B

Accredited By NAAC

SHIVAJI UNIVERSITY, KOLHAPUR.

Revised Syllabus of

M. E. (CAD/CAM/CAE)

(Sem –I & Sem.-IV)

To be introduced from the academic year 2010-11

(i.e. from June 2010) Onwards

(Subject to the modifications will be made from time to time)

M. E. (CAD/CAM/CAE)

(UNDER B.O.S. IN PRODUCTION ENGG.)

(Effective from July 2010)

M. E. (CAD/CAM/CAE) Semester - I

Sr. No.	Name of the Subject	Teaching Scheme (Hrs./Week)		Examination Scheme			Total Marks
		L	T/P	TP	T/W	P/O	
1	Advanced Machine Design	3	1	100	25	-	**125**
2	Computer Aided Manufacturing	3	-	100	-	-	**100**
3	Finite Element Analysis	3	-	100	-	-	**100**
4	Design of Experiments & Research Methodology	3	1	100	25	-	**125**
5	Elective – I	3	2	100	25	-	**125**
6	CAD/CAM Laboratory	-	2	-	50	25	**75**
7	Design & Analysis Laboratory-I	-	2	-	25	25	**50**
8	Seminar – I	-	1	-	25	-	**25**
	Total	15	9	500	175	50	**725**

L: Lecture,T/P:Tutorial/Practical,TP:Theory Paper,T/W:Term Work P/O: Practical/ Oral Exam.

M. E. (CAD/CAM/CAE) Semester - II

Sr. No.	Name of the Subject	Teaching Scheme (Hrs./Week)		Examination Scheme			Total Marks
		L	T/P	TP	T/W	P/O	
1	Manufacturing Systems Design	3	1	100	25	-	125
2	Product Life Cycle management	3	1	100	25	-	125
3	Indl. Automation & Robotics	3	-	100	-	-	100

4	Optimization Techniques	3	1	100	25	-	125
5	Elective - II	3	1	100	25	-	125
6	Design & Analysis Laboratory-II	-	2	-	25	25	50
7	Automation & Simulation Laboratory	-	2	-	25	25	50
8	Seminar - II	-	1	-	25	-	25
	Total	15	9	500	175	50	**725**

L: Lecture,T/P:Tutorial/Practical,TP:Theory Paper,T/W:Term Work P/O: Practical/ Oral Exam.

Note: A Mini project in related area to be undertaken and completed during vacation after Semester-II. The report shall be submitted and assessed at the beginning of the Semester-III.

List of Elective Subjects

Elective-I	Elective-II
1. Mechatronic System Design	1. Computational Fluid Dynamics.
2 Technology Management.	2. Quality & Reliability Engineering
3. Tribology & Surface Engineering	3. System Dynamics & Simulation
4. MEMS & Nanotechnology	4. Artificial Intelligence
5. Design & Development of CAD/CAM/CAE Software	5. Automatic Control Engineering
6. Advanced Materials & Processing	6. CAD/CAM/CAE Practices in Metal Forming
	7. Rapid Manufacturing

….2

[Note :- Examination scheme and term work marks strictly as per above structure]

SHIVAJI UNIVERSITY, KOLHAPUR,.

Modified Structure of

M. E. (CAD/CAM/CAE)

(UNDER B.O.S. IN PRODUCTION ENGG.)

(Effective from July 2010)

M. E. (CAD/CAM/CAE) Semester - III

Sr. No.	Name of the Subject	Teaching Scheme (Hrs./Week)		Examination Scheme			Total Marks
		L	T/P	TP	T/W	P/O	
1	Mini Project	-	1	-	50	-	50
2	Seminar - III	-	1	-	25	25	50
3	Dissertation Phase - I	-	2	-	50	-	50
	Total	-	3	-	125	25	**150**

L: Lecture,T/P:Tutorial/Practical,TP:Theory Paper,T/W:Term Work P/O: Practical/ Oral Exam.

M. E. (CAD/CAM/CAE) Semester – IV

Sr. No.	Name of the Subject	Teaching Scheme (Hrs./Week)		Examination Scheme			Total Marks
		L	T/P	Theory	TP	P/O	
1	Dissertation Phase - II	-	4	-	100	100	200
	Total	-	4	-	100	100	**200**

(Grand Total: 1800)

L: Lecture,T/P:Tutorial/Practical,TP:Theory Paper,T/W:Term Work P/O: Practical/ Oral Exam.

Note: for Teaching Workload Purpose:

1. Seminar I, II, III – One hour per student per week

2. Mini Project – One hour per student per week

3. Dissertation Phase I – Two hours per student per week

4. Dissertation Phase II– Three hours per student per week

Note: Eligibility for admission to this course is same as that for M.E. (Mech.- Prod. Engg.) or M.E.(Mech. –Design Engg.) of Shivaji University, Kolhapur.

M.E. (CAD/CAM/CAE) Semester:– I (Modified)
1. ADVANCED MACHINE DESIGN

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper (3 Hours): 100 marks
Practical: 1 Hr/ Week/ Batch	Term Work: 25 marks

Objectives:

1. To revise the fundamentals of stress analysis and vibration analysis.
2. To lay a strong foundation for design analysis.

1. Analysis of Stress: State of stress at a point, stress components on an arbitrary plane, principal stresses, Mohr's circle, plane stress, differential equations of equilibrium, boundary conditions.

2. Analysis of Strain: State of strain at a point, dilation, plane strain, compatibility conditions

3. Stress-Strain Relations: Generalizes Hooke's Law, relations between elastic constants, displacement equations of equilibrium.

4. Theories of Failure: Theory of dislocations, Maximum principal stress theory, maximum shear stress theory, maximum elastic strain theory, octahedral shearing stress theory, distortion energy theory, Mohr's theory, significance of theory of failure, use of factor of safety in design, selection of materials for engineering applications.

5. Energy Methods: Elastic strain energy, Maxwell-Betti-Rayleigh reciprocal theorem, Castigliano's theorems, strain energy due to axial force, shear force, torsion, bending moment, theory of virtual work.

6. Axi-symmetric Problems: Thick-walled cylinders, shrink fits, rotating discs.

7. **Fatigue Considerations in Design** : Variable loads- basic concepts; Load and Stress variations- different patterns; Cyclic stressing/straining- material response and the origin of fatigue failure; S-N curve - fatigue strength and endurance limit; Factors influencing fatigue, endurance strength modification factors; Fatigue stress concentration; Effect of mean stress- Goodman and Soderberg relations; Design approach to fatigue- design for infinite and finite life; Design of members under combined loading.

TERM WORK

Minimum six assignments based on the above topics including two exercises involving analysis and design modification for critical components using reverse engineering approach. (e.g. need to change material specifications of a connecting rod, etc.)

REFERENCE BOOKS

1. Advanced Solid Mechanics – L S Srinath, Tata McGraw-Hill
2. Theory of Elasticity (Third Edition) – S P Timoshenko, J N Goodier, McGraw-Hill
3. Computer Aided Mechanical Design and Analysis (Third Edition) – V Ramamurti, Tata McGraw-Hill
4. Elements of Vibration Analysis – L Meirovitch, McGraw-Hill
5. Design of Machine Elements – M.F. Spotts & T.E. Shoup, Pearson Education
6. Mechanical Engineering Design – Joseph E. Shigley & Chales R. Mischke, McGraw Hill
7. Engineering Design –George B. Dieter, McGraw Hill
8. Machine Design, An Integrated Approach – Robert L. Norton, Pearson Education
9. Mechanical Analysis & Design – Arhur H. Burr & John B. Chetham, Prentice Hall India
10. Fundamentals of Machine Component Design – Robert C. Juvinall & Kurt M. Marshel, John Wiley & Sons

11. Mechanical Vibrations (Fourth Edition) – S S Rao, Pearson Education
12. Fundamentals of Mechanical Vibrations – S Graham Kelly, McGraw-Hill
13. Mechanical Vibrations – G.K. Groover, Nemchand & Brothers, Roorkee.
14. Fundamentals of Machine Component Design – R. C. Juvinall

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

2. COMPUTER AIDED MANUFACTURING

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper (3 Hours): 100 marks

Objective: To study advanced features of CAM so as to be capable of accepting professional responsibilities and to understand the associativity between design and manufacturing.

1. Introduction to CAM: - CNC machine tools, Principle of operation of CNC, Construction features including structure, drive system, tool-work movement actuation system, Work holding features, Tool holding features, Feedback system, machine control system, 2D and 3D machining on CNC **(4)**

2. Theory of metal cutting – Types of work materials, Chip formation and types of chips, Thermal aspects of metal cutting, Tool wear and failure, Cutting fluids, economics of machining parameters – optimizing cutting parameters for minimum cost and maximum production, effect of heat treatment on machining operations. **(4)**

3. CNC Part Programming - Detailed Manual part programming on Lathe and machining centers using G & M codes, FAPT programming (FANUC) **(10)**

4. CNC Tooling:-Modern cutting tool materials and their applications, ISO nomenclature of tools and tool grades, Different types of tools and tool holders used on CNC Machines, parameters for selection of configuration of cutting tools, Modular tools and fixtures, use of pallets for work holding, palletizing of fixtures. **(4)**

5. Advanced CNC processes - EDM, Wire cut M, Abrasive water jet, LASER cutting, (Working principles, construction or set up of process, applications) **(3)**

6. Co-ordinate Measuring Machine – Working principle, Drives, Controls, Types and applications of CMM software and utilities; CMM Inspection routines for measuring straightness, roundness, concentricity, center distance and pitch circle diameters of holes, parallelism and perpendicularity of surfaces and bore axes etc. **(5)**

7. Process planning using CNC machines: Differences with respect to conventional machines; Design for manufacturing and assembly - Concept with case studies, **(3)**

8. Geometric Dimensioning and Tolerancing – Functional importance of various types of fits, Geometrical dimensioning and tolerancing, Tolerance stacking – types and remedies. **(3)**

9. Computer aided CNC part programming – Introduction to common CNC controllers like FANUC, SIEMENS, MAZAK etc., Generation of tool path, generation of G & M codes, Optimization of tool path (to reduce machining time), (Features available on a typical CAM software), **(4)**

REFERENCE BOOKS:

1. Jon Stenerson and Kelly Curran "Computer Numerical Control", Prentice-Hall of India Pvt. Ltd. New Delhi, 2008

2. Ibrahim Zeid "CAD/CAM – Theory and Practice" Mc Hill, International edition, 1998

3. P. N. Rao "CAD/Cam principles and operations", Tata McGraw Hill

4. Reference Manuals of FANUC, Siemens, Mazak, etc.

5. Thomas M. Crandell "CNC Machining and Programming, Industrial Press ISBN-0-8311-3118-7

6. Bedworth, Wolfe and Henderson – "Computer aided design and manufacturing" - McGraw Hill

7. A. Ghosh and Malik – "Manufacturing Science" Affiliated East West Press Pvt. Ltd.

8. Tilak Raj – "CNC Technology and Programming", Dhanpat Rai Publication Company.

9. Robert Quesada, T.Jeyapoovan "Computer Numerical Control: Machining and Turning Centers" , Pearson Education.

M.E. (CAD/CAM/CAE) Semester – I (Modified)

3. Finite Element Analysis

Teaching Scheme:

Lectures: 3 Hrs/ Week

Examination Scheme:

Theory Paper (3 Hours): 100 marks

Pre-requisites:

- A basic understanding of vectors, matrices and partial differential equations for thermal and mechanical problems.

Course Objectives:

- To provide the mathematical foundations of the finite element formulation for engineering applications
- To expose students to some of the recent trends and research areas in finite element analysis.

1. Introduction to Finite Element Method: Basic Concept, Historical Background, ngineering applications, general Description, comparison with other methods. **(3)**

2. Integral Formulation and Variation Methods: Need for weighted-integral forms, relevant mathematical concepts and formulate, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method and weighted residual approach**(4)**

3. Finite Element Techniques: Module boundary value problem, finite element decartelization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solutions, post processing, Compatibility and completeness requirements, convergence criteria, higher

order and isoparametric elements, natural coordinates, Lagrange and Hermit Polynomials

(7)

4. Applications to Solid and Structural Mechanics Problems: External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis symmetric and three dimensional stress strain problems, strain displacement relations, boundary conditions compatibility equations, analysis of trusses, frames and solid of revolution, computer programs. **(7)**

5. Applications to Heat Transfer Problems: Variational approach, Galerikn approach, one dimensional and two dimensional steady state problems for conduction, convection and radiation, transient problems. **(4)**

6. Applications to Fluid Mechanics Problems: Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function voricity formulation, solution of incompressible and compressible fluid film lubrication problems, Additional Applications: Steady state and transient field problem. **(7)**

7. Parameters Affecting Accuracy of the FEA results: How to validate and check accuracy of FEA results? Computational accuracy: strain energy norm, residuals, Reaction forces and moments; convergence test, Average and unaverage stress difference. Correlation with actual testing: strain gauging-stress comparison; natural frequency comparison; Dynamic response comparison, temperature and pressure distribution comparison. **(7)**

REFERENCE BOOKS

1. Finite Element Analysis – Theory & Practice by Fagan (Longman Scientific & Technical)
2. Fundamentals of Finite Element Analysis, David Hutton, TMH
3. Finite Element Method versus Classical Methods,- H.S. Govinda Rao, New Age International Publishers
4. An Introduction to Finite Element Analysis by J. N. Reddy, (Tata McGraw- Hill Pub. Co.)
5. The Finite Element Method: Linear Static and Dynamic Finite Element Analysis by T. J. R. Huges, Dover Publications, 2000

6. Finite Element Procedures by Bathe, Prentice-Hall.
7. Finite Element Analysis by P. Seshu (PHI)
8. Practical Finite Element Analysis - Nitin Gokhale (Finite To Infinite, Pune)
9. Introduction to Finite Elements in Engineering by Chandrupatala and Belegundu.
10. Concepts & Application of Finite Element Analysis by R. D. Cook, D. S. Malku, (John Wiley & Sons)
11. The Finite Element Methods, 3/e –Sienkiewicz(Tata McGraw Hill).

M.E. (CAD/CAM/CAE) Semester-I (Modified)

4. DESIGN OF EXPERIMENTS & RESEARCH METHODOLOGY

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs / Week	Theory Paper: 100 marks
Practical: 1 Hr. / week	Term Work: 25 marks

Course Objective:

To prepare the orientation of the student towards research and to understand the techniques in design of research and experimentation.

1. Design of Experiments (DOE): Objectives, strategies, Factorial experimental design, Designing engineering experiments, basic principles- replication, randomization, blocking, Guidelines for design of experiments, process of DOE, **Simple Comparative Experiments-**Basic statistical concepts, random variable, sample mean and variance, degrees of freedom, standard normal distribution, statistical hypothesis, Two sample *t*-test, *P*-value, Confidence Intervals, Paired comparison. **(6)**

2. Single Factor Experiment: Analysis of Variance (ANOVA) for fixed effect model; Total, treatment and error sums of squares, Decomposition of total sum of squares, ANOVA for Randomized complete block design to control effects of nuisance factors. **(4)**

3. Two factor Factorial Design: Basic definitions and principles, main effect and interaction, response surface and contour plots, Blocking, General arrangement for a two-factor factorial design; Models- Effects, means and regression, **(4)**

4. Taguchi Techniques for Experimental Design: Taguchi loss function, Average loss, nominal-the-best, smaller-the-best, larger-the-best, design process steps, selection of factors affecting- methods, factor levels, Test strategies- Full factorial experiment, fractional factorial experiment, Orthogonal arrays and their selection; Interaction effects, **Parameter Design**- Control and noise factors and parameter design, signal to noise ratio, types, parameter design strategy, tolerance design, robust design **(5)**

5. Research: Definition of research, Applications of research and types, Research process and steps in it, Deductive and inductive reasoning; **Validity**-conclusion, internal, construct and external; Problem Solving – Types, Process and Approaches – Logical, Soft System and Creative; Creative problem solving process, Development of Creativity, Group Problem Solving Techniques for Idea Generation – Brain storming and Delphi Method. **(5)**

6. Literature review- Need, Procedure- Search for existing literature, Review the literature selected, Develop a theoretical and conceptual framework, Writing up the review, **Formulating a research problem**: Sources, Considerations, Steps in formulation of a problem, formulation of objectives, **Definition of variables –** Concepts, indicators and variables, Types of variables, Types of measurement scales, **Constructing the Hypothesis**- Null(Research) and alternative, one-tailed and two-tailed hypotheses, Hypothesis testing, errors in testing **(4)**

7. Research Modeling: Types of Models, Model building and stages, Data consideration and testing, Heuristic and Simulation modeling, Data collection methods, Surveys-types and method selection **(4)**

8. Research Proposal: Contents-Preamble, the problem, objectives, hypothesis to be tested, study design, setup, measurement procedures, analysis of data, organization of report; Displaying data- tables, graphs and charts, **Writing a research report-** Developing an outline, Key elements- Introduction, Methods, Measurement section, Design & procedure section, Results, Conclusion section, Referencing of books and research papers, Report Writing- Prewriting considerations, Thesis writing, Formats of report writing, Formats of publications in Research journals **(5)**

TERM WORK:

1. Minimum three exercises using a statistical software (like MINITAB / SYSTAT or similar) for hypothesis testing involving Two sample *t*-test, *P*-value, Confidence Intervals, Paired comparison

2. Design of an experiment for an engineering application with two variables and 2 to 3 levels for the variables and analysis of variance for it- a case study.

3. One exercise on design of experiment using Taguchi technique and orthogonal arrays

4. Collection of research papers (at least five) published in referred / peer reviewed journals on any **single** research area related to mechanical engineering, preparing and presenting a review in front of the class. (The papers collected shall be different for each student.)

REFERENCE BOOKS:

1. Montgomery, Douglas C. (2007) – Design & Analysis of Experiments, 5/e. (New Delhi, Wiley Student Edition, Wiley India Pvt. Ltd.) ISBN: 978-81-265-1048-1

2. Montgomery, Douglas C. & Runger, George C. (2007) – Applied Statistics & Probability for Engineers, 3/e, . (New Delhi, Wiley Student Edition, Wiley India Pvt. Ltd.), ISBN: 978-81-265-1424-3

3. Ranjit Kumar, (2006), Research Methodology- A Step-By-Step Guide for Beginners, (Pearson Education, Delhi) ISBN: 81-317-0496-3

4. Trochim, William M.K., (2003), 2/e, Research Methods, (Biztantra, Dreamtech Press, New Delhi), ISBN: 81-7722-372-0

5. Kothari, C.K., (2004), 2/e, Research Methodology- Methods and Techniques, (New Age International, New Delhi)

6. Ross, Philip J. (1996), 2/e, Taguchi Techniques for Quality Engineering, (McGraw Hill, New York)

7. Besterfield, Dale H. (2005), 3/e, Total Quality Management, (Pearson Education, New Delhi)

8. Krishnaswamy, K. N., Sivakumar, Appa Iyer and Mathirajan, M. (2006), Management Research Methodology: Integration of Principles, Methods and Techniques (Pearson Education, New Delhi)

9. Dean, Angela & Voss, Daniel, - Design & Analysis of Experiments, (1999), (Springer Verlag), ISBN: 0-387-98561-1

10. Panneerselvam – Research Methodology, (PHI), ISBN: 81-203-2452-8
11. Hinkelmann & Kempthorne – Design & Analysis of Experiments, Vol. I- Introduction to Experimental Design, (2005), (John Wiley & Sons)
12. Hinkelmann & Kempthorne – Design & Analysis of Experiments, Vol. II- Advanced Experimental Design, (2005), (John Wiley & Sons)
13. Richard L. Shell & Ernest L. Hall - Handbook of Industrial Automation,– (Marcel Decker Inc.)

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

5. ELECTIVE I - 1. MECHATRONIC SYSTEM DESIGN

Lecture: 3 hours per week University Exam: Theory Paper100 marks

Practical: 2 hrs per week Term work: 25 marks

Course Objective

To study components of mechatronic systems and their integration for various applications.

1. Introduction: Introduction to mechatronic system, evolution, scope and components of mechatronic systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronic design **(3)**

2. Actuators, Sensors and Transducers: Hydraulic, pneumatic and electrical actuators and their system modeling, performance terminology, system modeling of sensors; displacement, position

and proximity sensors, velocity and acceleration sensors, flow sensors, force sensors, temperature sensors, ultrasonic and fibre-optic sensors, selection of sensor, piezo-electric sensors. **(6)**

3. Hardware Components: Number systems in Mechatronics, binary logic, Karnaugh map minimization, transducer signal conditioning process, principals of analogue and digital signal conditioning, protection, filtering, operational and instrumentation amplifiers and their gains, analogue to digital and digital to analogue conversion, multiplexers, pulse modulation. **(6)**

4. Programmable Logic Controller: Review of logic gates, basic structure, features, input/output processing, programming, functional block diagram (FBD), ladder diagram, logic functions, latching, sequencing, jumps, internal relays, counters, shift registers, master and jump control, data handling, data movement, data comparison, arithmetic operations, code conversion, analog input and output, applications for automation, diagnostics and condition monitoring. **(6)**

5. Microcontroller: Comparison between microprocessor and microcontroller, organization of microcontroller system, architecture of MCS 51 controller, pin diagram of 8051, addressing modes, programming of 8051, interfacing input and output devices, interfacing D/A converters and A/D converters, Various applications for automation and control purpose. **(6)**

6. Real-Time Interfacing: Introduction, Elements of Data Acquisition and Control System, Overview of I/O Process, Installation of the I/O Card and Software, Installation of the application Software, Examples, Over framing. **(4)**

7. Advanced Applications in Mechatronics: Mechatronic control in automated manufacturing, Artificial Intelligence in mechatronics, Fuzzy Logic application in Mechatronics, Microsensors in Mechatronics, Case studies of Mechatronic systems. **(5)**

TERM WORK

1. Minimum Three exercises on analog-digital trainer to study fundamentals of digital electronics
2. Minimum three programs on PLC for system automation involving of interfacing of sensors and actuators,
3. One exercise on interfacing of sensors and actuators with microcontroller
4. At least two exercises on a total Mechatronic System Design for applications like packaging, loading/unloading, pick and place etc.

REFERENCE BOOKS

1) Mechatronics, 3/e --- W. Bolton (Pearson Education)
2) Mechatronics -Dan Necsulescu (Pearson Education)
3) The 8051 Microcontroller: Architecture, Programming and Applications, 2/e—Kenneth J. Ayala (Penram International)

4) Mechatronics: Principles, Concepts and Applications - N.P.Mahalik (TMH)
5) Introduction to Mechatronics & Measurement Systems – David G. Alciatore & Michael B. Histand (TMH)
6) Process Control & Instrumentation Technology –Critis D. Johnson (Pearson Education)
7) Mechatronics System Design - Devdas Shetty, Richard A. Kolk (Thomson)
8) Computer Control of Manufacturing Systems - Yoram Koren (McGraw Hill)
9) Automated Manufacturing Systems: Sensors, Actuators - S. Brain Morriss (McGraw Hill)
10) Industrial Automation – David W. Pessen (John Wiley & Sons)
11) 99 Examples of Pneumatic Applications – FESTO Controls Pvt. Ltd. Bangalore.
12) Modular Pick and Place Device– FESTO Controls Pvt. Ltd. Bangalore.
13) Rationalization with Handling Technology– FESTO Controls Pvt. Ltd. Bangalore.
14) Rationalization with Small Workpiece Feeding- FESTO Controls Pvt. Ltd. Bangalore.
15) Sensors for Handling & Processing Pechnology- FESTO Controls Pvt. Ltd. Bangalore.
16) Sensors in Production Engg. - FESTO Controls Pvt. Ltd. Bangalore.
17) Handbook of Industrial Automation – Richard L. Shell & Ernest L. Hall (Marcel Decker Inc.)
18) Programmable Logic Controllers" Programming Methods and Applications (with CD Rom) – Jack R. Hackworth & Fredrick D. Hackworth,Jr.(Pearson Education).

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

5. ELECTIVE I - 2. TECHNOLOGY MANAGEMENT

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hours per week	Theory Paper: 100 marks
Practical: 2 hrs per week	Term work: 25 marks

1. Concepts of Technology Management: Description, Scope & Implications, Its relation to business management, systems Holistic Model of Management of Technology (MOT), Operational and Management Issues, Classification of Technology, Technology cycle, Industry-Institute partnership for targeted basic research. **(6)**

2. Strategic Management of Technology: Technology-strategy relationship, Elements of technology strategy and formulation of a technology strategy, Integration of technology strategy and business strategy for competitive success technology, the environment and sustainable development **(6)**

3. Organizational Aspects of Technology Management: Human dimension of technology and concepts of the entrepreneur, Organizational cultures and structures for promotion of creativity and innovation, the learning organization, the imperative of knowledge management **(6)**

4. Acquiring Technology through Technology Transfer: Definition, Source, Model of TT, System of TT with Public and Private Enterprises, Success and failure factors in technology transfer **(4)**

5. Acquiring Technology Through Research and Development: **T**he concepts of invention and innovation, Definition and classifications of research and development, new product development, Challenges in commercializing research results **(4)**

6. Intellectual Property Rights: Patentable and non-patentable inventions, statutory exceptions, Persons entitled to apply for patents.
(4)

7. National innovation systems for facilitating technology-based development Concepts of the national innovation system (NIS) and science and technology infrastructure, Various Government Schemes. **(2)**

8. Analytical Hierarchical Process (AHP): Introduction to AHP, self AHP for Technology Selection cases like Information Technology – Software & Hardware, Machine Tools, and Industrial Products. **(4)**

TERM WORK:

It shall consist of at least six assignments based on the syllabus, including Case Studies using Optimization & Simulation Software.

REFERENCE BOOKS :

1.Hand Book of Technology Management, by Gerard H. Gaynor, McGraw Hill.

2.Strategic Management of Technological Innovation, 2/e (SIE)

Authors: SCHILLING, MELISSA, Tata McGraw Hill Division: Higher Education
ISBN-13: 978-0-07-066712-9 ISBN-10: 0070667128 ©2007 | 2nd Edition,

3.Strategic Management Tata McGraw Hill Authors: Pearce, John; ROVINSON, RICHARD Division: Higher Education ISBN-13: 978-0-07-060393-6
ISBN-10: 0070603936 ©2005 | 9th Edition | 720 pages

4.Change Management. Tata McGraw Hill Authors: Sharma, Radha Division: Higher Education ISBN-13: 978-0-07-063586-9 ISBN-10: 0070635862 ©2006 | 1st Edition.

5.Business Policy And Strategic Management, 2E. Tata McGraw Hill Authors: Kazmi, Azhar Division: Higher Education ISBN-13: 978-0-07-044470-6
ISBN-10: 0070444706 ©2001 | 2nd Edition | 648 pages , Softcover

6.The Management Of Intellectual Property, by Satyawrat Ponkshe, Ponkshe & Bhate Publications, Pune.

7.Creating Breakthrough Products : Innovation from Product Planning to Program Approval, 1/e by Jonathan Cagan Craig M. Vogel Pearson Education ISBN 8129704927

8.Strategic Management of Technology and Innovation by Robert A. Burgelman, Clayton M. Christensen, Steven C. Wheelwright, and Modesto A. Maidique

9.Strategic Human Resource Management by Greer.

10.Managing Technical People by Humphrey, Pearson.

11.Product Design & Development by Karl T. Ulrich & Steven Eppinger, Tata McGraw Hill.

M.E. (CAD/CAM/CAE) Semester– I (Modified)

5. ELECTIVE I - 3. TRIBOLOGY & SURFACE ENGINEERING

Teaching Scheme:	**Examination Scheme:**
Lectures: 2 Hrs/ Week	Theory Paper (4 Hours): 100 marks
Practical: 2 Hrs/ Week/ Batch	Term Work: 25 marks

SECTION I: TRIBOLOGY

1. Friction Wear and Corrosion: Theory of friction- sliding and rolling friction, Tabor's model of friction, Friction properties of metallic and non metallic materials, friction in extreme conditions, Wear, types of wear, mechanisms of wear, wear resistant materials, Mechanisms and types of corrosion, Measurement and testing of Friction, Wear and Corrosion, Prevention of wear and Corrosion. **(5)**

2. Lubrication Theory: Lubricants and their physical properties, lubricants standards, Lubrication regimes, Hydrodynamic lubrication, Reynolds equation, Thermal, inertia and turbulent effects, Elasto, Plasto and magneto hydrodynamic lubrication, Hydrostatic, Gas lubrication. Design of fluid film bearings, Design of air bearing and gas bearing. **(9)**

3.Tribo Measurement and Instrumentation: Surface topography measurements, Electron microscope, Laser method, Instrumentation, International Standards, Bearing performance measurements, Bearing Vibration Measurement **(4)**

SECTION II: SURFACE ENGINEERING.

4. Introduction to Surface Engineering: Concept and Scope of Surface Engineering, Mathematical modeling and manufacturing of surface layers, The solid surface-geometrical , mechanical and physico chemical concept, Three dimensional structure of surface, The superficial layer and its parameters. **(4)**

5. Surface Engineering for Wear and Corrosion Resistance: Diffusion Coatings, Electro and Electroless platings, Hot dip coating, Metal Spraying, Cladded coatings, Crystallizing coatings, Flame and arc processes, Conversion coatings, selection of coatings for wear and corrosion resistance, Potential properties and parameters of coatings. **(8)**

6. Thin Layer Engineering Processes: Laser and electron beam hardening, its process parameters and their effects, Physical vapour deposition, Thermal evaporationArc vapourisation, Sputtering, Chemical vapour deposition, ion implantation technique,

Coating of tools, TiC, TiN, Al_2O_3 and Diamond coating properties, applications of thin Coatings. **(8)**

TERM WORK:

1. Measurement of Friction sliding / Rolling friction - case study
2. Measurement of wear of cutting tool
3. Measurement of corrosion – a case study.
4. Measurement of a bearing performance.
5. Study of general characteristics of superficial layer obtained by Machining.
6. Industrial visit to study techniques of coating – case study.
7. Case study of Physical Vapour deposition method.
8. Case study of Chemical vapour deposition method.

REFERENCE BOOKS:

1. Hulling J. " Principles of Tribology" Mc Millan, 1984
2. Williams J.A. "Engineering Tribology" Oxford University press, 1994.
3. Davis J. "Surface Engineering for corrosion and Wear Resistance", Woodhead Publishing, 2001.
4. Tadausz Burakowski, "Surface Engineering of Metals: Principles, Equipments, Tehnologies" Taylor and Francis.

Web References:

1 http://www.csetr.org

2. http://www.bstsa.org

3. http://www.sea.org.

M.E. (CAD/CAM/CAE) Semester-I (Modified)

5.ELECTIVE I – 4. MEMS & NANOTECHNOLOGY

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs / Week	Theory Paper: 100 marks
Practical: 1 Hr. / week	Term Work: 25 marks

Course Objective:

To understand the concepts and context of MEMS and nanotechnology.

1. Introduction: Micro-Electro-Mechanical Systems (MEMS), Microsystems and their products, miniaturization, applications, mechanical MEMS, thermal MEMS, micro-opto electro-mechanical systems, magnetic MEMS, radio frequency (RF) MEMS, micro fluidic systems, bio and chemo devices, Nanotechnology – definition, nanoscale, consequences of the nanoscale for technology and society, need and applications of nano electromechanical systems (NEMS) **(4)**

2. Micro Fabrication Processes & Materials: Materials for MEMS – substrate and wafers, silicon as a substrate material, crystal structure, single crystal and polycrystalline, mechanical properties, silicon compounds, silicon piezo-resistors, gallium arsenide, quartz, piezo-electric crystals, polymers, packaging materials; **Fabrication Processes** – Bulk micromanufacturing, photolithography, photoresists, structural and sacrificial materials, X-ray and electron beam lithography, Thin film deposition – spin coating, thermal oxidation, chemical vapour deposition (CVD), electron beam evaporation, sputtering; Doping – diffusion, ion implantation; Etching – wet etching, dry etching; Surface micromachining, bulk vs. surface micromachining; Wafer bonding – glass-frit, anodic and fusion bonding; LIGA process and applications. **(8)**

3. Microsensors and actuators: Sensing and actuation, Chemical sensors, Optical sensors, Pressure sensors, Thermal sensors – thermopiles, thermistors, micromachined thermocouple probes, thermal flow sensors, MEMS magnetic sensor, Piezoelectric material as sensing and actuating elements – capacitance, piezomechanics, Piezoactuators as grippers, microgrippers, micromotors, microvalves, micropumps, microaccelerometers, microfluidics, shape memory alloy based optical switch, thermally activated MEMS relay, microspring thermal actuator, data storage cantilever. **(6)**

4. Microsystem Design: Design constraints and selection of materials, selection of manufacturing process, selection of signal transduction technique, electromechanical system and packaging. **(4)**

5. Nanomaterials: Molecular building blocks to nanostructures – fullerenes, nanoscaled biomolecules, chemical synthesis of artificial nanostructures, molecular switches and logic gates, nanocomposites; Carbon nanotubes - structure, single walled, multi walled, properties of carbon nanostructures and their synthesis, Potential applications of nano-structures. **(8)**

6. Nanofinishing Techniques: Abrasive flow machining, magnetic abrasive finishing, magnetorheological finishing, elastic emission machining, ion beam machining, chemical mechanical polishing, Nanomanipulation, Nanolithography, Top-down versus bottom –up assembly, Visualisation, manipulation and characterization at the nanoscale; Applications - in Energy, Tribology, Informatics, medicine, etc **(8)**

TERM WORK

It shall consist of six exercises based on the syllabus.

REFERENCE BOOKS:

1. Bharat Bhushan (Ed.), (2004), Handbook of Nanotechnology, Spinger-Verlag Berlin Heidelberg New York, ISBN 3-540-01218-4

2. Hsu, Tai-Ran, (2003), MEMS & MICROSYSTEMS: Design & Manufacture, TMH, ISBN:0-07-048709-X

3. Mahalik, N. P., (2007), MEMS, TMH, ISBN: 0-07-063445-9

4. Mahalik, N.P. (Ed.) (2006), Micromanufacturing & Nanotechnology, Springer India Pvt. Ltd., ISBN: 978-81-8128-505-8 (Distributed by New Age International, New Delhi)

5. Nanosystems: Molecular Machinery, Manufacturing & Computation, K E Drexler, (Wiley), (1992), ISBN 0471575186

6. P.Rai- Choudhury, Handbook of Microlithography, Micromachining & Microfabrication, SPIE,1997.

7. David Ferry, Transports in Nanostructures, Cambridge University Press, 2000.

8. Poole, Charles & Owen, Frank J., - Introduction to Nanotechnology, Wiley (India) Pvt. Ltd. ISBN: 978-81-265-10993

9. Various Internet resources: www.nanotechweb.org, www.nano.gov, www.nanotec.org.uk

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

Elective I - 5. DESIGN & DEVELOPMENT OF CAD/CAM/CAE SOFTWARE

Teaching Load:

Lectures 3 Hrs/ week

Practical: 2 Hrs/ Week

Examination Scheme:

Theory: 100 marks

Term work: 25 marks

Course Objective:

To understand the methodologies for development of CAD/CAM/CAE Software and its customization.

1. **Introduction to Software Development:** Customization, Application Programming Interface (API), macros, scripts. **(4)**
2. Tools for Customization: Object Oriented Programming (OOP), OLE interfaces in CAD/CAM software, Use of general programming interfaces like VB, VBS, VC++, JAVA, OpenGL programming and System dependent programming interfaces like, Visual LISP (AutoCAD), GRIP (Unigraphics), Pro-Programming (Pro-Engineer), CATIA, SOLIDWORKS etc. **(4)**
3. Computer-based System Engineering: System engineering process, Software product development life cycle, software processes, software development project management, software prototyping **(8)**
4. Rapid Development: Core issues in rapid development, rapid development languages, life cycle planning and customer oriented development **(4)**
5. Solid Modeling Algorithms: Euler operations, basic solid modeling algorithms **(4)**
6. Automated Solid Modeling using Customization: Creating 2D, 3D and solid entities through API, Editing 2D, 3D and solid entities through API, Design and development of user interfaces- icons, menus, dialog boxes, integrating databases with CAD, creating bill of material or parts list, automated assembly modeling through customization, automated drafting and dimensioning using customization, creating automated animations using API and animation software. **(8)**
7. Parametric Modeling: Computer Aided Process Planning, Parametric Modeling**(4)**

Term Work:

Minimum six exercise based on the above syllabus.

Reference Books:

1. Rapid Development,- Steve McConnel, Microsoft Press
2. Software Engineering – Ian Sommerville, Pearson Education
3. Computer Gtraphics – Foley, Van Dam, et al, Pearson Education
4. Open GL Programming Guide – Mason Woo et al,
5. Advanced AutoCAD – George Omura
6. Customizing AutoCAD – Shyam Tickoo, Thomson Learning
7. CATIA - Shyam Tickoo, Thomson Learning
8. Solid Modelling – Martti Mantilya, Computer Science Press
9. Solid Works API Using VB and C++ - Custom Programming Unlimited LLC
10. GRIP Programming Manuals for Unigraphics – Vol. I & II
11. User Function Programming Manuals for Unigraphics– Vol. I, II & III
12. User Manuals for CATIA

M.E. (CAD/CAM/CAE) Semester– I (Modified)

5. Elective I - 6. ADVANCED MATERIALS & PROCESSING

Teaching Load:	**Examination Scheme**
Lectures 3 Hrs/ week	Theory: 100 marks
Practical: 2 Hrs/ Week	Term work: 25 marks

Objective:

1. To familiarize the students with latest developments in material science and materials to cope up with requirements of industry.
2. To familiarize the students with developments in non conventional manufacturing Processes

SECTION I

1. **Review of Engineering Materials**- metals, alloys- ferrous and non-ferrous, plastics and polymers, ceramics and composites. Dual phase steels, micro alloyed steels, High strength low alloy steels, transformation inducted plasticity (TRIP) steels, Maraging steels. Heat treatment of ferrous and non ferrous alloys for modification of structure and properties. **(3)**
2. **Modern materials**- Compositions, properties and applications of: Inter-metallics, Ni and Ti aluminides, smart materials, shape memory alloys, Metallic glass- quassi crystals, Dielectrics, semi conductors, conductors & super conducting materials. Magnetic and photoelectric materials, optical materials, Bio materials, micro electronic materials and nano materials. **(4)**
3. **Non Metallic Materials**- Polymer materials, formation of polymer structures, production techniques of fibers, foams, adhesives and coatings. Structure, properties and applications of engineering polymers. Advanced structural ceramics, WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN and diamond- properties, processing and applications. **(4)**
4. **Composites**: **Fibers**-glass, boron, carbon, organic, ceramic and metallic fibers- **Matrix materials**- polymers, metals and ceramics. Processing of polymer matrix composites: open mould process, bag molding, compression molding with BMC and SM- filament winding, pultrussion- centrifugal casting, injection molding, applications of PMC's. Processing of metal matrix polymers: solid state fabrication techniques- diffusion bonding, powder metallurgy techniques, plasma spray, chemical and physical vapor deposition of matrix on fibers, Liquid state fabrication methods, Infiltration, squeeze casting, Rheo casting, compo casting. Applications of MMC's. **(6)**

5. **Selection of Materials:** Motivation for selection, cost basis and service requirements- selection for mechanical properties, strength, toughness, fatigue and creep. Selection for surface durability, corrosion and wear resistance. Relationship between materials selection and processing. Case studies in material selection with reference to aero, automobile, marine, machinery and nuclear applications. **(3)**

SECTION II

6. **Classification and Types of Conventional Manufacturing Processes**- forging, rolling, extrusion, wire drawing, sheet metal processes. Manufacturing automation, Non traditional manufacturing processes. Economics of non

traditional and automated manufacturing. Introduction to micromachining and MEMS. Introduction to coatings and tribology **(4)**

7. **Rapid Prototyping:** Product development cycle & importance of prototyping. Types of prototypes, principles and advantages and different types of generative manufacturing processes, viz. stereolithography, FDM, SLS etc. Factors concerning to RP: consideration for adaptations, advantages, accuracy, economic considerations. **(4)**
8. **Non Conventional Machining Processes**: Introduction and ned for non-conventional machining processes, Principle and theory of material removal. Process parameters, advantages, limitations and applications of ultrasonic machining, laser beam machining and electrochemical machining **(4)**
9. **Special Processes and Electronic Fabrication:** Principles, salient features, advantages and applications of abrasive floor machining, magnetic abrasive finishing, wire EDM, electrochemical grinding, honing, lapping and super finishing.

   Principles, elements, process, advantages, applications and surface preparation etc. of physical vapor deposition, chemical vapor deposition, electro less coating and thermal metal spraying. **(5)**

TERM WORK

Minimum six exercises to be performed based on above topics including at least two industrial visits and their report.

REFERENCE BOOKS

1) "HMT Handbook" – Production Technology (TMH)
2) Willer, "Non- traditional Machining Processes", SME publications.
3) G.F.Benidict, "Advanced Manufacturing Processes", Marcel Dekker Publisher
4) E. Paul DeGarmo, J. T. Black & Ronald A. Kohser, "Materials & Processes in Manufacturing", (PHI)
5) Geoff Eckold "Design & Manufacturing of Composite Structures", (Jaico Publishing House)
6) S. Kalpaljian & Steven R. Schmidt, (Pearson Education) "Manufacturing Processe for Engineering Materials",
7) Krishnan K.Chawla, "Composite Material Science and Engineering", Springer- Verlog, 1987
8) Agarwal D & Brontman L.J., "Analysis & Performance of Fibre Composites", John Willey Publications, 1990

9) Mallik P.K. & Newman S.,"Composite Materials Technology", Henser Publications, 1990
10) Charles J A, Crane F.A.A. & Furness J A G ,"Selection and use of Engineering Materials", (3/e), Butterworth – Heiremann – 1977
11) "Materials and their applications", (4/e)- Jaico- 1999
12) "Non Conventional Machining", – P.K.Mishra (IIT, Kharagpur), Narosa Publishing House
13) "Manufacturing Science" - A. Ghosh and Malik – Affiliated East West Press Pvt. Ltd.
14) " Physical Metallurgy" – Vijendra Singh (Standard Publishers Distributors, New Delhi)
15) "Materials Handbook", (15/e) - Brady, George S.; Clauser, Henry R. & Vaccari, John A., McGraw Hill Handbooks.

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

6. CAD/CAM Laboratory

Teaching Scheme:

Practical: 2 Hrs/ Week

Examination Scheme:

Term Work: 50 marks

Practical: 25 marks

1. Introduction to Modeling software :
- 2D drawing and drafting using sketcher workbench – 2 drawings

- 3D modeling and drafting using 3D features – 5 models
- Assembling and drafting of 2 assemblies with interference checking.
- Surface modeling – 4 exercises

2. Computer aided manufacturing:

- CNC Lathe – 4 exercises
- CNC Machining Center – 4 exercises
  Generation of tool path, generation of NC code, Optimization of tool path

(to reduce machining time) using any CAM software

3. Co-ordinate Measuring Machine:

Case study: Inspection of a component using different probes, generation of report and interface (for example – Gears, Housings, Flywheels, Walls of machine structure, etc.)

Note- 1.The term- work will be accessed on the basis of completion of above assignments and submission of report.

2. Practical examination: Duration 3 hours, Candidate will carry out one exercise in modeling and one exercise in CNC part programming/ simulation/ manufacturing, followed by oral examination.

M.E. (CAD/CAM/CAE) Semester:– I (Modified)

7. Design and Analysis Laboratory – I

Teaching Scheme:

Practical: 2 Hrs/ Week

Examination Scheme:

Term Work: 25 marks

Oral / Practical: 25 marks

Minimum eight assignments are to be completed on following area using appropriate software.

1. Structural Analysis
2. Thermal Analysis
3. Fluid Flow Analysis
4. Coupled Field Analysis
5. Modal Analysis

- Minimum two problems shall be solved with hand calculations.
- In addition to above a visit to some facility where any of the above is actually used to prepare report of the same.
- Term work shall be assessed on the basis of completion of above assignments and submission of reports.
- Practical examination: Duration 3 hours – Each candidate shall carry out analysis using suitable FEA software followed by oral examination.

M.E. (CAD/CAM/CAE) Semester– I (Modified)

8. Seminar – I

Teaching Scheme:

Practical: 1 Hour/ Week

Examination Scheme:

Term Work: 25 marks

Seminar - I should be based on the literature survey on any topic relevant to CAD/CAM/CAE. It may be leading to selection of a suitable topic of dissertation.

Each student has to prepare a write-up of about 25 pages. The report typed on A4 sized sheets and bound in the necessary format should be submitted after approved by the guide and endorsement of the Head of Department.

The student has to deliver a seminar talk in front of the teachers of the department and his classmates. The Guide based on the quality of work and preparation and understanding of the candidate shall do an assessment of the seminar.

M.E. (CAD/CAM/CAE) Semester– II (Modified)

1. MANUFACTURING SYSTEMS DESIGN

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

1. Fundamentals: System concept, Hierarchical structure, System design, Decision making procedure, System types in manufacturing environments;

Manufacturing Systems: Structural aspects, transformational aspects, procedural aspects, integrated manufacturing systems; Modes of Production- Jobbing/Intermittent/ Continuous; Mass Production- Economies of Scale, Optimum production scale, Mass Customization; Multi-Product Small Batch Production- Economies of Scope with Diversification; Logistic Systems- Material flow: conversion / transportation / storage **(8)**

2. Product / Process Planning and Design: Product Life Cycle, Planning of a new product, Product Design Aspects, Design cost considerations, Concurrent Engineering; Process and Operation Design- Computer Aided Process Planning, Optimum routing analysis using Dynamic Programming and Network Techniques, Criteria for line balancing. **(5)**

3. Manufacturing Optimization: Criteria for Evaluation, Optimization of single stage manufacturing- Unit production time and cost; Optimization of multistage manufacturing system- Scope, basic mathematical models; Cost Estimating- Classical metal cutting cost analysis, Industrial cost estimation practices, Estimating material, setup and cycle times. **(5)**

4. Information Systems in Manufacturing: Database structures, hierarchical, network, Relational- concepts, keys, relational operations, query languages; Shop Floor Data Collection Systems- Types of data, on-line and off-line data collection, Automatic data collection systems.

(6)

5. Computer Simulation in Manufacturing System Analysis: Characteristics, Simulation Models, applications of probability and statistics;

Design and evaluation methodology of manufacturing systems, General design framework, Analysis of situation, Setting objectives, Conceptual modeling, Detailed design, Evaluation and Decision.
(7)

6. Modern approaches in Manufacturing: Cellular Manufacturing- Group Technology, Composite part, Rank Order Clustering Technique, Hollier method for GT cell layouts; Flexible Manufacturing- Concept, components, architecture; Lean Production- concept, principles, Agile Manufacturing- concept, principles and considerations for achieving agility. **(7)**

TERM WORK:

Minimum Six exercises from the following:

1. Case Study of a manufacturing system in a small / medium organization.
2. Exercise on Concurrent Engg., Optimum routing analysis, Line Balancing
3. Exercise on Optimization of Single stage / Multi stage manufacturing system
4. Cost estimation of manufacturing a medium complex component of an assembly.
5. Creation of a relational database for a module of a manufacturing system, use of a suitable query language and generation of reports
6. Exercise on designing and analysis of GT Cell layouts
7. Simulation and performance testing of a manufacturing system

REFERENCE BOOKS:

1. Katsudo Hitomi, (1998), "Manufacturing Systems Engineering", Viva Low Priced Student Edition, ISBN 81-85617-88-0
2. B. Wu, "Manufacturing Systems Design & Analysis: Context and Techniques" (2/e), Chapman & Hall, UK, ISBN 041258140X
3. Mikell P. Groover, (2002), "Automation, Production Systems and Computer Integrated Manufacturing", (2/e), Pearson Education, ISBN 81-7808-511-9
4. Radhakrishan P., Subramaniyan S. and Raju V., "CAD / CAM / CIM", (3/E), New Age International Publication
5. Luca G. Sartori,(1998), " Manufacturing Information Systems", Addison Wesley Publishing Co.
6. N. Viswanadhan & Y, Narhari, (1998), "Performance Modeling of Automated Manufacturing Systems", Prentice Hall of India
7. Phillip F. Ostwald, Jairo Munez, (2002), " Manufacturing Processes and Systems", John Wiley & Sons (Students' Edition), ISBN 9971-512-34-3
8. Sanjay B. Joshi, Jeffrey S. Smith ,(1994), "Computer Control of Flexible Manufacturing Systems: Research and Development", Springer, ISBN 0412562006, 9780412562006

M.E. (CAD/CAM/CAE) Semester– II (Modified)

2. PRODUCT LIFE CYCLE MANAGEMENT

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

1. INTRODUCTION : Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement.
(5)

2. PRODUCT LIFE CYCLE ENVIRONMENT : Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, Preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM.
(4)

3. PRODUCT DEVELOPMENT PROCESS & METHODOLOGIES : Integrated Product development process - **Conceive** – Specification, Concept design, **Design** - Detailed design, Validation and analysis (simulation), Tool design, **Realize** - Plan manufacturing , Manufacture, Build/Assemble , Test (quality check) , **Service -** Sell and Deliver , Use , Maintain and Support, Dispose. Bottom-up design, Top-down design, Front loading design workflow, Design in context, Modular design. **Concurrent engineering** - work structuring and team deployment - Product and process systemization - problem, identification and solving methodologies. Product Reliability, Mortality Curve. Design for Manufacturing, Design for Assembly. Design for Six Sigma. **(7)**

4. PRODUCT MODELLING : Product Modelling - Definition of concepts - Fundamental issues - Role of Process chains and product models -Types of product models - model

standardization efforts-types of process chains - Industrial demands.
(5)

5. TYPES OF ANALYSIS TOOLS : Design for manufacturing - machining - casting and metal forming - optimum design - Design for assembly and disassembly - probabilistic design concepts - FMEA - QFD - Taguchi Method for design of experiments -Design for product life cycle. Estimation of Manufacturing costs, Reducing the component costs and assembly costs, Minimize system complexity.
(5)

6. PRODUCT DATA MANAGEMENT (PDM) TECHNOLOGY - Product Data Management – An Introduction to Concepts, Benefits and Terminology, CIM Data. PDM functions, definition and architectures of PDM systems, product data interchange, portal integration, PDM acquisition and implementation.
(5)

7. RECENT ADVANCES : Intelligent Information Systems - Knowledge based product and process models - Applications of soft computing in product development process - Advanced database design for integrated manufacturing.
(4)

TERM WORK :

It shall consist of hands on case assignments on PLM software. It shall also include the eight assignments based on the entire syllabus.

REFERENCES :

1. Grieves, Michael. *Product Lifecycle Management*, McGraw-Hill, 2006. ISBN 0071452303

2. Product Life Cycle Management - by Antti Saaksvuori, Anselmi Immonen, Springer, 1st Edition (Nov.5, 2003)

3. Stark, John. *Product Lifecycle Management: Paradigm for 21st Century Product Realisation*, Springer-Verlag, 2004. ISBN 1852338105

4. Product Design & Process Engineering, McGraw Hill – Kogalkusha Ltd., Tokyo, 1974.

5. Product Design & Development – by Kari Ulrich and Steven D. Eppinger, McGraw Hill International Edns, 1999.

6. Effective Product Design and Development – by Stephen Rosenthol, Business One Orwin, Homewood, 1992 ISBN 1-55623-603-4.

7. Burden, Rodger *PDM: Product Data Management*, Resource Pub, 2003. ISBN 0970035225

8. Clement, Jerry; Coldrick, Andy; & Sari, John. *Manufacturing Data Structures*, John Wiley & Sons, 1992. ISBN 0471132691

9. Clements, Richard Barrett. Chapter 8 ("Design Control") and Chapter 9 ("Document Control") in *Quality Manager's Complete Guide to ISO 9000*, Prentice Hall, 1993. ISBN 013017534X

10. Crnkovic, Ivica; Asklund, Ulf; & Dahlqvist, Annita Persson. *Implementing and Integrating Product Data Management and Software Configuration Management*, Artech House Publishers, 2003. ISBN 1580534988

11. Garwood, Dave. *Bills of Materials for a Lean Enterprise*, Dogwood Publishing Co., 2004. ISBN 0962111848

12. Fan, D. (Ed.), Virtual Reality for Industrial Applications, Springer.

M.E. (CAD/CAM/CAE) Semester– II (Modified)

3. INDUSTRIAL AUTOMATION AND ROBOTICS

Teaching Scheme:

Lectures: 3 Hrs/ Week

Examination Scheme:

Theory Paper: 100 marks

1. Introduction: Automated manufacturing systems, fixed /programmable /flexible automation, need; Basic elements of automated systems- power, program and control; Advanced automation functions, Levels of automation; Industrial control systems in process and discrete manufacturing industries, Continuous and discrete control; Low cost automation, Economic and social aspects of automation. **(7)**

2.Transfer Lines: Fundamentals, Configurations, Transfer mechanisms, storage buffers, control, applications; Analysis of transfer lines without and with storage buffers. **(4)**

3.Assembly Automation: Types and configurations, Parts delivery at workstations- Various vibratory and non-vibratory devices for feeding and orientation, Calculations of feeding rates, Cycle time for single station assembly machines and partially automated systems; Product design for automated assembly. **(5)**

4. Fundamentals of Industrial Robots: Specifications and Characteristics, Basic components, configurations, Criteria for selection, Various industrial applications. **(4)**

5. Robotic Control Systems: Drives, Robot Motions, Actuators, Power transmission systems; Robot controllers, Dynamic properties of robots- stability, control resolution, spatial resolution, accuracy, repeatability, compliance. **(5)**

6. Robotic End Effectors and Sensors: Transducers and sensors- sensors in robotics and their classification, Touch (Tactile) sensors, proximity and range sensors, force and torque sensing, End Effectors- Types, grippers, Various process tools as end effectors; Robot-End effector interface, Active and passive compliance, Gripper selection and design. **(7)**

7. Robot Programming: Lead through method, Robot program as a path in space, Methods of defining positions in space, Motion interpolation, branching; Textual robot programming languages. **(4)**

REFERENCE BOOKS:

1. Groover, M.P., (2004), "Automation, Production Systems & Computer Integrated Manufacturing" 2/e, (Pearson Edu.) ISBN: 81-7808-511-9
2. Morris, S.Brian (1994), "Automated Manufacturing Systems", (McGraw Hill) ISBN: 0-07-113999-0
3. Pessen, David W.(1990), "Industrial Automation, Circuit Design & Components", (John Wiley & Sons, Singapore)
4. Groover, M.P.; Weiss, M.; Nagel, R.N. & Odrey, N.G. "Industrial Robotics, Technology, Programming & Applications", (McGraw Hill Intl. Ed.) ISBN:0-07-024989-X
5. Fu, K.S.; Gonzalez, R.C. & Lee, C.S.G. "Robotics-Control, Sensing, Vision and Intelligence", (McGraw Hill Intl. Ed.) ISBN:0-07-100421-1
6. Keramas, James G. (1998), " Robot Technology Fundamentals",(CENGAGE) ISBN: 981-240-621-2

7. Noff, Shimon Y. "Handbook of Robotics", (John Wiley & Sons)
8. Niku, Saeed B. (2002), "Introduction to Robotics, Analysis, Systems & Applications" , (Prentice Hall of India)
9. Koren, Yoram "Robotics for Engineers", (McGraw Hill)
10. Schilling, Robert J.(2004), "Fundamentals of Robotics, Analysis & Control", (Prentice Hall of India), ISBN: 81-203-1047-0

M.E. (CAD/CAM/CAE) Semester– II (Modified)

4. OPTIMIZATION TECHNIQUES

Teaching Scheme:

Lectures: 3 Hrs/ Week

Tutorial: 1 Hour per week

Examination Scheme:

Theory Paper: 100 marks

Term Work: 25 Marks

1. **Classical Optimization Techniques:** Single-variable and Multi-variable Optimization, Hessian Matrix, Saddle Point, Lagrange Multipliers Method, Kuhn-Tucker Conditions **(3)**
2. **Single-variable Optimization Techniques:** Unrestricted Search, Exhaustive Search, Dichotomous Search, Interval-halving Method, Fibonacci Method, Golden-section Method, Quadratic Interpolation Method, Newton Method, Quasi-Newton Method, Secant Method **(12)**
3. **Multi-variable Optimization Techniques:** Evolutionary Optimization Method, Simplex Search Method, Pattern Search Method, Conjugate Direction Method, Steepest Descent Method, Newton's Method, Conjugate Gradient Method, Davidon-Fletcher-Powell Method **(12)**
4. **Constrained Optimization Techniques:** Interior Penalty Function Method, Exterior Penalty function Method **(4)**
5. **Search Techniques**: Genetic Algorithm, Simulated Annealing, Artificial Neural Networks **(3)**
6. **Theory of Constraints:** Introduction to TOC, Optimized Production Technology (OPT), Nine principles of OPT, Five Focusing Steps (The 5FS) of TOC, Capacity Constrained Resources and the Time Buffer, Modeling the Time Buffer, Modeling Return-On-Investment (ROI) in TOC, Comparison of TOC and Local Optimization Approaches **(3)**

TERM WORK

Minimum Six assignments based on the above syllabus.

REFERENCE BOOKS:

- Deb K (2004). Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India.
- Dennis J Jr, Schnabel R (1996). Numerical Methods for Unconstrained Optimization and Nonlinear Equations, Society for Industrial and Applied Mathematics.
- Rao S (1996). Engineering optimization, Theory and Practice, New Age International Publishers
- Ravindran A, Ragsdell K and Reklaitis G (2006). Engineering Optimization: Methods and Applications, 2nd edition, John Wiley and Sons Inc.
- Goldratt, E. M. and Cox, J. (2004). The Goal: A Process of Ongoing Improvement. 3rd Edition, North River Press. ISBN-10: 0884271781, ISBN-13: 978-0884271789
- Dettmer, H. William (1997). Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement, American Society for Quality. ISBN 0873893700, 9780873893701

M.E. (CAD/CAM/CAE) Semester– II (Modified)

Elective II- 1. COMPUTATIONAL FLUID DYNAMICS

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

1. Introduction: CFD as the third dimension of fluid mechanics. Numerical Discretization methods such as Finite Difference, FEM and FVM. Why FVM as preferred method in CFD. **(9)**

2. Basic Equations of Fluid Dynamics : Potential flow , Nonlinear Potential flow , Inviscid flows and viscous flows. Navier Stokes Equations. Primitive variable vs. conservation form. Dimensional form vs. Non dimensional form. **(6)**

3. Numerical methods for Convection -Diffusion eqns: Upwinding and central difference schemes. Stability condition in terms of Courant number. **(9)**

4. Numerical Methods for Inviscid Flows: Characteristic form of eqns . Flux difference splitting. Application to 2-D flows such as flow through a nozzle.
(7)

5. Numerical methods for Incompressible flows: The continuity eqn divergence constraint. Poisson eqn. for pressure. Schemes such as SIMPLE due to Patankar and Spalding. **(6)**

TERM WORK:

Exercises (minimum six) using commercially available CFD Software in following areas like -

1. Heat transfer
2. Turbo machinery
3. Aerodynamics
4. Industrial processes involving fluid flow

REFERENCE BOOKS:

1. Computational Fluid Dynamics – The Basics with Applications, John D. Anderson, Jr., McGraw Hill International Editions,
2. Computational Fluid Dynamics - The Finite Volume Method, H. K. Versteeg and W. Malalasekara, Longman Scientific & Technical
3. Computational Fluid Mechanics and Heat Transfer, John C. Tannehill, Dale A. Anderson and Richard H. Pletcher, Taylor & Francis, Reprint 2010.
4. Computational Methods for Fluid dynamics: Vol 1 and 2, C A J Fletcher, Springer Verlag, 1987
5. Numerical Heat Transfer & Fluid Flow, Suhas V. Patankar, Taylor & Francis.
6. Computational Fluid Dynamics Vol 1 and 2, K. A. Hoffmann and S. T. Chiang, Engineering Education System

M.E. (CAD/CAM/CAE) Semester– II (Modified)

ELECTIVE II- 2. QUALITY AND RELIABILITY ENGINEERING

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

SECTION I: QUALITY ENGINEERING

1. Concepts of Quality Engineering, Taguchi's Approach to Quality, On-line and Off-line Quality Control, Difference from Classical Approach, Quality Loss Function, System Design, Parameter Design, Tolerance Design, Causes of Variation, Classification of Parameters, Parameter Design Strategy **(4)**
2. Steps in Robust Design, Quality Characteristics and Objective Functions, Control Factors and their Levels, Noise Factors and Testing Conditions, Planning and Conducting the Experiment **(2)**
3. Response Surface Methodology – First- order and Second-order Models **(8)**
4. Crossed Array Experiments, Signal-to-Noise Ratios **(6)**

SECTION II: RELIABILITY ENGINEERING

1. The Reliability Function, Failure Rate, Hazard Rate, Bath-tub Curve, Relationship between Various Reliability Characteristics **(3)**
2. Component Reliability, Mean-time-to-failure, Time-dependent Hazard Models – Constant-hazard, Linear-hazard, Nonlinear-hazard and Gamma Models **(3)**
3. System Reliability, Two-state Modeling, Series Models, Parallel Models, Series-parallel and Parallel-series Models, *k-out-of-m* Models, Standby Models, Non-series-parallel Models, Fault-tree Approach to System Modeling **(10)**
4. Maintained Systems, Classification of Maintenance Activities: Breakdown, Preventive and Predictive Maintenance, Condition Monitoring, Maintainability and Availability, Reliability-centered Maintenance **(4)**

TERM WORK

Minimum Six assignments based on the entire syllabus.

REFERENCE BOOKS

- Antony J (2003). Design and Experiments for Engineers and Scientists, Butterworth-Heinmann.
- Cochran W and Cox G (2000). Experimental Designs, 2nd edition, John Wiley and Sons Inc.
- Dean A and Voss D (2006). Design and Analysis of Experiments, Springer.
- Jeff Wu C and Hamada M (2000). Experiments: Planning, Analysis and Parameter Design Optimization, John Wiley and Sons Inc.
- Montgomery D (2001). Design and Analysis of Experiments, 5th edition, Wiley.
- Phadke, M (1989). Quality Engineering using Robust Design, Prentice Hall.
- Ross, P (1996). Taguchi Techniques for Quality Engineering, 2nd edition, McGraw Hill.
- Balgurusamy E (2003). Reliability Engineering, Tata McGraw Hill.
- Birolini A (2004). Reliability Engineering: Theory and Practice, 4th edition, Springer.
- Crowder M, Kimber A, Smith R and Sweeting T (1991). Statistical Analysis of Reliability Data, Chapman and Hall.
- Kumamoto H and Henley E (1996). Probabilistic Risk Assessment and Management for Engineers and Scientists, IEEE Press.

Pre-requisites for Quality and Reliability Engineering

Section I:

Experimental design fundamentals, Guidelines for designing experiments, Concepts of replication, blocking and randomization, Statistical techniques in experimentation, Sampling and sampling distributions, Confidence intervals, Inferences about means and variances

Experiments with single factor, Analysis of variance, Fixed effect model – Parameter estimation, Model adequacy checking, Residual plots, Comparing treatment means, Designing and testing contrasts

Factorial design, Two-factor factorial design, The 2^2 design and 2^3 design – Parameter estimation, Model adequacy checking

Section II:

Probability – Concept, Definitions, Rules of probability, Bayesian theorem

Continuous distributions – Normal, Lognormal, Exponential, Gamma, Chi-squared, and Weibull distribution

Discrete distributions – Binomial, Poisson, and Negative binomial distribution

M.E. (CAD/CAM/CAE) Semester– II (Modified)
ELECTIVE II- 3. SYSTEM DYNAMICS AND SIMULATION

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

I] System Dynamics: Learning in and about complex systems, The modeling process. Structure and Behavior of dynamic systems. Causal Loop Diagrams, stocks and flows, dynamics of stocks and flows, dynamics of simple structure. The dynamics of growth: S shaped growth, path dependence, delays. Modeling, decision making, formulating nonlinear relationship, model testing, Case Studies. **(16)**

II] Simulation: System and System Environment: Components of a system, Continuous and discrete systems, Models of a system, Modeling. Random Number Generation: Methods and Tests for random number generation, Random Variable Generation, Simulation of Systems: Simulation of continuous system, Simulation of discrete system, Simulation of event occurrences using random numbers. Simulation of component failures using Exponential and weibull models. Input modeling and output analysis, Simulation Applications: Single server queue problems and multi-server queue problems, Inventory system, Network problem, Shop Floor problems in a manufacturing environment. **(22)**

TERM WORK

It shall consist of six exercises based on the syllabus. Use of software is essential.

REFERENCES BOOKS

1. Banks J., Carson. J.S., and Nelson B.L., Discrete Event System Simulation, Prentice Hall of India, New Delhi, 1996.
2. Gottfried B.S., Elements of Stochastic Process Simulation, Prentice Hall, London, 1984.

1. Geoffrey Gordon., System Simulation, Prentice Hall of India, 1984.
2. Narsingh Deo., System simulation with Digital Computer, Prentice Hall of India, 1979

M.E. (CAD/CAM/CAE) Semester– II (Modified)

ELECTIVE II- 4. ARTIFICIAL INTELLIGENCE

Teaching Scheme:

Lectures: 3 Hrs/ Week

Practical: 1 Hr/Week

Examination Scheme:

Theory Paper: 100 marks

Term Work: 25 marks

Course Objective

To study the concepts, techniques and applications of artificial intelligence.

1. Concept of A.I.: Approaches, Foundations of A.I., Underlying assumptions **(2)**

2. Problem Formulation: Problem solving agents, Components of problem definition, defining the problem as state space approach, Problem characteristics, Production System, searching for solutions, Forward and backward reasoning, means end analysis, Graphs and trees, measuring problem solving performance **(4)**

3. Search Strategies: a)Uninformed (blind) search- breadth first, depth first, and their variations, avoiding repeated states; b) Informed (heuristic) search- heuristic function, Generate and test, Best first search, A* search, Local search algorithms- Hill climbing, Simulated annealing, Branch and bound and Local beam search, **(6)**

4. Knowledge Representation: Simple rational knowledge, Inheritable knowledge, Inferential knowledge, Procedural knowledge, the Frame problem, Propositional logic- Syntax and semantics, well formed formulas (WFF), conversion to clausal form, using FOPL, inference rules, unification, non-deductive inference methods, resolution, forward and backward chaining, the knowledge engineering process, Handling uncertain knowledge, probability propositions, atomic events, unconditional (prior) and conditional (posterior), priority Bayes' rule and its use, Bayesian network, its semantics and inference. **(7)**

5. Learning: Forms of learning, inductive learning, decision tree learning, ensemble learning, Pattern recognition- Introduction, recognition, and classification process, learning classification patterns. **(4)**

6. Knowledge based systems: Expert systems, components, characteristic features of expert systems, rule based system architecture, representing and using domain knowledge, expert system shell, explaining the reasoning and knowledge acquisition, applications. **(5)**

7. A.I. in Robotics: State space search, path selection, AND-OR graphs, means end analysis in a robotic problem, robot problem solving as a production system, robot learning and task planning, symbolic spatial relationship, obstacle avoidance, graph planning. **(5)**

8. Machine Vision: Functions, imaging devices, lighting, A-D conversion, quantization, encoding image storage, image data reduction, segmentation techniques, feature extraction, object recognition, training the vision system, applications. **(4)**

TERM WORK:

1. Minimum six programming exercises using a suitable language (i.e. PROLOG, LISP, C++ etc.) preferably in CAD/CAM related areas
2. One case study on applications of A.I. and E.S. in CAD/CAM or Manufacturing Management

REFERENCE BOOKS:

1. Stuart Russel, Peter Norwig (2003), "Artificial Intelligence : A Modern Approach" 2/e, (Pearson Education)
2. Elaine Rich, Kevin Knight, (1991), "Artificial Intelligence" 2/e, (Tata McGraw Hill)
3. Dan W. Patterson (1999), "Introduction to Artificial Intelligence and Expert Systems" (7th Indian Reprint) (EEE) (Prentice Hall of India)
4. Rex Mauss, Jessica Keyes , "Handbook of Expert Systems in Manufacturing", (McGraw Hill)
5. Groover, Weiss, Nagel, Audrey, "Industrial Robotics- Technology, Programming and Applications"", (McGraw Hill)
6. Fu, Gonzalea and Lee, "Robotics: Control, Sensing, Vision and Intelligence", (McGraw Hill)
7. Conference Proceedings and current journals for case studies and applications.

M.E. (CAD/CAM/CAE) Semester– II (Modified)

ELECTIVE II - 5. AUTOMATIC CONTROL ENGINEERING

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

Course Objective

To study the fundamentals of control engineering theory.

1. Introduction to Automatic Control Systems:-Basic definition, Structure of a feedback systems, closed loop and open loop control systems. Laplace Transformation, Building blocks and transfer functions of mechanical, electrical, thermal and hydraulic systems. Mathematical models of physical systems, control systems components. Systems with dead time, control hardware and their models, Electro-hydraulic valves, hydraulic servomotors, synchros, LVDT, electro-pneumatic valves, pneumatic actuators. **(8)**

2. Basic characteristic of feedback control systems:-Stability, steady state accuracy, transient accuracy, disturbance rejection, insensitive and robustness, Basic models of feedback control systems:-Proportional, integral, derivative and PID, feed forward and multi loop control configurations, stability, concept of relative stability. **(8)**

3. Root locus and frequency response methods, stability in frequency domain, frequency domain methods of design, compensation and their realization in time and frequency domain, improving system performance,. **(8)**

4. Design of Lead lag compensators, OpAmp based and digital implementation of compensators, Tuning of process controllers. (**4)**

5. Introduction to design, sample data control systems, stable variable analysis and design, optimal control systems. **(4)**

6. Introduction to non linear control systems, discrete time systems and Z-Transformation methods, Microprocessor based digital control, State space analysis, Optimal and adaptive control systems. **(5)**

TERM WORK:

Term Work shall consist of four design/control problems solved using MATLAB and three assignments based on the above topics. Additional exercises using Bond Graphs for system modelling are desirable.

REFERENCE BOOKS:

1. F.H.Raven,"Automatic Control Engineering", Third edition, McGraw Hill, 1983.
2. K.Ogata,"Modern Control Engineering", PHI, Estern Economy Edition, 1982.
3. I.J.Nagrath, M.Gopal,"Control Systems Engineering".
4. B.C.Kuo, "Automatic Control Systems".
5. Schaum Series," Theory and Problems of Feedback and Control Systems". (MGH)
6. Miller R.W.,"Servo Mechanism Devices and Fundamentals".
7. Dr.N.K.Jain,"Automatic Control Systems Engineering", Dhanpat Rai Publishing Company.
8. Jack Golten, Andy Verwer, "Control System Design and Simulation", McGraw Hill

M.E. (CAD/CAM/CAE) Semester– II (Modified)

Elective II- 6. CAD/CAM/CAE APPLICATIONS IN METAL FORMING

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

Course Objective

To study the use of computers in metal forming operations: planning and optimization.

SECTION – I

1. Introduction:-Process Modeling, The finite element method, Solid formulation and hollow formation, metal forming and FEM **(2)**

2. Metal forming Processes:-Introduction, Metal forming operations as a system, Classification and Description of metal forming processes, Casting process **(2)**

3. Analysis and Technology in Metal Forming:- Introduction, Flow stress of metals, Friction in metal forming, Temperatures in metal forming, Impression and closed die forging, Hot extrusion of Rods and Shapes, Cold forging and extrusion, Rolling of strip, plate and shapes, Drawing of Rod, wire, shapes and Tubes, Sheet metal forming, fine blanking **(6)**

4. Plasticity and Visco-plasticity: Introduction, Stress, strain and strain rate, The yield criteria, Equilibrium and Virtual work rate principle, Plastic potential and flow rate, Strain Hardening, Effective stresses and Effective strain, Visco-plasticity **(4)**

5. Method of Analysis: Introduction, Upper Bound method, Hills General Method, FEM **(2)**

6. Analysis Technology in Metal Casting: Introduction, Castability of important Ferrous and Non- ferrous metal, Shrinkage, Effect of Temperature, Effect of composition **(3)**

SECTION – II

7. Finite Element Method: Introduction, Finite Element Procedures, Elements and shape function, Element strain rate matrix, Elemental stiffness equation, Numerical integrations, Assemblage and Linear matrix solver, Boundary conditions, Direct / Iteration method, Time investment and Geometry updating, Rezoning **(4)**

8. Plane – Strain Problems: Introduction, Finite Element formulation, Closed die forging with flash, Sheet Rolling, Plate Bending, Side pressing **(3)**

9. Axi-symmetric Isothermal Forging: Introduction, Finite Element formation, Pre-form design method, Die design, Shell nosing at room temperature, Plane strain rolling, Axially Symmetric forging **(4)**

10. Steady State Processes of Extrusion and Drawing: Introduction, Method of Analysis, Bar Extrusion, Bar Drawing, Multi pass bar drawing and Extrusion, Applications to process design **(4)**

11. Sheet Metal Forming: Introduction, Plastic Anisotropy, In-plane deformation process, Axi-symmetric but of plane deformation, Axi-symmetric Punch stretching and deep drawing process, Sheet metal forming of General shapes, Square – cup drawing process **(4)**

12. Metal Casting: Introduction, Casting Design, FEA analysis, Die / pattern Design, Casting Simulation – Gating Design, Die / Pattern manufacture **(3)**

TERM WORK

Minimum **Four** Exercises using suitable software packages for the simulation.

1. Forging simulation to predict die fill load, energy and defect formation for simple components
2. Extrusion simulation to validates design of extrusion dies and process, Simulation of metal flow and heat transfer
3. Casting simulation to predict fluid flow, hot spots- shrinkage, designing of Gating and rising
4. Forging pre-form and Die design and FEA
5. Casting Design and FEA
6. Sheet metal simulation for validating forming feasibility, predict blank sizing, minimizing material scrap, determine wrinkles, splits etc.

REFERENCE BOOKS

1. Mechanical Metallurgy (2/e)– by Dieter (McGraw Hill)
2. Metal Casting – Dr. B. Ravi – (Prentice Hall of India)

3. Metal Forming & Finite Element Method – by Shiro Kobjashi
Oxford University.

4. Technology of Metal Forming Processes, -Surender Kumar (EEE)(PHI)
5. Theory of Plasticity- Amitav Chakraborty, McGraw Hill

M.E. (CAD/CAM/CAE) Semester– II (Modified)

Elective II - 7. RAPID MANUFACTURING

Course Objective

To study the concepts and applications of rapid prototyping and rapid manufacturing.

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 Hrs/ Week	Theory Paper: 100 marks
Practical: 1 Hr/Week	Term Work: 25 marks

1. Introduction to Rapid Manufacturing: Definition of rapid manufacturing (RM), rapid prototyping (RP) and rapid manufacturing, areas of application. **(1)**

2. Design Potential of Rapid Manufacturing: Conventional design for manufacturing and assembly (DFM, DFMA), impact of RM on DFA and DFMA, Geometrical freedom, design complexity/ optimization, parts consolidation, body fitting customization and multiple assemblies manufactured as one, Customer input and customization, CAD environment for RM. **(3)**

3. RM Processes: Liquid based processes, Powder based processes and Solid based processes; RP Processes : Process overviews, STL file Generation, File Verification & Repair, Build File Creation, Part Construction, Part Cleaning and finishing, Process Strength & limitations, Classes of RP systems: 3D Printers, Enterprise Prototyping centers,

Direct digital tooling, Direct digital manufacturing, system classification, Stereo lithography, SL with photo polymerization, SL with liquid thermal polymerization, Selective Laser Sintering, Fused deposition modeling, Laminated object manufacturing, Laser powder forming **(10)**

4. Materials in RM: Issues, viscous flow, photo-polymerization, sintering, infiltration, mechanical properties, Materials for RM processes, Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties; Functionally graded materials (FGM composites), processing technologies for FGMs, laser sintering, thermal and mechanical properties of FGM, Deposition systems and applications, **(6)**

5. Applications of RP & RM: Design, Concept Models, Form and fit checking, Ergonomic Studies, Functional testing, CAD data verification, Automotive applications- Parts of racing cars, Applications in Aerospace industry, Construction industry, Retail industry, Archeology, Paleontology and forensic science, miniaturization. **(5)**

7. Rapid Tooling: Mold making, Metal spraying, Rapid tooling for die, squeeze and permanent mold casting, Rapid manufacturing of sheet metal forming tools, casting pattern plates by rapid tooling, RP for series production investment casting. **(8)**

6. Management Issues of RM: Machine costs for RM, material cost, labour cost, comparison of cost of RM with cost of injection molding; Cost of manufacturing by RM, overheads, stock and WIP, location and distribution, supply chain management in RM **(4)**

TERM WORK

1. Two Assignments on 3SD modeling & STL File generation of industrial components.
2. Study of RP Processes and their parameters
3. Study of 3D printing & its applications
4. Assignment on use of rapid tooling for injection molds
5. Assignment on use of RP for reverse engineering

REFERENCES

1. Rapid Manufacturing: An Industrial Revolution for the Digital Age – Editors N. Hopkinson, R.J.M. Hague and P.M. Dickens, (2006) John Wiley & Sons, Ltd., ISBN-10 0-470-01613-2

1. T. A. Grimm & Associates, Users Guide to Rapid Prototyping, Society of Manufacturing Engineers (SME) ISBN 0872636976

2. Frank W. Liou, Rapid Prototyping & engineering applications, CRC Press, ISBN 978-0-8493-3409-2

3. Rapid Prototyping theory & practice, Manufacturing System Engineering Series, Ali K. Kamarani, Springer Verlag

4. Rapid Prototyping- case book, J. A. McDonalds, C. J. Ryall, Wiley Eastern

5. Rapid & Virtual Prototyping & applications, C. E. Bocking, AEW Rennie, Wiley Eastern

6. Carmen Gabriela BĂCILĂ*, Zoltan-Gabor BAKI-HARI, "The Main Applications of Rapid Tooling," RECENT, Vol. 8, nr. 3a(21a), November, 2007

7. ANNALS of the ORADEA UNIVERSITY. Fascicle of Management and Technological Engineering, Volume VI (XVI), 2007

8. John F. Wallace, David Schwam," Rapid manufacturing of sheet metal forming tools," Case Western Reserve University

9. A. Pereira, J.A. Pérez, J.L. Diéguez, G. Peláez and J.E. Ares, "Design and manufacture of casting pattern plates", by rapid tooling, *Archives of Materials Science, Vol. 29, No. 1-2, 2008* 63

10. Using RP for Series Production Investment Castings, Tom Mueller, Express Pattern

WEBSITES

1. **http:// www_rpl.stanford.edu**
2. **http:// home.utah.edu/**
3. **http:// www.me.psu.edu**
4. **http:// itri.loyola.edu/rp/02**
5. **http:// www.udri.udayton.edu/**

M.E. (CAD/CAM/CAE) Semester– II (Modified)

6. Design & Analysis Laboratory - II

Teaching Scheme:

Practical 2 Hrs./Week

Examination Scheme:

Term Work: 25 Marks

Practical/Oral Examination: 25 Marks

Minimum eight exercises are to be completed on following topics using suitable software packages.

1. Transient Thermal Analysis
2. Dynamic Analysis
3. Non-Linear Analysis
4. Design Optimization through FEA (Two Exercises)
5. Computational Fluid Dynamics (Optional)
6. A Composite project based on Exercises of Design & Analysis Laboratory I and II .

The Term work shall be assessed on the basis of completion of above exercises and submission of report.

Practical Examination duration: 3 Hours

The candidate shall carry out analysis using suitable software package followed by oral examination.

M.E. (CAD/CAM/CAE) Semester– II (Modified)

7. AUTOMATION & SIMULATION LABORATORY

Teaching Scheme:	Examination Scheme
2 Hrs. per week	Term work: 25 marks
	Practical Exam: 25 marks

The laboratory work shall consist of exercises as given below

1) Design of hydraulic / pneumatic circuits for different machine tools, automation projects and their performance testing
2) Study, design / simulation of automation projects in material handling/packaging
3) Exercise on flexible automation using PLC, different sensors and actuators
4) Exercise on control of electrical motors using microcontroller / microprocessor.
5) Simulation of Robotic system for automation using a suitable software

6) Simulation of Electrohydraulic / Electropneumatic circuits using a suitable software (like FESTO PneuSim & HydroSim: Demo versions available on Internet)

- Term work shall be assessed on the basis of completion of above assignments and submission of reports.
- Practical examination: Duration 3 hours – The candidate shall carry out the practical exercise on one of the above topics. It will be followed by an oral examination.

M.E. (CAD/CAM/CAE) Semester– II (Modified)

8. SEMINAR – II

Teaching Scheme:	**Examination Scheme:**
Practical: 1 Hour/ Week	Term Work: 25 marks

Seminar - II should be based on the literature survey on any topic relevant to CAD/CAM/CAE. It may be leading to selection of a suitable topic of dissertation. The report shall contain some contribution by the candidate in the form of experimental results, deductions, compilation and inferences etc.

Each student has to prepare a write-up of about 25 pages. The report typed on A4 sized sheets and bound in the necessary format should be submitted after approved by the guide and endorsement of the Head of Department.

The student has to deliver a seminar talk in front of the teachers of the department and his classmates. The Guide based on the quality of work and preparation and understanding of the candidate shall do an assessment of the seminar.

M.E. (CAD/CAM/CAE) Semester– III (Modified)
(Effective from July 2011)

1. MINI PROJECT

Teaching Scheme: **Examination Scheme**:

Practical: 1 Hour/ Week **Term work: 50 marks**

A Mini Project based on the subjects studied during Semester-I and Semester-II, shall be undertaken and completed by the candidate during vacation after Semester-II. The report of this project shall be submitted in the prescribed format at the beginning of Semester III. It will be approved by the guide and endorsed by the Head of Department. It will be assessed for term work during Semester III, by the evaluation committee(*) appointed by the Head of the Department.

M.E. (CAD/CAM/CAE) Semester– III (Modified)

2. SEMINAR- III

Teaching Scheme:	Examination Scheme:
Practical: 1 Hour/ Week	Term Work: 25 marks
	Oral Examination: 25 Marks

Seminar - III shall be based on topic of the Dissertation Work. It may include literature review, required theoretical input, study and comparison of various approaches for the proposed dissertation work. The candidate shall prepare a report of about 25 pages. The report typed on A4 sized sheets and bound in the prescribed format shall be submitted after approval by the Guide and endorsement of the Head of Department. It will be assessed for term work by the evaluation committee(*) appointed by the Head of the Department.

DISSERTATION

The dissertation work to be carried out individually commences in the Semester III and extends through Semester IV. The topic of dissertation work related should be related to the areas of CAD/CAM/CAE applications. Applications of computer as a tool for conceptualization, design, analysis, optimization, manufacturing, manufacturing planning /management, quality engineering, simulation of products / processes / mechanisms / systems, experimental study, etc. are to be encouraged and preferred.

SYNOPSIS APPROVAL

The Head of the Department shall appoint a committee comprising of the Guide and two experts to review and approve the synopses before submitting them to the University for approval. The candidates shall submit the synopsis to the University authorities for approval in the prescribed format before the due date.

M.E. (CAD/CAM/CAE) Semester– III (Modified)

3. DISSERTATION PHASE I

Teaching Scheme: **Examination Scheme:**

Practical: 2 Hour/ Week **Term Work: 50 marks**

It shall include the problem definition, literature survey, approaches for handling the problem, finalizing the methodology for the dissertation work and design calculations / experimental design etc. A report of the work shall be submitted at the end of Semester III after approval by the Guide and endorsement of the Head of Department. It will be assessed for term work, by the evaluation committee(*) appointed by the Head of the Department, for appropriateness, sufficiency of contents and offer suggestions if any.

M.E. (CAD/CAM/CAE) Semester– IV (Modified)

1. DISSERTATION PHASE II

Teaching Scheme: **Examination Scheme:**

Practical: 4 Hour/ Week **Term Work: 100 marks**

Oral Examination: 100 Marks

The candidate shall submit the detailed report as per the synopsis approved by the university, of the dissertation work in the prescribed format after approval by the Guide and endorsement by the Head of the Department. It will be assessed for term work by the evaluation committee(*)appointed by the Head of the Department, for completion of the proposed work.

(*) Note: The evaluation committee shall consist of the Guide, one senior expert faculty member and the Head of the Department or his/her representative.

########

SHIVAJI UNIVERSITY, KOLHAPUR.

B.O.S. IN PRODUCTION ENGINEERING

EQUIVALENCE FOR M.E.(CAD/CAM/CAE) (Modified) SYLLABUS

AFTER JULY 2010.

Sr. No.	Examination & Subject in Old Syllabus	Examination & Equivalent Subject in Modified Syllabus
Semester - I		
1	Advanced Machine Design	Advanced Machine Design
2	Computer Aided Manufacturing	Computer Aided Manufacturing
3	Finite Element Analysis	Finite Element Analysis
4	Design of Experiments & Research Methodology	Design of Experiments & Research Methodology
5	Elective – I	Elective – I

	1. Mechatronic System Design 2. Technology Management. 3. Tribology & Surface Engineering 4. Nanotechnology 5. Design & Development of CAD/CAM/CAE Software 6. Advanced Materials & Processing	1. Mechatronic System Design 2. Technology Management. 3. Tribology & Surface Engineering 4. MEMS & Nanotechnology 5. Design & Development of CAD/CAM/CAE Software 6Advanced Materials & Processing
6	CAD/CAM Laboratory	CAD/CAM Laboratory
7	Design & Analysis Laboratory-I	Design & Analysis Laboratory-I
8	Seminar – I	Seminar – I
Semester - II		
1	Manufacturing Systems Design	Manufacturing Systems Design
2	Product Life Cycle management	Product Life Cycle management
3	Indl. Automation & Robotics	Indl. Automation & Robotics
4	Optimization Techniques	Optimization Techniques
5	Elective - II	Elective - II
	1. Computational Fluid Dynamics. 2. Quality & Reliability Engineering 3. System Dynamics & Simulation 4. Artificial Intelligence 5. Automatic Control Engineering 6. CAD/CAM Practices in Metal Forming 7. Rapid Prototyping	1. Computational Fluid Dynamics. 2. Quality & Reliability Engineering 3. System Dynamics & Simulation 4. Artificial Intelligence 5. Automatic Control Engineering 6. CAD/CAM Practices in Metal Forming 7. Rapid Manufacturing
6	Design & Analysis Laboratory-II	Design & Analysis Laboratory-II
7	Automation & Simulation Laboratory	Automation & Simulation Laboratory
8	Seminar - II	Seminar - II

Semester - III		
1	Mini Project	Mini Project
2	Seminar - III	Seminar - III
3	Dissertation Phase - I	Dissertation Phase - I
Semester - IV		
1	Dissertation Phase - II	Dissertation Phase - II