VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR
M.TECH, COMPUTATIONAL ANALYSIS IN MECHANICAL SCIENCES

I SEMESTER **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16 MCS 11	Advanced Mathematics	4	2	3	20	80	100	4
16 MCS 12	Heat Transfer & Fluid Flow	4	2	3	20	80	100	4
16MCS 13	Optimization Techniques	4	2	3	20	80	100	4
16 MCM 251	Advanced Materials Technology	4	2	3	20	80	100	4
16--- 15X	Elective – I	4	2	3	20	80	100	4
16MDE16	LAB I	--	3	3	20	80	100	2
16MCS17	SEMINAR	--	3	--	100	--	100	1
	Total	**20**	**13**	**18**	**220**	**480**	**700**	**23**

ELECTIVE-I

16 MCM12	Automation & Computer Integrated Manufacturing	16 MCS 153	Reliability Engineering
16 MCS 152	Operations Analysis and Modelling	16MCS 154	Solar Energy Engineering

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. COMPUTATIONAL ANALYSIS IN MECHANICAL SCIENCES

II SEMESTER **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16 MTP 12	Finite Element Analysis	4	2	3	20	80	150	4
16 MDE 22	Advanced Machine Design	4	2	3	20	80	150	4
16 MTP 254	Computational Heat Transfer & Fluid Flow	4	2	3	20	80	150	4
16 MCS 24	Modeling & Simulation	4	2	3	20	80	150	4
16--- 25X	Elective – II	4	2	3	20	80	150	4
16MDE26	LAB II		3	3	20	80	75	2
16MCS27	SEMINAR	--	3	--	100	--	25	1
	**PROJECT WORK PHASE-I COMMENCEMENT (6 WEEKS DURATION)	--	--	--	--	--	--	--
Total		**20**	**13**	**18**	**220**	**480**	**700**	**23**

ELECTIVE-II

16 MCS 251	Numerical Methods In Mechanical Vibrations	16MCS253	Projects Analysis and Management
16MCM153	Rapid Prototyping	16MCS 254	Nano Technology

**** Between the II Semester and III Semester, after availing a vacation of 2 weeks.**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. COMPUTATIONAL ANALYSIS IN MECHANICAL SCIENCES

III SEMESTER : INTERNSHIP **CREDIT BASED**

Subject Code	Title	Teaching hours/week		Examination			Total Marks	CREDITS
		Theory	Practical / Field Work / Assignment	Duration	I.A. Marks	Theory / Practical Marks		
16MCS31	Seminar/ Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	20
16 MCS32	Report on Internship	-	-	-	25	-	25	
16 MCS 33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
16 MCS34	Project Work Phase-1	-	-	-	50	-	50	1
	Total	**-**	**-**	-	**100**	**50**	**150**	**21**

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

SCHEME OF TEACHING AND EXAMINATION FOR

M.TECH. COMPUTATIONAL ANALYSIS IN MECHANICAL SCIENCES

IV SEMESTER **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment / Tutorials		I.A.	Exam		
16MCM41	MEMS	4	--	3	20	80	100	4
16---42X	ELECTIVE-III	4	-	3	20	80	100	3
16MCS43	EVALUATION OF PROJECT WORK PHASE-II	-	-	-	50	-	50	3
16MCS44	EVALUATION OF PROJECT WORK AND VIVA-VOCE	-	-	3	-	100+100	200	10
	Total	**8**	**--**	**09**	**90**	**360**	**550**	**20**
	Grand Total (I to IV Sem.) : 2400 Marks; 94 Credits							

ELECTIVE-III

14MCS421	Wind Energy Engineering	14MCS423	Analysis & Design of Composites
14MAR 21	Robotics for Industrial Automation	14MCS424	Fluid Power System

NOTE:

1	Project Phase – I: 6 weeks duration shall be carried out between II and III Semesters. Candidates in consultation with the guides shall carryout literature survey / visit to Industries to finalize the topic of dissertation
2	Project Phase – II: 16 weeks duration. 3 days for project work in a week during III Semester. Evaluation shall be taken during the first two weeks of the IV Semester. Total Marks shall be 25.
3	Project Phase – III: 24 weeks duration in IV Semester. Evaluation shall be taken up during the middle of IV Semester. At the end of the Semester Project Work Evaluation and Viva-Voce Examinations shall be conducted. Total Marks shall be 250 (Phase I Evaluation: 25 Marks, Phase –II Evaluation: 25 Marks, Project Evaluation marks by Internal Examiner (guide): 50, Project Evaluation marks by External Examiner: 50, marks for external and 100 for viva-voce). Marks of Evaluation of Project: I.A. Marks of Project Phase – II & III shall be sent to the University along with Project Work report at the end of the Semester. During the final viva, students have to submit all the reports.
4	The Project Valuation and Viva-Voce will be conducted by a committee consisting of the following: a) Head of the Department (Chairman)(b) Guide (c) Two Examiners appointed by the university. (Out of two external examiners at least one should be present).

I SEMESTER

ADVANCED MATHEMATICS

Subject Code	:16**MCS11**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objectives:

The Student will learn different mathematical concept that can be used in finding solutions to many engineering problems and in formulating mathematic models to represent engineering applications.

Course Content:

1. **Introduction:** Numerical Analysis, Approximation errors-absolute and relative, round-off errors, round-off errors in arithmetical operations, Error in numerical method, Recursive Computation.

Interpolation: Problem of interpolation, Remainder or error in interpolation, Linear operators, Differences, difference table, Propagation of errors, Newton's forward interpolation formula, Newton's backward interpolation formula, Central interpolation, Stiriling's interpolation formula, Bessel's interpolation formula, Everett's interpolation formula, Steffensen's interpolation formula, Different interpolation zones, Error estimation, Working rules for use of different interpolation formulae, Sub-tabulation, Lagrange's interpolation formula, Aitken's interpolation method, Divided difference, Divided differences interpolation formula, Some important relations, Deductions from divided difference formula, Inverse interpolation, Estimate of remainder.

12 Hours

2. **Numerical Differentiation:** problem of numerical differentiation, Error term, Differentiation formulae for equidistant nodes, lagrange's differentiations formula.

Numerical Integration: Problem of numerical integration, A general formula, Some basic concepts, Newton-Cotes formula (closed type), Some lemmas, error in Newton-Cotes formula (closed type), Newton-Cotes formula (opened type), Some useful quadrature rules, Richardson extrapolation, Central- difference quadrature rules, Gaussian quadrature theory. Remarks on the use of different quadrature.

12 Hours

3. Euler-Maclaurin Sum Formula: Bernoulli polynomials, Euler-Maclaurin sum formula, Deductions of quadrature rules, Gregory- Newton quadrature formula, Romberg integration.

Numerical Solution of Equations: Introduction, Method of tabulation, Graphical method, Iteration proceses- basic concepts Method of bisection, Fixed-point iteration, Newton-Raphson method, Modified Newton-Raphson method, Inverse interpolation method, Secant method, Regula falsi method, Graeffe's method for algebraic equations. **12Hours**

4. Numerical Solution of Linear Equations: The problem and methods of solution, Gauss's elimination method, Iterative methods-preliminary concepts, Gauss-Jacobi iteration, Gauss-Seidel iteration, Ill- Conditioned equations.

6 Hours

5. Numerical Solution of Differential Equations: The problem. Basic concepts, Single-step methods-error and convergence, Euler's method, Runge-Kutta method, Multistep methods-general concepts, Methods for starting the solution, Adams-Bashforth method, Adams-Moulton method, Milne's method

8Hours

TEXT BOOKS:

1. Gupta A & Bose S C: **"Introduction to Numerical Analysis"** -Academic Publishers, 1989.
2. Hildebrand F B: **"Introduction to Numerical Analysis" –** Tata McGraw Hill, 1988.

REFERENCE BOOKS:

1. Conte S D and Carl de Boor: **"Elementary Numerical Analysis"-** McGraw Hill, 1980.
2. M K Jain, S R K Iyenger and Jain R K: **"Numerical Methods For Scientific & Engineering Com putation"** - New age international publishers.
3. Pervez Moin: **"Application Of Numerical Methods To Engineering"**
4. H K Dass: **"Advanced Engineering Mathematics"** - Chand and company Ltd., 12^{th} edition.

Course Outcomes:

The Student will be able to

1. Model some simple mathematical models of physical Applications.
2. Understand the application of Interpolation, Numerical Differentiation and Integration.

HEAT TRANSFER & FLUID FLOW

Subject Code	:**16MCS12**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
Students get exposed to various concepts of Heat Transfer and Fluid Flow.

Course Content:

1. Introduction and One-Dimensional Heat Transfer: The modes of heat transfer, the laws of heat transfer. Heat conduction in solids: Simple steady state problems in heat conduction, concept of thermal resistance, the critical radius problems, the differential equation of heat conduction, heat generation, two dimensional steady state heat conduction, unsteady state processes, extended surfaces- fins, other techniques for solving heat conduction problems, the finite difference method for steady state situations, the finite difference method for unsteady state situations, problem

06 Hours

2. Steady State Heat Conduction in Multiple Dimensions: Mathematical analysis of 2-D heat conduction without heat generation graphical analysis, the conduction shape factor, numerical method of analysis, Gauss-Siedel iteration, electrical analogy for 2-D conduction.

6 Hours

3. Thermal Radiation: Basic concepts, emission characteristics and laws of black body radiation, radiation incident on a surface, solid angle and radiation intensity, heat exchange by radiation between two black surface elements, heat Exchange by radiation between two finite black surfaces, the shape factor, radiant heat exchange in an enclosure having black surfaces, heat exchange by radiation between two finite parallel diffuse-gray surfaces, heat exchange by radiation in an annular space between two infinitely long concentric cylinders , radiant heat exchange in an enclosure having diffuse gray surfaces, problems.

Principles of Fluid Flow: The law of conservation of mass –the differential e quation of continuity, differential equations of motion in fluid flow –Navier-strokes equations, laminar flow in a circul ar pipe, turbulent flow in a pipe, the velocity boundary layer, laminar flow over a flat plate, the integral method-an appropriate technique for solving boundary layer problems, turbulent flow over a flat plate, problems.

13 Hours

4. Heat Transfer by Forced Convection: The differential equation of heat convection, laminar flow heat transfer in circular pipe, turbulent flow heat transfer in a pipe, the thermal boundary layer, heat transfer in laminar flow over a flat plate, the integral method, analogy between heat and momentum transfer, heat transfer in turbulent flow over a flat plate, flow across a cylinder, flow across a bank of tubes, problems.

Heat Transfer by Natural Convection: Natural convection heat transfer from a vertical plate, correlations for a horizontal cylinder and a horizontal plate, correlations for enclosed spaces, problems.

13 Hours

5. Heat Exchangers: Types of heat exchangers, direct transfer type of heat exchangers, classification according to flow arrangement, fouling factor, logarithmic mean temperature difference, the effectiveness-NTU method, other design consideration, Compact heat exchangers.

Condensation and Boiling: Film and drop condensation, film condensation on a vertical plate, condensation on horizontal tubes, bank of tubes, effect of superheated vapor and of non-condensable gases, types of boiling: correlations in pool boiling heat transfer, forced convection boiling, problems.

12 Hours

TEXT BOOKS:

1. Holmon J P: " **Heat Transfer"-** McGraw-Hill Publications, 2002.
2. Ozisik M N: " **Heat Transfer– A Basic Approach" -** McGraw-Hill Publications, 1985.

REFERENCE BOOKS:

1. A F Mills: **“Heat & Mass Transfer”**
2. Frank Kreith & M. S. Bohn:**“Principles of Heat Transfer” -** Thomson Publications, 2001.
3.W. M. Kays: **“Convective Heat and mass Transfer”-** Mc Graw Hill Publications 1984.

Course Outcome :
Students get to demonstrate their understanding in Thermal Radiation,Heat Exchangers, Condensation and Boiling.

OPTIMIZATION TECHNIQUES

Subject Code	:**16MCS13**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
The course aims at training students in various Optimization Techniques used in engineering analysis.

Course Content:

1.Introduction: Engineering application of optimization, Statement of optimization problem, Classification of optimization problems, Classical optimization techniques I: single variable optimization, Multivariable optimization with no constraints.

Classical Optimization Techniques II: Multivariable optimization with equality constraints and inequality constraints, Kuhn - Tucker conditions. **12 Hours**

2. Non - linear Programming: One - dimensional minimization methods: Unimodal function, Unrestricted search, Exhaustive search, Dichotomous search, Fibonacci method, Golden section method.
Interpolation Methods: Quadratic, Cubic and Direct root interpolation methods. **11Hours**

3. Unconstrained Optimization Techniques: Direct search methods : Univariate method, Hook and Jeeves' method, Powell's method, Simplex method.

Descent Methods: Steepest descent, Conjugate gradient, Quasi - Newton, Davidon - Fletcher - Powell method. **14 Hours**

4. Constrained Optimization Techniques: Direct methods: characteristics of a constrained problem, Indirect methods: Transformation techniques, Basic approach of the penalty function method. **06Hours**

5. Dynamic Programming: Introduction, Multistage decision processes, Principle of optimality, Computational Procedure in dynamic programming, Initial value problem, Examples.

07Hours

TEXT BOOK:

1. S. S. Rao, Optimisation: " **Theory and Application" -** Willey Eastern.
2. R.L Fox: " **Optimization methods for Engg. Design" -** Addison - Wesley.

REFERENCE BOOKS:

1. Ram:" **Optimisation and Probability in System Engg" -** Van Nostrand.
2. K. V. Mital & C. Mohan: **"Optimization methods"** - New age International Publishers, 1999.

Course Outcome:
Students develop skills to use appropriate optimization techniques for a specific engineering analysis problem.

ADVANCED MATERIALS TECHNOLOGY

(Common to MCS,MTE,MCM,IAE,MAR)

Subject Code	: **16MCM251**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objectives:

Students get an orientation into Newer Materials, Processing of Composites and analysis of composites, Nano Technology and Powder Metallurgy.

Course Content:

1 STRUCTURE-PROPERTY RELATIONS Introduction, Atomic structure, atomic bonds, secondary bonds, crystal structure, Miller indices, packing efficiency, crystal defects, grain structure, elastic and plastic deformation in single crystals, dislocation theory, strain /work hardening, plastic deformation in polycrystalline metals, fracture of metals, cold working, re crystallization and hot working, grain growth.

NEWER MATERIALS: Introduction, plastics, molecular structure, isomers, polymerization, thermosetting and thermoplastic materials, properties and applications of plastics. Ceramics, nature and structure, fine ceramics, properties and applications of ceramics. Composite materials – classification, matrix and reinforcemen t materials, properties, rule of mixtures, longitudinal strength and modulus (iso strain model), transverse strength and modulus (iso stress model), applications of composites. **13 Hours**

2. PROCESSING OF COMPOSITES: Liquid-state process, solid state process and in situ processes of MMC's. Slurry infiltration process, combined hot pressing and reaction bonding method, melt infiltration process, direct oxidation, isothermal chemical impregnation process and Sol-Gel and polymer pyrolysis of CMC's. Hand layup process, filament winding process, pultrusion process, pressure bag moulding, vacuum-bag moulding, autoclave moulding, injection moulding process and thermoforming process of PMC's.

METHODS OF ANALYSIS OF COMPOSITES: Micromechanics-Mechanics of material approach, elasticity approach to determine material properties. Macromechanics- Stress-strain relations with respect to natural axis, arbitrary axis and determination of material properties. Experimental characterization of laminates and particulate composites.

13 Hours

3.FAILURE ANALYSIS AND DESIGN OF COMPOSITES: Failure criterion for particulate and laminate composites. Design of laminated and particulate composites. Other mechanical design issues-Long term environmental effects, inter laminar stresses, impact resistance, fracture resistance and fatigue resistance.

NANO TECHNOLOGY: Introduction, concept of nanotechnology , nano science, nanomaterials (one, two and three dimensional), top down and bottom up constructions, fabrication of carbon nano tubes (CNT), nano material characterization – scanning probe microscopy, atomic force microscopy, scanning tunneling microscopy, applications of nano technology. **13 Hours**

4. SURFACE TREATMENT: Introduction, Surface Engineering, Surface quality & integrity concepts, Mechanical treatment, Thermal spraying processes and applications, Vapour depositions processes and applications, Ion-treatment. **5 Hours**

5. POWDER METALLURGY: Introduction, Steps in powder metallurgy, Production of Powder, Characterization & Testing of Powders, Powder Conditioning, Powder Compaction, Sintering, Finishing operations, Applications of PM components. **6 Hours**

TEXT BOOKS:

1. E.Paul Degarmo, J.T.Black, Ronald A Kohser. , **Materials and Processing in Manufacturing** 8th Edition – Prentice Hall India.
2. K.K.Chawla, **Composite materials –** Science & Engineering,. Springer.
3. A.K. Sinha, **Powder Metallurgy** 2nd Edition –. Dhanpat Rai Publications.
4. Dr. H.K.Shivanand, **Composite Materials** by. Asian Publication.
5. AUTAR K.KAW ,**Mechanics of composite materials**,Taylor and Francis group.

Reference Books:

1.**Composite Materials, Science & Engg -** Krishan K. Chawla, 2nd edition, Springer publicat1on.
2.**ASM Handbook on Metal Casting** - Vol .15, 9th edition, ASM publication
3.**ASM Handbook on Powder Metallurgy -** Vol 17, ASM publications
4.**Nanotechnology – Basic Science and Emerging Technol ogies**, -Mick Wilson, Kamali Kannangara, Overseas Press India Private Limited, First Indian Edition 2005.
5.V.S.R Murthy, A.K.Jena, K.P.Gupta, G.S.Murthy **Structure and Properties of Engineering Materials**, , Tata McGraw Hill.
6. M.M.Schwartz, **Composite Materials Hand book** –, McGraw Hill.
7. Rakesh Rath, **Nanotechnology**, S.Chand and company.

Course Outcomes:

Students will be able decide the application of various newer materials to engineering applications satisfying requirement of machinability, strength and weight requirements.

Elective-I

AUTOMATION &COMPUTER INTEGRATED MANUFACTURING

(Common to MCS,MCM,IAE,MAR)

Subject Code	: **16MCM12**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objectives:

To impart the knowledge of product cycle and its development. Understand the importance of prototypes, CAD/CAM & CIM. Students will get an exposure to types of Automatic material handling and storage systems.

Course Content:

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

7 Hours

2. Computer Integrated Manufacturing and Automation: Fundamentals of CAD/CAM, Computerized Manufacturing planning systems, shop floor control & automatic identification techniques. Computer Network for manufacturing and the future automated factor.

Detroit Type of Automation: Flow lines, Different Transfer Mechanisms, work pattern transfer, Different methods, Numericals.

10Hours

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

Computer Process Monitoring: Process control methods, direct digital control, supervisory computer control, steady state optimal control, on line search strategies, adaptive control. **13 Hours**

4.Fundamentals of Networking: Principles, techniques, networking methods, network standards, Ethernet, Internet, system security, remote systems, NFS, ATM, EWN, document and work flow management.

Automated Material Handling and Storage: Material functions, types of material handling equipment, analysis of material handling systems, design of system, conveyor system, automated guided vehicle systems, automated storage/retrieval systems, caroused storage systems work in process storage, interfacing handling & storage with manufacturing.

13 ours

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

7 Hours

TEXT BOOKS:

1. Groover, M.P:**"Automation, Production System and CIM"-** Prentice-Hall of India.
2.P.N. Rao:**"CAD/CAM Principles and Applications"-** TMH, New Delhi

REFERENCE BOOKS:

1.Vajpayee**:"Principles of CIM" -** Prentice-Hall of India.
2.Ranky, Paul G:**"Computer Integrated Manufacturing"-** Prentice-Hall of India.
3.Groover, M.P:**"CAD/CAM"-** Prentice-Hall of India.
4. David Bedworth:**"Computer Integrated Design and Manufacturing"-** TMH, New Delhi.

Course Outcome:

Students will be able to

1. Understand the importance of product development through CIM. Get knowledge of shop floor control , Computer Integrated Manufacturing and Automation.
2. Adopt appropriate material handling and storage in an automated manufacturing environment.
3. Incorporate methods of utilization of appropriate features in CAD application enhancing productivity in design

RELIABILITY ENGINEERING

Subject Code	:16**MCS152**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
The course aims at providing knowledge to students in methods to solve complex systems by Reliability Engineering Concepts.

Course Content:

1. **Reliability Definition:** Introduction, Definition of reliability, Failure data, Mean failure rate, mean time to failure((MTTF), Mean time between failures(MTBF), Graphical plots, Four important points, MTTF in terms of failure density, Generalization, Reliability in terms of Hazard rate and failure density, (Integral form), Mean time to failure in integral form, Reliability in other situations.

Hazard Models: Constant hazard, Linearly-increasing hazard, The weibull model, On density function and distribution function, Distribution function and reliability analysis, Some important distributions, Choice of distribution, Expected value, Standard deviation and variance, Theorems concerning expectation and variance.
12 Hours
2. **Conditional Probabilities and Multiplication Rule:** Conditional probability, Multiplication rule, Independent events, Venn diagrams-Sample space, Probability calculation by venn diagrams, Summary of probability rules, An example in structural reliability, Hazard rate as conditional probability, Bayes's Theorem

System Reliability: Series configuration, Parallel configuration, Mixed configurations, Application to specific hazard models, Anr-out-of-n structure, Methods of solving complex systems, Systems not reducible to Mixed configurations, Mean time to failure of systems, Logic diagrams, Markov models, Markov Graphs, Systems Subjected to Probability Laws
14 Hours
3. **Reliability Improvement**: Improvement of Components, Redundancy, Element Redundancy, Unit Redundancy, Standby Redundancy, Optimization, Reliability- cost Trade- off.

Fault-Tree Analysis and other Techniques: Fault-Tree Analysis, Fault-Tree Construction, Calculation of Reliability from fault tree, Tie-Set and cut-set, Use of Boolean Algebra, Basic operations, Truth Tables, De Morgan's Theorem, Application to reliability analysis, Probability Calculations.
12 Hours

4. **Maintainability and Availability**: Maintainability, Availability (Qualitative Aspects) SystemDowntime, Availability, Reliability and Maintainability trade-off, Instantaneous repair rate, Mean time to repair (MTTR), Reliability and Availability functions.

6 Hours

5. **Reliability Allocation and Applications**: Reliability Allocation for a Series System, Applications, Marine power plant, Computer System, Nuclear Power Plants, General Complex Systems, Failure Modes and Effects Analysis (FMEA).

6 Hours

TEXT BOOKS:

1. L. S. Srinath:**"Reliability Engineerring** "- Affiliated East **–** West press Pvt. Ltd., New Delh i.
2. New Juran, J.M and Gryna, F.M:**"Quality Planning and Analysis" -**Tata McGraw Hill publishing Company Ltd (1982) Delhi, India.

REFERENCE BOOKS:

1. Srinath K. S:**"Concepts in Reliability Engineering" -** Affiliated East-West Press Private Limited, New Delhi, India, 1985.
2. Halpern, Seigmund:**"The Assurances Sciences"** - Prentice Hall International, New Jersey, U.S.A, 1978.
3. Blanchard, Bejamin S:**"Logistics Engineering and Management" -** Prentice Hall International, New Jersey, U.S.A, 1986.
4. Kraus, John W:**"Handbook of Reliability Engineering"** -. McGraw Hill Book Company Inc. U.S.A, 1988.

Course Outcome:

Students will be able to adopt Reliability Engineering concepts to complex engineering problems

OPERATIONS ANALYSIS AND MODELLING

Subject Code	:16**MCS153**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
Various aspects of Operational analysis and modelling used in practical situations are dealt with to provide an insight to students on Operations analysis and modelling.

Course Content:

1. **Operations Decision Making, Analysis and Modelling**: Decision making process, model building, decision methodology, break even analysis and modelling, decision theory, expected monetary value and criteria, decision trees, statistical modelling, equations for discrete and continuous data.

Statistical Methods of Forecasting: Definitions, types and uses, forecasting decision variables and methodology, opinion and judgement methods, time series methods, exponential smoothing, adjusted exponential smoothing, regression and correlation analysis for forecasting, control and applications.
12 Hours
2. **Financial Analysis for Operations**: Capital investment and cash flows, depreciation, tax considerations, payback, present value, equivalent annual worth, internal rate of return, inflation effects.

Location Planning and Analysis: Nature and need for locations decision, procedure for making location decision, factors affecting location decision, domestic and international sites, cost-volume analysis of locations, factors rating systems, centre of gravity method, transportation linear programming.
13 Hours
3. **Process Planning and Analysis:** Process selection, intermittent and continuous production systems, flexible and robotic systems, assembly and flow process charts, multi-activity charts, Equipment selection, simulation modelling of operations, Monte Carlo simulation using empirical data, simulations using statistical distribution.
7 Hours

4. **Plant Design and Analysis:** Facility planning aids, plant design and capacity, locational factors and analysis models, layout analysis and optimization of plant design and productions.

Production Control: Production control objectives and overview of qlitative and variables subject to control, flow control order, project control, line balancing.

12 Hours

5. **Operations Analysis and Maintenance**: operations analysis and control, analysis of goods versus services systems, learning curve effects, maintenance objectives, probability models for breakdowns cost, expected value model for estimating breakdown cost, simulation model for estimating breakdown cost.

6 Hours

TEXT BOOKS:

1. Monks, J. G.:" **Operations Management"- I"** - McGraw-Hill International Editions, 1987.
2. Mahadevan:" **Operations Management, I. B"-** Theory and practice, Pearson, 2007.

REFERENCE BOOKS:

1. Buffa:**"Modern Production/Operations Management"-** Wiely Eastern Ltd., 2001.
2. Pannerselvam. R:**"Production and Operations Management"-** PHI.2002.
3. Adam & Ebert:**"Productions & Operations Management" -** 2002
4. Chary, S. N:**"Production and Operations Management"-** Tata-McGraw Hill. 2002.

Course Outcome:

Students will be able to use Operations analysis and modelling in various engineering analysis.

SOLAR ENERGY ENGINEERING

Subject Code	:16**MCS154**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

The course helps the student to understand various application and utilities of solar energy.

Course Content:

1. **Introduction:** Man and energy, World's production and reserves of commercial energy sources, India's production and reserves, Energy alternative. The Solar Energy option- an overview of Thermal Applications,Devices, for thermal collection and storage, Thermal application, Some observations.

Solar Radiation: Solar radiation outside the earth's atmosphere, Solar radiation at the earth's surface, Instruments for measuring solar radiation and sunshine, solar radiation data, solar radiation geometry, Empirical equations for predicting the availability of solar radiation, solar radiation on tilted surfaces, **12 Hours**

2. **Liquid Flat Plate Collectors:** Performance analysis, Transmissivity of cover system, Transmissivity-absrptivity product , Overall loss coefficient and heat transfer correlations, Collector efficiency factor, collector heat-removal factor, A numerical example, Effects of various parameters on performance , Analysis of collectors similar to the conventional collector, Transient analysis, testing procedures, Alternatives to the conventional collector. **09 Hours**

3. **Solar Air Heaters:** Performance analysis of a conventional air heater, other types of air heaters, Testing procedures.

Concentrating Collectors: Flat-plate collectors with plane reflectors, cylindrical parabolic collector, Compound Parabolic collector (CPC), Paraboloid dish collector, central receiver collector.
10 Hours

4. **Thermal Energy Storage:** Sensible heat storage, Latent heat storage, Thermo chemical storage**.** Solar Pond, Description, Performance analysis, Experimental studies Operational problems, Other solar pond concepts **7 Hours**

5. **Economic Analysis:** Initial and annual costs, Definitions, Present worth calculation, Repayment of loan in equal annual instalments, Annual Solar savings, Cumulative solar savings and life cycle savings, Payback period, Concluding remarks.

Other Methods for Solar Energy Utilization: Photovoltaic conversion, Wind energy, Energy from biomass, Wave energy, Ocean thermal energy conversion, Geothermal Energy.
12 Hours

TEXT BOOKS:

1. S P Sukhatme: **"Solar Energy** "**-** Tata McGraw-Hill publishing company limited New Delhi, 1996
2. H P Garg and J Prakash:**" Solar Energy Fundamentals"**

REFERENCE BOOKS:

1. D .Yogi Goswami**,** F. Kreith and J. F.Kreider: **"Principles of Solar Engineering** "- published by Taylor & Francis- 2000
2. A.B. Meinel and F.P. Meinel,: **"Applied Solar Energy"-** Addison-Wesley, 1976.
3. J.A. Duffie and W. A. Beckman C:**"Solar Engineering of Thermal Processes"-** John Wiley & Sons, 1991

Course Outcome:

Students will be able to realize the applications of solar energy in
Various engineering applications.

Design Engineering Laboratory -1

Sub Code :16MDE16 IA Marks: 20
Hr/Week: 6 Exam Hours:3
Total Hours :84 Exam Marks:80

Note:

1) These are independent laboratory exercises
2) A student may be given one or two problems stated herein
3) Student must submit a comprehensive report on the problem solved and give a presentation on the same.

Course Content:

Experiment #1
Single edge notched beam in four point bending.
Part A : Experimental Stress Analysis using 2D Photo elasticity.
Part B : Numerical Experiments using FEM.
Part C : Correlation Studies.

Experiment #2
Torsion of prismatic bar with rectangular cross section.
Part A : Experimental Investigation using Strain Guage Insrumentation.
Part B : Finite Element Analysis.
Part C : Correlation of stiffness and Surface Strains.

Experiment #3
Contact Stress Analysis diametrical compression of Two Circular Discs.
Part A : 2D Photo elastic Investigation.
Part B : Numerical Analysis using FEM.
Part C : Correlation Studies.

Experiment #4
Thin walled Tube under diametrical Compression.
Part A : Experimental studies using Strain Gauge Instrumentation.

Part B : Non Linear FEA.
Part C : Correlation Studies.

Experiment #5
Vibration Characteristics of a Spring Mass Damper System.
Part A : Analytical Solutions.
Part B : MATLAB Simulation.
Part C : Correlation Studies.

Experiment #6
Roots of a Cubic Polynomial.
Part A : Analytical Solutions.
Part B : MATLAB Simulation.
Part C : Correlation Studies.

Experiment #7
Modelling and Simulation of Control Systems using MATLAB.

Experiment #8
Fracture Toughness Testing of Glass.

II SEMESTER

FINITE ELEMENT ANALYSIS

(Common to MTP,MTH,MCS)

Subject Code	:**16MTP12**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objectives

1. Introduce the various aspects of FEM as applied to engineering problems.
2. Apply the fundamental concepts of mathematical methods solve Heat Conduction, Transient and Phase Change ,Convective Heat Transfer problems.

Course Content:

1. Introduction: Importance of stress analysis, heat transfer and fluid flow, conservation laws for mass, momentum and energy; Fourier equation, N-S equations; energy principles in stress analysis; Basic equations in elasticity; Boundary conditions. Some Basic Discrete Systems: Discrete systems as basis for FEM analysis; Examples of discrete systems in stress analysis, heat transfer and fluid flow.

1-D Finite Elements: Introduction; Elements and shape functions - one dimensional linear element (bar element), one dimensional quadratic element.
10 Hours

2. 2-D Finite Elements: two dimensional linear triangular elements, Local and Global coordinate systems, quadratic triangular elements, two dimensional quadrilateral elements, iso-parametric elements, three dimensional elements, beam, plate and shell elements, composite materials.
6 Hours

Formulation: Introduction; Variational approach; methods of weighted residuals for heat transfer problems, principle of virtual work for stress analysis problems; mixed formulation; penalty formulation for fluid flow problems. Primitive variables formulation for flow problems.
12 Hours

3. Heat conduction problems: FEM analysis of steady state heat conduction in one dimension using linear and quadratic elements; steady state heat conduction in two dimensions using triangular and rectangular elements; three dimensions problems, Axi-symmetric problems.

6 Hours

4. Transient and Phase change problems: Transient heat conduction in one and multi dimensional problems; time stepping scheme using finite difference and finite element methods; phase change problems - solidification and melting; Inverse heat conduction problems.

6 Hours

5. Stress Analysis Problems: Introduction; stress analysis in one, two (plane stress and plane strain) and three dimensions; Axi-symmetric problems; beam and plate bending problems; thermal stress development; shrinkage stress development; prediction of distortions in manufactured products; Introduction to simple dynamic problems.

10 Hours

6. Convective Heat Transfer Problems: Introduction; Galerkin method of Steady, convection-diffusion problems; upwind finite element in one dimension - Petro-Galerkin formulation, artificial diffusion; upwind method extended to multi-dimension; transient convection - diffusion problems - FEM solutions, extension to multi dimensions; primitive variables approach (u, v, w, p, t formulation); characteristic - based split scheme (CBS); artificial compressibility scheme; calculation of Nusselt number, drag and stream function; mesh convergence; Introduction to convection in Porous media; Laminar and turbulent flows.

8 Hours

Text Books:

1. **Fundamentals of the finite element method for heat and fluid flow -** R.W. Lewis, P. Nithiarasu and K. N. Seetharamu, , John Wiley and Sons, 2004.
2. **The finite element method in heat transfer analysis -** R.W. Lewis, K Morgan, H.R. Thomas, K.N. Seetharamu, John Wiley and Sons, 1996.

Reference Books:

1. **The finite element method in heat transfer and fluid dynamics -**J.N. Reddy and Gartling D.K., CRC publications, 2000.
2. **The finite element method volume 3: fluid dynamics -** O.C. Zienkiewicz and R.L. Taylor, John Wiley & Sons, 2001.
3. **The finite element and for solid and structural mechanics -** O.C. Zienkiewicz and R.L. Taylor, Elsevier Publishers , 2005.
4. **Introduction to Finite Elements in Engineering -** Tirupathi R. Chandrupatla, Ashok D. Belegundu, Prentice-Hall Ltd., 2002.
5. **Finite Element Analysis -** S.S. Bavikatti, New Age International, 2005.

Course Outcome:

Students will be able to

1. Define the element properties such as shape function and stiffness matrix for the various elements.
2. Formulate element properties for 1D and 2D elements.
3. Develop skill to solve simple Heat Transfer problems using the steps of FEM

ADVANCED MACHINE DESIGN

(Common to MDE,MEA,MMD,CAE,MCS)

Subject Code	:**16MDE22**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

This course enables the student to identify failure modes and evolve design by analysis methodology. Design against fatigue failure is given explicit attention.

Course Content:

1. Introduction: Role of failure prevention analysis in mechanical design ,Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr's theory and modified Mohr's theory, Numerical examples.

   Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models ,Fatigue design methods ,Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features. **12 Hours**

2. Stess-Life (S-N) Approach: S-N curves, Statistical nature of fatigue test data, General S-N behavior, Mean stress effects, Different factors influencing S-N behaviour, S-N curve representation and approximations, Constant life diagrams, Fatigue life estimation using S-N approach.

   Strain-Life(ε-N)approach: Monotonic stress-strain behavior ,Strain controlled test methods ,Cyclic stress-strain behavior ,Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by ε-N approach. **12 Hours**

3. LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects, Crack growth life estimation. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean

stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach, Neuber's rule , Glinka's rule, applications of fracture mechanics to crack growth at notches. **13 Hours**

4. Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach. **7 Hours**

5. Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength. **6 Hours**

Text Books:

1) Ralph I. Stephens, Ali Fatemi, Robert, Henry o. Fuchs, "Metal Fatigue in engineering", John Wiley New York, Second edition. 2001.
2) Failure of Materials in Mechanical Design, Jack. A. Collins, John Wiley, Newyork 1992.
3) Robert L. Norton , "Machine Design", Pearson Education India, 2000

Reference Books:

1) S.Suresh , "Fatigue of Materials", Cambridge Unive rsity Press, -1998
2) Julie.A.Benantine , "Fundamentals of Metal Fatigue Analysis", Prentice Hall,1990
3) Fatigue and Fracture, ASM Hand Book, Vol 19,2002.

Course Outcome:

This course enriches the student with state of the art design methodology namely design by analysis and damage tolerant design.

COMPUTATIONAL HEAT TRANSFER AND FLUID FLOW
(Common to MCS,MTP,MTH)

Subject Code	:**16 MTP254**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
To impart the knowledge of computational methods in heat transfer and fluid flow, Finite volume method, various techniques, boundary conditions.

Course Content:

1.Governing Equations: Review of equations governing fluid flow and heat transfer. Neumann boundary conditions, partial differential equations, Dirichlet boundary conditions.
Finite difference: Discretization, consistency, stability and fundamentals of fluid flow modeling, application in heat conduction and convection, steady and unsteady flow. **12 Hours**

2.Finite volume method: application to steady state Heat Transfer: Introduction, regular finite volume, discretization techniques.
Finite Volume Method: application to transient Heat Transfer. **12 Hours**

3.Finite Volume Method: application to Convective Heat Transfer.
Finite Volume Method: application to Computation of Fluid Flow Simple algorithms. **12 Hours**

4. Solution of viscous incompressible flow: Stream function and vorticity formulation. Solution of N S equations for incompressible flow using MAC algorithm. **8 Hours**

5. Compressible flows via Finite Difference Methods **6 Hours**

Reference Books:

1. **Numerical Heat Transfer and Fluid Flow -** S.V. Patankar, Hemisphere Publishing Company.
2. **Computational Fluid Dynamics -** T.J. Chung, Cambridge University Press
3. **Computational fluid flow and heat transfer -** K. Murlidhar and T. Sounderrajan, Narosa Publishing Co.

4. **Computational fluid mechanics and heat transfer -** D. A. Anderson, J. C. Tannehill, R.H. Pletcher, Tata McGraw-Hill Publications
5. Computational fluid dynamics - J.A. Anderson, McGraw-Hill Publications

Course Outcome:
Students will have a good knowledge about the computational methods to be used in heat transfer and fluid flow problems. Good knowledge about Finite Volume Methods.

MODELLING & SIMULATION

Subject Code	:16MCS24	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
The course gives exposure to students on various modelling and simulation techniques.

Course Content:

1. **Introduction and Overview:** Concept of System, System environment, element of system, system modeling, types of models, Monte Carlo method, system simulation, simulation-management laboratory, advantages limitations of system, simulation, continuous and discrete systems.

   Simulation of Continuous Systems: Characteristics of a continuous system, comparison of numerical integration with continuous simulation system, Simulation of an integration formula. **12 Hours**

12. **Simulation of Discrete System:** Time flow mechanism, discrete and continuous probability

Density Function, Generation of Random Numbers: Testing of random numbers for randomness and for auto correlation, generation of random variates for continuous probability distributions-binomial, normal, exponential and beta distributions, combination of discrete event and continuous models. **12Hours**

12. **Simulation of Queuing Systems**: Concept of queuing theory, characteristics of queues, stationary and time dependent queues, queue discipline, time series analysis, measure of system performance, Kendall 's notation, auto covariance and auto correlation function and

effects in queuing systems, simulation of single server queues, multi server queues, queues involving complex arrivals and service times with blanking reneging.

8 Hours

12. **Simulation of Inventory systems**: Rudiments of inventory theory, MRP, in process inventory, Necessity of simulation in inventory problems, forecasting and regression analysis, forecasting through simulation, generation of Poisson and Erlang variates, simulation of complex inventory situations.

06 Hours

5.Design of Simulation Experiments: Length of run, elimination of initial bias. Variance reduction techniques, stratified sampling, antipathetic sampling, common random numbers, time series analysis, spectral analysis, model validation, optimization procedures, search methods, single variable deterministic case search, single variable non-deterministic case search, regenerative techniques.

Simulation of PERT: Simulation of-maintenance and replacement problems, capacity planning production system, reliability problems, computer time sharing problem, the elevator system.

12 **Hours**

TEXT BOOKS:

1. Loffick:**"Simulation And Modeling"-** Tata McGraw Hill
2. Dr.D.S.Hira S.Chand &Co:**"System Simulation"**

REFERENCE BOOKS:

1. Meelamkavil: **"Computer Simulation and Modeling"-** John Willey.
2. Gordon**:"System Simulation"-** Prentice Hall of India.
3. Averill Law & David M. Kelton: **"Simulation, Modeling and Analysis"-** TMH 3 rd Edition.

Course Outcome:

Students will be able to simulate experiments,Capacity Planning,Inventory Systems,Queuing Systems related to various practical situations in Industrial practice.

Elective-II

NUMERICAL METHODS IN MECHANICAL VIBRATIONS

Subject Code	:**16MCS251**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objectives:
The course aims at giving students knowledge about various numerical methods in mechanical vibrations.

Course Content:

1. Formulation of the Equations of Motion: Dynamic equilibrium- Principal of virtual displacements , Hamilton's principle, Lagrange's equations, Equations of motion for a system with constraints, Element energyfunctions-Axial element, Torque element, Beam bending element, Deep beam bending element, Membrane element, Thin plate bending element, Thick plate bending element, Three-dimensional solid, Axi-symmetric solid, The dissipation function, Equations of motion and boundary conditions problems.

Finite Element Displacement Method: Raleigh- Ritz method, Finite element displacement method, Axial vibration of rods, Tensional vibration of shafts, Bending vibration of beams, Vibration of plane frameworks, Vibration of three- dimensional frameworks, Techniques for increasing the accuracy of elements, Shear deformation and rotary inertia effects, Numerical integration, and other considerations for beams.

12 Hours

2. Vibrations of Solids: Ax-symmetric solids, Applied loading, Displacements, Reduced energy expressions. Linear triangular element, Core elements, Arbitrary shaped solids, Rectangular hexahedron, Isoperimetric hexahedron, Right heptahedron, Volume coordinates for tetrahedral, Tetrahedron element, Increasing the accuracy of elements, Problems.

In - Plane and Flexural Vibration of Plates: In-plane vibration of plates, linear triangular element, linear rectangular element, linear quadrilateral element, Area coordinates for triangles, linear triangle in area coordinates, increasing the accuracy of elements and Problems Flexural vibration of plates, Thin rectangular element (non- conforming and conforming), Thick rectangular element, Thin triangular element (non- conforming and conforming), Cartesian Coordinates, Area coordinates, thick triangular element, other plate bending elements, Problems. **12 Hours**

3. Analysis of Free Vibration I: Some preliminaries, Orthogonality of eigenvectors, Transformation to standard form, Sturm sequences, Orthogonal transformation of a matrix, The Jacobin method, Givens' and Householder's methods, Eigen va lues and eigenvectors of a symmetric tridiagonal matrix, The bisection method, Inverse iteration, The LR, QR and QL methods, Reducing the number of degrees of freedom. Making use of symmetry, Rotationally periodic structures.

Analysis of Free Vibration II: Elimination of unwanted degrees of freedom - Component mode synthesis, Fixed interface method, Free interface method, solution of large Eigen problems - Bisection /inverse iteration, Subspace iteration, Simultaneous iteration, Lanczos' method and Problems **12 Hours.**

4. Forced Response I: Modal analysis- Representation of damping, Structural damping; Viscous damping, Harmonic response - Modal analysis, Direct analysis; Response to periodic excitation, Transient response – Modal analysis - Central difference method, The Houbolt method, The Newmark method, The Wilson method; Direct analysis - Central difference method, The Houbolt method, The Newmark method, The Wilson method; Selecting of time step and Problems. **7 hours**

5. Forced Response II: Response to Random excitation, representation of the excitation, Response of Single DOF system, Direct and Modal Response Multi DOF system, Truncation of the modal solution – mode acceleration method, Residual Flexibility, Response to imposed displacements – direct and modal response; Response spectrum methods- Single DOF and Multi DOF systems; reducing the number of degrees of freedom. Making use of symmetry, rotationally periodic structures, Elimination of unwanted degrees of freedom - Component mode synthesis. **7 Hours**

TEXT BOOK:

1. Maurice Petyt: **"Introduction Finite Element Vibration Analysis"-** Cambridge University Press.
2. Singiresu S. Rao: **"Mechanical Vibrations"-** Pearson Education.

REFERENCE BOOKS:

1. M.J.Fagaan:**"Finite Element Analysis Theory and Practice"-** Longman, Scientific and Technology Publishing house.
2. R. D. Cook:**"Concept and Applications of Finite Element Analysi s"-** John Wiley and sons Inc.

Corse Outcome:
Students will be able to apply various numerical methods in Vibration analysis to solve practical engineering problems.

RAPID PROTOTYPING

(Common to MCM,IAE,MAR,MTE,MCS **)**

Subject Code	:16MCM153	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective

The course enables students to conceive, design, and implement products quickly and effectively, using the latest rapid prototyping methods and CAD/CAM technology .The students learn to differentiate various process parameters associated with Rapid manufacturing technique .

Course Content:

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

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

2. **Selective Laser Sintering:** Type of machine, Principle of operation, process parameters, Data preparation for SLS, Applications, FUSION DEPOSITION MODELLING**:** Principle, Process parameter, Path generation, Applications. **6 Hours**

3. **Solid Ground Curing:** Principle of operation, Machine details, Applications, **Laminated Object Manufacturing**: Principle, of operation, LOM materials, process details, application.

Concepts Modelers: Principle, Thermal jet printer, Sander's model market, 3-D printer, Genisys Xs printer HP system 5, object Quadra systems, Laser Engineering Net Shaping (LENS) **12 Hours**

4. **Rapid Tooling :** Indirect Rapid tooling -Silicon rubber tooling —Al uminum filled epoxy tooling Spray metal tooling ,Cast kirksite ,3D keltool ,etc ,Direct Rapid Tooling — Direct, AIM, Q uick cast process, Copper polyamide, Rapid Tool ,DMILS, ProMetal ,Sand casting tooling ,Laminate tooling soft Tooling vs. hard tooling. **8 Hours**

5. **Software For Rp:** Stl files, Overview of Solid view, magics, imics, magic communicator, etc. Internet based software, Collaboration tools, **RAPID Manufacturing Process Optimization:** factors influencing accuracy, data preparation errors, Part building errors, Error in finishing, influence of build orientation.

Allied Processes: vacuum, casting, surface digitizing, surface generation from point cloud, surface modification — dat a transfer to solid models.

14 Hours

Text Books:

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

Reference Books:

1. Terry Wohler's " **Wohler's Report 2000** "- Wohler's Association 2000

Course Outcomes:

1. Students can express the concept of product design stages and methods, thereby making him a better product designer.
2. Student can assess and implement RP techniques for specific application leading to better ROI for the company that uses RP machines

PROJECTS ANALYSIS AND MANAGEMENT

Subject Code	: 14**MCS253**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
Project Management is an important aspect which an engineer has to know,the course aims at giving an insight into various aspect of Project analysis and Management.

Course Content:

1. Introduction: Capital Investments, types of Capital Investments, Phases of Capital Budgeting, Phases of Capital Budgeting, Levels of Decision Making, Facets of Project Analysis, Feasibility study, Weakness in Capital Budgeting.

Market and Demand Analysis: Situational Analysis and objectives specification, Collection of Information, Market survey, Market characterization, Demand Forecasting, Qualitative, Quantitative and Casual Methods of Forecasting, Uncertainties in demand forecasting, Market Planning.

12 Hours

2. Technical Analysis: Manufacturing Technology, Material Inputs, Product Mix, Plant Capacity, Location, Machineries and equipment, Structure and civil works, Environmental Aspects, Project charts and layouts, Project implementation, consideration of alternatives.

Financial Analysis: Cost of project, Means of Finance, Estimation of sales and production, cost of production, working capital requirements and financing, Profitability projections, Breakeven Analysis, Cash Flow and Balance sheet statements. **14 Hours**

3. Investment Analysis: Time value of Money, Interest factors, Compounding and Discounting, Investment criteria – NPV, BCR, IR R, Payback Period, Urgency, ARR, Investment Evaluation.

Risk Analysis: Sources, Measures and perspective of Risk, Sensitivity Analysis, Simulation Analysis, Decision Tree Analysis, Monte- Carlo Simulation, Project selection under Risk. **12 Hours**

4. Networks Techniques for Project Management: Project Network, Time estimation, Critical Path determination, PERT/*CPM* Model, Network cost system. **06 Hours**

5. Manpower Management in Projects: Functional Approach to Manpower Management- the element of decision process, project team concepts, filed autonomy, policies, government policies. **06 Hours**

TEXT BOOKS:

1. Prasanna Chandra: **"Projects - Appraisal, Preparation, Budgeting And I mplementation" -** Tata McGraw hill.
2. James P,Lewis: **"Project Planning, Scheduling & control"-** ,Meo Publishing company. 2001

REFERENCE BOOKS:

1. Dennis lock: **"Hand book of Project Management** "
2. Dennis lock: **"Project Management".**
3. Hardd kerzner **:"Project Management A System Approach To Planning Scheduling And Controlling"-** CBS Publishers and distributors. 2002
4. Beningston Lawrence: **"Project Management" -** Mc-Graw hill 1970

Course Outcome:

Students get to know market and demand analysis,financial analysis,investment analysis and risk analysis.

NANO TECHNOLOGY

Subject Code	: 14**MCS254**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

To provide exposure to principles of nanotechnology; characterization of nanostructured materials; and its applications

Course Content:

1. Introduction : Overview of Nanosience and Engineering, Classification of nanostructures, Nanoscale Architecture, Scaling and miniaturization laws, Why use miniaturization technology- Effect of the nanometer length scale, Fabrication processes- Top down and Bottom up processes, Characterization techniques

Physics Of Nanoscience: Electronic properties of Atoms & Solids**,** The isolated atom – Bonding between atoms – I, CAO Van der waals forces – Dispersion interaction – Orientational interactio n – Induction interaction. Stating Schrodinger's wa ve equation and its importance – physical significance of wave function – Eigen values and Ei gen functions. The Free electron (Particle) model and energy bands – particle in 1-D potential well of infinite height (discussion on energy values, wave functions – normalization and probability densities). Particle in 1-D potential well of finite height – Concept of tunneling. – Heisenberg' s uncertainty principle – Derivations of Density o f states for 3D, 2D, 1D and 0D and graphical representations. 07 **Hours**

2. Effects Of Nanometre Length Scale: Changes to the system total energy. Changes to the system structure. How nanoscale dimensions affect properties – structural, thermal, chemical, mechani cal, magnetic, optical and electrical. Semiconductor Physics – To Understand Inorganic Semiconductor Nanostructures:What is a semiconductor ? Doping, The concept of effective mass, Carrier transport, mobility and electrical conductivity, Optical property of semiconductors, Excitions, The pn junction, Phonons, Types of semiconductors, Quantum Confinement In Semiconductor Nanostructures,Quantum confinement in one dimension : quantum well.Quantum confinement in two dimension : quantum wires.Quantum confinement in three dimension : quantum dots, Superlattices, Band offsets.

07 Hours

3. **Chemistry Of Nanoscinece Concept And Materials:** chemistry of Carbon Fullerenes,structure and synthesis, chemical reactivity-chemistry of higher fullerenes- applications Nanotubes**,** Carbon forms structured by energetic species-amorphous nanotubes and crystalline forms, carbon-an ideal model system to study structuring by energetic species, structuring of amorphous carbon forms, structuring of ordered sp^2 forms, structuring carbon nanotubes : Electric arc (arc evaporation) technique, laser ablation, catalytic decomposition of hydrocarbons purification.

Structure and properties of carbon nanotubes. Inorganic nanotubes, structure, synthesis and properties. Electron transport in nanotubes. Ballistic, Spintronics, Coulomb blockade and Nanowire. Organic semiconductors, Organic light emitting diodes.

06 Hours

4. **Self- Organization:** Phase behavior of nanoparticle suspensions, hard sphere behavior, soft repulsions, and weakly attractive suspensions, Catalysis, Nanocrystalline Zeollites –Hydrothermal synthesis of nanocrystalline zeollites application in environmental catalysis, selective partial oxidation reactions of hydrocarbons and photo catalytic decomposition of organic contaminations using nanocrystalline zeollites.

Characterization Basic Of Scatering Physics Related To Characterization: X rays and their interaction with matter, Electron and their interaction with matter, Phonon scattering, Plasomon scattering, Single-electron excitation, Direct radiation losses, Neutrons and their interaction with matter, Ions and their interaction with matter, Elastic scattering and diffraction, Technology of Characterization, Profilometry, Optical microscope, SEM, TEM, FIB, STM, AFM, Surface Raman Scattering, wettability (contact angle) measurement small angle X-ray diffraction and electron diffraction. **15 Hours**

5. **Fabrications and Characterizations of Nano Structures:** Milling, Silicon VLSI fabrication processes-Doping, Oxidation / Deposition, Etching, Lithographic, processes – Photo, c-beam, F ocused ion beam, x-rays Soft lithography, Machining – Micromachining, micromachining, LIGA. (MEMS processes), Applications, Nano and Micro machines (NEMS AND MEMS), Liquid phase methods molecular and biological computing, Colloidal methods, Sol-gel methods, Electrodeposition, Self-assembly and self-organization, processes

Nanotribology Composition And Structure Of Surfaces Natural Condition : oxide and hydrocarbon films surface segregation and reaction with environments, thermodynamics structure of surfaces, atomistic simulations methods to study composition and structure of surfaces, composition –Auger electron spectroscop y, X-ray photoelectron spectroscopy, structure, LEED,STM/AFM XRD,HREM. Chemical interactions on surfaces, adsorption and deposition on surfaces (physisorption and chemisorption), Langmuir adsorption isothenn, desorption from surfaces : Electronic properties and surface reactions relevant to tribology, density functional studies analysis of structure sensitivity lubricant degradation. Nanomechanical properties : Determination of surface mechanical properties (AFM/nanoindentation), simple friction theories effects of surface compostion and structure on friction, environmental and temperature effects, relationship with surface chemistry, mixed and boundary lubrication, failure mechanisms.
15 Hours

TEXT BOOKS :

1. Ed. William A Goddard III, Donald W Brenner, Sergey Edwart Lyschevski and Gerald J. Iafrate: **“Handbook of Nanoscience Engineering and Technology”-** CRC Press, New York (2003)
2. Ueno T., Ito T and Nonogaki: **“Microlithography fundamentals in Semiconductor de vices and Fabrication Technology”-** S Marcel Dekker(1988).

REFERENCE BOOKS :

1. William moreau:**“Semiconductor lithography Principles, Practies and materials”** -plenum press (1988)
2. ULSI, ED. By Matsui S., Ochiai Y and Suzuki K:**“Sub-Half micron Lithography”** - Cambridge University Press (1999)
3. A Borderland Between STM, EB, IB and X-ray Lithographies, Ed. By Gentili M., GiovannellaC., and Selci S.,NATO: **“Nanolithography”**
4. Kluwer**: “Asi Series E Applied Sciences”-** vol.264, Academic Publishers (1994).

Course Outcome:
Students will be able to understand the synthesis, properties and industrial applications of nanostructures and nanomaterials .

Design Engineering Laboratory - Lab 2
(Common to MDE,MEA,MMD,CAE,MCS)

Sub Code : 14MDE26	**IA Marks :20**
Hrs/ Week : 6	**Exam Hours : 03**
Total Hrs:84	**Exam Marks :80**

Note:

- These are independent laboratory exercises
- A student may be given one or two problems stated herein
- Student must submit a comprehensive report on the problem solved and give a presentation on the same.

Course Content:

Experiment #1
Structural Analysis
Part A: FE Modeling of a stiffened Panel using a commercial preprocessor.
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2
Design Optimization
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3
Thermal analysis
Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4
Thermal Stress Analysis
Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment#5
CFD Analysis
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6
Welded Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #7
Bolted Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #8
Adhesive Bonded Joints.
Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

IV SEMESTER

MICRO ELECTRO MECHANICAL SYSTEMS (MEMS)

(Common to MCM,IAE,MAR,MCS)

Subject Code	:**16MCM253**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

Students get exposure to various Micro Electronic Mechanical systems which find extensive usage in Industrial applications

Course Content:

1. Introduction: Micro Electro-Mechanical Systems, Ultra Precision Engineering, Micro-sensors; Micro-actuators; Microelectronics Fabrication; Micromachining; Mechanical MEMS; Thermal MEMS : MOEMS; Magnetic MEMS; RF MEMS; Micro-fluidic Systems; Bio and Chemo – Devices; MEMS Packages and Design Considera tions; Micro-Instrumentation.

Microfabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining: Isotropic Etching and Anisotropic Etching, Wafer Bonding, High Aspect-Ratio Processes (LIGA) **12 Hours**

2. Mechanical Sensors and Actuators: Principles of Sensing and Actuation; Beam and Cantilever; Microplates; Capacitive Effects; Piezoelectric material as Sensing and Actuating Elements; Strain Measurement; Pressure measurement; Flow Measurement using Integrated Paddle – Cantilever Structure; Pressure Measurement by Microphone; Shearmode Piezoactuator; Gripping Piezoactuator; Inchworm Technology. **08 Hours**

3.Thermal and Fluidic Micro Sensors and Actuators : Thermal sensors, Electrical Sensors, Chemical and Biosensors Electromagnetic and Thermal microactuation, Mechanical design of microactuators, Microactuator examples, Micro Fluidic systems, Fluid actuation methods, microvalves, micropumps, micromotors-Microactuator systems : Ink-Jet printer heads, Micro-mirror TV Projector. **8 Hours**

4. Surface Micromachining: One or two sacrificial layer processes, Surface micromachining requirements, Polysilicon surface micromachining, Other compatible materials, Silicon Dioxide, Silicon Nitride, Piezoelectric materials, Surface Micromachined Systems: Success Stories, Micromotors, Gear trains, Mechanisms.

MEMS: Design and Analysis: Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modelling and simulation. **14 Hours**

5. MEMS: Characterization: Technologies for MEMS characterization, Scanning Probe Microscopy (SPM): Atomic Force Microscopy (AFM), Scanning tunneling microscopy (STM), Magnetic Force Microscopy, Scanning Electron Microscope, Laser Doppler vibrometer, Electronic Speckle Interference Pattern technology (ESPI). **8 Hours**

Text Books:

1.Rai-Choudhury P. MEMS and MOEMS Technology and Applications, PHI Learning Private Limited, 2009.
2.Stephen D. Senturia, "Microsystem Design" Springer, 2001.
3.Marc Madou, "Fundamentals of Microfabrication" Ta ylor & Francis Group, 2002.
4.Gregory Kovacs, "Micromachined Transducers Source book" McGraw Hill 1998.

Reference Books

1.M.H. Bao, "Micromechanical Transducers: Pressure sensors, accelerometers, and gyroscopes" Handbook, Elsevier.
2.Nadim Maluf, An Introduction to Microelectromechanical Systems Engineering, Artech House Publishers, 2000.
3.Stephen D. Senturia, "Microsystems Design" Kluwer Academic Publishers, New York,November 2000.

Course Outcome:

Students will be in a position to demonstrate their knowledge in micro machining and micro electro mechanical systems.

Elective-III

WIND ENERGY ENGINEERING

Subject Code	:**16MCS421**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:
The course aims at providing knowledge on an important form of energy: wind energy and its applications.

Course Content:

1. **Introduction:** Historical uses of wind, history of wind electric generation, horizontal axis, wind turbine, Innovative wind turbines.

Wind Characteristics: Metrology of wind, world distribution of wind, Atmospheric stability, Wind speed, variation with height, wind speed statistics, Weibull statistics, determining Weibull parameters, Rayleigh & normal distributions. **12 Hours**

2. **Wind Measurements:** Eolian features, biological indicators, rotational anemometers, other anemometers, wind direction, wind measurements with balloons.

Wind Turbine Power, Energy & Torque: power output from an ideal turbine, aerodynamics, power output from practical turbines, transmission & generator efficiencies, energy production & capacity factor, torque at constant speeds, turbine shaft power and torque at variable speeds. 12 Hours

3. **Wind Turbine Connected To Electrical Network:** Methods of generating synchronous power, AC circuits, the synchronous generator, the induction machine, power calculation, motor starting, features of electrical network.

Wind Turbines With a Synchronous Electrical Generators: Asynchronous systems, DC shunt generator life battery head permanent magnet generator, AC generators, self excitation of induction generator, single phase operation of induction generator, field mounted generator, Rosel generator.

14 **hours**

4.Asynchronous Head: Piston water pumps, Centrifugal pumps, paddle wheel heaters, batteries, hydrogen economy & electrolysis cells.

06 hours

5.Economics Of Wind Systems: Capital costs, economic concepts, revenue requirements, value of wind generated electricity, hidden costs & non economic factors in industrialized nations, economic & non economic factors in developing nations, break even points, tariff calculations.

06 hours

TEXT BOOKS:

1. Gary-L. Johnson: **"Wind Energy Systems" -** McGraw-Hill Book Company, 1982.
2. V.Daniel Hunt:**"Wind Power"-** Van Nostrand Rein-ford Company, 1985.

REFERENCE BOOKS:

1. D.F. Warne:**"Wind Power Equipment" -** E& FN Spon, 1983**.**
2. L. Jarass: " **Wind Energy"-** Springer London, Limited.

Course Outcome:

Students will be in a position to understand various applications of wind energy and economics of wind system.

ROBOTICS FOR INDUSTRIAL AUTOMATION

Sub Code	**:**	**14MAR21**	**IA Marks**	**:**	**20**
Hrs/ Week	**:**	**04**	**Exam Hours**	**:**	**03**
Total Hrs.	**:**	**50**	**Exam Marks**	**:**	**80**

Course Objectives:

- This course is an attempt to provide a more updated view of the available tools and technique for kinematics, dynamics and control system on various kinds of robot manipulator.
- Study of various applications and programming of industrial robots.

Course Content:

1. **Introduction:** Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots,Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive

Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Transformation and Block Diagram of Spring Mass System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Different Types of Controllers, Control Approaches of Robots

6 Hours

2. **Kinematics of Robot Manipulator**: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation.

12Hours

3. **Robotic Workspace & Motion Trajectory:** Introduction, General Structures of Robotic Workspaces, Manipulations with n Revolute Joints, Robotic Workspace Performance Index, Extreme Reaches of Robotic Hands, Robotic Task Description. **Robotic Motion Trajectory Design:** – Introduction, Trajectory Interpolators, Basic Structure of Trajectory Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories:**-** 4-3-4 & 3-5-3 Trajectories, Admissible Motion Trajectories.

Dynamics of Robotic Manipulators: Introduction, Bond Graph Modeling of Robotic Manipulators, Examples of Bond Graph Dynamic Modeling of Robotic Manipulator. Brief Discussion on Lagrange–Euler (LE) Dynamic Mod eling of Robotic Manipulators: - Preliminary Definitions, Generalized Robotic Coordinates, Dynamic Constraints, Velocity & Acceleration of Moving Frames, Robotic Mass Distribution & Inertia Tensors, Newton's Equation, Euler Equations, The Lagrangian & Lagrange's Eq uations. Application of Lagrange–Euler (LE) Dynamic Modeling of Robotic Manipulators: **-** Velocity of Joints, Kinetic Energy T of Arm, Potential Energy V of Robotic Arm, The Lagrange L, Two Link Robotic Dynamics with Distributed Mass, Dynamic Equations of Motion for A General Six Axis Manipulator.

14Hours

4. **Robot Teaching:** Introduction, Various Teaching Methods, Task Programming, Survey of Robot Level Programming Languages, A Robot Program as a Path in Space, Motion Interpolation, WAIT, SIGNAL & DELAY Commands, Branching, Robot Language Structure, various Textual Robot Languages Such as VAL II, RAIL, AML and their Features, Typical Programming Examples such as Palletizing, Loading a Machine Etc,

6 Hours

5. **Robot Sensing & Vision:** Various Sensors and their Classification, Use of Sensors and Sensor Based System in Robotics, Machine Vision System, Description, Sensing, Digitizing, Image Processing and Analysis and Application of Machine Vision System, Robotic Assembly Sensors and Intelligent Sensors.

Industrial Applications: Objectives, Automation in Manufacturing, Robot Application in Industry, Task Programming, Goals of AI Research, AI Techniques, Robot Intelligence and Task Planning, Modern Robots, Future Application and Challenges and Case Studies.

12 Hours

Text Books:

1. **"A Robot Engineering Textbook** "– Mohsen Shahinpoor – Harper & Row publishers, Ne w York, 1987.
2. **"Robotics, control vision and intelligence** ," Fu, Lee and Gonzalez. McGraw Hill International, 1987.
3. **"Introduction to Robotics:Mechanics and Control",** John J. Craig, Pearson, 3e, 2009..

Reference Books:

1. **"Robotics for Engineers"** , Yoram Koren, McGraw Hill International, 1985.
2. " **Industrial Robotics",** Groover, Weiss, Nagel, McGraw Hill International, 1986.
3. " **Robot Technology Fundaments**"- Keramas, Thomson Vikas Publication House, 1999.
4. **"Fundamentals of Robotics Analysis and Control** " -Schilling, PHI, 1990
5. **"Introduction to Robotics"** -Niku, Pearson Education, 2011.

6. **“Foundation of Robotics”** -Yoshikawa, PHI (EEE), 1990.
7. **“Robotic Engineering”** - An Integrated approach, Klafter, Chmielewski and Negin, PHI, 1989.
8. “Robot Vision and Sensor Controls”- Rooks B, Vol-3 North Holland.

Course Outcome:

Students will be able to

At the end of the course, students will be able to

1) decide various parameters to be considered in designing manipulators and analyzing them
2) Know basic programming language of industrial robot.

ANALYSIS AND DESIGN OF COMPOSITES

Subject Code	:16**MCS423**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

This course aims at providing comprehensive knowledge on composite materials, its design, analysis and fabrication

Course Content:

1. **Introduction to Composite Materials:** Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.

Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.
12 Hours

2. **Micro Mechanical Analysis of a Lamina:** Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems.

Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory, Numerical problems.
12 Hours

3. **Macro Mechanical Analysis of Laminate:** Introduction, code, Kirchoff hypothesis, CL T, A, B, and D matrices (Detailed derivation) Engineering constants, Special cases of laminates, Numerical problems.

Manufacturing: Lay up and curing - open and closed mould processing, Hand lay, Up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining and joining, tooling, Quality assurance, Introduction, material qualification, Types of defects, NDT methods. 14 Hours

4. **Application Developments:** Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.
06 Hours

5. **Metal Matrix Composites:** Re-inforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications.

06 Hours

TEXT BOOKS:

1. Mein Schwartz:**"Composite Materials handbook"-** Mc Graw Hill Book Company, 1984.
2. Autar K. Kaw CRC**: "Mechanics of composite materials"-** Press New York.

REFERENCE BOOKS:

1. Rober M. Joness:**"Mechanics of Composite Materials" -** Mc-Graw Hill Kogakusha Ltd.
2. Michael W, Hyer:**"Stress Analysis Of Fiber Reinforced Composite Mate rials"-** Mc-Graw Hill International.
3. Krishan K. Chawla Springer.:**"Composite Material Science and Engineering"**
4. P.C. Mallik Marcel Decker:**"Fibre Reinforced Composites"**

Course Outcome:

Students develop expertise in Composite materials application and its analysis in designing components for engineering applications.

FLUID POWER SYSTEM

Subject Code	:16**MCS424**	IA Marks	: 20
No. of Lecture Hours/Week	: 04	Exam Hours	: 03
Total no. of Lecture Hours	: 50	Exam Marks	: 80

Course Objective:

To understand the Hydraulic actuators, Power controlling elements and maintenance of hydraulic systems.

Course Content:

1. **Introduction to Hydraulic Power :** Pascal's Law, Advantages of Fluid Power, Applications of Fluid Power, Components of a Fluid Power,Pumping Theory, Pump Classification, Gear Pumps, (Vane Pumps- simple, balanced & pressure compensated vane pump, Vane design) Piston Pumps- Radial, Axial (Bent axis & Swash plate), Pump Performance, Pump Noise, Ripple in pumps.

07hours

2. **Hydraulic Actuators:** Linear actuator- cylinders, Mechanics of Hydraulic cylinder loading, limited rotation hydraulic actuator, cylinder cushioning, Gear, Vane & Piston motor, Motor performance, Hydrostatic transmission.

06hours

3. **Power Controlling Elements – Valves: (i)** Directional Control Valves – Classification, 2/2, 3/2,4/2 & 4/3 ways Dcv's, Different Centre configurations in 4/3 way valves, actuation of DCV's, Indirect actuation, Valve Lap – Lap during Stati onary and during switching. **(ii)** Pressure Control Valves: Classification, opening & Closing Pressure difference, Cracking Pressure, Pressure Relief Valve – Simple & Compound type, Pressure reducing valve, sequence, unloading & counter balance valve, Pressure switches. **(iii)** Flow Control valves – Fixed throttle, Variable throttle, Pressure Compensation principles, pressure compensated Flow control valve – Reducing & Relie f type. **(iv)** Check valve, Pilot operated check valve.

06hours

4. **Hydraulic Circuit Design & Analysis:** Control of Single & double acting cylinder, Regeneration circuit, cylinder sequencing & Synchronizing circuit. Speed control of cylinder & Motors, Analysis of Hydraulic system with frictional losses, Accumulators &accumulator circuits.

07hours

5. **Maintenance of Hydraulic System:** Hydraulic oils; Desirable, general type of fluids, sealing devices, reservoir system, filters and strainers, problem caused by gases in hydraulic fluids, wear of moving parts due to solid particle contamination, temperature control, trouble shooting

05hours

6. **Pneumatic System & Valves:** Introduction, – Generation of compressed air, air receiver, servicing FRL unit, Air filter, pressure regulation,

lubricator, Pneumatic cylinder & air motor – differ ent types of cylinder, cushion assembly. Cylinder performance, Directional control valves, impulse valve, Quick exhaust valve, shuttle valve, Twin pressure valve, Time delay valve,

07hours

7. **Pneumatic Circuit & Logic Circuits:**- Control of single and double acting cylinder, impulse operation, speed control, sequencing, Pneumatic Vacuum system AND,OR, NOT, NAND, NOR, YES Function, Logic circuits design using shuttle valve & twin pressure valve, Binary Arithmetic, logic & Boolean Algebra.

07hours

8. **Electrical Control in Fluid Power:** Contactors, & Switches, Relays, Limit switch, Electro hydraulic & Electro Pneumatic Circuits, Simple Cylinder reciprocation, interlocking using relays, Proximity switches, application of proximity switches, Time dependent will dependent and travel dependent circuits.

07hours

TEXT BOOKS:

1. Anthony Esposito:**"Fluid Power with application** "- 5 th edition, , Peason Education.
2. Andrew Parr**: "Pneumatics and Hydraulics "-** Jaico publishing Co 2000

REFERENCE BOOKS:

1. S.R. Majumdar**: "Oil hydraulics -Principles & maintenance"** - Tata M C Graw Hill
2. Bosch Rexroth didactic, Publication:**"Hydraulics Trainer"-** Vol 1 components & application,
3. S.R. Majumdar**: "Pneumatic system, principles and maintenance"** - Tata M C Graw Hill publication.
4. Bosch Rexroth: **"Pneumatics: Theory and applications"-** didactic, Publication
5. Bosch Rexroth **"Electro Pneumatics"-** Vol. 2 didactic, Publication
6. Pippenger, Hicks**: "Industrial Hydraulics"-** McGraw Hill, New York.

Course Outcome:

Students will be able to demonstrate their understanding in various fluid power systems,its analysis and application.