

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

PO No.	Program Outcomes (PO)
PO1	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.
PO2	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
PO3	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.
PO4	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.
PO5	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.
PO6	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.
PO7	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.
PO8	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.
PO9	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.
PO10	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.
PO11	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Scheme of Teaching for 2016-17

I Semester

CREDIT BASED

Sl.No	Subject Code	Course Title	Credits				CREDITS
			L	T	P	S	
1	16MEMSPCAM	Advanced Metal Cutting	3			1	4
2	16MEMSPCMC	Material Characterization	4				4
3	16MEMSPCPM	Plasticity and Metal Forming	4				4
4	16MEMSPCCM	Composite materials	3		1		4
5	16MEMSPEZZ	Elective -1	3				3
6	16MEMSPEZP	Elective - 2	3				3
7	16MEMSPCMM	Material characterization and Manufacturing Technology lab			1		1
8	16APRDICRM	Research Methodology	2				2
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	
16MEMSPENT	Nanotechnology
16MEMSPETQ	Total Quality management
16MEMSPECS	Corrosion and Surface Engineering

Course Elective - 2	
16MEMSPEAJ	Advanced Joining process
16MEMSPEAT	Additive Manufacturing Technology
16MEMSPECC	Computer control of Manufacturing systems

Scheme of Teaching for 2016-17

II Semester

CREDIT BASED

Sl.No	Subject Code	Course Title	Credits				CREDITS
			L	T	P	S	
1	16MEMSPCTD	Tool Engineering Design	4			1	5
2	16MEMSPCIR	Industrial Robotics	4				4
3	16MEMSPCFM	Finite Element Modeling	4		1		5
4	16MEMSPEZZ	Elective -3	3				3
5	16MEMSPEZZ	Elective -4	3				3
6	16MEMSIEZZ	Institution Elective	4				4
7	16MEMSPCCR	CNC and Robotics lab			1		1
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 - 3	
16MEMSPEAM	Advanced Manufacturing Processes
16MEMSPEMM	Modern Machining Technology
16MEMSPEAU	Automation in Manufacturing
16MEMSPEID	Industrial Design and Ergonomics

Course Elective - 4	
16MEMSPEAE	Advanced Engineering Materials
16MEMSPEND	Nondestructive Testing
16MEMSPEMS	MEMS
16MEMSPELM	Laser Materials Processing

Institution Elective	
16MEMSIECM	Computational methods in Engineering analysis
16MEMSIEDE	Design of Experiments
16MEMSIEDM	Design for Manufacture

Scheme of Teaching for 2016-17

III Semester			CREDIT BASED				
Sl.No	Subject Code	Course Title	Credits				CREDITS
			L	T	P	S	
1	16MEMSPCIN	Internship					21
2	16MEMSPCIP	Project work (I-phase)					04
		Total					25

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

IV Semester			CREDIT BASED				
Sl.No	Subject Code	Course Title	Credits				CREDITS
			L	T	P	S	
1	16MEMSPCPR	Project work (final phases)					23
2	16MEMSPCTS	Technical Seminar					02
Total							25

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

Category	I Sem	II Sem	III Sem	IV Sem	Total Credits to be earned
Core courses	18	14	-	-	32
Dept. Electives	6	6	-	-	12
Institution Elective	-	4	-	-	4
Lab Courses	1	1	-	-	2
Technical seminar	-	-	-	2	2
Internship	-	-	21	-	21
Project Work	-	-	4	23	27
Total	25	25	25	25	100

Manufacturing Subjects	Materials subjects	Management & Mathematics subjects
Advanced Metal Cutting	Composite materials	Research Methodology
Plasticity and Metal Forming	Material Characterization	Total Quality management
Advanced Joining process	Nanotechnology	Computational methods in Engineering analysis
Additive Manufacturing Technology	Corrosion and Surface Engineering	Design of Experiments
Computer control of Manufacturing systems	Advanced Engineering Materials	
Tool Engineering Design	Nondestructive Testing	
Industrial Robotics	MEMS	
Finite Element Modeling		
Advanced manufacturing process		
Modern machining Technology		
Automation in manufacturing		
Design for Manufacture		

I SEMESTER
SYLLABUS

ADVANCED METAL CUTTING

Subject Code	16MEMSPCAM	CIE Marks	50
L-T-P-S	3-0-0-1	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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.

Tool Wear, Tool Life: Mechanisms of tool wear, Sudden & gradual wear, crater wear, flank wear, tool failure criteria, tool life equations, effect of process parameters on tool life, tool life tests-conventional & accelerated, tool wear measurement, machinability index, problems.

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:

1. **Fundamentals of metal cutting & Machine Tools** - by B.L.Juneja & G.S – Sekhar - Wiley Eastern.

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:

1. <http://ceb.ac.in/knowledgecenter/EBOOKS/Metal%20Machining%20%20Theory%20and%20Applications%20-%20Thomas%20Childs.pdf>

MOOCS:

1. <http://nptel.ac.in/downloads/112105127/>

2. http://fmcet.in/MECH/ME6402_uw.pdf

3. http://www.gitam.edu/eresource/images/Mechanics_of_Metal_Cutting.pdf

Course Out comes

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

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

Subject Code	16MEMSPCMC	CIE Marks	50
L-T-P-S	4-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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.

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.

14 Hours

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

1. Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar; CRC press, (2008)
2. Transmission Electron Microscopy; D.B. Williams and C.B. Carter, Plenum Press (2004)

3. Modern ESCA The Principles and Practice of X-Ray Photoelectron Spectroscopy, Terry L.Barr, CRC press, (1994)
4. Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein, Dale E. Newbury, David C. Joy, and Charles E.; Springer Science (2003)
5. Advanced Techniques for Materials Characterization, Materials Science Foundations (monograph series) A. K. Tyagi, Mainak Roy, S. K. Kulshreshtha and S. Banerjee;, Volumes 49 – 51 (2009)
6. L. Yang, Materials Characterization: Introduction to microscopic and spectroscopic, Wiley.
7. ASM Handbook, Vol. 9, Metallography and Microstructures, ASM International, USA.
8. Goodhew, Humphreys and Beanland, Electron Microscopy and Microanalysis, Taylor and Francis.
9. Hatakayama 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/>
4. <http://nptel.ac.in/syllabus/syllabus.php?subjectId=113107033>

Course Out comes

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

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

Subject Code	16MEMSPCPM	CIE Marks	50
L-T-P-S	4-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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 - Vonmises 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

Unit-5

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:

1. **Mechanical Metallurgy** - Dieter G.E. - Mc Graw Hill Publications.

REFERENCE BOOKS:

1. **Metals Handbook** – ASM - Volume II - ASM
2. **Fundamentals of working of Metals** - Sach G. - Pergamon Press.

E BOOKS:

1. <http://staff.uny.ac.id/sites/default/files/pendidikan/aan-ardian-mpd/3c-handbook-metal-forming.pdf>
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
2. <http://nptel.ac.in/courses/112106153/>
3. <http://nptel.ac.in/downloads/112106153/>

Course Out comes

CO1	Describe elastic and plastic behavior of metals
CO2	Differentiate metal working techniques and describe parameters influencing metal working
CO3	Estimation of forging loads for plate and disc
CO4	Analyze roiling force and estimate the roiling load
CO5	Estimation of extrusion load and describe processes variables
CO6	Analyze drawing load and describe variables and defects

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.

COMPOSITE MATERIALS

Subject Code	16MEMSPCCM	CIE Marks	50
L-T-P-S	3-0-1-0	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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

Micro Mechanical Analysis of a Lamina: Introduction, Evaluation of the four elastic moduli by Strength of Materials Approach, Ultimate strengths of unidirectional lamina, Longitudinal Tensile Strength, Longitudinal Compressive Strength ,Transverse Tensile Strength ,Transverse Compressive Strength ,In-Plane Shear Strength, Numerical problems.

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. **11 Hours**

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) **5 Hours**

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. **26 Hours**

TEXT BOOKS:

1. Composite Science and Engineering by K. K. Chawla Springer Verlag 1998.
2. Introduction to composite materials by Hull and Clyne, Cambridge University.
3. Mechanics of Composite Materials, Second Edition Autar K Kaw University of South Florida, Tampa, USA
4. Mechanics of Composite Materials, Robert M. Jones, McGraw Hill Kogakusha Ltd.1998

E-BOOKS

1. www.ae.iitkgp.ernet.in/ebooks/
2. www.rjafari.iut.ac.ir/sites/.../1mechanics_of_composite_materials.pdf

MOOCS:

1. nptel.ac.in/courses/112104168/, nptel.ac.in/courses/101104010/,
2. nptel.ac.in/courses/.../IISc.../Composite%20Materials/New_index1.html

Course Out comes

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

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.

NANO TECHNOLOGY

Subject Code	16MEMSPENT	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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. **11 Hours**

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. **6 Hours**

Unit-3

Mechanics of polymer nanocomposites, Interfacial adhesion and characterization, factors influencing the performance of nanocomposites, physical and functional properties. Nano composite fabrication, matrices, methods, additives, moulding processes.

Polymer-carbon nanotubes based composites, processing methods and characterization using SEM, XRD, TEM. **11 Hours**

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 **6 Hours**

Unit-5

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

Text Books:

1. **Text Book of Polymer Science** - Fred W. Billimeyer, Jr - Wiley Interscience Publication - third edition, 1994.

2. **Polymer Science and Technology** - Joel R. Fried - Prentice- Hall, Inc. Englewood Cliffs, N. J., USA - 2000.

REFERENCE BOOKS:

1. **New Developments and Technology** -Hand book of Elastomers - (Eds. A. K. Bhowmic and H. C. Stephense), Marcel - Dekker Inc., New York - 1995.
2. **Polymer Blends** - D. R. Paul and S. Newman - Academic Press, New York - 1978.
3. **Short Fibre Reinforced Thermoplastics** - M. J. Folkes - John Wiley, New York - 1982.
4. **Nanocomposites Science and Technology** Physical Properties of Carbon Nanotubes - P. M. Ajayan, L.S. Schadler, P. V. Braun , R. Saito, Carbon Nanotubes (Carbon, Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus

E-BOOKS:

1. **Carbon Nanotubes – A scientometric study** by *Werner Marx and Andreas Barth*
nptel.ac.in/courses/118102003/
2. <http://www.zums.ac.ir/files/research/site/ebooks/nanotechnology/nano-technology.pdf>
3. <http://web.pdx.edu/~pmoeck/phy381/workbook%20nanoscience.pdf>

MOOCS:

1. <https://www.coursera.org/learn/nanotechnology1>
2. <https://www.coursera.org/learn/nanotechnology2>
3. <https://www.edx.org/course/nanotechnology-fundamentals-purduex-nano530x>
4. <http://nptel.ac.in/courses/118102003/>
5. nptel.ac.in/courses/118104008/
6. <http://nptel.ac.in/course.php?disciplineId=112>

Course Out comes

CO1	Classify metal based Nano composites
CO2	Describe polymer Nano composites
CO3	Model for physical and mechanical properties
CO4	Analyze structural properties of Nano composites using SEM and XRD
CO5	Analyze various properties of polymer Nano tubes
CO6	Compare different methods of thermal analysis techniques of Nano composites

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.

TOTAL QUALITY MANAGEMENT

Subject Code	16MEMSPETQ	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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

PRINCIPLES OF TOTAL QUALITY MANAGEMENT: Elements of Total Quality Management– A Customer Focus – Fact-Based Management– Continuous Improvement – Teamwork and Participation. Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement, Malcolm Baldrige National Quality Award, Award Criteria. Benefits of TQM. The Deming Management Philosophy – Profound Knowledge –The Impact of Profound Knowledge – Deming’s 14 Points for Management- PDCA Cycle, The Juran Philosophy – The Juran Quality Trilogy. The Crosby Philosophy. The Taguchi Loss Function, 5S, Kaizen, Performance Measures **11 Hours**

Unit-3

TQM TOOLS

Ishikawa ‘s Seven Quality Tools, Ishikawa Fish bone diagram –Nominal Group Technique – Quality Circles – Flow Charts – Pareto Analysis– Poka Yoke (Mistake Proofing), Process, Quality Function Deployment (QFD), House of Quality, QFD Process, Benefits, Total Productive Maintenance (TPM) Concept, Improvement Needs, FMEA, Stages of FMEA, cybernetic Analysis **11 Hours**

Unit-4

QUALITY BY DESIGN:

Introduction – Rationale for implementation – Benefits– Teams – Communication models – Implementation – Tools – Misconceptions and Pitfalls **6 Hours**

Unit-5

QUALITY MANAGEMENT STANDARDS Introductory aspects only)

a. The ISO 9001:2000 Quality Management System Standard

- b. The ISO 14001:2004 Environmental Management System Standard
- c. ISO 27001:2005 Information Security Management System
- d. ISO / TS16949:2002 for Automobile Industry
- e. CMMI Fundamentals and Concepts

5 Hours

TEXT BOOKS:

1. **A New American TQM Four Practical Revolutions in Management**” –Shoji Shiba, Alan Graham and David Walden,– Productivity Press, Portlans (USA) , 1993
2. **Management for Total Quality**” –N Logothetis- Prentice Hall of India, New Delhi, 1994.

REFERENCE BOOK:

1. **The Quality Improvement Hand Book**, -Roger C Swanson, Publisher Vanity Books International, New Delhi, 1995.
2. **Total Quality Management** – Kesavan R – I K International Publishing house Pvt. Ltd, 2008

E BOOKS:

1. <http://psbm.org/Ebooks/Total%20Quality.pdf>
2. http://www.mescenter.ru/images/abook_file/Total_Quality_Management_and_Six_Sigma.pdf

MOOCs:

1. <https://www.mooc-list.com/course/fundamentals-six-sigma-quality-engineering-and-management-edx?static=true>
2. <https://www.mooc-list.com/course/quality-management-uninettuno?static=true>

Course Out comes

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

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.

CORROSION AND SURFACE ENGINEERING

Subject Code	16MEMSPECS	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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 :

1. Fontana and Greene."Corrosion Engineering". McGraw Hill Book Co. New York. USA 1983.
2. Raj Narayan. "An Introduction to Metallic Corrosion and its prevention". Oxford & 1BH. New Delhi. 1983.
3. Kenneth G Budinski."Surface Engineering for Wear Resistance". Prentice Hall Inc.. Engelwood Cliff. New Jersey. USA 1988

REFERENCE BOOKS:

1. Uhlig. H.H . "Corrosion and Corrosion Control". John Wilcy & Sons. New York. USA. 1985.
2. ASM Metals Handbook. Vol.5. "Surface Engineering". ASM Metals Park. Ohio. USA. 1994.
3. ASM Metals Handbook. Vol.13,"Corrosion".ASM Metals Park. Ohio. USA. 1994

E-BOOKS:

- 1.https://app.knovel.com/web/toc.v/cid:kpHCDE000D/viewerType:toc/root_slug:handbook-corrosion-data
2. <http://uotechnology.edu.iq/dep-materials/lecture/fourthclass/SurfaceEng2.pdf>

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.

ADVANCED JOINING PROCESS

Subject Code	16MEMSPEAJ	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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 under water 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:

1. **Welding Engineering Handbook** - A.W.S.
2. **Welding Engineering** - Rossi - McGraw Hill.
3. **Welding Technology** - O.P. Khanna
4. **Welding for Engineers** - Udin, Funk & Wulf

E-BOOKS:

1. <https://www.wilhelmsen.com/globalassets/marine-products/welding/documents/wilhelmsen-ships-service---unitor-welding-handbook.pdf>
2. https://pubs.aws.org/Download_PDFS/WHB-1.9PV.pdf

MOOCS:

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

Course Out comes

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

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

Subject Code	16MEMSPEAT	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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.

Stereo lithography Systems: Principle, Process parameter, process details, Data preparation, data files and machine details, Application. **11 Hours**

Unit-2

Selective Laser Sintering: Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, **FUSION DEPOSITION MODELLING:** Principle, Process parameter, Path generation, Applications. **5 Hours**

Unit-3

Solid Ground Curing: Principle of operation, Machine details, Applications,

Laminated Object Manufacturing: Principle, of operation, LOM materials, process details, applications.

Concepts Modelers: Principle, Thermal jet printer, Sander's model market, 3-D printer, Genisys Xs printer HP system 5, object Quadra systems, Laser Engineering Net Shaping (LENS) **6 Hours**

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. **6 Hours**

Unit-5

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

RAPID Manufacturing Process Optimization: factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation.

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

TEXT BOOKS:

1. Paul F. Jacobs: —**Stereo lithography and other RP & M Technologies**—SME NY, 1996.
2. Flham D.T & Dinjoy S.S —**Rapid Manufacturing**— Verlog London 2001.

REFERENCE BOOKS:

1. Terry Wohler’s —**Wohler’s Report 2000**— Wohler’s Association 2000

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

Subject Code	16MEMSPECC	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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

Adaptive control systems: Introduction, Adaptive control with optimization, Adaptive control with Constraints. ACC for turning, Variable Gain AC systems Adaptive control for grinding, Cost analysis in machining **5 Hours**

Unit-5

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

Text Books:

1. **Computer control of manufacturing systems** - Yorem Koren, Tata McGraw-Hill edition, 2005.

Reference Books:

2. **Computer Aided Design and Manufacturing** - Dr.Sadhusingh, Khanna Publishers, 2002

Reference Books

1. **Simulation modeling and Analysis** - Avverill M Law, TMH,2008.

2. **Martin J. Numerical control of machine tools”.**

MOOCS:

1. <http://nptel.ac.in/courses/112102103/>

2. <http://nptel.ac.in/courses/112102101/>

Course Out comes

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

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.

MATERIAL CHARACTERIZATION AND MANUFACTURING TECHNOLOGY LAB

Subject Code	16MEMSPCMM	CIE Marks	50
L-T-P-S	0-0-1-0	SEE Marks	50
Total no. of practical classes	13	Exam Hours	03

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

CO1	Synthesize and test composites & Nano composites with respect to wear and porosity
CO2	Analyze and characterize elements and compounds of materials
CO3	Estimate Process capabilities for different materials using abrasive water jet and wire EDM

RESEARCH METHODOLOGY

Subject Code	16APRDICRM	CIE Marks	
L-T-P-S	2-0-0-0	SEE Marks	
Total no. of practical classes	26	Exam Hours	

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, monographspatents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

Module 3:

IPRs- Invention and Creativity- Intellectual Property-Importance and Protection of Intellectual Property Rights (IPRs)- A brief summary of: Patents, Copyrights, Trademarks, Industrial Designs- Integrated Circuits-Geographical Indications-Establishment of WIPO-Application and Procedures.

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 about 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:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Anderson, T. W., An Introduction to Multivariate Statistical Analysis, Wiley Eastern Pvt., Ltd., New Delhi
4. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
5. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
6. Day, R.A., 1992. How to Write and Publish a Scientific Paper, Cambridge University Press.
7. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
8. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
9. Intellectual Property Rights in the Global Economy: Keith Eugene Maskus, Institute for International Economics, Washington, DC, 2000
10. Subbarau NR-Handbook on Intellectual Property Law and Practice-S Viswanathan Printers and Publishing Private Limited.1998

II SEMESTER

SYLLABUS

TOOL ENGINEERING DESIGN

Subject Code	16MEMSPCTD	CIE Marks	50
L-T-P-S	4-0-0-1	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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:

1. **Tools Design** - Cyril Donaldson, George H.LeCain, V C Goold and Joyjeet Ghose, McGraw Hill Education (India) Private Limited, New Delhi, 2015.
2. **Metal Cutting and Tool design** - Dr. B.J. Ranganath, Vikas Publishing house, 1993.

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
3. **Introduction to Jigs & Fixtures-** Kempster. ELBS, Edn. 1974.
4. **Fundamentals of Tools Design-** ASTME – Prentice Hall India Publications – 1983.
5. **Jigs and Fixtures** - Prakash Hiralal Joshi, Tata McGraw-Hill Education, 2010

MOOCS:

<http://nptel.ac.in/courses/112105126/35>

Course Out comes

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

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

Subject Code	16MEMSPCIR	CIE Marks	50
L-T-P-S	4-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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 SYATEMS 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

MICRO/NANO ROBOTICS SYSTEM: Future trends, Micro/Nano robotics overview-Scaling effect-Actuators of Micro/Nano robotics system-Micro/nano grippers-Wall climbing micro robot working principles-Biomimetic robot- Nanorobot in targeted drug delivery system.

04 Hours

TEXT BOOKS:

1. **Robotics Engineering An integrated approach** - Richard D Klafter, Thomas A Chmielewski, Michael Negin – Prentice Hall of India Pvt. Ltd. - Eastern Economy Edition, 1989.

2. **Robotics: Control Sensing, Vision, intelligence** - Fu KS Gomaler R C, Lee C S G - McGraw Hill Book Co.- 1987.

REFERENCE BOOKS:

1. **Handbook of Industrial Robotics** - Shuman Y. Nof - John Wiley & Sons, New York - 1985.

2. **Robotics Technology and Flexible Automation** - Deb SR - McGraw Hill BookCo. - 1994.

3 **Robotics for Engineers** , Yoram Koren, McGraw Hill International.

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

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

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

7 Bharat Bhushan., “Springer Handbook of Nanotechnology”, Springer, 2004. 11.

8 Julian W. Gardner. “Micro sensor MEMS and Smart Devices”, John Wiley & Sons, 2001

MOOCS:

<https://www.edx.org/course/robot-mechanics-control-part-i-snu446-345-1x>

<https://www.edx.org/course/robot-mechanics-control-part-ii-snu446-345-2x>

Course Out comes

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

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.

FINITE ELEMENT MODELING

Subject Code	16MEMSPCFM	CIE Marks	50
L-T-P-S	4-0-1-0	SEE Marks	50
Total no. of Lecture Hours.	52	Exam Hours	03

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

Finite Element in Manufacturing Processes: Types of Non Linearity, Plasticity Fundamentals, Material Behavior Models, Yielding Criteria, Governing Equations, Finite Element Formulation for Large Deformation Processes. **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:

- 1.T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
- 2.Lakshminarayana H. V., Finite Elements Analysis– Procedures in Engineering, Universities Press, 2004.
3. G. W. Rowe , C. E. N. Sturgess , P. Hartley and I. Pillinger, Finite-Element Plasticity and Metal forming Analysis,Cambridge University Press, 1991

REFERENCE BOOKS:

- 1.Rao S. S. , Finite Elements Method in Engineering- 4th Edition, Elsevier, 2006
- 2.P. Seshu, Textbook of Finite Element Analysis, PHI, 2004.
- 3.J. N. Reddy, Introduction to Finite Element Method, McGraw -Hill, 2006.
- 4.Bathe K. J., Finite Element Procedures, Prentice-Hall, 2006.
- 5.Cook R. D., Finite Element Modeling for Stress Analysis, Wiley, 1995.

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-tsinghuax-70120073x>
2. A Hands-on Introduction to Engineering Simulations
<https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x>
3. <https://www.mooc-list.com/course/finite-element-method-fem-analysis-and-applications-edx?static=true>
4. <https://www.coursetalk.com/providers/mit/courses/finite-element-analysis-of-solids-and-fluids-i>
5. <https://online-learning.tudelft.nl/courses/linear-modeling-fem/>

Course Out comes

At the end of Course, Student will be able to

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

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

Subject Code	16MEMSPEAM	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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 tolerances, 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

Thermoset: 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 Alloying: Introduction, Process, Milling parameters, Process Control Agents, Process Variables, Mechanism of Alloying, 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) Processe 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 hydraulics forming magnetic pulse. **5 Hours**

TEXT BOOKS:

1. Dominic v. Rosato, Injection molding handbook, CBS publishers
2. Rao, P.N, 'Manufacturing Technology', Tata McGraw Hill, 1996.

REFERENCE BOOKS:

1. Kalpakjian, S, 'Manufacturing Engineering and Technology', Addison-Wesley, 1995.
2. Suryanarayana, Mechanical Alloying an Introduction.
3. P. C. Angelo and R. Subramanian, Powder Metallurgy – Science , Technology and Applications, PHI Publications, 2009.

MOOCS:

1. https://www.ielm.ust.hk/dfaculty/ajay/courses/ieem215/lecs/6_plastics.pdf
2. <http://www.m-ep.co.jp/en/pdf/product/novaduran/molding.pdf>

Course Out comes

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

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.

MODERN MACHINING TECHNOLOGY

Subject Code	16MEMSPEMM	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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 **5 Hours**

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 **6 Hours**

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, lasing 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:

1. <http://www.download4referencebook.com/journals/nontraditional-machining-processes>

MOOCS:

1. <http://nptel.ac.in/courses/112105126/36>

Course Out comes

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

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

Subject Code	16MEMSPEAU	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

Course Content:

Unit-1

Production Development through CIM:

Computers in Industrial manufacturing, Product cycle & Production development cycle, Introduction of CAD/CAM & CIM, sequential and concurrent engineering, soft and hard prototyping. **6 Hours**

Unit-2

Computer Integrated Manufacturing and Automation:

Fundamentals of CAD/CAM, Computerized Manufacturing planning systems, shop floor control & automatic identification techniques. Computer Network for manufacturing and the future automated factor. Detroit Type of Automation: Flow lines, Different Transfer Mechanisms, work pattern transfer, Different methods, Problems. **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.

11 Hours

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.

5 Hours

TEXT BOOKS:

1. CAD/CAM – Zimmers & Grover, PHI.
2. CAD/CAM/CIM – P. Radhakrishna, New Age International.
3. M. P. Grover, Automation, Production Systems & Computer Aided manufacturing, Prentice Hall.

REFERENCE BOOKS:

1. CAD/CAM – Zeid, Mc-Graw Hill
2. CAD/Cam, P. N. Rao.
3. Koren.Y “Robotics for Engineering” Mc-Graw Hill.
4. Rooks. B. (ed) “Robert vision & Sensory controls vol-3 North Holland.

E-BOOKS:

- 1 <http://nptel.ac.in/downloads/112103174/>
2. <http://nptel.ac.in/courses/112102011/>

MOOCS:

1. <http://nptel.ac.in/courses/108105062/>

Course Out comes

CO1	Describe production cycle
CO2	Identify flow lines in automation and solve real world problems
CO3	Analyze automated flow lines
CO4	Describe Networking principles and models
CO5	Categorize inspection methods and illustrate modern inspection methods
CO6	Schedule the material flow in the shop floor

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.

INDUSTRIAL DESIGN AND ERGONOMICS

Subject Code	16MEMSPEID	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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:

1. **Industrial design for Engineers** - Mayall W.H. - London Cliffee Books Ltd. - 1988.
2. **Applied Ergonomics Hand Book** - Brien Shakel (Edited) - Butterworth Scientific, London – 1988.

E-BOOKS:

1. <http://textofvideo.nptel.iitm.ac.in/107103004/lec40.pdf>

MOOCS:

1. <http://nptel.ac.in/courses/107103004/>

Course Out comes

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

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.

ADVANCED ENGINEERING MATERIALS

Subject Code	16MEMSPEAE	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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.

Bio-Materials, Bio compatibility, Applications, 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 **6 Hours**

Unit-5

High Temperature Materials Inconel steels, Titanium super alloys – structure, properties and applications **Nano Materials** Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Quantum Dots. Applications of nanostructures, Thermodynamic of nano materials. **5 hours**

Text Book:

1. W.F. Smith, Principles of Materials Science and Engineering, Mc Graw Hill, New York (1994)

References:

1. W.D. Callister, An Introduction to Materials Science & Engineering, John Wiley & Sons (2007)
2. V. Raghavan, Material Science and Engineering, Prentice Hall of India, 2004.
3. R. Sharma, Heat Treatment: Principles and Techniques, Prentice Hall of India (2004)

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.

NON DESTRUCTIVE TESTING

Subject Code	16MEMSPEND	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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. **11Hours**

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:

1. **Non Destructive Testing** - Mc Gonnagle JJ – Garden and reach New York.

REFERENCE BOOKS:

1. **Non Destructive Evolution and Quality Control** - volume 17 of metals hand book 9 edition Asia internal 1989.

2. **The Testing instruction of Engineering materials** - Davis H.E Troxel G.E wiskovil C.T - McGraw hill.

E-BOOKS :

1. <https://www.asnt.org/Store/ProductDetail?productKey=f3f52371-81eb-4cd3-b463-179a55ec36a5>.

MOOCS:

1. https://onlinecourses.nptel.ac.in/noc16_mm07/preview

2. <http://nptel.ac.in/courses/114106035/1>

Course Out comes

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

MICRO ELECTRO - MECHANICAL SYSTEMS (MEMS)

Subject Code	16MEMSPEMS	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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

Modeling of Micro Electro Mechanical Devices: Direct current Micro machines induction micro machine synchronous micro machine, permanent-magnet stepper micro motors.

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 pezo-resistors, 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:

1. Max J. Madou: “**Fundamentals of Micro Fabrication**”- The science of miniaturization-, Nanogen corporation, USA, CRC press, March 2002.
2. Sergey Edward Lyshevski: “**Nano-And Micro Electro Mechanical Systems**” – Second edition, CRC press, Boca Raton London.

REFERENCE BOOKS:

1. Sherif sedky: “**Integrated MEMS**”- Artech House, Boston London.
2. N. Maluf : “**Introduction To Micro Mechanical Systems Engineering**” –, Artech House, Norwood, MA, 2000.
3. Tai – Ran Hsu: “**MEMS And Micro Systems: Design And Manufacture**” – Tata Mc Graw Hill, 2002.

E-BOOKS:

1. <http://textofvideo.nptel.iitm.ac.in/117105082/lec1.pdf>

MOOCS:

1. <http://nptel.ac.in/courses/117105082/>
2. <http://nptel.ac.in/courses/117105082/>

Course Out comes

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

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.

LASER MATERIALS PROCESSING

Subject Code	16MEMSPELM	CIE Marks	50
L-T-P-S	3-0-0-0	SEE Marks	50
Total no. of Lecture Hours.	39	Exam Hours	03

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 welding: types of welding: Conduction welding, keyhole welding, Hybrid laser welding. Process parameters in laser welding: Beam power density, Beam diameter, Polarization, Welding speed, Shielding gas. Advantages, disadvantages and applications. Simple problems

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

3D laser machining and micro machining: Laser assisted machining (LAM): turning, milling, grinding. Laser machining (LM): single laser beam machining, Machining using intersecting laser beams, 3D machining, Laser micro machining: Direct writing technique, mask projection technique, Laser assisted chemical etching. laser marking. Applications. Nano machining of laser. **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

1. **Laser Material Processing**, 4th edition, William M. Steen, Jyotirmoy Mazumdet, springer publication.
2. **Advances in Laser Materials Processing**, J.R. Lawrence, J. Pou, D.K.Y. Low and E. Toyserkani , Woodhead Publishing in Materials.

Reference Books:

1. **Physics of Laser Materials Processing:** Theory and Experiment, Gennady G. Gladush, Igor Smurov, springer publication 2011.
2. Lasers in manufacturing edited by J.Paul Davim. Willy publications.

E-BOOKS:

1. http://www.pblprojects.org/PhotoMachining/docs/Ron_Schaeffer_Course_Notes.pdf

Course Outcomes

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

CO 1	Classify different types of lasers based on its beam properties and power
CO 2	Correlate laser interaction types with different materials
CO 3	Evaluate best methods of laser cutting of different materials
CO 4	Analyze process parameters of laser welding and laser drilling
CO 5	Identify how laser can be used in traditional machining
CO6	Select various safety precautions during laser machining

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

Subject Code	16MEMSPCCR	CIE Marks	50
L-T-P-S	0-0-2-0	SEE Marks	50
Total no. of Lecture Hours.	13	Exam Hours	03

- 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

CO1	Develop CNC programming for turning and milling
CO2	Design and develop simulations of robot's work
CO3	Create programs for simple operations of Robot

III SEMESTER

INTERNSHIP

Subject Code	16MEMSPCIN	CIE Marks	100
L-T-P-S	0-0-21-0	SEE Marks	100
Total no. of Lecture Hours.	-	Exam Hours	3

Course objectives for Internship

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

PROJECT WORK (I PHASE)

Subject Code	16MEMSPCIP	CIE Marks	100
L-T-P-S	0-0-4-0	SEE Marks	100
Total no. of Lecture Hours.	-	Exam Hours	3

IV SEMESTER

PROJECT WORK (FINAL PHASE)

Subject Code	16MEMSPCPR	CIE Marks	100
L-T-P-S	0-0-23-0	SEE Marks	100
Total no. of Lecture Hours.		Exam Hours	3

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

Subject Code	16MEMSPCTS	CIE Marks	50
L-T-P-S	0-0-2-0	SEE Marks	-
Total no. of Lecture Hours.	-	Exam Hours	-

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)