BMS COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU

VISION
Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION
Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION
To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION
• To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
• To continue their education through post-graduation, Research & Development.
• To provide service to the society.

Scheme and Syllabus for
M.Tech-Manufacturing Science and Engineering
With effect from A. Y-2016 – 17
Program Educational Objectives

PEO1– Graduates will have knowledge in the discipline of Manufacturing processes and systems with hands on skills in using modern machine tools and equipment to address real world engineering problems and be socially responsible.

PEO2– Graduates shall be successful in their career as materials and manufacturing engineers of various engineering components using conventional and advanced materials and processes, participating in a team or individually in industry, research or academia.

PEO3– Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.

Programme Outcomes

<table>
<thead>
<tr>
<th>PO No.</th>
<th>Program Outcomes (PO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.</td>
</tr>
<tr>
<td>PO2</td>
<td>Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.</td>
</tr>
<tr>
<td>PO3</td>
<td>Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.</td>
</tr>
<tr>
<td>PO4</td>
<td>Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.</td>
</tr>
<tr>
<td>PO5</td>
<td>Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.</td>
</tr>
<tr>
<td>PO6</td>
<td>Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.</td>
</tr>
<tr>
<td>PO7</td>
<td>Demonstrate knowledge and understanding of engineering and management principles and apply the same to one’s own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.</td>
</tr>
<tr>
<td>PO8</td>
<td>Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.</td>
</tr>
<tr>
<td>PO9</td>
<td>Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.</td>
</tr>
<tr>
<td>PO10</td>
<td>Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.</td>
</tr>
<tr>
<td>PO11</td>
<td>Observe and examine critically the outcomes of one’s actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.</td>
</tr>
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</table>
# Scheme of Teaching for 2016-17

## I Semester

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Subject Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>CREDITS</th>
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<td>1</td>
<td>16MEMSPCAM</td>
<td>Advanced Metal Cutting</td>
<td>3</td>
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<td>2</td>
<td>16MEMSPCMC</td>
<td>Material Characterization</td>
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<td>3</td>
<td>16MEMSPCPM</td>
<td>Plasticity and Metal Forming</td>
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<td>16MEMSPCCM</td>
<td>Composite materials</td>
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<tr>
<td>5</td>
<td>16MEMSPEZZ</td>
<td>Elective -1</td>
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<tr>
<td>7</td>
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<td>Material characterization and Manufacturing Technology lab</td>
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<td>8</td>
<td>16APRDICRM</td>
<td>Research Methodology</td>
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**Total** 22 2 1 25

**Note:** Two electives to be chosen from the list below:
Elective will be offered for a minimum strength of six candidates (out of 18) / eight Candidates (out of 24)

### Course Elective - 1

<table>
<thead>
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<tr>
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<td>16MEMSPENT</td>
<td>Nanotechnology</td>
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### Course Elective - 2

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<tr>
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### Scheme of Teaching for 2016-17

#### II Semester

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**Note:** Two electives to be chosen from the list below:
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#### Course Elective - 3

<table>
<thead>
<tr>
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<td>16MEMSPEMM</td>
<td>Modern Machining Technology</td>
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<td>16MEMSPEAU</td>
<td>Automation in Manufacturing</td>
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<td>16MEMSPEID</td>
<td>Industrial Design and Ergonomics</td>
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#### Course Elective - 4

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<td>16MEMSPEND</td>
<td>Nondestructive Testing</td>
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<td>16MEMSPEMS</td>
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<td>16MEMSPELM</td>
<td>Laser Materials Processing</td>
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#### Institution Elective

<table>
<thead>
<tr>
<th>Subject Code</th>
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<tr>
<td>16MEMSIECM</td>
<td>Computational methods in Engineering analysis</td>
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<tr>
<td>16MEMSIEDE</td>
<td>Design of Experiments</td>
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<td>Design for Manufacture</td>
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</table>
### Scheme of Teaching for 2016-17

<table>
<thead>
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<th>Sl.No</th>
<th>Subject Code</th>
<th>Course Title</th>
<th>Credits</th>
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<td>P</td>
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**III Semester:**

- **Internship:** The student shall undergo internship for 16 weeks. 
  
  **Preliminary Report** submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks.
  
  **Final Report** submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty. Report Evaluation to be completed within two weeks of submission for 100 marks.
  
  **Viva-Voce on Internship** - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks.

- **Project Phase: I**

  **Problem formulation** and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.
  
  **Literature survey and progress** done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks.
## Scheme of Teaching for 2016-17

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Subject Code</th>
<th>Course Title</th>
<th>Credits</th>
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<td>Technical Seminar</td>
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<td><strong>Total</strong></td>
<td><strong>25</strong></td>
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</table>

### IV Semester:

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman.
- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.
- **Final Evaluation of Project Work and Viva-voce.**
  - Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4th semester.
  - The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.
- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.
- **Viva – Voce**: The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks.
## Curricular Components

<table>
<thead>
<tr>
<th>Category</th>
<th>I Sem</th>
<th>II Sem</th>
<th>III Sem</th>
<th>IV Sem</th>
<th>Total Credits to be earned</th>
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<tbody>
<tr>
<td>Core courses</td>
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<tr>
<td>Technical seminar</td>
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<td>Internship</td>
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<td>Project Work</td>
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### Manufacturing Subjects

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Materials subjects</th>
<th>Management &amp; Mathematics subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Metal Cutting</td>
<td>Composite materials</td>
<td>Research Methodology</td>
</tr>
<tr>
<td>Plasticity and Metal Forming</td>
<td>Material Characterization</td>
<td>Total Quality management</td>
</tr>
<tr>
<td>Advanced Joining process</td>
<td>Nanotechnology</td>
<td>Computational methods in Engineering analysis</td>
</tr>
<tr>
<td>Additive Manufacturing Technology</td>
<td>Corrosion and Surface Engineering</td>
<td>Design of Experiments</td>
</tr>
<tr>
<td>Computer control of Manufacturing systems</td>
<td>Advanced Engineering Materials</td>
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<td>Tool Engineering Design</td>
<td>Nondestructive Testing</td>
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<tr>
<td>Industrial Robotics</td>
<td>MEMS</td>
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<tr>
<td>Finite Element Modeling</td>
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<tr>
<td>Advanced manufacturing process</td>
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<td>Modern machining Technology</td>
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<td>Automation in manufacturing</td>
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<tr>
<td>Design for Manufacture</td>
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</table>
I SEMESTER
SYLLABUS
Course Content:

Unit-1
Mechanics of Metal Cutting: Mechanism of chip formation, Orthogonal & Oblique cutting, types of chips, built-up edge, Determination of shear plane angle, forces on the chips, forces in orthogonal cutting, Merchant circle diagram and analysis, Theory of Lee & Shaffer, coefficient of friction, power & energy relationship, velocity relationship, shear-strain, factors affecting forces and power, Problems. 12 Hours

Unit-2
Geometry of Cutting Tools: Single point and multi point cutting tools, tools nomenclature, tool point reference systems, tool angle specifications–ISO and ASA systems, conversion from one system to another, recommended tool angles, effect of cutting parameters on tool geometry.

Tool Materials and Their Properties: Characteristics of tool materials, types of tool materials– carbon tool steels, high speed steels, cast alloys, cemented carbides, ceramics, diamonds, SIALON, CBN, UCON, recommended cutting speeds for the above tools, discussion on tool steels, air, water, oil hardening of tools and their applications. 6 Hours

Unit-3
Measurement of Cutting Forces: Reasons for measuring cutting forces, Classification of cutting force dynamometers – mechanical, hydraulic, pneumatic, optical, inductance, piezoelectric, and strain gage type dynamometers, Dynamometers for lathe, drilling, milling and grinding.

Economics of Machining: Introduction, elements of total production cost, optimum cutting speed and tool life for minimum cost, optimum cutting speed and tool life for maximum production, problems.  

12 Hours

Unit-4

Thermal Aspects in Metal Cutting: Heat sources in metal cutting, temperature in chip formation, temperature distribution, experimental determination of tool temperatures, problems.

Cutting fluids: Basic actions of cutting fluids, properties of cutting fluids, selection of cutting fluids, application of cutting fluids, filtration of fluids, recommended cutting fluids.

Surface finish and surface integrity: Surface finish, Effect of machining parameters on surface finish, Expression for surface in machining with single point tool and problems

5 Hours

Unit-5

Recent Developments: Hot machining, Cryogenic machining, High speed machining, Hard machining, Micromachining, Metal cutting vibrations, Turning of composites

4 Hours

Self-study topics:

A. Analysis of cutting forces using graphical method
B. Analytical and simulation models on chip formation and force analysis - Two case studies
C. Selection of cutting tools based on applications
D. Calibration of dynamometers
E. Analytical and simulation models on tool wear analysis - Two case studies
F. Analytical and simulation models on thermal aspects - Two case studies

TEXT BOOK:


REFERENCE BOOKS:

1. Metal Cutting Principles - M.C. Shaw - Oxford Publication
2. Metal Cutting - Dr. B.J.Ranganath -Vikas Publications.
3. Fundamentals of machining and machine tools - Boothroyd and Knight – Taylor and Francis

E-BOOKS:

MOOCs:
1. http://nptel.ac.in/downloads/112105127/

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Analyze forces in metal cutting and problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Demonstrate tool angles and relate one system to another</td>
</tr>
<tr>
<td>CO3</td>
<td>Categorize different tool materials used in metal cutting application</td>
</tr>
<tr>
<td>CO4</td>
<td>Estimation of cutting forces and tool life during metal cutting</td>
</tr>
<tr>
<td>CO5</td>
<td>Experimental determination of tool tip temperature during metal cutting and select appropriate cutting fluid</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe advancement in metal cutting and develop chip formation model</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 2, 4 and 5 and two questions each from units 1 and 3.
MATERIALS CHARACTERISATION

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPCMC</th>
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Course Content:
Unit-1
**Introduction to the course:** Relevance of advanced characterization to materials development, scientific understanding of phenomena in materials technology. Importance of surface characterization techniques. Optical microscopy-principle, types and applications

8 Hours

Unit-2
**Advanced Diffraction Techniques:** Introduction to X-Ray their production & properties, Review of basic diffraction theory; Various SAXS techniques and its applications in characterizing material, SAXS, GISAXS, LEED and RHEED, EXAFS, SEXAFS/NEXAFS.

14 Hours

Unit-3
Properties of neutron radiation; neutron sources; Small angle neutron scattering; Examples Instrumentation, XPS patterns; Spin orbital Splitting; Quantitative analysis, Chemical effect, Chemical shift, XPS imaging Auger electron generation; Principle, Chemical effect, Quantitative analysis, Depth profiling, Applications.

Unit-4
**Advanced Spectroscopic Techniques:** Introduction; Electromagnetic spectroscopy; UV-Visible Spectroscopy; Photo-luminescence spectroscopy; Infra-red spectroscopy; Raman; STEM; EELS.

8 Hours

Unit-5
**Advanced Microscopic Techniques:** Introduction; Electron-materials interactions; TEM: HR, HAADF, STEM, In-situ TEM; SEM, EBSD, In-situ SEM, AFM, STM, Laser Confocal Microscopy.

8 Hours

REFERENCES
7. ASM Handbook, Vol. 9, Metallography and Microstructures, ASM International, USA.
9. Hatekayama and Quinn, Thermal analysis techniques, Wiley.

MOOCs:
1. http://nptel.ac.in/courses/113104004/
2. http://nptel.ac.in/course.php?disciplineId=112
3. http://nptel.ac.in/courses/113106032/

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Describe the requirements and importance material characterization</th>
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</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyze different materials structure using advanced diffraction techniques</td>
</tr>
<tr>
<td>CO3</td>
<td>Analyze qualitatively and quantitatively materials XPS instrumentation and patterns</td>
</tr>
<tr>
<td>CO4</td>
<td>Explain and analyze materials using advanced spectroscopy techniques</td>
</tr>
<tr>
<td>CO5</td>
<td>Chose and adopt most advanced imaging instruments for investigating the modern material at the highest topographic resolution</td>
</tr>
<tr>
<td>CO6</td>
<td>Select appropriate characterization methods to the analysis and characterization of materials</td>
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</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
PLASTICITY AND METAL FORMING

<table>
<thead>
<tr>
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<td>SEE Marks</td>
<td>50</td>
</tr>
<tr>
<td>Total no. of Lecture Hours.</td>
<td>52</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

Course Content:

Unit-1

**Brief review of elastic and Plastic behavior of metals:**
Continuous, homogeneous and isotropic bodies, Concept of stress and strain, types of stresses and strains, description of stress at a point, plane stress, state of stress in three dimensions, Principal Stresses, Description of strain at a point, hydrostatic and deviator components of stress and strain energy. Flow curves for different materials, true stress and strain, yield criteria for ductile metals - Vonmisse criterion, Tresca criterion, yield locus, anisotropy in yielding, yield surface, octahedral shear stress and shear strain, invariants of stress and strain, plastic stress-strain relations, Levy-Mises equations for ideal plastic solid, problems on yield criteria and true stress and strain

14 Hours

Unit-2

**Fundamentals of Metal Working:**
Classification of forming processes, Hot working, Cold Working, Warm Working, Mechanics of Metal Working, Temperature in metal working, Strain-rate effects, Metallurgical Structure, friction and lubrication, Deformation – Zone Geometry, Workability limit diagram, residual stresses, hydrostatic pressure and flow stress determination

8 Hours

Unit-3

**Forging:** Classification, forging equipment, determination of compressive stress for plate and disc, open and closed die forging, residual stresses in forgings, forging defects and problems.
Simulation models – Case studies

8 Hours

Unit-4

**Rolling of metals:** Classification of Rolling mills, forces and geometrical relationships in rolling, simplified analysis of rolling load, theories of cold and hot rolling, roll separating force, Power loss in bearings, torque and power, front and back tensions, defects in rolled products and problems, Simulation models – Case studies

8 Hours
**Extrusion:** Classification, extrusion equipment, Process variables, Analysis of extrusion processes, tube extrusion, production of seamless pipe and tubing, extrusion defects and problems. Simulation models – Case studies

**Drawing:** Analysis of wire drawing, Rod and wire drawing, dies in drawing, tube drawing, analysis of tube drawing, Residual stresses, redundant work and estimation, optimal cone angle and dead zone formation, defects and problems. Simulation models – Case studies

14 Hours

**TEXT BOOK:**

**REFERENCES BOOKS:**

**E BOOKS:**
2. [http://killerwall.net/USA/survman/Manuals/Metal-Forming(2).pdf](http://killerwall.net/USA/survman/Manuals/Metal-Forming(2).pdf)

**MOOCS:**
1. [http://web.iitd.ac.in/~pmpandey/MEL120_html/Metal%20Forming%20Processes.pdf](http://web.iitd.ac.in/~pmpandey/MEL120_html/Metal%20Forming%20Processes.pdf)
2. [http://nptel.ac.in/courses/112106153/](http://nptel.ac.in/courses/112106153/)
3. [http://nptel.ac.in/downloads/112106153/](http://nptel.ac.in/downloads/112106153/)

**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Describe elastic and plastic behavior of metals</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Differentiate metal working techniques and describe parameters influencing metal working</td>
</tr>
<tr>
<td>CO3</td>
<td>Estimation of forging loads for plate and disc</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyze rolling force and estimate the rolling load</td>
</tr>
<tr>
<td>CO5</td>
<td>Estimation of extrusion load and describe processes variables</td>
</tr>
<tr>
<td>CO6</td>
<td>Analyze drawing load and describe variables and defects</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**
Answer five full questions selecting one from each unit. To set one question each from units 2, 3 and 4 and two questions each from units 1 and 5.
Course Content:

Unit 1

**Introduction**: Definition, Reason for composites, Types, constituents, interface, Role of interface, bonding mechanisms and bond strength.

**Production of composites**: Production of MMC’s by Spray (Osprey) Process, Dispersion Processes - Stir-casting & Compo-casting, Liquid-metal impregnation technique - Squeeze casting, Pressure infiltration, Rheo-casting FRP’s by Hand Layup, Pressure and Vacuum bag processes, CMC’s by Vapour deposition technique cold and hot isostatic pressing techniques, Fabrication of nano-composites.

6 Hours

Unit 2

**Fabrication of Composites**: Cutting, machining, drilling, mechanical fasteners & adhesive bonding, joining, computer aided design manufacturing, tooling, fabrication equipment

**Testing of Composites**: Destructive (Tensile, Compression, Flexural, ILSS, Impact strength, HDT) & non-destructive (ultrasonic, thermography, shearography & X-ray radiography)

**Application Developments** – Aerospace, Automobile, electrical and electronics, marine, Bridge and other Civil Engineering Structures, recreational and sports equipment-future potential of composites

6 Hours

Unit 3


**Macro Mechanics of a Lamina**: Introduction, Hooke's law for different types of materials, Number of elastic constants, relationship of compliance and stiffness matrix.

11 Hours

Unit 4

**Macro Mechanics of a Lamina** Hooke's law for two-dimensional–unidirectional lamina, angle lamina, engineering constants for an angle lamina - Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.
**Biaxial Strength Theories:** Macro mechanical Failure Theories: - Maximum stress theory, Maximum strain theory, Tsai-Hill theory, Tsai, Wu tensor theory, Comparison of Failure Theories, Numerical problems.

**Unit-5**

**Laminated Composites:** Introduction, laminate code, Kirchhoff’s Plate Theory, Classical Laminated Plate Theory, Kirchhoff’s Hypothesis, Stress-resultants in a Laminate, Laminate forces and moments, Laminate Stiffness and ABD Matrices (Detailed derivation), Special cases of laminates (Symmetric, Antisymmetric and Nonsymmetrical laminates)

**Lab component**

1. Manufacturing of FRP composites using hand layup process.
2. Manufacturing of Metal matrix composites using stir casting process.
3. Manufacturing of Metal matrix composites using Squeeze casting.

**TEXT BOOKS:**

2. Introduction to composite materials by Hull and Clyne, Cambridge University.

**E-BOOKS**

1. [www.ac.iitkgp.ernet.in/ebooks/](http://www.ac.iitkgp.ernet.in/ebooks/)

**MOOCS:**

1. [nptel.ac.in/courses/112104168/](http://nptel.ac.in/courses/112104168/), [nptel.ac.in/courses/101104010/](http://nptel.ac.in/courses/101104010/), [nptel.ac.in/courses/.../IISc.../Composite%20Materials/New_index1.html](http://nptel.ac.in/courses/.../IISc.../Composite%20Materials/New_index1.html)

**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Identify the different reinforcement and matrix materials and their properties and applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Select the different processing/ fabrication techniques of composite materials to satisfy the service conditions</td>
</tr>
<tr>
<td>CO3</td>
<td>Develop stress-strain relationships for a unidirectional/bidirectional lamina</td>
</tr>
<tr>
<td>CO4</td>
<td>Establish the failure criteria for laminates based on failure of individual lamina in a laminate</td>
</tr>
<tr>
<td>CO5</td>
<td>Analyze the micro and macro structural characteristics of the composite materials and application to problem solving.</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe laminated composites</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Answer five full questions selecting one from each unit. To set one question each from units 1, 2 and 5 and two questions each from units 3 and 4.
Course Content:

Unit-1
**Metal based nanocomposites** - Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Metal-metal nanocomposites, some simple preparation techniques and their new electrical and magnetic properties.

**Design of Super hard materials** - Super hard nanocomposites, its designing and improvements of mechanical properties.  

**Unit-2**
**Nanofiller synthesis**, applications, Polymer nanocomposites, particulate and fibre modified nanocomposites, matrices and fibres, polymer- filler interphase, pull- out strength, effect of various treatments.  

**Unit-3**

**Polymer-carbon nanotubes based composites**, processing methods and characterization using SEM, XRD, TEM.  

**Unit-4**
**Characterization of Polymer nanotubes based composites** for Mechanical, Electrical and Thermal Properties and their applications - Polymer / nanofillers (metallic nanopowders) systems, Rheological measurements, processing characteristics  

**Unit-5**
Testing of nanocomposites, Thermal analysis such as TGA, TMA, DSC, DMTA  

Text Books:
REFERENCE BOOKS:

E-BOOKS:
1. Carbon Nanotubes – A scientometric study by Werner Marx and Andreas Barth
   nptel.ac.in/courses/118102003/

MOOCS:
1. https://www.coursera.org/learn/nanotechnology1
2. https://www.coursera.org/learn/nanotechnology2
3. https://www.edx.org/course/nanotechnology-fundamentals-purdue-nano530x
4. http://nptel.ac.in/courses/118102003/
5. nptel.ac.in/courses/118104008/

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Classify metal based Nano composites</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Describe polymer Nano composites</td>
</tr>
<tr>
<td>CO3</td>
<td>Model for physical and mechanical properties</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyze structural properties of Nano composites using SEM and XRD</td>
</tr>
<tr>
<td>CO5</td>
<td>Analyze various properties of polymer Nano tubes</td>
</tr>
<tr>
<td>CO6</td>
<td>Compare different methods of thermal analysis techniques of Nano composites</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 2, 4 and 5 and two questions each from units 1 and 3.
Course Content:

Unit-1
**INTRODUCTION:** Basic, concepts of Total Quality Management, Principles of TQM, Quality in Manufacturing and Service Systems, Leadership Concepts, Benchmarking - Re-engineering - Concurrent Engineering.  
6 Hours

Unit-2
11 Hours

Unit-3
**TQM TOOLS**
11 Hours

Unit-4
**QUALITY BY DESIGN:**
6 Hours

Unit-5
**QUALITY MANAGEMENT STANDARDS** Introductory aspects only)


c. ISO 27001:2005 Information Security Management System

d. ISO / TS16949:2002 for Automobile Industry

e. CMMI Fundamentals and Concepts  

**TEXT BOOKS:**

1. **A New American TQM Four Practical Revolutions in Management**” – Shoji Shiba, Alan Graham and David Walden,– Productivity Press, Portlans (USA) , 1993


**REFERENCE BOOK:**


**E BOOKS:**

1. [http://psbm.org/Ebooks/Total%20Quality.pdf](http://psbm.org/Ebooks/Total%20Quality.pdf)


**MOOCs:**


**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Describe management policies of quality control and implementation of quality standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Develop an understanding on the necessary information and skills needed to manage, control and improve quality practices in the organization through TQM Philosophy.</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply the reactive and proactive improvement methodologies for problem solving in organizations.</td>
</tr>
<tr>
<td>CO4</td>
<td>Demonstrate the importance of team work in problem solving processes</td>
</tr>
<tr>
<td>CO5</td>
<td>Analyze implementation of quality by design</td>
</tr>
<tr>
<td>CO6</td>
<td>Apply Quality management standards for manufacturing firms</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Answer five full questions selecting one from each unit. To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
Course Content:
Unit-1
CORROSION
Definition, classification, forms of corrosion, expressions for corrosion rate. Emf and galvanic series - merits and demerits, Forms of corrosion - Uniform, pitting, intergranular, stress corrosion, corrosion fatigue, dezincification, erosion corrosion, crevice corrosion - Cause and remedial measures CORROSION IN INDUSTRIES Boiler water - corrosion by carbon di oxide and unstable salts - corrosion prevention methods by treatment. Cooling water - specification, types of scales and causes - use of antiscalant - water treatments. Maintenance of boilers - protection of boilers during off loading, high temperature corrosion, turbine corrosion, 11 Hours

Unit-2
CORROSION TESTING
Corrosion failure – Inspection and analysis of corrosion damage. Atomic Scale Machining of Surfaces. Anodization, Titanium Dioxide Coatings in Medical Device Applications. Purpose of corrosion testing - Classification - Susceptibility tests for intergranular corrosion-Stress corrosion test. salt spray test humidity and porosity tests, accelerated weathering tests. ASTM standards for corrosion testing, 11 Hours

Unit-3
CORROSION BEHAVIOR OF MATERIALS:
Selection of material for various corrosive environments - Corrosion of Steels, Stainless Steel, Aluminum alloys, Copper alloys, Nickel and Titanium alloys – Corrosion of Polymers, Ceramics and Composite materials. 6 Hours

Unit-4
SURFACE ENGINEERING METHODS Electroless plating and Anodizing - Cathodic protection, metallic, organic and inorganic coatings, corrosion inhibitors, surface preparation, Coating Characterization. 6 Hours
Unit-5
SPECIAL SURFACING PROCESSES - CVD and PVD processes, sputter coating. Laser and ion implantation. Arc spray. Plasma spray. Flame spray. HVOF. 5 Hours

TEXT BOOKS:

REFERENCE BOOKS:

E-BOOKS:

MOOCS
1. http://nptel.ac.in/courses/112105053/

Course Out comes

| CO1 | Describe corrosion mechanisms and classify corrosion forms |
| CO2 | Analyze different applications of corrosion in industries |
| CO3 | Categorize various corrosion tests and testing standards |
| CO4 | Select different corrosive materials in order to increase the corrosion resistance |
| CO5 | Illustrate organic and inorganic surface coating methods |
| CO6 | Describe special coating techniques |

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.
Course Content:
Unit-1
**Distortion** - methods to avoid distortion. Stresses in Joint Design.
**Welding and Cladding of dissimilar materials**, overlaying and surfacing.
**Advanced welding techniques**: TIG and MIG welding, Electro Slag, Welding Electron Beam Welding, Plasma arc Welding, Laser Beam Welding, Explosion Welding, Diffusion Welding, Ultrasonic Welding, Friction welding, friction stir welding, linear friction welding, thermit welding and underwater welding. 11 Hours

Unit-2
**Inspection of Welds**: Destructive techniques like Tensile, Bend, Nick break, Impact & Hardness. Non-Destructive techniques like 'X' rays, Ultrasonic, Magnetic particle, Dye Penetrant, Gamma ray inspection. 6 Hours

Unit-3
**Welding Symbols** - Need for symbols representing the welds, Basic weld symbols, Location of Weld, Supplementary symbols, Dimensions of welds, Examples
**Welding Design** - Introduction, Principles of sound welding design, Welding joint design. Welding positions, Allowable strengths of welds - static/steady loads and dynamic loads, Design welds subjected to combined loads, Weld throat thickness, Problems
**Quality Control in Welding** - Introduction, Quality assurance v/s Quality control, Weld quality, Discontinuities in welds, their causes and remedies and Quality conflicts. 11 Hours

Unit-4
**Computer-Aided Welding Design** – Design in broad sense, narrow sense, Welding analysis, Engineering design and welding design, Perspectives in welding design, Solution to welding design problems, Computer aided welding analysis, Computer aided welding design and at least two case stud 5 Hours
Unit-5

**Welding of composites** - Special challenges posed to joining by composites, mechanic joining versus adhesive bonding of composites, Joining of Polymer Matrix composites, Joining of Metal Matrix Composites, Joining of Dissimilar material combinations – The need and challenges of joining dissimilar materials, Logical and Illogical combinations of material

6 Hours

**REFERENCE BOOKS:**

3. *Welding Technology* - O.P. Khanna
4. *Welding for Engineers* - Udin, Funk & Wulf

**E-BOOKS:**


**MOOCS:**

1. http://nptel.ac.in/courses/112107090/
2. http://nptel.ac.in/courses/112107089/

**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Classify various welding processes according to their importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Evaluate best method of inspection of welds</td>
</tr>
<tr>
<td>CO3</td>
<td>Identify weld symbols and their need</td>
</tr>
<tr>
<td>CO4</td>
<td>Design weld joints and consider theories of design</td>
</tr>
<tr>
<td>CO5</td>
<td>Model a weld design using computer application</td>
</tr>
<tr>
<td>CO6</td>
<td>Elaborate welding of composites based on its applications</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Answer five full questions selecting one from each unit. To set one question each from units 2, 4 and 5 and two questions each from units 1 and 3.
ADDITIVE MANUFACTURING TECHNOLOGY

<table>
<thead>
<tr>
<th>Subject Code</th>
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<td>Total no. of Lecture Hours.</td>
<td>39</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

Course Content:

Unit-1

Introduction: Definition of Prototype, Types of prototype, Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry, classification of RP systems.


Unit-2


Unit-3


Unit-4

Rapid Tooling: Indirect Rapid tooling -Silicon rubber tooling — Aluminum filled epoxy tooling Spray metal tooling, Cast kirksite, 3D keltool, etc >Direct Rapid Tooling — Direct, AIM, Quick cast process, Copper polyamide, Rapid Tool, DMILS, ProMetal, Sand casting tooling, Laminate tooling soft Tooling vs. hard tooling.

Unit-5

Software For RP: Stl files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools,

Allied Processes: vacuum, casting, surface digitizing, surface generation from point cloud, surface modification — data transfer to solid models. 11 Hours

TEXT BOOKS:

REFERENCE BOOKS:

MOOCS:
1. https://www.coursera.org/specializations/3d-printing

Course Out comes

| CO1 | Classify Rapid prototyping systems and survey current trends in Additive Manufacturing |
| CO2 | Illustrate selective laser sintering and identify influence of process parameters |
| CO3 | Identify different printers used to make component Choose best rapid tooling method |
| CO4 | Develop a model using software tools |
| CO5 | Identify the process parameters and optimize it to produce qualitative components |
| CO6 | Classify aligned processes identify merits and demerits |

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 2, 3 and 4 and two questions each from units 1 and 5.
Computer Control of Manufacturing Systems

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPECC</th>
<th>CIE Marks</th>
<th>SEE Marks</th>
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<tbody>
<tr>
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<td>3-0-0-0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total no. of Lecture Hours</td>
<td>39</td>
<td></td>
<td>Exam Hours</td>
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</tr>
</tbody>
</table>

Course Content:

Unit-1

Introduction: Basic concepts in Manufacturing Systems, Fundamentals of numerical control, advantages limitations of N.C systems-classification of N.C systems, design consideration of N.C machine tools — increasing productivity with N.C machines, Machining center and tooling for CNC machines. System devices: Drives, feedback devices, counting devices digital to analog converters. **11 Hours**

Unit-2

Interpolators for manufacturing systems: DDA Integrator, DDA Hardware Interpolator, CNC software Interpolators, Reference word CNC interpolators, the concept of reference word interpolators. Tustin Method

Control Loops of CNC Systems: Introduction, Control of Point-to-point Systems, Control loops in Contouring Systems, Mathematical Analysis, operation of a two axis system. **11 Hours**

Unit-3

Computerized numerical control: CNC Concepts, Advantages, The Digital Computer, Reference Pulse Technique, Sampled-Data Technique, Design Principles, Optimization for Circular Motion, summary of design considerations, micro computers in CNC. **5 Hours**

Unit-4


Unit-5

CNC part programming: Introduction, manual part programming computer aided programming, Post processors, APT programming, Examples. **7 Hours**
Text Books:

Reference Books:

Reference Books

MOOCS:
1. [http://nptel.ac.in/courses/112102103/](http://nptel.ac.in/courses/112102103/)
2. [http://nptel.ac.in/courses/112102101/](http://nptel.ac.in/courses/112102101/)

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Illustrate NC and CNC machining centers and categorize the interpolators used in manufacturing systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyze control loops used in CNC systems</td>
</tr>
<tr>
<td>CO3</td>
<td>Describe CNC system devises</td>
</tr>
<tr>
<td>CO4</td>
<td>Compose Part programing using Manual and APT</td>
</tr>
<tr>
<td>CO5</td>
<td>Describe design principles and optimize controller motion</td>
</tr>
<tr>
<td>CO6</td>
<td>Explain adaptive control systems and estimate cost</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.
Lab Experiments:

- Specimen preparation and microstructure studies using Optical Microscope and Scanning electron Microscope
- Material analysis using XRD
- Testing of composites, Nanocomposites, Wear analysis, Porosity studies
- Abrasive waterjet Cutting
- Wire EDM

Course Out comes

<table>
<thead>
<tr>
<th>CO</th>
<th>Synthesize and test composites &amp; Nano composites with respect to wear and porosity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyze and characterize elements and compounds of materials</td>
</tr>
<tr>
<td>CO3</td>
<td>Estimate Process capabilities for different materials using abrasive water jet and wire EDM</td>
</tr>
</tbody>
</table>
RESEARCH METHODOLOGY

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16APRDICRM</th>
<th>CIE Marks</th>
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</thead>
<tbody>
<tr>
<td>L-T-P-S</td>
<td>2-0-0-0</td>
<td>SEE Marks</td>
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<tr>
<td>Total no. of practical classes</td>
<td>26</td>
<td>Exam Hours</td>
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</table>

COMPULSORY TO ALL BRANCHES

Module 1:
Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

Module 2:
Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monograph, patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

Module 3:

Module 4:
Aim of this part of the course: is to strengthen students minds towards high quality research through publications, patents and also to learn research ethics.
Publications (8-9 hours)
Research concepts (2 hour) Research importance on economy, Research in India and abroad, Importance of publications, Why, where, when to publish?
Publication ethics (2 hour), Plagiarism (how to use turn it in effectively), International ethics on research, What and what not to publish, Ethical guidelines, Case studies
Quality vs quantity (2 hour) Searching literature with high quality, Impact factor, Citations (google scholar vs web of science), H-index, Case studies
How to write paper (2 hour), In High quality journals, Conference Articles, Poster preparation, PhD thesis, Inclusion of References

Journal reviewing process (1 hour), Selection of the good journal, Knowledge bout journal template, Refereeing process, Research topic selection, Research today and tomorrow, Lab scale to Industry, Traditional research to Technology based research

**Module 5: Self study**

Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis

**REFERENCES:**

II SEMESTER
SYLLABUS
Use of Tool Design Data Handbook is permitted in the examination

Course Content:

Unit-1

INTRODUCTION: Tool design procedure, drafting practice and drawing layout, abbreviations and shortcuts in tool drawings, tools of the tool maker, EDM application in tool manufacturing, tooling materials, factors affecting heat treatment 06 Hours

Unit-2

DESIGN OF SINGLE POINT CUTTING TOOLS: Force and power requirement in turning, Drilling and Milling. Types of single point tools, design of shank dimensions based on strength and rigidity, numerical problems on shank dimensions, tool signature (ASA), selection of tool geometry, influence of tool geometry on tool life, inserts and chip breakers.

DESIGN OF DRILL: Force and power requirement in drilling, Types of drills, tool angles, design of twist drill, numerical problems on design of twist drill, influence of tool geometry on tool life.

DESIGN OF MILLING CUTTER: Force and power requirement in milling, Types of milling cutters, tool angles, design of plain milling cutter, numerical problems on design of plain milling cutter, influence of tool geometry on tool life.

DESIGN OF TOOLS FOR INSPECTION AND GAUGING: Introduction, work piece quality criteria, principles of gauging, types of gages and their applications, amplification and magnification of error, gage tolerances, selection of material for gages, indicating gages, automatic gages, gauging positionally tolerance parts, problems. 14 Hours

Unit-3

JIGS AND FIXTURES: Differences between jigs and fixtures, Design principles, Economic analysis, Principles of location: 3-2-1 and 4-1-1 types of location, types of locators, redundant location, Clamping: clamping principles, types of clamps - mechanical, hydraulic, vacuum and magnetic.

DRILL JIGS: Drill bushes, Template, plate, channel, diameter, leaf, box, pot, angular, turnover, indexing jigs.

FIXTURES: Turning and milling fixtures, Indexing type of fixtures. 8 Hours

Unit-4
PRESS TOOLS: Sheet metal operations, Classification, components of simple die, drive mechanisms, die accessories, press features, press working dies- simple, progressive, compound, and combination, punch and die clearances, shear action. 8 Hours

Unit-5
PRESS TOOLS DESIGN: Center of pressure. Scrap strip layout, Computation of capacities/tonnage requirements, Design of blanking die and progressive die
Bending- bend allowance, spring back, edge bending die design
Drawing- Single, double and triple action dies, factors affecting drawing, drawing die design, forming limit criteria, deep drawing & redrawing methods, defects in formed parts 16 Hours

Self study topics:
A. Drawing of single point tool, drill bit and milling cutter as per the design
B. Drawing of one type jig and fixture as per the design
C. Drawing of cutting die as per the design
D. Drawing of bending die as per the design
E. Drawing of drawing die as per the design

TEXT BOOKS:

REFERENCE BOOKS:
1. **Metal cutting theory and Tool Design** - Arshinav MIR Publications
2. **Press Tools Design and Construction** - P. H. Joshi, S. Chand Publisher, 2010

MOOCS:
[http://nptel.ac.in/courses/112105126/35](http://nptel.ac.in/courses/112105126/35)
**Course Outcomes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Analyze cutting forces in turning, milling and drilling, describe tool angles</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Design drill bit and milling cutter and select tool signature based on work material.</td>
</tr>
<tr>
<td>CO3</td>
<td>Choose inspection tools and describe materials for gauges</td>
</tr>
<tr>
<td>CO4</td>
<td>Design and draw jigs and fixtures based on work part geometry</td>
</tr>
<tr>
<td>CO5</td>
<td>Analyze press tool operations</td>
</tr>
<tr>
<td>CO6</td>
<td>Design and draw press tools based on operations</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Answer five full questions selecting one from each unit. To set one question each from units 1, 3 and 4 and two questions each from units 2 and 5.
INDUSTRIAL ROBOTICS

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPCIR</th>
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<td>4-0-0-0</td>
<td>SEE Marks</td>
<td>50</td>
</tr>
<tr>
<td>Total no. of Lecture Hours.</td>
<td>52</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

Course Content:

Unit-1

**FUNDAMENTAL CONCEPTS OF ROBOTICS:** Historical evolution of robotics, Automation and robotics, Definition of robots, Laws of robots, Robot anatomy, Basic features of the manipulator and manipulator arm configurations, Specification of Robots, Resolution, Repeatability and Accuracy of a Manipulator, Economic and Social aspects of robotics.  **08 Hours**

Unit-2

**ROBOT POWER SYSTEMS AND END EFFECTORS:**

Types of Robot drives – Basic components of Pneumatic, hydraulic and electrical drive systems. Pneumatic and hydraulic actuators, AC, DC and stepper motors. Mechanical transmission methods – Rotary-to-Rotary motion conversion. Rotary-to-linear motion conversion

End effectors – types- Mechanical - Slider crank mechanism, Screw type, Rotary actuators, cam type, Magnetic -Vacuum – Adhesive, gripping problems, Remote-Cantered compliance devices.  **08 Hours**

**SENSORY DEVICES:** Non optical and optical position sensors - Velocity and Acceleration sensors, Range sensors, Proximity sensors, touch sensor, Slip sensor, Force –Torque sensor.

Robot vision - Functions, sensing and digitizing-imaging, devices, lighting techniques, analogue to digital signal conversion, image storage, image processing and analysis-image data reduction, segmentation, feature, extraction, object recognition. AI and Robotics.  **08 Hours**

Unit-3

**ROBOT ARM KINEMATIC ANALYSIS AND COORDINATE TRANSFORMATIONS:** Direct coordinate problems, Rotation Matrices, Composite Rotation matrices, Rotation matrices with Euler angle representation- Homogeneous coordinates and transformations, Composite homogeneous transformations , Links Joints and their parameters, The DH representation and applications, Geometry based Direct Kinematic analysis, Inverse kinematic solution.  **10 Hours**
Unit-4

**TRAJECTORY PLANNING AND GENERATION:** Introduction, Joint space schemes (Example-A cubic Trajectory), Joint space schemes with via points (Example-A cubic Trajectory with via points). Cartesian space schemes, Straight line and circular motion.

**ROBOT PROGRAMMING AND LANGUAGES:** Manual teaching, lead through teaching, Programming Languages, Programing with graphics, Storing and operating task programs.

08 Hours

Unit-5

**APPLICATIONS OF ROBOTS:** Present and future of robotics – Material handling – Manufacturing Processes – Welding, Machining, Assembly and Inspection, CIM and hostile environments - safety considerations.

**Robot cell design:** Robot cell layouts-robot cantered cell, inline robot cell, mobile robot cell

06 Hours


04 Hours

**TEXT BOOKS:**


**REFERENCE BOOKS:**


4 **Robot Technology Fundaments”**- Keramas, Thomson Vikas Publication House.

5 **Company Fundamentals of Robotics Analysis and Control”** -Schilling, PHI.

6 **Introduction to Robotics”**-Niku, Pearson Education, Asia.


MOOCs:
https://www.edx.org/course.robot-mechanics-control-part-i-snux-snu446-345-1x
https://www.edx.org/course.robot-mechanics-control-part-ii-snux-snu446-345-2x

Course Outcomes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Analyze the manipulator design including actuator, drive and sensor issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Illustrate kinematics of robots. Calculate the forward kinematics, inverse kinematics</td>
</tr>
<tr>
<td>CO3</td>
<td>Identify different types of end effectors and sensors required for specific applications</td>
</tr>
<tr>
<td>CO4</td>
<td>Develop programming principles and languages for a robot control system</td>
</tr>
<tr>
<td>CO5</td>
<td>Discuss various applications of industrial robot systems</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe Micro and Nano robotics</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
Course Content:

Unit - 1

**Fundamental concepts:** Principles of Elasticity: stresses-principal, maximum shear and Vonmises stresses, Equilibrium equations, strain displacement relationships in matrix form – Constitutive relationships for plane stress, plane strain, Axi-symmetric and 3D. Boundary conditions.
Potential energy and equilibrium, Rayleigh-Ritz method and Galerkin method-applied to simple problems on axially loaded members, cantilever, simply supported beams, with point loads and distributed loads.
Introduction to FEM, basic concept, historical background, general applicability, engineering applications, general description, comparison with other methods of analysis, commercial packages-preprocessor, solver and post processor.

09 Hours

Unit - 2

**Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis –**
Bars- Introduction; Finite Element Modeling – Element Division; Numbering Scheme; Coordinate and Shape Functions; The Potential Energy Approach; Assembly of Global Stiffness Matrix and Load Vector; Treatment of Boundary Conditions; Temperature Effects; Numericals.
Truss-Local and Global co-ordinate systems, Trusses – assumptions, formulation of Truss element, Numericals
Beam- Hermite functions, formulation of beam. Numericals

14 Hours

Unit - 3

**Two Dimensional Finite Element Formulations for Solid Mechanics Problems:**
Formulation of triangular and quadrilateral elements. Formulation of axis symmetric triangular elements. Numericals
Convergence criteria-requirements of convergence of a displacement model, Displacement models and shape functions for Higher order elements in triangular, quadrilateral elements.
Lagrangian and serendipity elements. Iso parametric, sub parametric and super parametric elements.  

14 Hours

Unit - 4

Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of 4 noded Tetrahedral Element, 8 noded Hexahedral Element, Shape functions for Higher order elements.  

7 Hours

Unit - 5


8 Hours

Simulation (Lab) Exercises:
1. Linear and Non Linear Analysis of Bars and Beams
2. Stress analysis in Curved beam in 2D, rectangular plate with circular hole under Uniform Tension
3. Simulation of bending pipe process
4. Analysis of Welded Joints: FE Modeling and Failure Analysis
5. Melting Using Element Death
6. Metal Forming analysis. Solving metal rolling problem  

26 hours

TEXT BOOKS:

REFERENCE BOOKS:

E-Books / Web References
http://nptel.ac.in/courses/112104115/
MOOCs

1. Finite Element Method (FEM) Analysis and Applications
   https://www.edx.org/course/finite-element-method-fem-analysis-tsinghua-x-70120073x

2. A Hands-on Introduction to Engineering Simulations
   https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x


5. https://online-learning.tudelft.nl/courses/linear-modeling-fem/

Course Out comes

At the end of Course, Student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>APPLY basics of Theory of Elasticity to continuum problems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>FORMULATE finite elements like bar, truss and beam elements for linear static structural analysis.</td>
</tr>
<tr>
<td>CO3</td>
<td>DEVELOP models for 2D and axisymmetric finite elements</td>
</tr>
<tr>
<td>CO4</td>
<td>SOLVE problems of limited complexity in structural domain</td>
</tr>
<tr>
<td>CO5</td>
<td>UTILIZE finite element software to simulate practical problems</td>
</tr>
<tr>
<td>CO6</td>
<td>IDENTIFY issues related to Finite Element in Manufacturing Processes</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit 1, 4, 5 and Two questions each from units 2 & 3.
ADVANCED MANUFACTURING PROCESSES

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPEAM</th>
<th>CIE Marks</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-T-P-S</td>
<td>3-0-0-0</td>
<td>SEE Marks</td>
<td>50</td>
</tr>
<tr>
<td>Total no. of Lecture Hours.</td>
<td>39</td>
<td>Exam Hours</td>
<td>03</td>
</tr>
</tbody>
</table>

Course Content:

Unit-1
Injection moulding

Elements of plastic moulding tools – injection moulds (initial considerations) – shot capacity, number of cycles per minute, clamping force, number of impressions, position of gate, type of gate runners, parting surface, ejection system, core, cavity, cooling methods. Mould shrinkage, taper and tolerences, types of injection moulding tools – 2 plate and 3 plate moulding tools.

**Tool construction:** Side cores, methods of actuating side cores, split moulds, methods of actuating, split moulds, moulds of threaded components. Internal under-cuts, external under-cuts, moulds with under-feed system. Ejection methods - pin, sleeve, and stripper – plate ejection, blade ejection, air ejector, double ejection, delayed action ejection etc.

Multi – colour moulding tools. Defects in moulded components and their remedies. **11 Hours**

Unit-2
Thermo set:

Compression moulding tool, transfer moulding tool, Design principles of compression and transfer moulding tools.

**Plastic processing techniques:** Extrusion, blow moulding, forming, calendaring etc. **6 Hours**

Unit-3
Powder Metallurgy Processes

Introduction to powder metallurgy, Benefits of Powder Metallurgy, Limitations and Applications, Production of Powders, Powder Treatment, Powder Characteristics, Compaction of powders, High temperature compaction, Pre Sintering and Post Sintering operations, sintering

**Ceramic Materials Processing:** Processing of ceramics, Forming – Pressing, dry-pressing, isostatic pressing, hot pressing, slip casting, extrusion, thermal treatment, vitrification, properties and applications.

**Mechanical Alloaying:** Introduction, Process, Milling parameters, Process Control Agents, Process Variables, Mechanism of Alloaying, Powder Contamination, Consolidation, Types of Mills, Oxide dispersion strengthened alloys, Reactive milling, Applications. **11 Hours**
Unit-4

**Metal Injection Moulding (MIM) and Self Propagating high temperature synthesis (SHS) Processes**

Metal Injection Moulding: Introduction, Steps in MIM, Advantages, Requirements, Materials Processed by MIM, Self Propagating high temperature synthesis: Introduction, Advantages, Process, Parameters to be considered, Types of products and Applications

6 Hours

Unit-5

**High Velocity Forming Process**

Introduction - comparison of conventional and high velocity forming methods - Types of high velocity forming methods - explosion forming process-electro hydraulic forming magnetic pulse.

5 Hours

**TEXT BOOKS:**

1. Dominic v. Rosato, Injection molding handbook, CBS publishers

**REFERENCE BOOKS:**

2. Suryanarayana, Mechanical Alloying an Introduction.

**MOOCS:**


**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Compute shot capacity and clamping force and Describe parts of the die</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Differentiate types of plastic and plastic and plastic processing techniques</td>
</tr>
<tr>
<td>CO3</td>
<td>Illustrate powder metallurgy processes for ceramic materials</td>
</tr>
<tr>
<td>CO4</td>
<td>Describe mechanical alloying methods variables and mechanisms</td>
</tr>
<tr>
<td>CO5</td>
<td>Synthesize metal components using metal injection molding</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe high velocity forming processes</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**

Answer five full questions selecting one from each unit. To set one question each from units 2, 4 and 5 and two questions each from units 1 and 3.
Course Content:

Unit-1

**INTRODUCTION**- History, need, classification, comparison between conventional and non-conventional machining process and selection.

**ULTRASONIC MACHINING (USM)** - Introduction, equipment details, cutting tool system design, mechanism of metal removal, effect of parameters, USM process characteristics, applications, advantages & disadvantages of USM, Modeling of USM.

**ABRASIVE JET MACHINING (AJM)** - Introduction, equipment details, variables in AJM, nozzle design, shape of cut, mechanism of metal removal, process characteristics, applications, advantages & disadvantages of AJM, Modeling of AJM

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Unit-2

**ABRASIVE WATER JET MACHINING (AWJM)**- Principal, equipment, operation, mechanism of metal removal, application, advantages and limitations, Modeling of AWJM.

**ABRASIVE FLOW MACHINING (AFM)**- Equipment, working principle, process variables, applications

**MAGNETIC ABRASIVE FINISHING (MAF)**- Equipment, working principle, process variables, applications

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Unit-3

**ELECTROCHEMICAL MACHINING (ECM)**- Introduction, study of ECM machine, elements of ECM process, mechanism of metal removal, process characteristics, ECM Tooling: ECM tooling technique & example, Tool & insulation materials, Tool size Electrolyte flow arrangement, handling of slug, economics of ECM, Applications such as Electrochemical Grinding, Electrochemical Honing, Electrochemical deburring, advantages, limitations and applications. Modeling of ECM.

**CHEMICAL MACHINING (CHM)**- Introduction, elements of process, mechanism of metal removal, chemical blanking process: Preparation of work piece, preparation of masters, masking with photo resists, etching for blanking, accuracy of chemical blanking, applications of chemical blanking, chemical milling (contour machining), Process steps –
masking, Etching, process characteristics of CHM, hydrogen embrittlement, advantages, imitations & application of CHM. Modeling of CHM.  

11 Hours  

Unit-4  

ELECTRICAL DISCHARGE MACHINING (EDM) - Introduction, mechanism of metal removal, dielectric fluid, spark generator, EDM tools (electrodes) Electrode feed control, Electrode manufacture, Electrode wear, EDM tool design, choice of machining operation, electrode material selection, under sizing and length of electrode, machining time. Flushing; pressure flushing, suction flushing, side flushing, pulsed flushing, synchronized with electrode movement, EDM process characteristics, machine tool selection, advantages, imitations & application of EDM, EDM accessories / applications, electrical discharge grinding, models for material removal rates (MRR), Traveling wire EDM. Modeling of EDM.  

6 Hours  

Unit-5  

PLASMA ARC MACHINING: Introduction, transferred and non-transferred arc, equipment, mechanism of metal removal, process parameters, process characteristics, plasma gas selection, advantages, imitations & applications.  

LASER BEAM MACHINING: Introduction, equipment, mechanism of metal removal, process short pulse laser machining, lazing medium, parameters, process characteristics, advantages, imitations & applications.  

ELECTRON BEAM MACHINING: Introduction, equipment, mechanism of metal removal, process parameters, process characteristics, advantages, imitations & applications  

ION BEAM MACHINING: Introduction, equipment, focused ion beam machining, mechanism of metal removal, process parameters, process characteristics, advantages, imitations & applications  

HYBRID MACHINING: Chemical and Mechanical processing, micro-machining with chemical etching, ultrasonic assisted turning, laser assisted turning, unconventional micro machining  

11 Hours  

Text Books:  

1. Advanced machining process - Vijay K. Jain, Allied Publishers PVT. Limited  

REFERENCE BOOKS:  

1. Production Technology - HMT - Tata Mc Graw Hill
2. **Modern Machining Process** - P.C Pandy & H.S. Shan - Tata McGraw Hill

**E-BOOKS:**

**MOOCS:**
1. [http://nptel.ac.in/courses/112105126/36](http://nptel.ac.in/courses/112105126/36)

**Course Outcomes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Examine machining techniques and highlight the importance of NTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Demonstration of abrasive water jet machining and explain mechanical methods and model for Material Removal Rate</td>
</tr>
<tr>
<td>CO3</td>
<td>Illustrate mechanism of material removal in chemical and electro chemical machining and describe the process parameters and tools and model for Material Removal Rate</td>
</tr>
<tr>
<td>CO4</td>
<td>Demonstration of wire cut EDM and describe process parameters and tools and model for Material Removal Rate</td>
</tr>
<tr>
<td>CO5</td>
<td>Outline material removal mechanisms of evaporation processes and model for Material Removal Rate</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe advanced techniques such as micro machining and hybrid machines</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**
Answer five full questions selecting one from each unit. To set one question each from units 1, 2 and 4 and two questions each from units 3 and 5.
AUTOMATION IN MANUFACTURING

<table>
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<th>Subject Code</th>
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<td>Total no. of Lecture Hours.</td>
<td>39</td>
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<td>03</td>
</tr>
</tbody>
</table>

Course Content:

Unit-1
Production Development through CIM:

6 Hours

Unit-2
Computer Integrated Manufacturing and Automation:

6 Hours

Unit-3
Analysis of Automated flow lines:
Analysis of transfer lines without storage, with storage buffer, single stage, Double stage, Multistage with problems, Automated assembly systems, Design for automated assembly, parts feeding devices, analysis of Multi station assembly machine, Analysis of Single stage assembly machine, Numericals.

Computer Process Monitoring: Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control.  

11 Hours

Unit-4
Fundamentals of Networking:
Principles, techniques, networking methods, network standards, Ethernet, Internet, system security, remote systems, NFS, ATM, EWN, document and work flow management. Automated Material Handling and Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.
Unit-5

**Computer Aided Quality Control:** The computer in Q.C, automated inspection principles and methods, Contact inspection methods, non-contact inspection methods, machine vision system, optical inspection method, sensors, coordinate measuring machine, Computer Aided testing, Integration of CAQC with CAD/CAM.

**TEXT BOOKS:**
1. CAD/CAM – Zimmers & Grover, PHI.
2. CAD/CAM/CIM – P. Radhakrishna, New Age International.

**REFERENCE BOOKS:**
1. CAD/CAM – Zeid, Mc-Graw Hill
2. CAD/Cam, P. N. Rao.

**E-BOOKS:**
1. [http://nptel.ac.in/downloads/112103174/](http://nptel.ac.in/downloads/112103174/)
2. [http://nptel.ac.in/courses/112102011/](http://nptel.ac.in/courses/112102011/)

**MOOCS:**
1. [http://nptel.ac.in/courses/108105062/](http://nptel.ac.in/courses/108105062/)

**Course Out comes**

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Describe production cycle</td>
</tr>
<tr>
<td>CO2</td>
<td>Identify flow lines in automation and solve real world problems</td>
</tr>
<tr>
<td>CO3</td>
<td>Analyze automated flow lines</td>
</tr>
<tr>
<td>CO4</td>
<td>Describe Networking principles and models</td>
</tr>
<tr>
<td>CO5</td>
<td>Categorize inspection methods and illustrate modern inspection methods</td>
</tr>
<tr>
<td>CO6</td>
<td>Schedule the material flow in the shop floor</td>
</tr>
</tbody>
</table>

**Scheme of Examination:**
Answer five full questions selecting one from each unit. To set one question each from units 1, 2 and 5 and two questions each from units 3 and 4.
Course Content:

Unit-1  
**Introduction:** An approach to industrial design - elements of design structure for industrial design in engineering application in modern manufacturing systems.  
**Ergonomics and Industrial Design:** Introduction - general approach to the man-machine relationship-workstation design-working position.  

06 Hours

Unit-2  
**Control and Displays:** shapes and sizes of various controls and displays-multiple displays and control situations - design of major controls in automobiles, machine tools etc., - design of furniture design of instruments.  
**Ergonomics and Production:** Ergonomics and product design ergonomics in automated systems-expert systems for ergonomic design, Anthropomorphic data and its applications in ergonomic design limitations of anthropomorphic data - use of computerized database.  

11 Hours

Unit-3  
**Visual Effects of Line and Form:** The mechanics of seeing psychology of seeing, general influences of lined and form.  
**Colour:** colour and light - colour and objects - colour and the eye colour consistency - colour terms - reactions to colour and colour continuation - colour on engineering equipments.  

11 Hours

Unit-4  
**Aesthetic Concepts:** Concept of unity - concept of order with variety - concept of purpose style and environment - Aesthetic expressions. Style-components of style - house style, observations style in capital goods.  

06 Hours

Unit-5  
**Industrial Design in Practice:** General design - specifying design equipments - rating the importance of industrial design – industrial design in the design process.  

05 Hours
TEXT BOOKS:

E-BOOKS:
1. [http://textofvideo.nptel.iitm.ac.in/107103004/lec40.pdf](http://textofvideo.nptel.iitm.ac.in/107103004/lec40.pdf)

MOOCS:
1. [http://nptel.ac.in/courses/107103004/](http://nptel.ac.in/courses/107103004/)

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Illustrate general approaches to the man- machine relationship and design of work station</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyze various control and displays in various industries</td>
</tr>
<tr>
<td>CO3</td>
<td>Design and develop an effective expert systems for ergonomic design</td>
</tr>
<tr>
<td>CO4</td>
<td>Identify visual effects of line and form and analyze mechanics of seeing psychology</td>
</tr>
<tr>
<td>CO5</td>
<td>Identify colour, light and colour codes of engineering equipment</td>
</tr>
<tr>
<td>CO6</td>
<td>Design an industrial equipment in perspective of ergonomics</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
Course Content:

Unit-1
Ferrous Materials: Fe-C phase diagram, steel, low carbon steel, dual phase steels, mild steels, micro-alloyed steels, weathering steels, free cutting steels, medium carbon steels, high strength structural steels, ausformed steels, martensitic stainless steels, austenitic stainless steels, properties and applications.

Tool Materials – Classification, properties, heat treatment of high speed steel, medium duty tools, tools for cold and hot forming, tools for high speed cutting.

Cast Iron, Gray C I, White C I, Malleable C I, Nodular C I or Ductile Iron, Vermicular Graphite Iron, properties and applications

11 Hours

Unit-2
Polymeric Materials: Thermoplastics, thermosetting plastics, industrial polymerization methods, processing of plastic materials, processes used for thermoplastic materials, injection molding, extrusion, blow molding and thermo-forming, properties and applications.

Processes used for thermosetting materials – Compression molding, transfer molding, injection molding, elastomers, material preparation

Ceramic Materials: Processing of ceramics, Forming – Pressing, dry-pressing, isostatic pressing, hot pressing, slip casting, extrusion, thermal treatment, verification, properties and applications.

Engineering Ceramics – Alumina, silicon nitride, silicon carbide

11 hours

Unit-3
Super alloys: Ni, Fe and Co based super alloys, properties and applications.


Magnetic Materials: Magnetic fields, types of magnetism, soft magnetic materials, hard magnetic materials, properties and applications.

6 Hours

Unit-4
Semi-conducting Materials: Intrinsic and extrinsic semiconduction, The Hall effect, semiconductor devices, properties and applications.
Superconducting Materials: Meissner effect, current flow and magnetic fields in superconductors, high critical temperature superconducting oxides  

Unit-5

Text Book:

References:

E-BOOKS:
1. http://nptel.ac.in/courses/113108051/
2. http://nptel.ac.in/courses/112104122/

Course Out comes

| CO1 | Describe different types of steels with properties and applications |
| CO2 | Describe polymeric materials and explain the several processing methods |
| CO3 | Categorize ceramic materials and illustrate processing methods |
| CO4 | Identify importance of advanced materials in engineering components |
| CO5 | Describe semi and super conducting materials with properties and applications |
| CO6 | Outline Nano materials with applications |

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.
Course Content:

Unit-1
**Introduction to ND Testing:** Selection of ND methods, visual inspection (Boroscopes, Image sensors, Magnifying Systems) leak testing: Method of leak testing systems at pressure or at vacuum, liquid penetration inspection, its advantages and limitation.

**Magnetic Particle Inspection:** Methods of generating magnetic field, types of magnetic particles and suspension liquids steps in inspection – application and limitations.  

11 Hours

Unit-2
**Ultrasonic inspection:** Basic equipment, advantages and disadvantages, applicability, characteristics of ultrasonic waves, variables inspection, attenuation of ultrasonic beams, inspection methods:- pulse echo, A,B,C scans transmission.

Transducer elements couplets, search units, contact types and immersion types, inspection standards-standard reference blocks, Indian standards for NDT.  

11 Hours

Unit-3
**Eddy Current Inspection:** principles, operation variables, procedure, inspection coils, and detectable discounts by the method.  

5 Hours

Unit-4
**Radiography Inspection:** principles, radiation source X-rays and gamma rays, X-ray-tube, radio graphic films, neutron radiography, Thermal inspection principles, equipment inspection methods applications.  

6 Hours

Unit-5
**Optical Holography:** Basics of Holography, recording and reconstruction - Acoustical Holography: systems & techniques applications. Microwave holography: Technique, applications and limitations.  

6 Hours

Text Books:

REFERENCE BOOKS:

E-BOOKS:

MOOCS:
1. https://onlinecourses.nptel.ac.in/noc16_mm07/preview
2. http://nptel.ac.in/courses/114106035/1

Course Outcomes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Categorize the Basic principles, techniques, equipment, applications and limitations of NDT methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Select appropriate NDT method for various Engineering applications</td>
</tr>
<tr>
<td>CO3</td>
<td>apply correct NDT technique for various components</td>
</tr>
<tr>
<td>CO4</td>
<td>interpret various casting, welding and other manufacturing defects</td>
</tr>
<tr>
<td>CO5</td>
<td>Identify the codes, specifications and standards in NDT</td>
</tr>
<tr>
<td>CO6</td>
<td>Describe the optical holography in engineering applications</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 3, 4 and 5 and two questions each from units 1 and 2.
MICRO ELECTRO - MECHANICAL SYSTEMS (MEMS)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPEMS</th>
<th>CIE Marks</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-T-P-S</td>
<td>3-0-0-0</td>
<td>SEE Marks</td>
<td>50</td>
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<tr>
<td>Total no. of Lecture Hours</td>
<td>39</td>
<td>Exam Hours</td>
<td>03</td>
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</tbody>
</table>

Course Content:

Unit-1
Introduction: Concepts of MEMS (Micro Electro mechanical system)- Principles, application and design.
Classification & Consideration: Mechanical systems, Fluidic systems; example & MEMS Architecture, Introduction to Micro-fabrication & Micromachining.
Devising & Synthesis: Micro Accelerometers as Micro Electro Mechanical Micro-devices  
11 Hours

Unit-2
Modeling of Micro Electro Mechanical System & Devices: Model developments of micro electromagnetic, mechanics and its application to MEMS.  
6 Hours

Unit-3
Controls of MEMS: Analog control of MEMS, Sliding mode control of MEMS, Digital control of MEMS.  
11 Hours

Unit-4
Materials for MEMS: Substrate and wafers, Active substrate material, silicon, Silicon compound, Silico pezoresisters, Gallium arsenide, Quartz, piezoelectric crystals, Polymers.  
5 Hours

Unit-5
Micro System Packaging: Over view of mechanical packaging of microelectronics micro system packaging, Interfaces in micro system packaging, Packaging technologies.  
6 Hours

TEXT BOOKS:
REFERENCE BOOKS:

E-BOOKS:
1. [http://textofvideo.nptel.iitm.ac.in/117105082/lec1.pdf](http://textofvideo.nptel.iitm.ac.in/117105082/lec1.pdf)

MOOCS:
1. [http://nptel.ac.in/courses/117105082/](http://nptel.ac.in/courses/117105082/)
2. [http://nptel.ac.in/courses/117105082/](http://nptel.ac.in/courses/117105082/)

Course Out comes

<table>
<thead>
<tr>
<th>CO1</th>
<th>Classify the concepts of MEMS based on its applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Apply the concepts of MEMS for different mechanical systems</td>
</tr>
<tr>
<td>CO3</td>
<td>Synthesize the designed MEMS for pre defined application</td>
</tr>
<tr>
<td>CO4</td>
<td>Modeling of MEMS to evaluate better performance</td>
</tr>
<tr>
<td>CO5</td>
<td>Identify control mechanisms of MEMS</td>
</tr>
<tr>
<td>CO6</td>
<td>Select a system packaging based on its performance</td>
</tr>
</tbody>
</table>

Scheme of Examination:
Answer five full questions selecting one from each unit. To set one question each from units 2, 4 and 5 and two questions each from units 1 and 3.
Course Content:

UNIT – 1

**Introduction to lasers:** Construction and working of lasers, Stimulated emission phenomenon, Types of industrial lasers: Co2 laser, Carbon monoxide laser, Solid state lasers, Diode lasers, Excimer laser.

**Laser material interaction:** Reflection, Scattering, Absorption, Transmission. Reflectivity of different metals, Reflectivity and absorptivity of semiconducting materials.  

6 Hours

UNIT – 2

**Laser cutting:** Methods of cutting: Vaporization cutting, Fusion cutting, Reactive fusion cutting, Controlled fracture, Scribing, Cold cutting. Process parameters in cutting: Beam properties, Transport properties, Gas properties, material properties. Advantages and disadvantages of laser cutting, Applications. simple problems  

11 Hours

UNIT – 3


**Laser drilling:** Mechanism of laser drilling, single pulse drilling, percussion drilling, trepanning. Operating parameters of laser drilling: Wave length, Continues wave or pulse, Pulse Energy, Pulse duration, Focal spot size. Advantages and limitations, applications.  

11 Hours

UNIT – 4


6 Hours
UNIT – 5

**Laser surface treatments:** Laser surface transformation hardening, process parameters. Laser re-solidification, Laser surface alloying and cladding, laser surface texturing, laser shock peering, surface cleaning.

**Laser safety:** types of laser hazards, Laser safety classification, Maximum permissible exposure limit, Laser safety practices

5 Hours

Text Books


Reference Books:


E-BOOKS:

1. [http://www.pblprojects.org/PhotoMachining/docs/Ron_Schaeffer_Course_Notes.pdf](http://www.pblprojects.org/PhotoMachining/docs/Ron_Schaeffer_Course_Notes.pdf)

Course Outcomes

Upon completion of this course, student will be able to:

<table>
<thead>
<tr>
<th>CO 1</th>
<th>Classify different types of lasers based on its beam properties and power</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO 2</td>
<td>Correlate laser interaction types with different materials</td>
</tr>
<tr>
<td>CO 3</td>
<td>Evaluate best methods of laser cutting of different martials</td>
</tr>
<tr>
<td>CO 4</td>
<td>Analyze process parameters of laser welding and laser drilling</td>
</tr>
<tr>
<td>CO 5</td>
<td>Identify how laser can be used in traditional machining</td>
</tr>
<tr>
<td>CO 6</td>
<td>Select various safety precautions during laser machining</td>
</tr>
</tbody>
</table>

Scheme of Examination:

Answer five full questions selecting one from each unit. To set one question each from units 1, 4 and 5 and two questions each from units 2 and 3.
CNC AND ROBOTICS Lab

<table>
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<th>Subject Code</th>
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<tr>
<td>Total no. of Lecture Hours.</td>
<td>13</td>
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<td>03</td>
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</table>

- Exercises in CNC turning and milling
- Exercises in Programming of Industrial Robot for Pick and place, Continuous path applications, Simulation and practical exercises.

**Course Out comes**

<table>
<thead>
<tr>
<th>CO1</th>
<th>Develop CNC programming for turning and milling</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Design and develop simulations of robot’s work</td>
</tr>
<tr>
<td>CO3</td>
<td>Create programs for simple operations of Robot</td>
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</table>
III SEMESTER
INTERNSHIP

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<thead>
<tr>
<th>Subject Code</th>
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<tr>
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<td>Exam Hours</td>
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</table>

Course objectives for Internship

<table>
<thead>
<tr>
<th>CO1</th>
<th>Understand the structure, culture and working of an industry and gain awareness of possible careers. (PO1, PO10, PO11)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Apply critical thinking in identification and solution of problems by integrating knowledge and skills. (PO2, PO3, PO4, PO5)</td>
</tr>
<tr>
<td>CO3</td>
<td>Identify and understand the application of various industrial practices and professional ethics. (PO10)</td>
</tr>
<tr>
<td>CO4</td>
<td>Perform efficiently in taking up assigned responsibilities. (PO7, PO9)</td>
</tr>
<tr>
<td>CO5</td>
<td>Communicate effectively and professionally with individuals and while working in groups. (PO6, PO7, PO8)</td>
</tr>
<tr>
<td>CO6</td>
<td>Prepare technical reports and make oral presentation (PO5, PO8)</td>
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</table>

PROJECT WORK (I PHASE)

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPCIP</th>
<th>CIE Marks</th>
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IV SEMESTER
PROJECT WORK (FINAL PHASE)

<table>
<thead>
<tr>
<th>Subject Code</th>
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<td>SEE Marks</td>
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<tr>
<td>Total no. of Lecture Hours.</td>
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<td>Exam Hours</td>
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</table>

**Course objectives for Project Work**

| CO1 | Apply relevant knowledge and skills acquired during the course in the domain to the problem on hand (PO1, PO2) |
| CO2 | Formulate the specifications of the project work, identify a set of feasible solutions and prepare and execute project plan considering professional, cultural and societal factors (PO3, PO7) |
| CO3 | Extract information pertinent to problem using literature survey (PO4) |
| CO4 | Analyze independently and discuss complex issues (PO2) |
| CO5 | Use appropriate techniques and tools to conduct experiments, analyze data (PO4, PO5) |
| CO6 | Evaluate and critically examine the outcomes of one’s own work and others’ work (PO11) |
| CO7 | Draw suitable conclusions based on the results and identify relevant applications (PO8, PO9) |
| CO8 | Document the findings and prepare a report in the prescribed format (PO8) |
| CO9 | Demonstrate working knowledge of ethics and professional responsibility at different stages such as formulation, design, implementation, and presentation (PO10) |
| CO10 | Publish the outcomes of the project work in a reputed journal, make effective presentation of the work and communicate confidently in defending the work (PO8) |

TECHNICAL SEMINAR

<table>
<thead>
<tr>
<th>Subject Code</th>
<th>16MEMSPCTS</th>
<th>CIE Marks</th>
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</thead>
<tbody>
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<td>L-T-P-S</td>
<td>0-0-2-0</td>
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</tr>
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<td>-</td>
<td>Exam Hours</td>
<td>-</td>
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</tbody>
</table>

**Course objectives for Technical Seminar**

| CO1 | Identify and understand current trends and real-world issues related to topics in Manufacturing. (PO1) |
| CO2 | Classify appropriate content and sources, through literature survey, that can be summarized and integrated into presentation (PO1, PO4, PO9) |
| CO3 | Review, analyses, and interpret data & results using critical thinking skills (PO2, PO4) |
| CO4 | Revise and present scientific case studies in presentation (PO3, PO10) |
| CO5 | Collaborate effectively with other students in analyzing results and preparing oral presentations (PO6, PO11) |
| CO6 | Prepare a technical seminar report and communicate effectively through oral presentation using multimedia tools (PO5, PO8) |