The theory subjects will be of maximum 125 Marks each having 25 Marks as course work and 100 Marks for University examination.

First Semester

S. No.	Code No.	***Subject***	L	T	P	Max Marks	Ex. Hrs.
1.	1MEPE1	Machining Science – I	3	1	0	125	3
2.	1MEPE2	Machining Science – II	3	1	0	125	3
3.	1MEPE3	Metal Forming	3	1	0	125	3
4.	1MEPE4	Metrology and Computer Aided Inspection	3	1	0	125	3
5.	1MEPE5	Manufacturing Lab	0	0	3	100	3
Total			12	4	3	600	

Second Semester

S. No.	Code No.	***Subject***	L	T	P	Max Marks	Ex. Hrs.
6	2MEPE6	Advanced Optimization Techniques	3	1	0	125	3
7.	2MEPE7	Mechatronics	3	1	0	125	3
8.	2MEPE8	Machine Tool Design	3	1	0	125	3
9.	2MEPE9	Computer Integrated manufacturing Systems	3	1	0	125	3
10.	2MEPE10	CAM Lab	0	0	3	100	3
Total			12	4	3	600	

Third Semester

S. No.	Code No.	***Subject***	L	T	Max Marks	Ex. Hrs.
11	3MEPE11	Elective 1	3	1	125	3
12	3MEPE12	Elective 2	3	1	125	3
13	3MEPE13	Seminar			150	
14	3MEPE14	Dissertation – I			100	
Total			6	2	500	

Fourth Semester

S. No.	Code No.	***Subject***	L	T	Max Marks	Ex. Hrs.
15	4MEPE15	Dissertation – II			500	
Total					500	

List of Electives (For 3MEPE11 & 3MEPE12):

Choose any two out of six given below.

3MEPE11&12.1:Micro Electrical and Mechanical Systems (MEMS)

3MEPE11&12.2:Nanotechnology

3MEPE11&12.3:Design of Experiments

3MEPE11&12.4:Advanced Welding Technology

3MEPE11&12.5:Rapid Prototyping

3MEPE11&12.6:Simulation and Modeling

1MEPE1: MACHINING SCIENCE I

3L+1T **MM:125** **Ex.Hrs. 3**

1. **INTRODUCTION** to Machining: Basic Mechanism involved.
2. **PLASTIC DEFORMATION**: Tensile test; stress and strain; Mechanism of Plastic Deformation - slip, dislocation.
3. **CHIP FORMATION**: Typical lathe tools; Orthogonal cutting; oblique cutting; Types of chips; Mechanism of built-up-edge formation.
4. **TOOL GEOMETRY**: Reference planes; Tools specification in ASA, ORS and NRS; conversation from ASA to ORS; Selection of tools angles; Multi-point cutting tools-geometry of peripheral milling cutters and twist drills.
5. **MECHANICS OF METAL CUTTING**: Merchant's circle diagram- determination of cutting and thrust forces; Coefficient of friction; Stress, strain and strain rate; Measurement of shear angle - direct and indirect methods; Mohr's circle diagram; slip line field method; Thin zone model - Lee and Shaffer's relationship; Thick zone model - Okushima and Hitomi model (analysis) ; Friction in Metal cutting.
6. **MECHANICS OF OBLIQUE CUTTING:** Concept of rake angle measured in different planes; Shear angle; Velocity and force relationship.
7. **PRACTICAL MACHINING OPERATIONS:** Turning, shaping and planning, Drilling, milling and broaching.
8. **MEASUREMENT OF CUTTING FORCES:** Cantilever beams, rings; Dynamometer requirement; turning and drilling.
9. **TOOL WEAR AND TOOL LIFE:** Mechanism of wear; Progressive tool wear; Flank wear; Crater wear; Model of diffusion wear; Tool life : Variables affecting tool life- Cutting conditions; tool geometry; Tool materials; work materials; Work materials; Cutting fluids; Determination of tool life equation; Machinability.
10. **ECONOMICS OF MACHINING:** Minimum production cost criterion; Maximum production rate criterion; maximum profit rate criterion; Restriction on cutting conditions.
11. **ABRASIVE MACHINING PROCESSES:** Introduction; Grinding: Characterstics of a grinding wheel; Specification of grinding wheels; Mechanics of grinding process; Chip length in horizontal surface grinding; External and internal cylindrical grinding; Specific energy in grinding; Wheel wear; Thermal analysis; Selection of grinding wheels; Honning and lapping operations.
12. **THERMAL ASPECTS OF MACHINING:** Regions of heat generation; Distribution of heat generated; Equations of flow due to conduction, transportation, heat absorbed and heat generated; Average shear plane temperature; Average chip-tool interface temperature;

Experimental determination of cutting temperature - tool-work thermocouple technique, infrared photographic technique.

13. **SURFACE FINISH**: Ideal and natural roughness; Surface finish during turning, milling and grinding. Topics of Term Papers.
14. **SPECIAL TOPICS**: Topics of Term Papers.

1MEPE2: MACHINING SCIENCE II

3L+1T **MM:125** **Ex.Hrs. 3**

Limitations of conventional machining process. General classification of unconventionalmachining, ECM, electric discharge machining, electron beam machining, laser beam machining, ion beam machining, and plasma arc machining, AJM, USM, Non conventional finishing process. Comparative evaluation of different processes. Conventional machining with modifications.

1MEPE3: METAL FORMING

3L+1T **MM:125** **Ex.Hrs. 3**

Plasticity

Introduction - stress, strain, invariants, stress-stress strain relations; Yield and Flow/ Yield criteria; Plastic Anisotropy/ Anisotropic yield criterion; Governing equations and formulations of plasticity problem; Plastic instability slab method; Slip-line field theory; Upper and Lower Bound Techniques.

Analysis of Forming Processes

Forging; Strip, wire and tube drawing; Extrusion; Rolling; Deep drawing; High velocity forming (Explosive/ Electro magnetic process)

Term Paper on recent trends in Metal forming

1MEPE4: METROLOGY AND COMPUTER AIDED INSPECTION

3L+1T **MM:125** **Ex.Hrs. 3**

Metrological concepts – Concept of accuracy, Need for high precision measurement associated with high precision measurements. Accuracy of numerical control system, Inaccuracy due to thermal aspects, Detailed surface roughness concept, Dimensioning & Dimensional chains, Surface and form metrology-flatness, roughness, waviness cylindricity, etc., Methods of improving accuracy & surface finish, Influence of forced vibration on accuracy, Dimensional wearof cutting tools and its influences on accuracy.

Standards for length measurement standards and their calibration - Light interference - Method of coincidence - Measurement errors. Various tolerances and their specifications, gauging assembly, comparators.

Angular measurements - principles and instrument measurements.

Computer Aided Metrology - Principles and interfacing, soft metrology - Application of lasers in precision measurements- laser interface, laser scanners, Coordinate measurement machine (CMM), Type of CMM & applications, Non contact CMM, Electro optical sensors for dimension, contact sensors for surface finish measurements. Image processing and its Metrology. Acoustical measurements, Digital techniques in mechanical measurements, Assessing and presenting experimental DATA.

Special topics for term papers

1MEPE5: MANUFACTURING LAB

3P **MM:100** **Ex.Hrs. 3**

Machining practice and parametric analyses on USM, EDM, ECM, AJM.

Measurement of forces, surface roughness and temperature in case of milling and grinding operations.

2MEPE6: ADVANCED OPTIMIZATION TECHNIQUES

3L+1T **MM:125** **Ex.Hrs. 3**

Classical optimization techniques for unconstrained optimization. Karush-Kuhn-Tucker conditions. Sensitivity analysis for linear programming problems. Non-linear programming. Penalty function methods. Sequential linear programming. Feasible direction methods. Quadratic programming. Geometric programming. Integer programming. Fuzzy linear programming.

2MEPE7: MECHATRONICS

3L+1T **MM:125** **Ex.Hrs. 3**

Introduction to mechatronic systems and components. Principle of basic electronics. Microprocessors and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Principles of electronic/system communication. Interfacing, DA and AD converters, software and hardware principles and tools to build mechatronic systems. Selection of mechatronic systems, namely, sensors like encoders and resolvers. Stepper and servomotors; Solenoid like actuators; Transmission elements like Ball screw; and Controllers. Analysis and synthesis of mechatronic systems with applications to robotics, CNC systems, and others.

2MEPE8: MACHINE TOOL DESIGN

3L+1T **MM:125** **Ex.Hrs. 3**

Design requirements of machine tools. A design approach for machine tools. Identification and quantification of objectives and constraints in machine tool design. Estimation of power requirements and selection of motor for metal cutting machine tool spindles. Design of gearbox, spindle and guideways. Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and overarms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements.

2MEPE9: COMPUTER INTEGRATED MANUFACTURING SYSTEMS

3L+1T **MM:125** **Ex.Hrs. 3**

Evolving manufacturing environment, New competitive challenges, Evolving Role of Information Technology, CIM Systems: Flexibility, Integration and Automation Opportunities, Automation of information and manufacturing systems, Automation strategies, Towards Flexible Automation, Islands of automation, Evolution Towards CIM systems, Computer based integration between various functions - manufacturing, sales, design, materials etc Flexible Manufacturing Systems (FMS) as mini CIM, Computer Integrated Production Management, ERP, Group technology, Concurrent Engineering, Simulation and AI in CIM systems, CIM and Beyond.

2MEPE10: CAM LAB.

3P **MM:100** **Ex.Hrs. 3**

The experiments may be designed based on different aspects of computer aided manufacturing.

III SEMESTER M-TECH (PRODUCTION ENGINEERING) SYLLABUS (FOR 3MEPE11 and 3MEPE12)

3MEPE11&12.1: MICRO ELECTRICAL AND MECHANICAL SYSTEMS (MEMS)

1. **Introduction:** Production Engineering; Precision Engineering and Ultra Precision Engineering; Integrated Circuits (IC); Micro Electromechanical Systems (MEMS); Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS; MOEMS; Magnetic MEMS; RF MEMS; Micro fluidic Systems; Bio and Chemo – Devices; Nano-technology; Modeling and Simulation; MEMS Packaging and Design consideration; Micro instrumentation.
2. **Micromachining:** Introduction; Photolithography; Structural and Sacrificial Materials; other lithography Methods; Thin Film Deposition; Impurity Doping; Etching; Surface Micromachining; Bulk versus Surface Micromachining; Wafer Bonding; LIGA
3. **System Modeling and Properties of Material:** The need for Modeling; System Types; Basic Modeling Elements in Mechanical System; Basic Modeling Elements Electrical Systems; Basic Modeling Elements Fluid Systems; Basic Modeling Elements Thermal Systems; Translational Pure Mechanical System with Spring. Damper and Mass; Rotational Pure Mechanical System with spring, Damper and Mass; Modeling Hybrid Systems.
4. **Passive Components and Systems:** Introduction; System on a Chip (SOC); Passive Electronic Systems; Passive Mechanical Systems (PMS).
5. **Mechanical Sensors and Actuators:** Principal of Sensing and Actuation; Beam and Cantilever; Micro Plates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain measurements; Pressure Measurement; Flow Measurement; using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shear mode Piezo-actuator; Gripping Piezo-actuator; Inchworm technology.
6. **Thermal Sensors and Actuators:** Thermal Energy Basics and Heat Transfer Processes; Transistors; Thermistors; Thermo-devices; Thermo-couple; Micromachined Thermo-couple Probe; Peltier Effect Heat Pumps; Thermal Flow Sensors; Microhotplate Gas Sensors; MEMS Thermovessels; Pyroelectricity; Shape Memory Alloys (SMA); U Shaped Horizontal and Vertical Electro-thermal Actuator; Thermally Activated MEMS Relay; Microspring Thermal Actuator.
7. **Microfludic Systems:** Applications; Important Considerations on Microscale Fluid; Fluid Actuation Methods; Dielectrophoresis (DEP); Electro-wetting; Electro-thermal Flow; Thermo-capillary Effect; Electroosmosis Flow; Optoelectro-wetting (OEW); Tuning Using Micro-fluidcs; Typical Micro-fludic Channel; Micro-fluid Dispenser; Micro- needle; Molecular Gate; Micropumps; The Continous Flow System.
8. **Principal and introduction of Micro-Opto-Electromechanical system, Magnetic sensors and actuators and Radio frequency(RF) MEMS**

3MEPE11&12.2: NANOTECHNOLOGY

1. **The Canvas of Nano:** Nano and Nature; Our Technologies and the world we live in; Nano – The Beginning.
2. **Investigating and Manipulating Materials in the Nanoscale:** Introduction; Electron Microscopies; Scanning Probe Microscopies; Optical Microscopies for Nanoscience and Technology; Other Kinds of Microscopies; X-Ray Diffraction; Associated Techniques.
3. **Fullerenes:** Introduction: Discovery and Early year; Synthesis and Purification of Fullerenes; Mass Spectrometry and Ion/Molecule Reaction; Chemistry of Fullerenes in the Condensed Phase; Endohedral Chemistry of Fullerenes; Orientational Ordering; Pressure Effects; Conductivity and superconductivity in doped fullerenes; ferromagnetism in C_{60} TDAE.
4. **Carbon Nanotubes:** Introduction; Synthesis and Purification; Filling of Nanotubes; Mechanism of Growth; Electronic Structure; Transport Properties; Mechanical Properties; Physical Properties; Applications; Nanotubes of other Materials.
5. **Nanoshells:** Introduction; Types of Nanoshells; Properties; Characterization; Application.
6. **Nanosensors:** Introduction; what is a Sensor?; Nanosensors – what make them possible?, Order from Chaos – Nanoscale Organization for Sensors; Characterization – To knowwhat has been put in; Perception – Nanosensors based on optical properties, Nanosensors based on Quantum size Effects; Electrochemical Sensors; Sensors based on physicalproperties; Nanobiosensores- A step towards Real- time Imaging and Understanding of Biological Events; Smart Dust – Sensors of the Future.
7. **Nanomedicines:** Introduction; Approach to Developing Nanomedicines; Various kinds of Nanosystems in Use; Protocols for Nanodrug Administration; Nanotechnology in Diagnostic Application; Materials for Use in Diagnostic and Therapeutic Applications; Future Directions.
8. **Molecular Nanomachines:** Introduction; Covalent and Non Covalent Approaches; Molecular Motors and Machines; Molecular Devices; Single Molecular Devices; Practical Problems with Molecular Devices.
9. **Nanotribology:** Introduction; Studying Tribology at the Nanoscale; Nanotribology Applications; Outstanding Issues.

3MEPE11&12.3: DESIGN OF EXPERIMENTS

1. **Introduction:** Strategy of Experimentation; Some Typical Applications of Experimental Design; Guidelines for Designing Experiments; Historical Perspective; Summary; Using Statistical Techniques in Experimentation.
2. **Simple Comparative Experiments:** Introduction; Basic Statistical Concepts; Sampling and Sampling Distributions; Inferences About the Differences in Means, Randomized Designs; Hypothesis Testing; Choice of Sample Size; Confidence Intervals; The case Where $\sigma_1^2 \neq \sigma_2^2$, The Case where σ_1^2 and σ_2^2 are Known; Comparing a Single Mean to a Specified Value. Inferences about the Differences in Means, Paired Comparison Design; Inferences about the Variances of Normal Distributions.
3. **Experiments with a Single Factor- The Analysis of Variances:** The Analysis of Variance. Analysis of the Fixed Effects Model; Decomposition of the Total Sum ofSquares; Statistical Analysis; Estimation of the Model Parameters; Unbalanced Data. Model Adequacy Checking; The Normality Assumption; Plot of Residuals in Time Sequence; Plot of Residuals Versus Fitted Values; Selecting a Variance- Stabilizing Transformation; Plot of Residuals versus Other Variables. Practical Interpretation of Results; A Regression Model; Comparisons Among Treatment Means; Contracts; Orthogonal Contrasts; Scheffe's Method for Comparing all contrasts, Comparing Pairs of Treatment Means, Comparing Treatment Means with a Control; Sample Computer Output;The Random Effects Model.
4. **Introduction to Factorial Designs:** Basic Definitions and Principles, the Advantage of Factorials, Model Adequacy Checking; Estimating the Model Parameters; Choice of Sample Size; The Assumption of no Interaction in a Two Factor Model; One Observation Per Cell. The General Factorial Design; Fitting Response Curves and Surfaces; Blocking in a Factorial Design, Unbalanced Data in a Factorial Design; Proportional Data- an Easy Case; Approximate Methods; The Exact Method.
5. **The 2^k Factorial Design:** Introduction; The 2^2 Design; The 2^3 Design; The General 2^k Design; A Single Replicate of the 2^k design. The Addition of Center Points to the 2^k Design; Yates Algorithm for the 2^k Design, Problems.
6. **Fitting Regression Models:** Introduction; Linear Regression Models; Estimation of the Parameters in linear Regression Models.
7. **Response Surface Methods and Other Approaches to Process Optimization:** Introduction to Response Surface Methodology; The Method of Steepest Ascent; Analysis of a Second Order Response Surface – Location of the Stationary Point; Characterizing the Response Surfaces; Ridge Systems; Design for Fitting the First Order Model; Taguchi's Contributions to Experimental Design and Quality Engineering- The Taguchi Philosophy; The Taguchi Approach to Parameter Design.

3MEPE11&12.4: ADVANCE WELDING TECHNOLOGY

Analysis of heat sources for welding, Mechanism of metal transfer and solidification of fusion weldments. Thermal stresses and distortion in welded structure. Mechanism of solid state joining process.
Parameters in welding and their control, analysis of 2D, 3D heat flow in welds. Modern welding process like EBW, LBW, Diffusion bonding. Ultrasonic welding etc. Pulsed current welding processes.
Welding of Ceramics, Plastics and Composites. Weldment design for pressure vessels. Off-shore structures and Submarine Pipe lines. Heavy structures, Failure of welds.NDT of welds. Inspection codes for weldments.

3MEPE11&12.5: RAPID PROTOTYPING

Overview of Rapid Product Development (RPD). Product Development Cycle; Definition of RPD; Components of RPD. Rapid Prototyping (RP);Principle of RP; Technologies and their classifications; Selection of RP process; Issues in RP; Emerging trends. Rapid Tooling (RT);Introduction to RT, Indirect RT process-Silicon rubber molding, Epoxy tooling, Spray metal tooling and Investment Casting, Direct RT processes-Laminated Tooling, Powder Metallurgy based technologies, Welding based technologies, Direct pattern making (Quick Cast, Full Mold Casting),Emerging Trends in RT, Reverse Engineering: Geometric data acquistion,3D reconstruction, Applications and Case Studies, Engineering applications, Medical applications. Processing Polyhedral Data: Polyhedral BRep modeling, STL format, Defects and repair of STL files, Overview of the algorithms required for RP&T and Reverse Engineering-slicing, support generation, feature recognisation etc. Laboratory and Demonstration Sessions, Processing STL files, Demonstration of FDM RP machine, Demonstration of RT.