University of Pune

Faculty of Engineering
Board of Production and Industrial Engineering

Master of Engineering

Syllabus
for
Production - CAD / CAM Engineering

Effective from June 2013

UNIVERSITY OF PUNE
COURSE STRUCTURE FOR
M.E.CAD/CAM (2013 Course)

Semester I

Code	Subject	Teaching Scheme	Examination Scheme					Credits
		Lecture / Practical	Paper Assessment		TW	Oral / Presentation	Total	
			In-Semester	End-Semester				
511301	Computer aided design	4	50	50	-	-	100	4
511302	Computer aided Manufacturing	4	50	50	-	-	100	4
511303	Advanced Mathematics and Statistics	4	50	50	-	-	100	4
511304	Design of Experiments & Research Methodology	4	50	50	-	-	100	4
511305	Elective I	5	50	50	-	-	100	5
511306	Lab Practice I	4	-	-	50	50	100	4
Total		**25**	**250**	**250**	**50**	**50**	**600**	**25**

M.E. CAD/CAM (2013 Course)

Semester II

Code	Subject	Teaching Scheme	Examination Scheme					Credits
		Lecture / Practical	Paper Assessment		TW	Oral / Presentation	Total	
			In-Semester	End-Semester				
511307	Computer integrated manufacturing	4	50	50	-	-	100	4
511308	Finite Element Analysis	4	50	50	-	-	100	4
511309	Optimization Techniques	4	50	50	-	-	100	4
511310	Elective II	5	50	50	-	-	100	5
511311	Lab Practice II	4	-	-	50	50	100	4
511312	Seminar I	4	-	-	50	50	100	4
Total		**25**	**200**	**200**	**100**	**100**	**600**	**25**

M.E. CAD/CAM (2013 Course)
Semester III

Code	Subject	Teaching Scheme	Examination Scheme					Credits
		Lecture / Practical	Paper		TW	Oral / Presentation	Total	
			In-Semester	End-Semester				
511313	Advanced Stress Analysis	4	50	50	-	-	100	4
511314	Computer aided Production planning.	4	50	50	-	-	100	4
511315	Elective III	5	50	50	-	-	100	5
511316	Seminar II	4	-	-	50	50	100	4
511317	Project Work Stage I	8	-	-	50	50	100	8
Total		**25**	**150**	**150**	**100**	**100**	**500**	**25**

M.E. CAD/CAM (2013 Course)
Semester IV

Code	Subject	Teaching Scheme	Examination Scheme					Credits
		Lecture / Practical	Paper		TW	Oral / Presentation	Total	
			In-Semester	End-Semester				
511318	Seminar III	5	-	-	50	50	100	5
511319	Project Work Stage II	20	-		150	50	200	20
Total		**25**	**-**	**-**	**200**	**100**	**300**	**25**

Elective I
a) Computational Fluid Dynamics
b) Concurrent Product Design
c) Industrial Robotics and Artificial Intelligence
d) Advanced Mechatronics

Elective II
a) Manufacturing System Design
b) Rapid Prototyping
c) Product Life Cycle Management
d) CAD/CAM/CAE Software Development

Elective III (Open Elective)
a) Tribology and Surface Engineering
b) Advanced Material and Processing
c) Energy Resource Management
d) Quality and Reliability Engineering

511301 Computer Aided Design

Teaching Scheme
Lectures: 4 hrs/week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. Introduction , Product Life Cycle, Design Process, Application of Computers for Design, Benefits of CAD, Computer configuration for CAD Applications, Grover's Model of Product life Cycle for Selection of CAD/CAM.

2. Configuration of graphics workstations, Fundamentals of 2D graphics, Menu design and Graphical User Interface (GUI), Parametric Programming, Vector representation of geometric entities, Homogeneous coordinate systems, Geometric transformations.

3. Space Curve design -Analytical and Synthetic approaches, parametric equations, modeling of cubic spline, Bezier curve, B-spline curve and NURBS and their manipulation techniques.

4. Planes and surfaces design -Analytical and Synthetic approaches, parametric equations, modeling of biparametric Surfaces, Surfaces- Coons, Bezier, B-spline and NURBS patches, Surface manipulation techniques.

5. Geometric modeling techniques- Wireframes, B-Rep, CSG and Hybrid modelers, Feature based, Parametric and Variation modeling.

6. Virtual realism, computer animation, mechanical assembly and mass property calculations, CAD/CAM integration,

Text/ References:

1. Rogers D. F. and Adams A., Mathematical Elements for Computer Graphics, McGraw Hill Inc, NY, 1989.
2. Faux I. D. and Pratt M. J., Computational Geometry for Design and Manufacture, John Wiley & sons, NY, 1979
3. Mortenson M. E., Geometric Modeling, John Wiley &sons, NY, 1985
4. Choi B.K., Surface Modeling for CAD/CAM, John Wiley & Sons, NY, 1991.
5. Zeid Ibrahim, CAD/CAM theory and practices, McGraw Hill international edition. 2009.

511302 Computer Aided Manufacturing

Teaching Scheme
Lectures: 4hrs/week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. Machine Centre : Principles of Numerical control, Types of CNC Machine Tools, Features of CNC Systems, Direct numerical control (DNC), Elements of CNC viz. Ball screws, rolling guide ways, structure, drives and controls, standard controllers, Manual part programming with APT, Virtual machining. Machining Centers and Interpolators

2. CNC Programming: Types, Manual Part Programming, Canned Cycle, Offset, APT.

3. Allied Machines:CNC **Presses**, CNC-EDM, CNC-WEDM, CNC-CMM, CNC Molding Machines, Automated Welding**.**

4. Automated Material Handling: Types **of** Material Handling System, Configuration, Equipments, Elements AGVS, ASRS, Carousal System, Design & Analysis of Material Handling System, Conveyors, Stores& Storage Systems

5. Automated Assembly &Inspection :Automated Assembly Systems, Automated Inspection Principles & Methods, SectorsAutomated inspection principles and methods – sectors techniques for automated inspection - techniques for automated inspection – contact and non-contact inspection methods – in processes automated measuring methods – machine vision – optical inspection methods. Automatic identification

6.Techniques: Shop floor control – factory data collection system – Bar code techniques Computer for local area network – the future automated factory – Human workers in future automated factory – The impact on the society, Digital Manufacturing.

REFERENCES:

1. Mikell P. Grover, Automation, Production System and Computer Integrated Manufacturing, Prentice Hall of India Pvt Ltd, 1995.
2. C. Ray Astaihe, Robots of Manufacturing automation, John Wiley and Sons, New York.
3. Jon Stenerson and Kelly Curran “Computer Numerical Control”, Prentice-Hall of India Pvt. Ltd. New Delhi, 2008
4. Ibrahim Zeid “CAD/CAM – Theory and Practice” Mc Hill, International edition, 1998
5. P. N. Rao “CAD/Cam principles and operations”, Tata McGraw Hill
6. Reference Manuals of FANUC, Siemens, Mazak, etc.
7. Thomas M. Crandell “CNC Machining and Programming, Industrial Press ISBN- 0-8311-3118-7
8. Bedworth, Wolfe and Henderson – “Computer aided design and manufacturing” – McGraw Hill
9. A. Ghosh and Malik – “Manufacturing Science” Affiliated East West Press Pvt. Ltd.
10. Tilak Raj – “CNC Technology and Programming”, DhanpatRai Publication Company.

511303 Advanced Mathematics and Statistics

Teaching Scheme **Examination Scheme**
Lectures: 4hrs/week **In semester: 50**
Credits: 4 **End semester: 50**

1. Matrices and Linear Equations :Orthogonalization of vector sets, Quadratic forms, Equivalent matrices and transformations. Hermitian matrices, Multiple characteristics number of symmetric matrix. Discriminates and invariants. Functions of symmetric matrices. Numerical solution of characteristic value problems. Multiple characteristic numbers of non-symmetric matrices. Functions space. Sturm – Liouville problems.

2. Calculas of variations : Maxima and minima, Simplest case, Natural boundary conditions and transition conditions, variational notation, general case, Constraints and Language multipliers, Variable end points, Sturm – Liouville problems, Hamilton's principle, Lagrange's equation. Generalized dynamical entities, Constraints in dynamical systems.

3. Fourier Transforms: Sine transform, Cousine Transform, Inverse Fourier Transforms and their simple problems. Laplace transforms. Application to differential equations with Laplace transform derivatives, convolution theorem. Problems on convolution theorem.
4. Application of partial differential equations for solutions of
    1. One dimensional wave equation
    2. One dimensional heat conduction equation
    3. Laplace equation - with separation of variable method

5. Mathematical modeling- Proportion models, fitting models to data, creating simulations, dimensional analysis, probabilistic models optimization, discrete and continuous models, Monte Carlo simulation, efficiency improvement techniques, simulation output analysis.

6. Probability distributions: random variables, Chi – Square distribution, Gamma distribution, Normal distribution and their properties. Sampling theory, Chi-square test, t-tests, F-tests.

References:

1. B. S. Agrawal, Higher Engineering Mathematics, Khanna Publishers, 25th Ed., 1999.
2. Sneddon, Integral Transforms John Wiley and Company, 1987.
3. S. C. Gupta, V. K. Kapoor, Fundamentals of Mathematical Statistics, Sultanchand& Sons, 1987.
4. Francis B. Hilderbrand, Applied Mathematics, Prentice Hall of India, New Delhi, 2nd Ed. 1968.
5. A. S. Gupta, Calculus of Variation with applications, Prentice Hall of India, New Delhi, 2001.
6. Mark Meerschaert, Mathematical modeling, Academic press
7. S. P. Gupta, Advanced statistical method

511304 Design of Experiments and Research Methodology

Teaching Scheme	Examination Scheme
Lectures: 4 hrs/week	End semester: 50
Credits: 4	In semester: 50

1. **Introduction:** Defining Research, Scientific Enquiry, Hypothesis, Scientific Method, Types of Research, Research Process and steps in it. Research Proposals – Types, contents, sponsoring agent's requirements, Ethical, Training, Cooperation and Legal aspects

   Research Design: Meaning, Need, Concepts related to it, categories; Literature Survey and Review, Dimensions and issues of Research Design, Research Design Process – Selection of type of research, Measurement and measurement techniques ,Selection of Sample, Selection of Data Collection Procedures, Selection of Methods of Analysis, Errors in Research.

2. **Research Problem:** 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.

3. **Research Modeling:** (a) Mathematical – Classification of Models, Development of Models, Stages in Model building, Principles of Modeling, Use of Analogy, Models as Approximations, Data consideration and Testing of **Models** (b) Heuristics and Simulation – Definition, Applications and reasons for using Heuristics, Heuristic Methods and approaches, Meta-Heuristics; Simulation – Meaning, Applications and Classification of Simulation Models, Process of Simulation, Steps and Features of Simulation Experiments and their Validation.

4. **Experimentation:** Objective, Strategies, Factorial Experimental Design, Applications of Experimental Design, Basic Principles – Replication, Randomization and Blocking, Guidelines for designing experiments; Laboratory Experiments, Methods of manipulating Variables, Errors in Experiments, Steps in Design of Experiments, Basis

5. **Process Optimization:** Factorial Design principles, Two factor Factorial Design, General Factorial Design, Fitting response **Curves** and Surfaces, Blocking, Taguchi Approach to Parameter Design, Robust Design

6. **Analysis and Report writing** Analysis of Variance and Co-variance, Hypothesis Testing – Parametric and Non-Parametric Tests, Uni-variate and Bi-variate analysis.Pre-writing Considerations, Principles of Thesis Writing, Format of Report Writing, Format of Publication in Research Journals, Oral Presentations (Briefing).

Reference Books:

1. Krishnaswamy, K.N., Sivakumar, AppaIyer&Mathirajan M., (2006) - Management Research Methodology: Integration of Principles, Methods & Techniques (New Delhi, Pearson Education)
2. Montgomery, Douglas C. (2004) – Design & Analysis of Experiments, 5/e. (New York, John Wiley & Sons)
3. Kothari, C.K. (2004) – Research Methodology, Methods & Techniques, 2/e. (New Delhi, New Age International Ltd. Publishers)

4. Ross, Phillip J. (1996) – Taguchi Techniques for Quality Engineering, 2/e. (New York, McGraw Hill)
5. Rao S. S. (2004) – Engineering Optimization Theory & Practices, 3/e (New Delhi, New Age International Ltd., Publishers)
6. Handbook of Industrial Automation – Richard L. Shell & Ernest L. Hall (Marcel Decker Inc.)
7. Trochim, William M.K. (2003), - Research Methods 2/e, (New Delhi, Biztantra, Dreamtech)
8. Antony J (2003). Design and Experiments for Engineers and Scientists, Butterworth-Heinmann.
9. Cochran W and Cox G (2000). Experimental Designs, 2nd edition, John Wiley and Sons Inc.
10. Dean A and Voss D (2006). Design and Analysis of Experiments, Springer.
11. Jeff Wu C and Hamada M (2000).Experiments: Planning, Analysis and Parameter Design Optimization, John Wiley and Sons Inc.
12. Montgomery D (2001). Design and Analysis of Experiments, 5th edition, Wiley.

511305 Elective I, a) Computational Fluid Dynamics

Teaching Scheme
Lectures: 5hrs/week
Credits: 5

Examination Scheme
In semester: 50
End semester: 50

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.

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

3. **Numerical methods for Convection** - Diffusion equations: Upwinding and central difference schemes, Stability condition in terms of Courant number.

4. **Numerical Methods for Inviscid Flows:** Characteristic form of equations, Flux difference splitting, Application to 2-D flows such as flow through a nozzle

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

6. **Turbulance Models:** Algebraic Models - One equation model, K-I Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes.

Reference Books

1. Veersteeg and Malalasekara, CFD: The Finite Volume Method, Prentice Hall, 1996
2. Anderson, Tannehill and Pletcher, Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishers, 1984.
3. C A J Fletcher, Computational Methods for Fluid dynamics: Vol 1 and 2.Springer Verlag, 1987
4. C. Hirsch, Numerical Computation of Internal and External Flows Vol.1 and 2.
5. D C Wilcox, Turbulence Modeling for CFD, DCW Industries.
6. Fletcher, C.A.J.,"Computational Techniques for Fluid Dynamics 1" Fundamental and General Techniques,Springer-Verlag,1987.
7. Flectcher, C.A.J., "Computational Techniques for Different Flow Categories, Springer-Verlage 1987.
8. Bose,T.K.,"Numerical Fluid Dynamics" Narosa Publishing House, 1997.

511305 Elective I, b) Concurrent Product Design

Teaching Scheme	Examination Scheme
Lectures: 5 hrs/week	**In semester: 50**
Credits: 5	**End semester: 50**

1. Introduction: Types of design, importance of design, design considerations, product life cycle, technology life cycle, benchmarking and mass customization. Concurrent design team its elements.

2. Product Design Process: Steps in design, Functional requirement analysis, Axiomatic design, Product design specifications, concurrent design model

3. Material And Manufacturing Process Selection In Design: Factors influencing material and process selection, approaches, tools and software used in selection. Design For 'X': An introduction: Design for manufacturing, assembly and dissemble, an overview of DF'X'. Deign for maintainability and serviceability, design for environment, design for aesthetic, design for packaging, design for handling, design for safety, etc.

4. Design Cost Estimation: Need, cost indexes, categories; cost-capacity factors; design to cost and life cycle costing.

5. Product Development Approaches: Concurrent engineering, partnership with supplier, collaborative and Internet based design, Design Project Management: PDM tools.

6. Introduction to VRML, modular product design, mechanical and electronic products design. Concurrent and collaborative product development case studies

Reference Books

1. Dieter George E., Engineering Design, McGraw Hill Publication, 2000.
2. Ulrich Karl T and Eppinger Steven D., Product design and development, McGraw Hill Publication, 1995.
3. Chitale A.K. and Gupta R.C. Product Design and Manufacture, Prentice-Hall of India, New Delhi
4. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Publication

511305 Elective I, c) Industrial Robotics and Artificial Intelligence

Teaching Scheme	Examination Scheme
Lectures: 5 hrs/week	**In semester: 50**
Credits: 5	**End semester: 50**

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

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

2. **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 effectors interface, Active and passive compliance, Gripper selection and design.

3. **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. **Artificial Intelligence.**Concept of A.I., Approaches, Foundations of A.I., 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

5. **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. **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.

Reference Books:

1. Groover, M.P., (2004), “Automation, Production Systems & Computer IntegratedManufacturing” 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 andIntelligence”, (McGraw Hill Intl. Ed.) ISBN:0-07-100421-1
6. Keramas, James G. (1998), “ Robot Technology Fundamentals”,(Thomson Learning-Delmar) 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
11. Stuart Russel, Peter Norwig (2003), “Artificial Intelligence : A Modern Approach” 2/e, (Pearson Education)
12. Elaine Rich, Kevin Knight, (1991), “Artificial Intelligence” 2/e, (Tata McGraw Hill)
13. Dan W. Patterson (1999), “Introduction to Artificial Intelligence and Expert Systems” (7th Indian Reprint) (EEE) (Prentice Hall of India)
14. Rex Mauss, Jessica Keyes , “Handbook of Expert Systems in Manufacturing”, (McGraw Hill)
15. Groover, Weiss, Nagel, Audrey, “Industrial Robotics- Technology, Programming and Applications”, (McGraw Hill)
16. Conference Proceedings and current journals for case studies and applications.

511305 Elective I, d)Advanced Mechatronics

Teaching Scheme
Lectures: 5 hrs/week
Credits: 5

Examination Scheme
In semester: 50
End semester: 50

1. Introduction

Introduction to mechatronics system, evolution, scope and components of mechatronics systems, mechatronics in product and measurement system, control system and modes of control, traditional design and mechatronics design

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.

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.

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.

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. Advanced Applications in Mechatronics

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. Mechatronic control in automated manufacturing, Artificial Intelligence in mechatronics, Fuzzy Logic application, Microsensors, Case studies of Mechatronics systems.

Reference Books :

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

4. N.P.Mahalik, Mechatronics: Principles, Concepts and Applications, TMH
5. David G. Alciatore& Michael B. Histand, Introduction to Mechatronics & Measurement Systems, TMH
6. Critis D. Johnson, Process Control & Instrumentation Technology, Pearson Education
7. DevdasShetty, Richard A. Kolk, Mechatronics System Design,Thomson
8. YoramKoren, Computer Control of Manufacturing Systems, McGraw Hill
9. S. Brain Morriss, Automated Manufacturing Systems: Sensors, Actuators, McGraw Hill
10. David W. Pessen, Industrial Automation, John Wiley & Sons
11. Richard L. Shell & Ernest L. Hall, Handbook of Industrial Automation, Marcel Decker Inc.
12. Jack R. Hackworth & Fredrick D. Hackworth,Jr., Programmable Logic Controllers" Programming Methods and Applications (with CD Rom), Pearson Education

511306 Lab Practice I

Teaching Scheme
Practical: 4 hrs/week
Credits: 4

Examination Scheme
Oral: 50 Marks
TW:50 Marks

Each student should write at least two assignments on each theory subject studied in Semester I and conduct minimum Six experiments from the list given below as laboratory work.

1. 2D drawing and drafting using sketcher workbench – 2 drawings
2. 3D modeling and drafting using 3D features – 5 models
3. Assembling and drafting of 2 assemblies with interference checking.
4. Surface modeling – 4 exercises
5. CNC Lathe – 4 exercises
6. CNC Milling – 4 exercises
   Generation of tool path, generation of NC code, Optimization of tool path (to reduce machining time) using any CAM software
7. Robot programming for any two industrial application.(e.g. pick and place, welding, painting etc.)
8. Minimum three programs on PLC for system automation involving of interfacing of sensors and actuators
9. Exercises on a total Mechatronics System Design for applications like packaging, loading/unloading, pick and place etc.

511307 Computer Integrated manufacturing

Teaching Scheme
Lectures: 4 hrs/week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. **Concept of CIM:** Introduction to CIM, Types of Manufacturing, CIM hardware and software, Elements of CIM, Product development through CIM

2. **CIM database**: Introduction, Database requirements of CIM, Database, Database management, Database Models, Product Data Management (PDM), Advantage of PDM.

3. **Work Cell :**Manufacturing cell, Group Technology, Cellular Manufacturing.

4. **Flexible Manufacturing System:** Introduction to FMS, Manufacturing integration model, flexible manufacturing strategy, Components of Flexible Manufacturing-Pallets and fixtures, machining centers, inspection equipment, material handling stations, storage system,In-process storage, manually operated stations, allied operation centers, FMS system design

5. **Robots in CIM** : integration of the industrial robot into CIM system, product design of automatic manufacture of robots, computer aided inspection using robots.

6. **Networking in CIM:** Principles of networking, Network Techniques, Local area network (LAN), networking standards, Design Activities in a networked environment, networking in a manufacturing company, hardware elements of networking, Collaboration Engineering.

References Book:

1. Paul G. Ranky, The design and operation of FMS, I.F.S. Publi 1983 Harrington J, C.I.M. m Krieger 1979
2. Richard shover, An analysis of CAD/ CAM Application with introduction to C.I.M.
3. Prentice hall inc.Engelwood Cliffs NJ David Bedworth et.al Computer integrated design and manufacturing McGraw hill 1991
4. Scolz B. Reiter C.I.M interfaces Chapman & Hall 1992 David L. Goetsch, fundamental of CIM technology, Delmer Publication 1988

511308 Finite Element Analysis

Teaching Scheme
Lectures: 4 hrs/week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. **Introduction:** Structural analysis, objectives, static, Dynamic and kinematics analyses, Skeletal and continuum structures, modeling of infinite d.o.f. system into finite d.o.f system, Basic steps in finite element problems formulation, general applicability of the method.

2. **Element types and characteristics:** Discretization of the domain, Basic element shapes, Aspect ratio, shape function, generalized co-ordinates and nodal shape functions, 2d rectangular and triangular elements, Axisymmetric elements.

3. **Assembly of elements and matrices:** Concept of element assembly, Global and local coordinate system, band width and its effects, Banded and skyline assembly, Boundary conditions, solution of simultaneous equations, Guassian elimination methods, one and 2D applications Higher order and isoparametric elements

4. **One-Dimensional:** One dimensional quadratic and cubic element, Use of natural co-ordination system, area co-ordinate system continuity nad convergence requirements, 2D rectangular and triangular requirement

5. **Static analysis :** Analyses of trusses and frames, analyses of machine subassemblies, Use of commercial software packages, advantages and limitations

6. **Dynamic analysis:**Hmilton's principle, derivation of equilibrium, consistent and lumpe mass matrices, Determination of natural frequencies and mode shapes, use of commercial software packages.

References Books:

1. Trupathi R Chandrupatla and Ashook D. Belegundu, Introduction of Finite Element in Engineering, Prentice Hall of India, 1997.
2. Rao S. S., The Finite Element Methods of Engineering, Pergamon Press, 1989.
3. Segerland L. J., Applied Finite Element Analysis, Wiley Publication, 1984
4. Reddy J. N., An Introduction to Finite Element Methods, McGraw Hill Company, 1984.

511309 Optimization Techniques

Teaching Scheme
Lectures: 4 hrs/week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. **Classical Optimization Techniques:** Single-variable and Multi-variable Optimization, Hessian Matrix, Saddle Point, Lagrange Multipliers Method, Kuhn-Tucker Conditions

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

3. **Multi-variable Optimization Techniques:** Evolutionary Optimization Method, SimplexSearch Method, Pattern Search Method, Conjugate Direction Method, Steepest Descent Method, Newton's Method, Conjugate Gradient Method, Davidon- Fletcher-Powell Method

4. **Constrained Optimization Techniques:** Interior Penalty Function Method, Exterior Penaltyfunction Method

5. Genetic Algorithm, Simulated Annealing, Artificial Neural Networks

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.

Reference Books:

1. Deb K (2004). Optimization for Engineering Design: Algorithms and Examples, Prentice Hall of India.
2. Dennis J Jr, Schnabel R (1996). Numerical Methods for Unconstrained Optimization and Nonlinear Equations, Society for Industrial and Applied Mathematics.
3. Rao S (1996). Engineering optimization, Theory and Practice, New Age International Publishers
4. Ravindran A, Ragsdell K and Reklaitis G (2006). Engineering Optimization: Methods and Applications, 2nd edition, John Wiley and Sons Inc.
5. 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
6. Dettmer, H. William (1997). Goldratt's Theory of Constraints: A Systems Approach to Continuous Improvement, American Society for Quality. ISBN 0873893700

511310 Elective II, a) Manufacturing Systems Design

Teaching Scheme
Lectures: 5hrs. /week
Credits: 5

Examination Scheme
In Semester: 50
End Semester: 50

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

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.

3. Manufacturing Optimization: Criteria for Evaluation, Optimization of single stagemanufacturing- 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.

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.

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.

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.

Reference Books:

1. KatsudoHitomi, (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, JairoMunez, (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

511310 Elective II, b) Rapid Prototyping

Teaching Scheme
Lectures: 5 hrs. /week
Credits: 5

Examination Scheme
In semester: 50
End semester: 50

1. Introduction to RP, Technology Description and Definition to RP, Overview of RP, Benefits and Application. RP Processes: Process overviews, STL file Generation, File Verification and Repair, Build File Creation, Part Construction, Part Cleaning and finishing, Process Strength and its limitations.
2. 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

3. Prototype properties: Material properties, color, dimensional accuracy, stability, surface finish, machinability, environmental resistance, operational properties

4. RP Applications: Design, Concept Models, Form & fit checking, Ergonomic Studies, Functional testing, Requesting Price quotes, CAD data verification, Rapid Tooling, Rapid manufacturing, Science & Medicine, Archeology, Paleontology & forensic Science, miniaturization

5. Fundamental Process: Background, The line spread function of scanned Gaussian Laser Beam. The Parabolic Cylinder, The working curved equation, The curved linewidth function, Mechanical properties, Bilateral exposure of a Thin Sample, The Photomodulus Model, Experimental Method, Experimental Results.

6. Alternate Approach to RP and Manufacturing: Introduction, Laser – Additive Laser Point-by-Point Method, Laser –Additive Non Laser Point-by Point Fabrication, Laser Subtractive Laser Fabrication, Laser Additive Non Laser Fabrication.

REFERENCES

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. Paul F. Jacobs, Rapid Prototyping and Manufacturing, First Edition Published by Society of Manufacturing Engineers. ISBN: 0-87263-425-6

511310 Elective II, c) Product Life Cycle Management

Teaching Scheme	Examination Scheme
Lectures: 5 hrs. /week	In semester: 50
Credits: 5	End semester: 50

1. **Introduction:** Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. 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.

2. **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.

3. **Product Modeling** - 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.

4. **4.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. **Product Data Management –(PDM Technology:** 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.

6. **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.

Reference Books :

1. Grieves, Michael. Product Life cycle Management, McGraw-Hill, 2006. ISBN 0071452303
2. Product Life Cycle Management - by AnttiSaaksvuori, AnselmiImmonen,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, AnnitaPersson. 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

511310 Elective II, d) CAD/CAM/CAE Software Development

Teaching Scheme	Examination Scheme
Lectures: 5 hrs. /week	**In semester: 50**
Credits: 5	**End semester: 50**

1. **Introduction to Customization:** Customization, Application Programming Interface (API), macros, scripts.

2. **Tools for Customization:** Object Oriented Programming (OOP), OLE interfaces in CAD/CAM software, Use of general programming interfaces like VB, VBS, VC++, OpenGL programming

3. **System dependent programming interfaces** : Visual LISP (AutoCAD), GRIP (Unigraphics), Pro-Programming (Pro-Engineer), CATIA etc.

4. **Computer-based System Engineering:** System engineering process, Software product development life cycle, software processes, software development project management, software prototyping

5. **Rapid Development**: Core issues in rapid development, rapid development languages, life cycle planning and customer oriented development Solid Modeling Algorithms: Euler operations, basic solid modeling algorithms

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.

Reference Books:

1. Steve McConnel, Rapid Development, Microsoft Press
2. Ian Sommerville, Software Engineering, Pearson Education
3. Foley, Van Dam, et al, Computer Graphics, Pearson Education
4. Mason Woo et al, Open GL Programming Guide
5. George Omura, Advanced AutoCAD
6. ShyamTickoo, Customizing AutoCAD, Thomson Learning
7. ShyamTickoo, CATIA, Thomson Learning
8. MarttiMantilya, Solid Modelling, Computer Science Press

511311 Lab Practice II

Teaching Scheme **Examination Scheme**
Practicals: 4 hrs. /week **TW: 50**
Credits: 4 **Oral: 50**

Each student should write at least two assignments on each theory subject studied in Semester II and conduct minimum Six experiments listed below as laboratory work.

1. Structural Analysis
2. Thermal Analysis
3. Fluid Flow Analysis
4. Coupled Field Analysis
5. Nodal Analysis
    - Minimum four problems shall be solved with hand calculations.
6. Simulation of any manufacturing system and its analysis using any manufacturing simulation package like Witness, Promodel, Arena etc.
7. 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.)
8. Solution of constrained and unconstrained non-linear optimization problem using any computer software packages.
9. Development of manufacturing data knowledgebase using any programming language.

511312 Seminar I

Teaching Scheme
Practicals: 4 hrs. /week
Credits: 4

Examination Scheme
Term work: 50 Marks
Oral:50 Marks

Each student is required to deliver a Seminar on state of the art topic of his/her choice relevant to any area of CAD/CAM/CAE and submit it in the form of short report.

511313 Advanced Stress Analyses

Teaching Scheme
Lectures: 4 hrs. /week
Credits: 4

Examination Scheme
In semester: 50
End semester: 50

1. Component of stress and strain, their principle values and invariant, Generalized Hook's lawGeneral 3-D Problems and Classical theorems, Plane stress and plane strain. Airy's stress function. 2-D problems in rectangular and polar coordinates

2. Complex variable approach. Complex representation of stresses, displacements and appliedboundary loads Different methods of solution of 2-d problems for finite and infinite plates with simply and multiply connected regions.

3. Experimental methods of stress analysis. Strain gauges, Photo-elasticity, Bio-refringent coatings, Brittle coatings, Moirefrings, X-ray techniques and holography.

4. Introduction to fatigue and fracture mechanics, ductile and brittle fractures, Mechanism of fatigue crack initiation and propagation, fatigue data representation, factors influencing fatigue strength, life prediction, prevention of fatigue failures, corrosion fatigue.

5. Linear elastic fracture mechanics (LEFM), The pattern of stress and deformation near the tip of the crack. Determination of fracture toughness, Stress intensity factor, elastic plastic fracture mechanics, the size of the plastic zone, condition for the fracture, the energy release rate, sub-critical growth in reactive environment, crack extension behavior, Paris equation.

6. Fatigue and fracture safe designs, Investigation and analysis of failures, case studies in fatigue and fracture mechanics.

Reference Books:

1. S.P. Thimoshenko and J.N. Goodier, Theory of Elasticity, McGraw-Hill, 1982
2. J. W. Dally and W. F. Riely, Experimental stress analysis, McGraw-Hill, 1978
3. Knott J. F.; Fundamentals of fracture mechanics; Butter worth Publication, 1973 Kocanda S.; Fatigue failure of Metals; SynthoffordNoordhoff, 1978.
4. Fros N.E. et al.; Metal fatigue; Clarendon Press, 1974.
5. Broek D.; Elementary Engineering Fracture Mechanics; Noordhoff, 1975.
6. Rolfe S.T., Barsom J.M.; Fracture and Fatigue Control in Structure; Prentice Hall, 1977.

511314 Computer Aided Production Planning

Teaching Scheme	Examination Scheme
Lectures: 4 hrs. /week	**In semester: 50**
Credits: 4	**End semester: 50**

1. **Computer Aided Forecasting** : Nature and use of forecast, sources of data, demand patterns,forecasting models, selection of forecasting technique, measurement of forecast Accuracy, Adoptive methods.

   Computerized relative allocation of facility technique, automated layout design program and computerized relationship layout planning for facility location and layout

2. **Group Technology:** - Introduction, objectives part families, algorithms and models for G.T. - Rank order clustering, Bond energy, mathematical model for machine – component cell formation. Design and manufacturing attributes. Parts classification and coding, concept of composite job machine group, cell group tooling, design rationalization, CAD/CAM and GT benefits.

3. Computer Aided Process Planning, Operation Management, Computer Aided Inspection-Computer Aided Testing, Contact type, non contact type

4. **MRP:** Introduction, Objective, Input, Computational procedure, information provided by the system. Detailed capacity planning, manufacturing resources planning

   ERP: Introduction, main features, generic model of ERP system, selection of ERP, proof of concept approach, analytic hierarchy approach, ERP implementation.

5. Job Sequencings, scheduling,Shop floor control- data collection, computer generated time standard.

6. Simulation – Major activities, purpose, simulation process, types methodology, simulation packages, process quality simulator, computer requirements trends, applications simulation of manufacturing systems.

Reference Books

1. An introduction to Automated Process Planning – Tien – Chien Chang and Richard Awysk/Prentice hall
2. M.P. Groover, Automation production systems and computer aided mfg.-
3. P.N.Rao, N.K.Tewari, T.K. Kundra, Computer aided manufacturing
4. G.T. in the engineering industry Bur bridge
5. MRP – by Orlikey
6. Buffa&Sarin, Modern Production Management
7. P.B.Mahapatra, Computer Aided production management
8. Averill M Law & David Kelton, Simulation modeling and analysis, Tata Mcgraw Hill

511315 Elective III, a)Tribology and Surface Engineering (Open elective)

Teaching Scheme	**Examination Scheme**
Lectures: 5hrs. /week	**In semester: 50**
Credits: 5	**End semester: 50**

1. Friction Wear and Corrosion: Theory of friction- sliding and rolling friction, Tabor'smodel of friction, Friction properties of metallic and non metallic materials, friction inextreme conditions, Wear, types of wear, mechanisms of wear, wear resistant materials,Mechanisms and types of corrosion, Measurement and testing of Friction, Wear andCorrosion, Prevention of wear and Corrosion.

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

3. Tribo Measurement and Instrumentation: Surface topography measurements, Electronmicroscope, Laser method, Instrumentation, International Standards, Bearingperformance measurements, Bearing Vibration Measurement

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 ofsurface, The superficial layer and its parameters.

5. Surface Engineering for Wear and Corrosion Resistance: Diffusion Coatings, Electroand Electro-less plating, Hot dip coating, Metal Spraying, Cladded coatings, Crystallizingcoatings, Flame and arc processes, Conversion coatings, selection of coatings for wearand corrosion resistance, Potential properties and parameters of coatings.

6. Thin Layer Engineering Processes: Laser and electron beam hardening, its processparameters and their effects, Physical vapor deposition, Thermal evaporation Arcvaporization, Sputtering, Chemical vapor deposition, ion implantation technique,Coating of tools, TiC, TiN, Al2O3 and Diamond coating properties, applications of thinCoatings.

Reference Books:

1. Hulling J. "Principles of Tribology" McMillan, 1984
2. Williams J.A. "Engineering Tribology" Oxford University press, 1994.
3. Davis J. "Surface Engineering for corrosion and Wear Resistance", WoodheadPublishing, 2001.
4. TadauszBurakowski, "Surface Engineering of Metals: Principles, Equipments,Tehnologies" Taylor and Francis.

511315 Elective III, b)Advanced Materials and Processing (Open elective)

Teaching Scheme	Examination Scheme
Lectures: 5 hrs. /week	In semester: 50
Credits: 5	End semester: 50

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.

2. Modern materials- Compositions, properties and applications of: Inter-metallic's,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.

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, Al2O3, SiC, Si3N4, CBN and diamond- properties, processing and applications.

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 MMCs.

5. Non conventional machining processes: Introduction and need 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

6. 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.

Reference Books :

1. "HMT Handbook" – Production Technology (TMH) 2) "Non- traditional machining processes", Willer, SME publications.
2. G.F.Benidict, "Advanced Manufacturing Processes", Marcel Dekker Publisher
3. E. Paul DeGarmo, J. T. Black & Ronald A. Kohser, "Materials & Processes in Manufacturing", (PHI)

4. Geoff Eckold, “Design & Manufacturing of Composite Structures”, Jaico Publishing House
5. S. Kalpaljian& Steven R. Schmidt, “Manufacturing Processe for Engineering Materials”, Pearson Education
6. Krishnan K.Chawla, “Composite Material Science and Engineering”, Springer- Verlog, 1987
7. Agarwal D &Brontman L.J., “Analysis & Performance of fibre composites”, John Willey Publications, 1990
8. Mallik P.K. & Newman S.,”Composite Materials Technology”, Henser Publications, 1990
9. Charles J A, Crane F.A.A. & Furness J A G ,”Selection and use of Engineering Materials”, (3 rd edition), Butterworth – Heiremann – 1977
10. P.K.Mishra (IIT, Kharagpur), “Materials and their applications”, (4 th edition)- Jaico-1999
11. “Non Conventional Machining”, –Narosa Publishing House
12. A. Ghosh and Malik, “Manufacturing Science”, Affiliated East West Press Pvt. Ltd.
13. Vijendra Singh, “ Physical Metallurgy”, Standard Publishers Distributors, New Delhi

511315 Elective III, c)Energy Resource Management (Open elective)

Teaching Scheme
Lectures: 5 hrs. /week
Credits: 5

Examination Scheme
In semester: 50
End semester: 50

1. **Introduction:** Global and Indian energy market, Energy scenario in various sectors and Indianeconomy. Need and importance of energy conservation and management. Payback period. Return on Investment (ROI). Life Cycle Cost. Sankey Diagrams. Specific Energy consumption. Load Management.

2. **Energy Auditing-** Methodology, analysis and reporting. Portable and on-line instruments, costing of utilities like steam, compressed air, electricity and water.

3. **Steam and Condensate Systems**. Boilers (including packaged boilers), efficiency, testing, excess air and flue gas monitoring. Steam distribution. Steam traps. Condensate and flash steam utilization. Thermal insulation. Economic Thickness of Insulation (ETI).

4. **Electrical systems**: Demand control, power factor improvement, benefits and ways of improvement. Load scheduling. Electric motors, losses, efficiency, energy- efficient motors, motor speed control, variable speed drive. Lighting: Illumination levels, fixtures, timers, energy efficient illumination.

5. **Energy conservation:** Energy conservation in compressed air systems, refrigeration and air-conditioning systems and water systems. Elementary coverage of energy conservation in pumps and fans. Opportunities in Process Industries for Energy conservation.

6. **Cogeneration:** Concept, options (steam/gas turbine/DCT -based). Selection criteria. Application in various industries

Reference Books:

1. P. H. Henderson: India-The Energy Sector, Oxford university Press.
2. D. A. Ray: Industrial Energy Conservation. Pergamon Press.
3. IGC Dryden, editor: The efficient use of Energy (Butterworths).
4. W. C. Turner, editor: Energy Management handbook (Wiley).
5. Patrick Steven R., Patric Dale R., Fordo Stephen: Energy Conservation Guide book, The Fairmont Press Inc.
6. Frank Keith, Yogi Goswami, “Energy Management and End Use Efficiency Handbook”, Taylor & Francis.

511315 Elective III, d)Quality and Reliability Engineering (Open elective)

Teaching Scheme **Examination Scheme**
Lectures: 5 hrs. /week **In semester: 50**
Credits: 5 **End semester: 50**

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

2. Steps in Robust Design, Quality Characteristics and Objective Functions, ControlFactors and their Levels, Noise Factors and Testing Conditions, Planning andConducting the Experiment

3. Response Surface Methodology – First- order and Second-order Models, Crossed Array Experiments, Signal-to-Noise Ratios

Reliability Engineering

4. The Reliability Function, Failure Rate, Hazard Rate, Bath-tub Curve, Relationshipbetween Various Reliability Characteristics

Component Reliability, Mean-time-to-failure, Time-dependent Hazard Models –Constant-hazard, Linear-hazard, Nonlinear-hazard and Gamma Models

5. 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

6. Maintained Systems, Classification of Maintenance Activities: Breakdown,Preventive and Predictive Maintenance, Condition Monitoring, Maintainability andAvailability, Reliability-centered Maintenance

Reference Books

1. 1Phadke, M (1989). Quality Engineering using Robust Design, Prentice Hall.
2. Ross, P (1996). Taguchi Techniques for Quality Engineering, 2nd edition, McGrawHill.
3. Balgurusamy E (2003). Reliability Engineering, Tata McGraw Hill.
4. Birolini A (2004). Reliability Engineering: Theory and Practice, 4th edition, Springer.
5. Crowder M, Kimber A, Smith R and Sweeting T (1991). Statistical Analysis ofReliability Data, Chapman and Hall.
6. Kumamoto H and Henley E (1996). Probabilistic Risk Assessment and Managementfor Engineers and Scientists, IEEE Press.

511316Seminar II

Teaching Scheme
Practicals: 4 hrs/week
Credits: 4

Examination Scheme
Term works: 50 Marks
Oral:50 Marks

Each student is required to review the literature related to proposed dissertation work to be done. He/she is required to deliver the seminar and submit it in the form of short report.

511317Project Stage I

Teaching Scheme
Practicals: 8hrs/week
Credits: 8

Examination Scheme
Term work: 50 Marks
Oral: 50 Marks

Student has to submit a report based upon the following:

- Objective of the Project
- Problem statement
- Literature review
- Methodology
- Progress Achieved
- Difficulties encountered
- Experimental set up preparation
- Future plan of action

511318Seminar III

Teaching Scheme
Practicals: 5 hrs/week
Credits: 5

Examination Scheme
Term works: 50 Marks
Oral:50 Marks

Each student is required to review the literature related to the dissertation work to be done, or on any other relevant topic.
He/she is required to deliver the seminar and submit it in the form of short report.

511319 Project Stage II

Teaching Scheme
Practicals: 20hrs/week
Credits: 20

Examination Scheme
Term work: 150 Marks
Oral: 50 Marks

Student has to submit a report based upon the following:
1. Objectives of work
2. Review of literature
3. Development of methodology
4. Experimental and numerical analysis.
5. Results obtained.
6. Comparison of results with previous work done
7. Conclusions.