson, McGraw-Hill Book Company New York.

Subject Code: MMT 202	
Subject Name: Non-traditional & Modern Machining	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

1. Understand the need and importance of non-traditional machining methods and process selection.
2. Gain the knowledge to remove material by thermal evaporation, mechanical energy process.
3. Apply the knowledge to remove material by chemical and electro chemical methods.
4. Analyze various material removal applications by unconventional machining process.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Mechanical Processes:** Abrasive Jet Machining (AJM), Water Jet Machining (WJM) Abrasive Water Jet Machining (AWJM): Principles of material removal, Computation of MRR, Salient process variables, equipments, applications.	5
2	**Non Traditional Machining Processes:** Importance and need, Classifications.	3
3	**Ultrasonic Machining (USM):** Mechanism of material removal, factors affecting material removal, equipment, transducers, different types of horn, Dimensional accuracy.	5
4	**Electrochemical Processes:** Electrochemical Machining (ECM): Basic mechanics of ECM, Electrochemistry & process characterization, Computation of MRR for single metal and alloys, Dynamics of ECM, ECM hydrodynamics, Operating variables, equipments and applications.	5
5	**Electro-Thermal Processes:** Electro-discharge machining (EDM): Principles of EDM, Process variables and characteristics, Modeling of material removal, Equipments: Types of power supply, Analysis of RC Relaxation EDM Generator, Determination of Surface roughness and over cut, Applications. Laser Beam Machining (LBM): Laser generation and types, Laser construction, Mechanism of material removal, Process characteristics of different lasers, Applications. Electron Beam Machining (EBM): Principle, Mechanism of material removal, Effect of process variables on process criteria, Applications. Plasma Arc Machining (PAM): Principle, Mechanism of material removal, Effect of process variables on process criteria, Applications. Ion Beam Machining (IBM)	6

6	**Computer Integrated Manufacturing:** Batch Production and Mass Customization, Concept of Integrated automation, Concurrent Engineering.	3
7	**CAD & CAE:** Feature based Design, parametric design, Fundamentals of FEA, Role of CAD in CIM environment.	2
8	**Group Technology:** Need & Utility, Different types of coding, Clustering Techniques & Benefits. CAPP: Variant & Generative, Feature Recognition, Feature-Process co-relation, Application Programs in CAPP.	5
9	**Computer aided quality control:** Quality control, Inspection, Contact and Non-contact Inspection, Computer aided data acquisition, CMM.	3
10	**FMS:** Types of flexibility, FMM, FMC, Modules of FMS, Materials handling in FMS, Quantitative analysis in FMS, Tool Management, Automatic Tool wear monitoring, Performance evaluation.	4
11	**CIM**: Definition & Concept, CIM wheel, External and Internal challenges, World-class order winning criteria, Product Development Cycle. Concurrent Engineering, Design for Manufacturing & Assembly, Data base requirements in CIM, Computer Networking, CIM Implementation & Barriers.	5
12	**Emerging trends in manufacturing:** High speed machining, micro, meso and nano manufacturing.	2
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Compare non-traditional machining, classification, material applications in material removal process
2. Summarize the principle and processes of abrasive jet machining.
3. Understand the principles, processes and applications of thermal metal removal processes.
4. Identify the principles, processes and applications of EBM.
5. Understand the principles, processes and applications of Plasma Machining.

Learning Resources:

1. Non-Conventional Machining by P.K.Mishra, Narosa Publishers.
2. Modern machining processes by P. C. Pandey, H. S. Shan, Tata McGraw Hill.
3. Fundamentals of Machining Processes, H. El-Hofy (2007), CRC Press, Taylor and Francis Group
4. Automation, Production Systems and Computer Integrated Manufacturing by Groover, Prentice Hall.
5. Computer-Integrated Manufacturing by RehgKraebber, 2nd Edition, Pearson Education.
6. The Design and Operation of FMS by P. G. Ranky, IFS Ltd., U.K., North Holland.
7. Computer Integrated Manufacturing by Joseph Harrington, Industrial Press

Subject Code: MMT 203	
Subject Name: Robotics	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

To introduce the students to the standard terminologies, applications, design specifications, and mechanical design aspects both kinematics, Trajectory planning, work cell control and dynamics of industrial robotic manipulators.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	Automation & Robotics; Spatial Descriptions & Transformations, Manipulator Kinematics – Forward and Inverse; Jacobians: Velocities & Static Forces.	8
2	Robot Arm Dynamics: Lagrange-Euler formulation of manipulator dynamics.	4
3	Trajectory Planning: Joint-interpolated trajectories, Geometric problems with Cartesian paths, Collision-free path planning.	6
4	Robot Control Systems: Feedback and Closed-loop control, Transfer Functions, Control of Second-order systems, Non-linear & time varying systems, Adaptive Control.	7
5	Robotic Prehension: Dexterous manipulation; ANN approach in prehension,	5
6	Sensors in Robotics: Machine vision, Force & Torque sensors.	5
7	Robot programming: simulators and languages, Tele-robotics and virtual interfaces for task specification and programming, Concept of nanorobotics,	8
8	Performance analysis of industrial robots and their manufacturing applications, Economics of robotics, Social issues & future of robotics.	5
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Apply the concepts of coordinate transformations for development of arm equation and subsequently the inverse kinematics model for given serial manipulator.
2. Apply the concepts of robotic workspace analysis for design of robotic manipulator for required work cell applications.
3. Design and analyze the workcell environment for given robotic manipulator configuration and workcell devices for required integrated industrial application.
4. Develop and analyze the mathematical model for trajectory planning, resolved motion rate control and dynamics model for a given serial robotic manipulator.
5. Develop the algorithms for design of robotic work cell controller and its programming for given serial robotic manipulator.

Learning Resources:

1. Robotics for Engineers by Y. Koren, McGraw Hill New York
2. Robotics Technology and Flexible Automation by S.R.Deb, TMH.
3. Industrial Robotic Technology - Programming and Application by M.P.Grooveret. al., McGrawHill
4. Robotics: Control, Sensing, Vision and Intelligence by Fu, Lee and Gonzalez, McGraw Hill New York

Subject Code: MMT 204A	
Subject Name: Reverse Engineering And Rapid Prototyping	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

To provide the students with an understanding of the basic fundamentals of rapid prototyping, its fabrication techniques, materials and various areas of defects and improvements in Rapid Prototyping.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Prerequisite:** Classification of manufacturing processes, Different Manufacturing Systems, Introduction to Rapid Prototyping (RP), Need of RP in context of batch production, FMS and CIM and its application; Basic Principles of Generative Manufacturing Processes.	16
2	**Reverse Engineering:** Need & Techniques, Data collection, Point-Cloud of data.	4
3	**Steps in RP:** Process chain in RP in integrated CAD-CAM environment, Advantages of RP; Utility of Rapid Prototyping in Reverse Engineering. Classifications of different RP techniques – based on raw material, layering technique (2D or 3D) and energy sources; Comparative study of: - Stereo-lithography (SL) with photo-polymerization, SL with liquid thermal polymerization.	12
4	**Process Technology:** Solid foil polymerization, Selective laser sintering, Selective powder binding, Ballastic particle manufacturing – both 2D and 3D, Fused Deposition Modelling, Shape Melting, Laminated Object Manufacturing, Solid Ground Curing, Repetitive Masking and deposition.	16
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Apply solid modeling concepts and techniques in RP.
2. Analyze and implement the different algorithms associated with STL file errors.
3. Calculate the layer thickness in different layering techniques and carry out design manipulations for the generation of support structure.
4. Identify, characterize and select the ideal materials for a given Rapid Prototyping system.

Learning Resources:

1. Chua, C.K., Leong, K.F., Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley and Sons Inc., 2000.
2. Pham, D.T., Demov, S.S., Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer-Verlag London Limited, 2001.
3. Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, 2006.
4. Patri, K. V., Weiyin, Ma, Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A., 2003.
5. Saxena, A., Sahay, B., Computer Aided Engineering Design, Anamaya Publishers, New Dehi, 2005.
6. Zeid, I., Mastering CAD/CAM, Tata McCraw Hill, 2006.

Subject Code: MMT 204B	
Subject Name: Mechatronics	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

To impart interdisciplinary knowledge to study modern Electro-Mechanical Devices.The aim of this course to make a bridge between Mechanical, Electronics, Instrumentation, Computer and Controls field.To familiarize the students with all the important elements of a Mechatronic device.To understand the importance of each control action and how to choose a proper controller for an engineering problem.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Introduction to Mechatronics:** Definition, Mechatronics System Architecture, Comparison between Conventional and Mechatronics approach. Building Blocks of Automation: Sensors, Analyzers, Actuators, Drives.	6
2	**Digital Electronics:** Fundamentals of digital electronics, logic gates and their operations, Data conversion devices, Truth Tables, Boolean Algebra, Karnaugh Maps, Sequential and Combinational Logic Circuits ,Encoder , Decoder , Data Multiplexing &Demultiplexing.	8
3	**Sensors and Transducers:** Sensor characteristics, different types of sensors and transducers, micro sensors, electrical contacts, actuators, and switches, signal processing devices; relays, output devices.	7
4	**Drives:** Electrical, Mechanical, Hydraulic & Pneumatic.	2
5	**Automatic Production and Assembly Machines**: Transfer lines, Production and throughput, Buffer Storage	4
6	**Control Systems:** Open loop and closed loop control, block diagrams, transfer functions, Laplace transforms; Mathematical model of physical system; P, PD,PI and PID controllers, Time domain analysis, transient response of first and second order systems; Introduction to nonlinear control; State space analysis.	8
7	**Microprocessor:** 8085 & 8086 Microprocessor Architecture, Instruction Set, Addressing Modes, Interrupts, Programmable Peripheral Interface, Different Interfacing with Keyboard, Stepper Motor, Servo Motor, 7 Segment LED.	7
8	**PLC:** PLC controller and Ladder diagrams, Timers, Response diagrams, Logic Control versus Sequencing, PLC Internal Features, PLC Programming. Logic Networks, Stage Programming, Advantages of PLCs **Design and fabrication of Mechatronics systems**.	6

	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Construct the block diagram of any physical mechatronics device used in day-to-day life.
2. Calculate the output to input relation of any physical model in the form of a transfer function.
3. Evaluate the performance of any physical system in terms of its performance parameters.
4. Develop the mathematical model of any physical model from any engineering domain.
5. Interface the sensors and actuators of a mechatronic device to the computer/laptop.
6. Recognize the key features of different type of controllers and develop a suitable controller to obtain the desired performance from the system.

Learning Resources:

1. Introduction to Mechatronics and Measurement Systems by David G. Alciatore, Michael B. Histand, McGraw Hill
2. Mechatronics by Bolton, Pearson Education.
3. AutomaticControl Engineering by F.H.Raven, 5th ed., McGrawHill International.
4. Modern Control Engineering by K.Ogata, 3rd ed., Prentice Hall.
5. Automatic Control Systems by B.C.Kuo, 6th ed., Prentice Hall.
6. Digital Principles and Application by Malvine& Leach, TMH, 1999
7. Microprocessor Architecture Programming and Application with 8085 by Ramesh S. Gaonkar, PHI, 2001
8. Programmable Logic Controllers and Industrial Automation book (PLC book) by MadhuchhandaMitra and SamarjitSen Gupta, PenramInt, Pub. (India) Pvt. Ltd.

Subject Code: MMT 204C	
Subject Name: Agent Based Holonic Manufacturing	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester**=12 minimum

Course Objectives:

To impart interdisciplinary knowledge to study multi-objective scheduling in an agent based holonic manufacturing system to satisfy the goal of several communities namely the product, the resource, and the organization simultaneously. In this attempt, first a multi criteria based priority rule is developed following Simple Additive Weight (SAW) method under Multi Criteria Decision Making (MCDM) environment to rank the products.

Course Content:

Module No.	**Descriptionof Topic**	**Contact Hrs.**
1	Business requirements analysis, Market requirements versus Manufacturing requirements,Batch Manufacturing and Mass customization, Limitations of Hierarchical and traditional control approach to manufacturing,Emergence of heterarchical and Agent based Systems, Scope and limitations.	4
2	Holonic Control approach to MES; Concept, definition of holon, holarchy, HMS, Holonic attributes: Autonomy, Cooperation, Reconfiguration, plug and play, Self-organizing; Comparison between Bionic, fractal and holonic control; Hybrid nature of holonic control.	9
3	Generic holonic model: PROSA architecture, Holonic manufacturing, Distributed Problem Solving (DPS), Design of HMS; Aggregation and specialization of holons: Unified Modelling Language (UML) [Class diagram]	12
4	Concept of Intelligent agent: Agent characteristics and properties; Agent oriented holonic control architecture; Multi-agent system (MAS) based on DPS; Agent internal architecture; Agent technology: Objected-oriented programming (OOPs) to realize agent behaviour; Agent communication language: FIPA compliant (XML), Document type definition (DTD), and Sequence diagram for dynamic communication.	12
5	Implementation of MAS and Holonic control in MES: MCDM techniques in Holonic and agent based systems, Agent based approach to distributed planning and scheduling, Multi-objective scheduling; Negotiation protocol: Contract Net Protocol (CNP), Market based approach, Auction based approach; Ant algorithm, Holonic control implementation & case Study: ADACOR, HOLOMAS etc.	14
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Discuss about hierarchical control, heterarchical and Agent based Systems.
2. Understand Holonic Control system
3. Understand various generic Holonic models
4. Explain MCDM techniques in Holonic manufacturing
5. Define about holonic control implementation & case Study on this.

Learning Resources:

1. Design for the Unexpected: From Holonic Manufacturing Systems towards a Humane Mechatronics Society 1st Edition by Paul Valckenaers (Author), Hendrik Van Brussel (Author), Butterworth-Heinemann; 1st edition (December 2, 2015)
2. ANEMONA: A Multi-agent Methodology for Holonic Manufacturing Systems (Springer Series in Advanced Manufacturing), by VicentBotti (Author), Adriana GiretBoggino (Author), Springer; Softcover reprint of hardcover 1st ed. 2008 edition (28 October 2010)

Subject Code:MMT 204 D	
Subject Name:Cyber Physical Production Systems	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester**=12 minimum

Course Objectives: At the end of the course, students will be able to

1. Develop knowledge of basics, drivers and enablers of Industry 4.0
2. Gain knowledge of advanced automation and techniques of planning, dimensioning, design and optimization of Industry 4.0 production systems
3. Develop knowledge and understanding of Smart manufacturing (SM) and Cyber Physical Production Systems (CPPS)
4. Formulate methods and techniques of production system planning considering SM and CPPS.
5. Establish design, architectural, and functional requirements of Digital Twin
6. Apply the knowledge to design and develop CPPS considering machine tool 4.0 and associated MTDT

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Introduction to Industry 4.0** History of Industrial Revolution: Duration, motivation, majo Definition of Industry 4.0: What is it all about and why it is neces motivation: German Federal Govt. initiative, Comparison of In Factory and today's Factory, The 10 most important things that w	4

	with Industry 4.0, Difference between conventional automation an 4.0.	
2	**Basic principles and technologies of a Smart Factory** 9 pillars of Industry 4.0, Concept of smart factory: Conceptualframework: Data- driven approach, definition, scenarios, and future perspectives; Smart design, smart manufacturing, smart scheduling, smart monitoring and control, smart decision-making. Data standards. Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Big data, Cyber-Physical Systems (CPS), Cyber-Physical Production Systems (CPPS), Value chains in manufacturing companies, Customization of products, Digital Twins, Cloud Computing / Cloud Manufacturing, Security issues within Industry 4.0 networks. The intelligent work piece as basic functionality in implementing Industry 4.0; What is an intelligent work piece? How to make a work piece intelligent? Work piece tagging, QR codes and RFID, Communication between work piece and environment. Applications for smart work pieces (examples of existing or future applications in the field of manufacturing	10
3	**Cyber-Physical Systems (CPS) and Cyber-Physical Production Systems (CPPS)** What are cyber-physical systems? (Definitions, demarcation to embedded systems, ubiquitous computing, etc.), Core elements of Cyber-Physical Systems and Cyber-Physical Production Systems, 5C architecture of CPPS, Schematic representation of CPPS, Control theory and real-time requirements, Communication in cyber-physical systems, Security aspects in CPPS. Interplay between CS, ICT and manufacturing. Design Methods for Cyber-physical Systems (Modelling, Programming, Model-Integrated Development), Applications for cyber-physical systems (examples of existing or future applications in the field of manufacturing, traffic, medical technology, etc.)	10
4	**Agent based and holonic control approach to CPPS** Multi-agent systems in production: Definition of an agent and agent based systems, properties of MAS, advantages. Agent based approach to smart MES control and CPPS.	6
5	**Digital Twins in Production** Basic concepts of Digital Twin by Greaves, DT definition,benefits, impact and challenges; Features and Implementation of Digital Twins, Types of Digital Twins: Digital model, digital shadow, and digital twin, Digital Twin use cases. Applications of digital twins in production (examples of existing or future applications in the field of manufacturing), Digital twin design and functional requirements, 5D model of DT, Knowledge representation: Knowledge graph, Formal Concept Analysis, data visualization and data virtualization, Semantic meta data modelling, Various softwares used in decision-making, Digital twin vs. Digital thread.	12

6	**CPMT** Cyber-physical modules for machine tools, Machine tool 4.0 (CPMT/MTDT): Architecture, Concept, Connection through MT Connect (XML adapter, XML agent), OPC-UA, etc. Data-filtering and pre-processing, Data fusion in DT, Decision making: Optimization, simulation, prediction, PHM etc., Use of ML in decision-making, Advantages, and challenges. MTDT case studies.	6
	Total Contact Hrs.	**48**

Course Outcomes:

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

1. Develop knowledge of basics, drivers and enablers of Industry 4.0
2. Gain knowledge of advanced automation and techniques of planning, dimensioning, design and optimization of Industry 4.0 production systems
3. Develop knowledge and understanding of Smart manufacturing (SM) and Cyber Physical Production Systems (CPPS)
4. Formulate methods and techniques of production system planning considering SM and CPPS.
5. Establish design, architectural, and functional requirements of Digital Twin
6. Apply the knowledge to design and develop CPPS considering machine tool 4.0 and associated MTDT

Learning Resources:

Published research articles

Subject Code:MMT 205A	
Subject Name: Reliability	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester**=12 minimum

Course Objectives:
Understand major concepts of reliability prediction. Analyze statistical experiments leading to reliability modelling. Identify reliability testing components. Apply reliability theory to assessment of reliability in engineering design.

Course Content:

Module No.	DescriptionofTopic	Contact Hrs.
1	**Elements of Probability:** Probability concepts, Rules for addition of probabilities, Complementary events,Conditional probability, Random events, Sample distribution.	9
2	**Reliability:** Fundamental aspects of reliability, Failure patterns and mathematical models (Constant failurerate models and Time Dependent failure models), System Reliability, Fault tree analysis, FMEA andFMECA.	12
3	**Reliability testing:** Burn in testing, Binomial Testing, Acceptance testing, Accelerated life Testing,Degradation Models.	8
4	**Reliability Improvement:** Reliability specification and system measurements, System effectiveness,Economic analysis and life cycle cost, Reliability allocation (AGREE method, Redundancies).	10
5	**Reliability Design Methods:** Parts and material selection, De-rating, Stress-Strength analysis, Complexityand Technology, Redundancy.	9
	Total Contact Hrs.	**48**

Course Outcomes:
Upon successful completion of the course, students will be able to

6. Discuss about what is Reliability.
7. Understand how to allocate Reliability to each component
8. Understand what is Reliability and Maintability
9. Understand Different Reliability Analysis Technique and how to apply it
10. Understand about Maintenance technique and apply these technique to different component
11. Understand about strength based reliability.
12. Explain fault tree analysis and how to use it in engineering applications.

13. Define system reliability and how to solve the system reliability

Learning Resources:

1. Mechanical Reliability Engineering by ADS Carter, Mc Milan.
2. Reliability Evaluation of Engineering Systems by Roy Bilington and R. N. Allen, Pitman.
3. Introduction to Reliability Engineering by Dhilan& Singh.
4. Reliability Engineering by L. A. Doty, Industrial Press Inc.

Subject Code:MMT 205B	
Subject Name: Quality Function Deployment	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:

The aim of QFD is to translate objective and even subjective quality criteria into objective quality criteria that can be quantified and measured. It is a complementary approach for indicating how and where priorities are to be assigned in product development.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	**Quality function parameters:** Product planning, product design, process planning process control,Customer requirements, Design requirements, Process operation, operation requirements.	8
2	**QFD Process:** Customer requirements, Fuzzy Logic, Planning Matrix, Technical features, DeploymentMatrix, Process Plan and Quality control charts, Operating instructions.	8
3	**House of Quality:** Voice of the customer, technical requirements, Relationship between customerrequirements and technical requirements, Priorities of technical requirements, Priorities of customerrequirements, Competitive evaluation, Trade off.	10
4	**Four Houses of Quality:** Technical requirements, Component characteristics, Process operations, Qualitycontrol plan.	7

5	**Using the House of Quality:** Engineering Characteristics strongly influencing the desired attributes,Check for adverse interaction and weigh tradeoff, Set target levels (not ranges), Link to lower level housescomponentcharacteristics, Key process operations, Production requirements.	9
6	**Problems with QFD:** Too large matrix, Customer priorities not clear, Need of Market segmentation, Useof revealed preference techniques, QFD is messy.	6
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Explain about different quality function parameters.
2. Understand various QFD Process and control charts.
3. DefineHouse of Quality related to customers' requirements.
4. Understand different Four Houses of Quality.
5. Explain about the usehouse of Quality.
6. Solveproblems with QFD.

Learning Resources:

1. Quality planning and analysis by J.M. Juran, F.M. Gryna, Tata McGraw –Hill
2. Total quality management by K. ShridharaBhat, Himalaya Publishing House.
3. Total quality management by S. Ramasamy, Tata McGraw –Hill

Subject Code:MMT 205C	
Subject Name: Business Process Reengineering (BPR)	**Semester:** Second
L-T-P: 4-0-0	**Credit:** 4
Contact Per Week- 4L	**Contact Week / Semester=**12 minimum

Course Objectives:
It involves the radical redesign of core business processes to achieve dramatic improvements in productivity, cycle times and quality and also aims at cutting down enterprise costs and process redundancies but unlike other process management techniques.

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	Reengineering: Definition, Reasons for Reengineering, Development of Business Process reengineering,Three 'R's of Reengineering, Requirements of reengineering process, Reengineering in the serviceindustries, Quality and reengineering, Reengineering and TQM.	14
2	Human Process Reengineering, Organizational Reengineering, Reengineering Tools, Changes that occur inReengineering, Success of Reengineering, Role of Information Technology, Reengineering leadership,Style of implementation for reengineering, Role of Industrial engineer in BPR. Employee support forreengineering, Information system for BPR. BPR and innovation, reengineering by OPISys.	16
3	Integrating Reengineering and Process Improvements, Benefits and Limitations of Reengineering.	8
4	Beyond Business Process Reengineering: The Holonic concept, How the Holonic network works?,Advantages of Holonic Business systems, Types of Holonic networks.	10
	Total Contact Hrs.	**48**

Course Outcomes:
Upon successful completion of the course, students will be able to

1. Understanding various BPR methodologies and their applications.
2. Understanding the critical success factors for implementing BPR.
3. Appreciate various alternative techniques of BPR – TQM, Work Study, Benchmarking and their applications.
4. Basic understanding of ISO standard 9001:2015, IACBE and their applications in education and industry.
5. Analyze and integrate issues and challenges of applying tools/techniques of Information Technology for BPR and learn to apply them in the industry.
6. Familiarizing, analyzing and applying the role of process of Change Management in implementing BPR.

Learning Resources:

1. Total quality management by K. ShridharaBhat, Himalaya Publishing House.
2. Total quality management by K. C. Arora, S. K. Kataria& Sons.

Subject Code:MMT 291	
Subject Name: Robotics & Mechatronics Lab	**Semester:** Second
L-T-P: 0-0-4	**Credit:** 2
Contact Per Week- 4P	**Contact Week / Semester=**12 minimum

Course Objectives:

1. To understand the basic concepts associated with the design and Functioning and applications of Robots
2. To study about the drives and sensors used in Robots.
3. To learn about analysing robot kinematics and robot programming

Course Content:

Module No.	**DescriptionofTopic**	**Contact Hrs.**
1	To study a class room robot and developing the program for performing the pick and place task.	12
2	To study the different components of a modular automation production system demonstrating the operations of a bottling plant and running the sequential operations by developing and executing the program.	12
3	To study the SCARA robot and performing the operation of sorting the containers on the basis of weight by developing the program.	12
4	To develop hierarchical decomposition model for understanding difference among the quality of low, medium and high carbon steel using fuzzy logic tool box provided by MATLAB.	12
	Total Contact Hrs.	**48**

Course Outcomes:

Upon successful completion of the course, students will be able to

1. Upon completion of this course, the students can able to apply the basic engineering
2. To learn about knowledge for the design of robotics.
3. Will understand robot kinematics and robot programming.
4. Will understand application of Robots
5. To learn about force and torque sensing
6. To learn about application of robot

Learning Resources:

1. Introduction to Robotics: Mechanics and Control (3rd Edition) by John Craig
2. Modern Robotics Mechanics, Planning, and Control by Kevin M. Lynch, Frank C. Park