



Rajasthan Technical University (RTU)

Mechanical (Production Engineering)

M. Tech Program in Mechanical Engineering with specialization in Production Engineering

Courses

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 | |



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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.

Simulation and Modeling

Advanced Welding Technology

Nanotechnology

Design of Experiments

Micro Electrical and Mechanical Systems (MEMS)

Rapid Prototyping



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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; conversion 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 planing, 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: Characteristics 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;



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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 unconventional machining, 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-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



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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 wear of 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.



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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.



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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)

MICRO ELECTRICAL AND MECHANICAL SYSTEMS (MEMS)

1. **Introduction:** Production Engineering; Precision Engineering and Ultra-Precision Engineering; Integrated Circuits (IC); Microelectromechanical Systems (MEMS): Microsensors; Microactuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS : MOEMS; Magnetic MEMS; RF MEMS; Microfluidic Systems; Bio and Chemo – Devices; Nano technology; Modeling and Simulation; MEMS Packaging and Design Considerations; Microinstrumentation.
2. **Micromachining:** Introduction; Photolithography; Structural and Sacrificial Materials; other lithography Methods; Thin Film Deposition; Impurity Dopping; 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 in Electrical Systems; Basic Modeling Elements in Fluid Systems; Basic Modeling Elements in 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 System:** Introduction; System On A chip (SOC); Passive Electronic Systems; Passive Mechanical Systems (PMS).
5. **Mechanical Sensors and Actuators:** Principles of Sensing and Actuation; Beam and Cantilever; Microplates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shearmode Piezoactuator; Gripping Piezoactuator; Inchworm Technology.
6. **Thermal Sensors and Actuators:** Thermal Energy Basics and Heat Transfer Processes; Thermistors; Thermodevices; Thermocouple; Micromachined Thermocouple Probe; Peltier Effect Heat Pumps; Thermal Flow Sensors; Microhotplate Gas Sensors; MEMS Thermovessels; Pyroelectricity; Shape

Memory Alloys (SMA); U-shaped Horizontal and Vertical Electrothermal Actuator; Thermally Activated MEMS Relay; Microspring Thermal Actuator.

7. **Microfluidic Systems:** Applications; Important Considerations on Microscale Fluid; Fluid Actuation Methods; Dielectrophoresis (DEP); Electrowetting; Electrothermal Flow; Thermocapillary Effect; Electroosmosis Flow; Optoelectrowetting (OEW); Tuning using Microfluidics; Typical Microfluidic Channel; Microfluid Dispenser; Microneedle; Molecular Gate; Micropumps; The Continuous Flow system.
8. **Principle and introduction of Micro-Opto-Electromechanical system, Magnetic sensors and actuators, and Radio frequency (RF) MEMS.**

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 years; Synthesis and Purification of Fullerenes; Mass Spectrometry and Ion/Molecule Reactions: 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; Applications.
6. **Nanosensors:** Introduction; What is a Sensor?; Nanosensors – what makes them possible?, Order from Chaos – Nanoscale Organization for Sensors; Characterization – To know what has been put in; Perception – Nanosensors Based on optical properties, Nanosensors Based on Quantum Size Effects; Electrochemical Sensors; Sensors Based on Physical Properties; Nanobiosensors – 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 Applications; 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 Molecule Devices; Practical Problems with Molecular Devices.
9. **Nanotribology:** Introduction; Studying Tribology at the Nanoscale; Nanotribology Applications; Outstanding Issues.

DESIGN OF EXPERIMENTS

1. **Introduction:** Strategy of Experimentation; Some Typical Applications of Experimental Design; Basic Principles; 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 Designs; The paired comparison problem; Advantages of the Paired Comparison Design; Inferences About the Variances of Normal Distributions.
3. **Experiments with a single factor-The Analysis of Variance:** The Analysis of Variance. Analysis of the Fixed Effects Model; Decomposition of the Total Sum of Squares; 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; Plots of Residuals Versus Other Variables. Practical Interpretation of Results; A Regression Model; Comparisons Among Treatment Means; Graphical Comparisons of Means; Contrasts; 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, The Two Factor Factorial Design; Statistical Analysis of the Fixed Effects Model; 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 Surface; Ridge Systems; Multiple Responses; Experimental Designs for Fitting Response Surfaces; Designs for Fitting the First order Model; Taguchi's Contributions to Experimental Design and Quality Engineering - The Taguchi Philosophy; The Taguchi Approach to Parameter Design.