GOVERNMENT COLLEGE OF ENGINEERING, SALEM-11

(An Autonomous Institution Affiliated to Anna University, Chennai)

Department of Mechanical Engineering

Curriculum and Syllabus –Regulation 2018

For

M.E. COMPUTER AIDED DESIGN (FT)

(For Students admitted from 2018-2019)

GOVERNMENT COLLEGE OF ENGINEERING, SALEM

DEPARTMENT OF MECHANICAL ENGINEERING

VISION, MISSION, P.E.O., P.O & PSO.

Vision:

The department of Mechanical Engineering is committed to blossom into a center of excellence, dedicated and competent engineers by providing global quality interactive technical education to cater the needs of the industries and nation into technologically, socially and culturally advanced one.

Mission:

- Constantly updating the departmental resources, faculty and other infrastructure by acquiring the state-of-the-art equipment's and by imparting constant in-service training to the faculty and supporting staff.
- Promoting skilled and employable graduates to meet the challenges in emerging fields of engineering.
- To prepare the students for prosperous career in entrepreneurship with leader ship qualities, ethics and human values.
- The department executes life-long learning skills and provides engineering services for sustainable development of the society.

Programme Educational Objectives (PEO): M.E. – Computer Aided Design

- **PEO 1:** To deliver competent CAD engineers to make progress in their current position or pursue doctoral studies.
- **PEO 2:** To attain and apply technical skills creatively in the design process to identify, analyze and solve real world problems and issues related to R&D in mechanical engineering and allied areas.
- **PEO 3:** To possess and exhibit professionalism, ethical attitude, communication skills, team work in their profession and adapt to current trends by engaging in lifelong learning.

PROGRAM OUTCOMES (POs): M.E. – Computer Aided Design

- **PO 1:** Ability to apply acquired theoretical and practical technical know how to solve real world engineering problems.
- **PO 2:** Ability to analyze complex engineering problems and formulate them for conducting research activities.
- **PO 3:** Ability to design mechanical systems, meeting varied needs of industry with appropriate consideration for public health and safety and environment.
- **PO 4:** An ability to design and conduct experiments for complex problems involving multiphasic as well as to analyze and interpret data.
- **PO 5:** An ability to apply the knowledge adapting to current techniques, software skills, and modern tools for mechanical engineering domain.
- **PO 6:** An ability to function effectively individually and on teams, including diverse and multidisciplinary, to accomplish a common goal
- **PO 7:** An understanding of engineering and management principles and apply these for effective project implementation
- **PO 8:** Ability to communicate effectively with a range of audiences and write technical report for knowledge transfer meeting global standards.
- **PO 9:** Recognition of the need for and an ability to engage in continuing professional development through lifelong learning
- **PO 10:** An understanding of professional, ethical, legal, security and social issues and responsibilities.
- **PO 11:** Ability to observe and examine critically and learn independently from mistakes without depending on external feedback.

PROGRAMME SPECIFIC OUTCOMES (PSOs): M.E. – Computer Aided Design

- **PSO1:** Design products, select materials and process, perform simulation and analysis in the field of automobile, consumer goods, machine tools and allied industries.

- **PSO2:** Extend and implement new thoughts on product design and development with the aids of modern CAD/CAM tools, while ensuring best manufacturing practices.

- **PSO3:** Fruitfully apply the values of design, analysis and execution of mechanical systems/processes which have been feed as a part of the curriculum.

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Curriculum for PG Programme: Computer Aided Design

L –Theory lecture, T–Tutorial; P – lab work: Numbers under ting scheme indicate contact clock hours- Curriculum Structure – Semester-wise

Course code	Name of the Course	Hours/Week						Maximum Marks		
		Category	Contact periods	Lecture	Tutorial/ Demo*	Practical	Credit	CA	FE	Total
SEMESTER I										
18CDC11	Concepts of Engineering Design	PC	45	3	0	0	3	40	60	100
18CDC12	Computer Aided Modeling and Design	PC	45	3	0	0	3	40	60	100
18CDE**1X**	Programme Electives-I	PE	45	3	0	0	3	40	60	100
18CDE**2X**	Programme Electives-II	PE	45	3	0	0	3	40	60	100
18CDC13	CAD Modeling and Drafting Lab	PC	60	0	0	4	2	40	60	100
18CDC14	Finite Element Analysis Lab- I	PC	60	0	0	4	2	40	60	100
18MLC01	Research Methodology and IPR	MLC	30	2	0	0	3	40	60	100
18AC0X	Audit Course – 1	AC	24	2	0	0	0	-	-	-
TOTAL				**16**	**0**	**8**	**19**	**0**	**0**	**700**
SEMESTER II										
18CDC21	Finite Element Methods in Design	PC		3	0	-	3	40	60	100
18CDC22	Mechanical Vibrations and Acoustics	PC		3	-	-	3	40	60	100
18CDE**3X**	Programme Electives-III	PE		3	-	-	3	40	60	100
18CDE**4X**	Programme Electives-IV	PE		3	-	-	3	40	60	100
18CDC23	Finite Element Analysis Lab –II	PC		-	-	4	2	40	60	100
18CDC24	CAM and Robotics Lab	PC		-	-	4	2	40	60	100
18CDC25	Mini Project	PRO		-	-	4	2	40	60	100
18AC0X	Audit -2	AC		2	-	-	0	-	-	-
TOTAL				**15**	**0**	**12**	**18**	**0**	**0**	**700**
SEMESTER III										
18CDE**5X**	Programme Electives-V	PE		3	-	-	3	40	60	100
18CDE6**X**	Programme Electives-VI	PE		3	-	-	3	40	60	100
18CDC31	Dissertation Phase – I	PRO		-	-	20	10	80	120	200
TOTAL				**6**	**0**	**20**	**16**	**0**	**0**	**400**
SEMESTER IV										
18CDC41	Dissertation Phase – II	PRO		-	-	32	16	160	240	400
TOTAL						**32**	**16**	**0**	**0**	**400**

Total Credits for the programme = 19 + 18 + 16 + 16 = 69

List of Programme Electives:

Course Code	Name of Course
Elective 1	
18CDE11	Advanced Mathematical Methods in Engineering
18CDE12	Advanced Composite Materials
18CDE13	Product Lifecycle Management
18CDE14	Design for Manufacturing, Assembly
18CDE15	Advanced Engineering Materials
18CDE16	Experimental Stress Analysis
Elective II	
18CDE21	Advanced Kinematics of Mechanisms
18CDE22	Advanced Tool Design
18CDE23	Advanced Strength of Materials
18CDE24	Mechanics of Fracture
18CDE25	Rapid Prototyping and Tooling
18CDE26	Nano Materials Technology
Elective III	
18CDE31	Productivity Management and Re-engineering
18CDE32	Theory of Plates and Shells
18CDE33	Optimization Techniques in Design
18CDE34	Computational Fluid Dynamics
18CDE35	Computer Integrated Manufacturing systems
18CDE36	Industrial Robotics and Expert Systems
Elective – IV	
18CDE41	Experimental Techniques and Data analysis
18CDE42	CAD/CAM tools
18CDE43	Contact Mechanics
18CDE44	Advanced Automotive Systems
18CDE45	Design of Material Handling Equipment

18CDE46	Plasticity and Metal Forming
Elective –V	
18CDE51	Tribology in Design
18CDE52	Enterprise Resource Planning
18CDE53	Mechatronics System Design
18CDE54	Failure Analysis
18CDE55	Maintenance Engineering
18CDE56	Design of Pressure Vessels
Elective- VI	
18CDE61	Integrated Product And Processes Development
18CDE62	Industrial Safety Management
18CDE63	Reliability in Engineering Systems
18CDE64	Neural Networks and Fuzzy Logic
18CDE65	Ergonomics in Manufacturing

List of Audit Courses

Course Code	Name of Course
18AC01	English for Research Paper Writing
18AC02	Disaster Management

SEMESTER I

18CDC11	CONCEPTS OF ENGINEERING DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on materials selection and manufacturing processes integrated with Engineering Design.
2. To understand the need for component design.

UNIT I DESIGN PROCESS 9 + 0

Design process – Morphology – Drawings – Computer Aided Engineering – Standards – Concurrent Engineering – Product life cycle – Technological Forecasting – Market Identification – Competition Bench marking – Systems Engineering – Life Cycle Engineering – Human Factors in industrial Design.

UNIT II DESIGN METHODS- INTRODUCTION 9 + 0

Creativity and Problem Solving – Product Design Specifications – Conceptual design – Decision Theory – Decision Tree – Embodiment Design – Detail Design – Mathematical Modeling – Simulation – Geometric Modeling – Finite Element Modeling – Optimization – Search Methods – Geometric Programming – Structural and Shape Optimization

UNIT III MATERIAL SELECTION PROCESSING AND DESIGN 9 + 0

Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design for Manufacture – Design for Assembly –Design for castings, Forging, Metal Forming

UNIT IV RELIABILITY AND QUALITY ENGINEERING 9 + 0

Reliability Theory – Design for Reliability – Reliability centered Maintenance- Total Quality Concept – Quality Assurance – Statistics Process Control – Taguchi Methods – Robust Design – Failure Model Effect Analysis.

UNIT V COMPUTERS IN DESIGN 9 + 0

Solid modeling of Mechanical components – Associative features – Sheet metal components, nesting and development – plastic parts with draft and shrinkage allowance – Reverse engineering of components assembly of parts – tolerance analysis – mass property calculations.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 **:** Apply design principles for Quality Products to create economically viable products.

CO2 **:** Identify the materials and integrate the manufacturing processes with Engineering Design

CO3 **:** Synthesize the principles of design for machinability, accessibility and assembly with greater concern towards environmental issues.

CO4 **:** To compute reliability engineering parameters and estimates for applications in mechanical devices and manufacturing environments.

TEXT BOOKS:

1. Dieter George E, “Engineering Design - A Materials and Processing Approach”, McGraw Hill International Editions, Singapore, 2000.
2. Karl T. Ulrich and Steven D. Eppinger, “Product Design and Development”, 4th Edition, McGraw Hill, 2008.

REFERENCE BOOKS:

1. Pahl, G, and Beitz, W.,” Engineering Design”, Springer – Verlag, NY. 2007.
2. Suh, N.P., “The principles of Design”, Oxford University Press, NY.1990.
3. Ray M.S., “Elements of Engineering Design”, Prentice Hall Inc. 1985.

4. A.K. Govil, Reliability Engineering, Tata McGraw-Hill Publishing Co. Ltd., 1983.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	3	1	-	-	-	2	-	1	3	3	1
CO2	2	3	2	2	3	-	-	-	-	-	1	3	2	3
CO3	2	1	1	2	2	1	-	-	-	-	1	-	1	-
CO4	1	1	1	1	2	-	-	-	1	-	1	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDC12	COMPUTER AIDED MODELING AND DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To learn fundamental concepts of geometric modelling.
2. Real understanding of designing synthetic surfaces and solid modelling.
3. To study about advanced aspects of enabling computer aided technologies used in design.

UNIT I INTRODUCTION TO COMPUTER GRAPHICS 9 + 0

Definition of CAD Tools - Types of system - CAD/CAM system evaluation Criteria - functional areas of CAD - Graphics standards - Modeling and viewing, Output primitives (points, lines, curves etc.,) - 2-D & 3-D transformation (translation, scaling, rotating) - windowing - view ports - clipping transformation - software documentation, efficient use of CAD software.

UNIT II CURVES AND SURFACES 9 + 0

Mathematical and Parametric representation of Analytical and synthetic curves - Hermite cubic splines, Bezier curves, B-Splines, rational curves – NURBS Surface Model and entities - Mathematical and Parametric representation of analytical and synthetic surfaces – plane, ruled and Tabulated surface, surface of revolution– Hermite, Bi-cubic, Bezier and B-Spline surface, COONs surface, Surface manipulation

UNIT III SOLID MODELING 9 + 0

Fundamentals of Solid Modeling - Boundary Representation (B-rep), Constructive Solid Geometry (CSG) and other methods – Sweep Representation - Coordinate system, Modeling features and entities - Geometric constraints, Datum Plane - Transformations - 2D and 3D - Orthogonal and Perspective transformations – Solid Manipulation.

UNIT IV DRAFTING AND ASSEMBLY 9 + 0

Drafting features - Customization, 3D sketches, Feature manipulation, Datum features - Modeling operation Strategy, Modeling aids and tools - Generalized views, Presentation of dimensioning / tolerances/symbols & annotation. Different approaches of creating an assembly - Associatively, Parent child relationship - Parametric design, Concept of computer animation.

UNIT V ADVANCED MODELING CONCEPTS 9 + 0

Feature Based, Assembly and Behavioral Modeling - Conceptual Design - Top-down Design. Techniques for visual realism - Hidden line removal – Hidden Surface removal - Algorithms for shading and Rendering. Parametric and Variational modeling - Feature recognition, Design by features, Assembly and Tolerance Modeling, Tolerance representation - specification, analysis and synthesis, AI in Design.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Apply mathematical skills in the design and generation of modelling in software.
CO2 : Apply basic concepts to develop construction techniques and solid modelling concepts.
CO3 : Apply the modeling concept, to design the product in manufacturing.
CO4 : Use computer and CAD software for design and modelling.

TEXT BOOKS:

1. Ibrahim Zeid, R.Sivasubramanian, “CAD/CAM Theory and Practice”, McGraw Hill international. 2007.
2. AnupamSaxena, Birendrasahay, “Computer Aided Engineering and Design”, Springer, 2005.

REFERENCE BOOKS:

1. P.N. Rao, *"CAD / CAM Principles and Applications"*, TMH, 2nd Edition, 2008.
2. Martenson, E. Micheal, Geometric Modelling, John Wiley & Sons, 1995.
3. Foley, Van Dam, Feiner and Hughes, Computer Graphics Principles and Practice, second edition, Addison–Wesley, 2000.
4. Hill Jr, F.S., Computer Graphics using Open GL, Pearson Education, 2003.
5. M.P. Groover and E.W. Zimmers, "CAD/CAM", PHI, 1st Edition, 1995.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	-	-	-	2	-	1	1	1	2
CO2	2	2	2	2	3	-	-	-	-	-	1	1	1	3
CO3	2	1	1	2	3	-	-	-	-	-	1	2	2	1
CO4	1	1	1	-	3	-	-	-	1	-	1	3	2	1

1- Faintly
2- Moderately
3- Strongly

18CDC13 **CAD MODELING AND DRAFTING LAB** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To understand the computer-aided drafting software such as SOLID EDGE and CATIA.
2. To learn the various features in software.
3. To model the 3D and understand the assembly and drafting techniques using software assistance.

MODULE I LIST OF SOLID EDGE EXPERIMENTS **30 + 0**

i. 2D Drawing of machine elements
ii. 3D drawing of machine elements
iii. 3D assembly drawing of machine elements
iv. Detail Drawing of machine elements

MODULE II LIST OF CATIA EXPERIMENTS **30 + 0**

i. Sketcher exercises
ii. Part design
iii. Assembly drawing of machine element
iv. Sheet metal design

Total =60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Use SOLID EDGE and CATIA software toolbars and menus, draw and modify tools
CO2 : Model the 3D mechanical components with dimensioning
CO3 : Model the automobile parts
CO4 : Assembling and detailing of a given mechanical component using software assistance.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	1	2	3	-	1	3	-	1	1	-	1	2	3
CO2	-	2	3	3	-	2	3	-	2	1	-	2	1	3
CO3	-	2	3	3	-	2	3	-	2	2	-	3	2	-
CO4	-	2	3	3	-	2	3	-	3	2	-	1	3	-

1- Faintly
2- Moderately
3- Strongly

18CDC14 **FINITE ELEMENT ANALYSIS LAB - I** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To understand the general steps of finite element methods.
2. To understand the basic finite element formulation techniques
3. To understand the simple finite element packages to solve linear problems
4. Understand the general purpose F.E. packages to model and analyze real mechanical structures

MODULE I LIST OF EXPERIMENTS **60 + 0**

1. Force and Stress analysis using link elements in Trusses, cables etc.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates and simple shells.
4. Stress analysis of axisymmetric components.
5. Analysis of bracket using ANSYS.
6. Buckling analysis of linear materials using ANSYS.
7. Vibration analysis of spring-mass systems.
8. Modal analysis of Beams.
9. Creation and analysis of solid model – I Using ANSYS APDL.
10. Creation and analysis of solid model – II Using ANSYS APDL.

Total =60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Derive equations in finite element methods for 1D, 2D and 3D problems
CO2 : Formulate and solve basic problems in heat transfer, solid mechanics and fluid mechanics
CO3 : Demonstrate a knowledge and understanding of the fundamentals of the finite element method as an approximation method for analysis of a variety of engineering problems.
CO4 : Analyze a real component using a finite element package.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	3	-	1	1	-	1	-	-	1	2	3
CO2	3	1	2	1	-	1	1	-	2	1	-	3	-	-
CO3	3	2	1	2	3	1	1	-	2	1	-	2	2	2
CO4	3	1	1	1	3	-	-	-	2	2	-	1	-	3

1- Faintly
2- Moderately
3- Strongly

18MLC01	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		2	0	0	3

COURSE OBJECTIVES:

1. To develop the subject of their research, encourage the formation of a higher level of trained intellectual ability, critical analysis, rigor, and independence of thought, foster individual judgment, and skill in the application of research theory and methods, and develop skills required in writing research proposals, reports, and dissertation.

UNIT I INTRODUCTION TO RESEARCH 6 + 0

Meaning of research problem, Sources of the research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem. Approaches to investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II EFFECTIVE LITERATURE STUDIES APPROACHES, ANALYSIS 6 + 0

Developing the theoretical framework of the research - Developing operational statements of the problem - Criteria for evaluating research approach - Hypotheses: Parametric and non-parametric testing- Establishing the reliability and validity of findings with literature review and experiments – documentation, Plagiarism, Research ethics.

UNIT III EFFECTIVE TECHNICAL WRITING, HOW TO WRITE REPORT, PAPER 6 + 0

Developing a Research Proposal, Format of a research proposal, a presentation and assessment by a review committee

UNIT IV NATURE OF INTELLECTUAL PROPERTY 6 + 0

Patents, Designs, Trade and Copyright. The process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V PATENT RIGHTS AND IPR 6 + 0

Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Total = 30 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand research problem formulation.
CO2 : Analyze research-related information
CO3 : Follow research ethics
CO4 : Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
CO5 : Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to the creation of new and better products, and in turnbrings about, economic growth and social benefits.

TEXT BOOKS:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.

REFERENCE BOOKS:

1. Mayall, “Industrial Design”, McGraw Hill, 1992.
2. Niebel, “Product Design”, McGraw Hill, 1974.
3. Asimov, “Introduction to Design”, Prentice Hall, 1962.
4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”, 2016.
5. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand, 2008

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	-	-	-	-	1	1	2	-
CO2	-	3	-	-	-	1	-	-	-	-	1	2	1	-
CO3	-	-	2	-	1	1	-	-	-	-	1	-	-	-
CO4	-	-	-	2	1	-	-	-	-	2	1	-	-	2
CO5	-	-	-	-	-	-	-	-	-	-	1	2	-	3

1- Faintly
2- Moderately
3- Strongly

SEMESTER-II

18CDC21	FINITE ELEMENT METHODS IN DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To develop a thorough understanding of the advanced finite element analysis techniques.
2. An ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.

UNIT I INTRODUCTION 9 + 0

Classification of problems – Dimensionality, time dependence, Boundary Value problems, Initial value problems, Linear/Non-linear,etc. Historical Perspective of FEM and applicability to mechanical engineering design problems. Differential equation as the starting point for FEM, steps in finite element method, discretization, types of elements used, Shape functions, Linear Elements, Local and Global coordinates, Coordinate transformation and Gauss-Legendre scheme of numerical integration, Nodal degrees of freedom. Compatibility conditions, Assembly and boundary considerations.

UNIT II ONE DIMENSIONAL PROBLEMS 9 + 0

Structural problems with one dimensional geometry. Formulation of stiffness matrix , consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies with emphasis on boundary conditions and introduction to contact problems. Beams and Frames: Review of bending of beams, higher order continuity (C_0 and C_1 Continuity), interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations. Algorithmic approach for developing computer codes involving 1-D elements.

UNIT III TWO DIMENSIONAL PROBLEMS 9 + 0

Interpolation in two dimensions, natural coordinates, Iso parametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, subparametric, Isoparametric and superparametric elements. General considerations in finite element analysis of two dimension problems. Introduction plate bending elements and shell elements.

UNIT IV DYNAMIC ANALYSIS 9 + 0

FE formulation in dynamic problems in structures using Lagragian Method, Consistent and lumped mass models, Formulation of dynamic equations of motion and introduction to the solution procedures. Modelling of structural damping and formulation of damping matrices, Model analysis, Mode superposition methods and reduction techniques.

UNIT V FEM IN HEAT TRANSFER & FLUID MECHANICS 9 + 0

Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Introduction to thermo-elastic contact problems. Finite element applications in potential flows; Formulation based on Potential function and stream function. Design case studies

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand the concept of finite element method for soling design problems.
CO2 : Formulate and solve manually problems in 1-D structural systems involving bars, trusses, beams and frames.

CO3 : Develop 2-D FE formulations involving triangular, quadrilateral elements and higher order elements

CO4 : Apply the knowledge of FEM for stress analysis, model analysis, heat transfer analysis and flow analysis

TEXT BOOKS:

1. K. J. Bathe, Finite Element Procedures, Prentice-Hall of India Private Limited, New Delhi, 1996
2. J. C. Simo and T. J. R. Hughes, Computational Inelasticity, Springer-Verlag New York, Inc., New York, 1998

REFERENCE BOOKS:

1. Cook and Robert Davis etal, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley and Sons, 2001.
2. Segerlind L.J, "Applied Finite Element Analysis", 2nd Edition, John Wiley, 1984.
3. O. C. Zienkiewicz and R. L. Taylor, Finite Element Method: Volume 2 Solid Mechanics, FifthEdition, Butterworth-Heinemann, Oxford, 00
4. D. R. J. Owen and E. Hinton, Finite Elements in Plasticity: Theory and Practice, Pineridge Press Ltd.,
5. T. Belytschko and W. K. Liu and B. Moran, Nonlinear Finite Elements for Continua andStructures, John Wiley & Sons Ltd., England, 00

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	3	1	-	-	-	1	1	-	-	1	2	-
CO2	3	1	3	3	3	-	-	1	1	-	-	-	-	3
CO3	3	1	3	3	2	-	-	1	1	-	-	-	-	-
CO4	3	2	3	3	2	-	2	2	1	-	-	1	2	-

1- Faintly
2- Moderately
3- Strongly

18CDC22 MECHANICAL VIBRATIONS AND ACOUSTICS L T P C

(Use of approved Data Book and Charts may be permitted) **3 0 0 3**

COURSE OBJECTIVES:

1. To understand the Fundamentals of Vibration and its practical applications
2. To understand the working principle and operations of various vibration measuring instruments.
3. To be creative problem solvers whilst dealing with machinery involving periodic phenomena.

UNIT I VIBRATION FUNDAMENTALS 9 + 0

Introduction – Single degree freedom free vibration systems – Damped vibrations – Single degree freedom forced vibration with elastically coupled viscous dampers- System Identification from frequency response-Support motion – Two-degree freedom system -Free vibration of spring-coupled system – mass coupled system – Vibration of two-degree freedom system – Forced vibration.

UNIT II MULTI DEGREE FREEDOM SYSTEM 9 + 0

Multi Degree Freedom System-Free Vibration equation of motion- Influence Coefficient - Stiffness Coefficient-Flexibility Coefficient- Generalized coordinates- and Coordinate couplings. Langranges Equations- Matrix Method-Eigen Values - Eigen Vector problems. Modal Analysis- Forced Vibrations of undamped system and modal analysis. Multi Degree System Numerical Methods-Raleigh's Method- Rayleigh-Ritz Method- Holzer`s Method-Methods of Matrix iterations- Transfer Matrix Method- Impulse response and frequency response-functions.

UNIT III CONTINUOUS SYSTEM AND TRANSIENT- RANDOM VIBRATIONS 9 + 0

Continuous System - vibrations of String- Bars- Shafts and beams- free and forced vibration of continuous systems. Transient vibrations- Response of a single degree of freedom system to step and any arbitrary excitation-convolution (Duhamel's) integral- impulse response functions. Random Vibrations- Expected values auto and cross correlation function- Spectral density- response of linear systems- and analysis of narrow band-systems.

UNIT IV VIBRATION CONTROL AND VIBRATION MEASUREMENT 9 + 0

Balancing of rotating machine- In-situ balancing of rotors- control of natural frequency introduction of damping-vibration isolation and vibration absorbers.

Vibration Measurement- FFT analyzer- vibration exciters- signal analysis- Time domain and Frequency domain analysis of signals. Experimental modal analysis-Machine Conditioning and-Monitoring-fault diagnosis.

UNIT V NOISE AND ACOUSTICS 9 + 0

Sound waves- governing equation its propagation- Plane acoustic waves, Sound speed, characteristic acoustic impedance of elastic media-Fundamentals of Noise - Decibel- Sound Pressure level- Sound Intensity- Sound fields- reflection- absorption and transmission. Noise measurement - Sound meter - Allowed exposure levels and time limit by B.I.S.- Octave Band analysis of sound- Fundamentals of Noise control- source control- path control - enclosures-noise absorbers- noise control at receiver.

Total 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Define the basic terms of vibrating system

CO2 : Illustrate and identify the basic components of vibrating system

CO3 : Formulate mathematical models of problems in vibrations using Newton's second law or energy principles

CO4 : Determine a complete solution to mechanical vibration problems using Mathematical or numerical techniques

TEXT BOOKS:

1. Rao, S.S.," Mechanical Vibrations," Addison Wesley Longman, 2005.
2. Thomson, W.T. – "Theory of Vibration with Applications", CBS Publishers and Distributors, New Delhi, 2000.

REFERENCE BOOKS:

1. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2010.
2. A H Church, "Mechanical Vibrations", 2ndEdition, John Wiley & Sons Inc, 1973.

3. Srinivasan , “Mechanical Vibration Analysis”, 2ndEdition,-McGraw Hill, 1982.
4. KewalPujara, “Vibration and Noise for Engineers”, DhanpatRai& Co

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	-	-	-	-	-	1	-	-	1
CO2	1	3	1	1	2	2	-	-	-	-	1	-	-	-
CO3	2	1	2	1	-	1	1	-	-	-	1	1	2	-
CO4	1	3	2	1	1	-	-	-	-	-	1	-	-	-

1- Faintly
2- Moderately
3- Strongly

18CDC23 **Finite Element Analysis Lab –II** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To understand the Finite Element method using Analysis Software
2. To understand the Steady-state Thermal Analysis of different shapes
3. To understand the Transient state of Thermal Analysis
4. To understand the Heat flux, energy equations.

LIST OF EXPERIMENTS **60 + 0**

FE Analysis using ANSYS Package for different structures that can be discredited with 1-D, 2-D & 3-D elements to perform the following analysis:

1. Thermal stress and heat transfer analysis of plates.
2. Thermal stress analysis of cylindrical shells.
3. Thermal analysis of temperature distribution in a 2-D fin cooled electronic components.
4. Temperature distribution in a 3-D fin cooled electronic component.
5. Heat flux analysis of a composite slab.
6. Heat flux analysis of a cylindrical rod.
7. Transient heat transfer analysis of a rectangular slab.
8. Heat flux analysis of a spear.
9. CFD Analysis of a circular tube
10. Coupled structural/Thermal analysis.

Total = 60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand the concept of FEM.
CO2 : Apply the FEM technology for Thermal & Fluid Flow Analysis
CO3 : Make familiar with the use of CAE Software.
CO4 : Make familiar of the use of Mass, moment, energy conservation of fluid flow.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	3	-	1	1	-	1	-	-	2	1	-
CO2	3	1	2	1	-	1	1	-	2	1	-	2	2	3
CO3	3	2	1	2	3	1	1	-	2	1	-	1	-	2
CO4	3	1	1	1	3	-	-	-	2	2	-	3	1	1

1- Faintly
2- Moderately
3- Strongly

18CDC24 **CAM AND ROBOTICS LAB** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

1. To understand Features and Selection of CNC machines.
2. To learn CNC programming for a variety of products using APT language.
3. To impart CNC part programming skills for turning and milling applications.
4. To give a good exposure of CAM software in order to perform Simulation and to generate CL data.
5. To learn robot programming and simulation of machining processes.

MODULE I LIST OF CNC EXPERIMENTS **30 + 0**

Features and selection of CNC turning and milling centers.

Practice in part programming and operation of CNC turning machines, subroutine techniques and use of cycles mentioned below:

CNC Turning

1. Facing Cycle
2. Turning Cycle
3. Drilling Cycle
4. Grooving Cycle
5. Taper Turning Cycle
6. Step Turning Cycle

CNC Milling

1. Linear & circular interpolation
2. Mirroring
3. Circular pocketing
4. Rotation
5. Rectangular pocketing

MODULE II LIST OF ROBOTICS EXPERIMENTS **30 + 0**

Practice in Robot programming and its languages

1. Robotics: Introduction to online programming.
2. Robotics: Motion control
3. Robotics: Pick & Place
4. Robotics: Interface with external equipment.

Total = 60 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Apply the basic concepts in NC technology for turning and milling applications.
CO2 : Make familiar with the use of CAE and CAM Software.
CO3 : Practice in part programming and operating a machining center.
CO4 : Program and control robot path for industrial applications.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	1	2	3	-	1	3	-	1	1	-	3	1	1
CO2	-	2	3	3	-	2	3	-	2	1	-	2	2	1
CO3	-	2	3	3	-	2	3	-	2	2	-	3	1	-
CO4	-	2	3	3	-	2	3	-	3	2	-	3	1	2

1- Faintly
2- Moderately
3- Strongly

18CDC25	MINI PROJECT	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1. To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination

CONTENTS:

1. Students can take up small problems in the field of design engineering as a mini project.
2. It can be related to the solution to an engineering problem, verification and analysis of experimental data available, conducting experiments on various engineering subjects, material characterization, studying a software tool for the solution of an engineering problem etc.

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Students will get an opportunity to work in the actual industrial environment if they opt for an internship.

CO2 : In the case of a mini project, they will solve a live problem using Software/analytical/computational tools.

CO3 : Students will learn to write technical reports.

CO4 : Students will develop skills to present and defend their work in front of a technically qualified audience.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	-	1	2	3	-	1	3	-	1	1	-	1	1	1
CO2	-	2	3	3	-	2	3	-	2	1	-	1	1	2
CO3	-	2	3	3	-	2	3	-	2	2	-	1	-	-
CO4	-	2	3	3	-	2	3	-	3	2	-	1	-	-

1- Faintly
2- Moderately
3- Strongly

18CDC31 **DISSERTATION PHASE – I**

L	T	P	C
0	0	20	10

COURSE OBJECTIVES:

1. To develop the ability to solve a specific problem right from its identification and literature review until the successful solution of the same.
2. To train the students in preparing project reports and to face reviews and viva voce examination

CONTENTS:

1. The Project Work will start in semester III and should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.
2. The seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M. E.
3. The examination shall consist of the preparation of a report consisting of a detailed problem statement and a literature review.
4. The preliminary results (if available) of the problem may also be discussed in the report. The work has to be presented in front of the examiner'spanel set by Head and PG coordinator.
5. The candidate has to be in regular contact with his guide and the topic of the dissertation must be mutually decided by the guide and student.

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Students will be able to use different experimental techniques.
CO2 : Students will be able to use different software/ computational/analytical tools.
CO3 : Students will be able to design and develop an experimental set up/ equipment/test rig.
CO4 : Students will be able to conduct tests on existing set ups/equipment's and draw logical conclusions from the results after analyzing them.
CO5 : Students will be able to either work in a research environment or in an industrial environment.
CO6 : Students will be conversant with technical report writing.
CO7 : Students will be able to present and convince their topic of study to the engineering community.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	3	1	1	1	1	1	2	1	1	1	-	-
CO2	-	1	1	-	-	-	3	1	-	1	-	1	-	-
CO3	2	-	1	2	-	1	-	1	2	1	1	1	2	1
CO4	-	-	-	-	-	2	-	1	-	1	-	-	-	1
CO5	-	-	-	-	-	2	2	-	1	-	1	-	-	1
CO6	1	1	1	-	-	1	3	1	1	-	1	2	1	-
CO7	1	1	1	-	-	-	1	1	-	-	-	-	1	-

1- Faintly
2- Moderately
3- Strongly

SEMESTER IV

18CDC41	**DISSERTATION PHASE – II**	**L**	**T**	**P**	**C**
		0	**0**	**32**	**16**

COURSE OBJECTIVES:

1. It is expected to complete the thesis work, which is normally based on Project (phase I)
2. To work on the topic, and get the result
3. To develop the skill of achieving specific research target in a limited time
4. To implement/complete the thesis work

CONTENTS:

1. It is a continuation of Project work started in semester III. He has to submit the report in prescribed format and also present a seminar.
2. The dissertation should be presented in standard format as provided by the department.
3. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) of solution and results and discussion.
4. The report must bring out the conclusions of the work and future scope for the study.
5. The work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head and PG coordinator.
6. The candidate has to be in regular contact with his guide.

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Students will learn to survey the relevant literature such as books, national/international refereed journals and contact resource persons for the selected topic of research.

CO2 : Students will be able to use different experimental techniques.

CO3 : Students will be able to use different software/ computational/analytical tools.

CO4 : Students will be able to design and develop an experimental set up/ equipment/test rig.

CO5 : Students will be able to conduct tests on existing set ups/equipment and draw logical conclusions from the results after analyzing them.

CO6 : Students will be able to either work in a research environment or in an industrial Environment.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	3	1	1	1	1	1	2	1	1	1	1	1
CO2	-	1	1	-	-	-	3	1	-	1	1	1	-	2
CO3	2	-	1	2	-	1	-	1	2	1	-	1	-	-
CO4	-	-	-	-	-	2	-	1	-	1	-	1	-	-
CO5	-	-	-	-	-	2	2	-	1	-	1	-	1	-
CO6	1	1	1	-	3	-	1	1	-	-	-	3	1	1

1- Faintly
2- Moderately
3- Strongly

PROGRAMME ELECTIVE-I

18CDE11	ADVANCED MATHEMATICAL METHODS IN ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To familiarize with the numerical solution of linear and non-linear equations and fitting curve by the method of least squares.
2. To acquire the knowledge about the solution of wave equation by method of Eigen function.
3. To obtain the solutions of diffusion and wave equation by using techniques of Laplace and Fourier transforms.
4. To understand the significance of central limit theorem and testing of hypothesis.
5. To analyze the variance of factors by one way and two way classification and some standard design of experiments.

UNIT I CURVE FITTING AND SOLUTION OF EQUATIONS 9 + 0

Curve fitting by the method of least squares- Fitting of straight lines, second degree parabolas and curves reduced to linear forms- solution of algebraic and transcendental equations by Newton –Rapson method- solutions of linear equation by Gauss elimination, Gauss Jordan and Gauss Seidel methods.

UNIT II PARTIAL DIFFERENTIAL EQUATIONS 9 + 0

Classification of second order PDE- Solution of PDE by separation of variables- Solution of Parabolic, Elliptic and Hyperbolic equation in cylindrical and spherical co-ordinates- Initial and Boundary value problems for Two dimensional wave equation by the method of Eigen function- D Alembert's solution for the wave equation.

UNIT III FOURIER AND LAPLACE TRANSFORMS 9 + 0

Maximum-Minimum principle for Elliptic equations- Solution of diffusion equation and wave equation by Laplace transform technique – Solution of Diffusion equation, wave equation and Laplace equation by Fourier transform technique.

UNIT IV STANDARD DISTRIBUTIONS AND TESTING OF HYPOTHESIS 9 + 0

Random variables- Standard discrete and continuous distributions (Binomial, Poisson, Normal, uniform and Exponential) – Central limit theorem and its significance- Testing a statistical hypothesis Sampling distributions (t-test, F-test and Chi-square test).

UNIT V ANALYSIS OF VARIANCE AND DESIGN OF EXPERIMENTS 9 + 0

Analysis of variance –One way and Two way classifications- Principles of Design of Experiments- Some standard designs (Completely Randomized Design, Randomized Block design and Latin square design).

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Obtain the solutions of homogeneous and non-homogeneous differential equations.

CO2 : Obtain the solution of wave equation by method of Eigen function

CO3 : Obtain the solutions of diffusion and wave equation involved in engineering problems by using Laplace and Fourier transform techniques.

CO4 : Gain the knowledge on statistical sampling and its applications, analysis of variance as one and two way classification.

TEXT BOOKS:

1. K.Sankara Rao, "Introduction to Partial Differential Equations", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Veerarajan.T, "Probability, Statistics and Random process", Tata McGraw- Hill publications, second

edition, New Delhi, 2002.
3. Kandasamy.P,Thilagavathy.K,Gunavathi.K, “Numerical Methods”, S.Chand&Co.,New Delhi, 2005.

REFERENCE BOOKS:

1. Grewal, B.S., “Higher Engineering Mathematics”, 43rd edition, Khanna Publishers, New Delhi 2014.
2. J.B.Joshi, “Differential equations for Scientists and Engineers”, Narosa Publications, 2010.
3. Peter O’Neil, “Advanced Engineering Mathematics”, 7th edition, Cengage Learning, 2012.
4. Gupta, S.C. and Kapur, V.K., “Fundamentals of Mathematical Statistics”, S.Chand and Sons, New Delhi, 11th Edition 2014
5. Devore, Jay L., “Probability and Statistics for Engineering and the Sciences”, 5th Edition, Brooks- Cole, 1999.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	1	3	-	-	-	2	-	1	-	1	-
CO2	2	2	2	2	3	-	-	-	-	-	1	-	-	-
CO3	2	1	1	2	3	-	-	-	-	-	1	1	-	-
CO4	1	1	1	-	3	-	-	-	1	-	1	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE12	ADVANCED COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand composite material, reinforcements and their selection.
2. To develop and processing of metal- matrix, ceramic -matrix and carbon- carbon Composites.
3. To understand engineering mechanics, analysis and design, macro and micro mechanics of composites
4. To understand and analyze the properties and performance of composite
5. To understand the basics of nanocomposite materials.

UNIT I INTRODUCTION 9 + 0

Definition and Classification of Composites, MMC, PMC, CMC. Reinforcing fibres- Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids etc. Particulate fillers-importance of particle shape and size. Matrix resins-thermoplastics and thermosetting matrix resins. Coupling agents-surface treatment of fillers and fibres, significance of interface in composites. Short and continuous fibre reinforced composites, critical fibre length, and anisotropic behaviour.

UNIT II PROPERTIES AND PERFORMANCE 9 + 0

Properties and microstructure of high-strength fiber materials (glass, carbon, polymer, ceramic fibers) and matrix materials (polymer, metal, ceramic, and carbon matrices). Specific strength and stiffness of high-performance composites. Rule of mixtures. Stress, strain transformations.

UNIT III MECHANICS AND MANUFACTURING 9 + 0

Engineering mechanics analysis and design- concepts of Isotropy vs. Anisotropy, composite micromechanics (effective stiffness/strength predictions, load-transfer mechanisms), ClassicalL amination Plate theory (CLPT). Fabrication techniques- pultrusion, filament winding, prepreg technology, injection and compression moulding, bag moulding, resin transfer moulding, reaction injection moulding.

UNIT IV FAILURE CRITERIA AND APPLICATIONS 9 + 0

Hygrothermal stresses, bending of composite plates, analysis of sandwich plates, buckling analysis of laminated composite plates, inter-laminar stresses, First Order Shear Deformation Theory (FSDT). Applications: Industrial, aerospace, automobile, house hold etc.

UNIT V NANOCOMPOSITIES 9 + 0

Introduction-Types of Nanocomposite (i.e. metal oxide, ceramic, glass and polymer based); Core-Shell structured nanocomposites, Superhard Nanocomposite: Synthesis, applications and milestones.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 **:** Choose and select the suitable composite material and their reinforcements
CO2 **:** Select constituent materials glass, carbon, aramid, ceramic fibers and resins
CO3 **:** Understand & Apply engineering mechanics, analysis and design, macro and micro mechanics of composites
CO4 **:** Highlight the appropriate use of composite structures in the industry.

TEXT BOOKS:

1. Mallick P.K., “Fiber-Reinforced Composites: Materials- Manufacturing and Design”, Maneel Dekker Inc, 1993.
2. Krishan K. Chawla, Composite Materials, Science and Engineering, Springer, 2001.

REFERENCE BOOKS:

1. Steven L. Donaldson, ASM Handbook Composites Volume 21, 2001.
2. Nanocomposite science and technology – P.M. Ajayan, L.S. Schadler, P.V. Braun, Wiley, New York, 2003.
3 Suresh G. Advani, E. Murat Sozer, Process Modelling in Composites Manufacturing, 2nd Ed. CRC Press, 2009.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	3	1	-	-	-	2	-	1	-	-	-
CO2	1	1	1	2	2	1	-	-	-	-	1	-	-	1
CO3	2	2	1	1	2	2	3	-	-	2	1	1	-	-
CO4	1	1	1	1	2	-	-	-	1	-	1	-	1	-

1- Faintly
2- Moderately
3- Strongly

18CDE13	PRODUCT LIFECYCLE MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand history, concepts and terminology of PLM
2. To understand functions and features of PLM/PDM
3. To understand different modules offered in commercial PLM/PDM tools
4. To understand PLM/PDM implementation approaches
5. To understand integration of PLM/PDM with other applications

UNIT I HISTORY, CONCEPTS AND TERMINOLOGY OF PLM 9 + 0

Introduction to PLM, Need for PLM, Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement, Threads of PLM- Computer aided design (CAD), Engineering Data Management (EDM), Product data management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II PRODUCT LIFECYCLE ENVIRONMENT 9 + 0

Product Data and Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Developing a PLM strategy, Strategy identification and selection, PLM System Architecture (2tier/3tier/4tier etc). Concept of cloud PLM.

UNIT III ROLE OF PLM IN INDUSTRIES 9 + 0

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance

UNIT IV PRODUCT DATA MANAGEMENT (PDM) 9 + 0

Product Data Management (PDM) Concepts, Benefits and Terminology, reason for implementing a PDM system, financial justification of PDM, barriers to PDM implementation.

UNIT V CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE 9 + 0

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD,SLM and ERP, Case study examples based on top few commercial PLM/PDM tools.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand history, concepts and terminology of PLM.
CO2 : Understand and analyse the product life cycle environment.
CO3 : Understand PLM/PDM implementation approaches.
CO4 : Integrate PLM/PDM with other applications

TEXT BOOKS:

1. AnttiSaaksvuori and AnselmiImmonen, “Product Lifecycle Management”, Springer Publisher (3rd Edition), 2008.
2. IvicaCrnkovic, Ulf Asklund and AnnitaPerssonDahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House Publishers, 2003.

REFERENCE BOOKS:

1. John Stark, “Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question”, Springer Publisher, 2007.

2. John Stark, “Product Lifecycle Management: 21st Century Paradigm for Product Realisation”, Springer Publisher (2nd Edition), 2011.
3. Michael Grieves (2006), “Product Life Cycle Management”, Tata McGraw Hill, 2006.
4. International Journal of Product Lifecycle Management, Inderscience Publishers.
5. Fabio Giudice, Guido La Rosa, “Product Design for the environment-A life cycle approach”, Taylor & Francis, 2006.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	-	-	1	1	1	-	-	1
CO2	2	2	1	2	2	2	2	2	2	3	1	1	-	-
CO3	1	2	2	2	3	2	1	1	2	3	1	-	1	-
CO4	1	-	1	2	3	2	1	1	1	1	1	-	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE14 DESIGN FOR MANUFACTURING, ASSEMBLY L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To apply fundamental principles in the design and production of engineered products including the factors that control the rate of production and influence the quality, cost and flexibility of processes
2. To study about the various assembly methods and processes and design for assembly guidelines
3. To Understand the complex interrelationships between design and manufacturing
4. To study the various factors influencing the manufacturability of components and the use of tolerances in manufacturing
5. Critique product designs for ease of assembly

UNIT I INTRODUCTION 9 + 0

Introduction: Design philosophy – steps in design process – general design rules for manufacturability – basic principles of designing for economical production – creativity in design, application of linear and non-linear optimization techniques. Materials: Selection of materials for design – developments in material technology – criteria for material selection – material selection interrelationship with process selection – process selection charts.

UNIT II MACHINING PROCESS 9 + 0

Machining process: Overview of various machining processes – general design rules for machining - dimensional tolerance and surface roughness – design for machining – redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.

UNIT III METAL JOINING 9 + 0

Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines – pre and post treatment of welds – effects of thermal stresses in weld joints – design of brazed joints.

UNIT IV METAL CASTING AND FORGING 9 + 0

Metal casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting – casting tolerances – use of solidification simulation in casting design – product design rules for sand casting.

Forging: Design factors for forging – closed die forging design – parting lines of dies – drop forging die design – general design recommendations.

UNIT V ASSEMBLY AND ENVIRONMENT 9 + 0

Assembly: Compliance analysis and interference analysis for the design of assembly – design and development of features for automatic assembly – liaison diagrams.

Environment: Introduction to environment; motivations for environment principles of environment- eco-efficiency, product life cycle perspective, environment tools and processes, environment design guidelines.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Select various machining and metal joining processes for economical production and select the materials.

CO2 : Understand constraints of manufacturing processes that limit design possibilities with respect to cycle time

CO3 : Integrate the knowledge of compliance analysis and interference analysis for assembly

CO4 : Prepare project or report to illustrate applied DFM principles in manufacturing and service industries

TEXT BOOKS:

1. A K Chitale and R C Gupta, “Product Design and Manufacturing”, PHI, New Delhi, 2013.

REFERENCE BOOKS:

1. George E Deiter, “Engineering Design”, McGrawHill, International, 2012.
2. Boothroyd G, “Product design for Manufacture and Assembly”, First Edition, Marcel Dekker Inc., New York, 2010.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	-	1	1	-	-	1	-	-	-
CO2	1	2	1	1	1	3	1	1	-	-	1	1	1	3
CO3	2	2	-	3	-	-	1	1	-	-	2	3	2	1
CO4	1	1	1	2	-	1	-	1	-	-	2	2	-	2

1- Faintly
2- Moderately
3- Strongly

18CDE15 ADVANCED ENGINEERING MATERIALS L T P C
3 0 0 3

COURSE OBJECTIVES:

1. To identify fundamental issues and establish directions for investigation of materials
2. To familiarize various types of characterization tools used in material study
3. To understand structure-properties properties relationships
4. To impart knowledge about the fundamentals of micro/Nano , smart materials, devices and electronics, in particular those related to the development of smart structures and products
5. To increase the skills, knowledge and motivation in the design, analysis and manufacturing of smart structures and products.

UNIT I INTRODUCTION 9 + 0

Introduction- advanced metallic materials - ceramic materials and polymeric materials - processing of materials - interactions between materials characteristics – applications-the effects of processing on their subsequent structure and properties- design for use.

UNIT II CHARACTERIZATION OF MATERIALS 9 + 0

Particle / material interactions & wave / material interactions-the experimental process- crystallography- defects- reciprocal space & diffraction. Instrumentation- vacuum systems- electron sources and detectors etc and described with reference to the techniques of SEM- TEM- XRD- XRF and XPS. Surface analysis techniques and ion beam techniques is provided- Aspects of sample preparation.

UNIT III HIGH STRENGTH, LOW AND TEMPERATURE MATERIALS 9 + 0

Methods of strengthening of alloys - Materials available for high strength applications - Properties required for high strength materials - Applications of high strength materials.

Properties required for low and high temperature applications - Requirements of materials for low and high temperature applications

UNIT IV SMART MATERIALS 9 + 0

Overview of Smart Materials -Physical Properties-Piezoelectric Materials-Electrostrictive Materials - Magnetostrictive Materials -Magneto electric Materials -Magnetorheological Fluids - Electrorheological Fluids- Shape Memory Materials - Sensor Arrays -Smart Actuators

UNIT V NANOMATERIALS 9 + 0

Definition - Types of nanomaterial's including carbon nanotubes and nanocomposites - Physical and mechanical properties - Applications of nanomaterials.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Identify fundamental issues and establish directions for selection of materials
CO2 : Prepare high strength materials.
CO3 : Suggest materials for low and high temperature applications.
CO4 : Integrate knowledge of different types of advanced engineering materials
CO5 : Analyse problem and find appropriate solution for use of materials.

TEXT BOOKS:

1. D. R. Askeland and P. P. Phule, "The Science and Engineering of Materials", Thomson Publication, 2015.

REFERENCE BOOKS:

1. Gregory Tirp, "Nano Technology", , Springer Publication 2012.
2. Van Vlack, "Elements Of Material Science And Engineering", Pearson Education India 1989
3. A.V. Srinivasan, "Smart Structures Analysis and Design", Cambridge University Press, Cambridge, 2001.

4. V.D. Kodgire, “Material science and Metallurgy”, Everest Publishing House 2002.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	1	1	1	-	-	-	-	1	-	-	-
CO2	1	2	-	1	1	1	-	-	-	-	1	-	-	-
CO3	1	2	3	1	1	-	-	-	-	-	1	-	-	1
CO4	1	1	2	1	1	1	-	-	2	-	1	-	-	-
CO5	1	-	1	1	-	-	-	-	-	1	1	1	2	-

1- Faintly
2- Moderately
3- Strongly

18CDE16	EXPERIMENTAL STRESS ANALYSIS	L	T	P	C
	(Use of approved Data Book and Charts may be permitted)	3	0	0	3

COURSE OBJECTIVES:

1. To use indicial notation to represent the compatibility, equilibrium, and constitutive equations of mechanics
2. To use alternate definitions of stress to solve problems involving large deformations
3. To use alternate definitions of strain to solve problems involving large deformations

UNIT I THEORY OF ELASTICITY 9 + 0

Analysis of stress - Analysis of stain - Elasticity problems in two dimension and three dimensions - Mohr's circle for three dimensional stresses - Stress tensor - Airy's stress function in rectangular and polar coordinates - Energy method for analysis of stress - Strain and deflection - The three theorem's - Theorem of virtual work - Theorem of least work - Castigliano's theorem - Rayleigh Ritz method - Galekin's method - Elastic behaviour of anisotropic materials like fiber reinforced composites.

UNIT II THEORY OF TORSION 9 + 0

Torsion of prismatic bars of solid section and thin walled section - Analogies for torsion - Membrane analogy - Fluid flow analogy and electrical analogy - Torsion of conical shaft, bar of variable diameter - Thin walled members of open cross section in which some sections are prevented from warping - Torsion of noncircular shaft.

UNIT III UNSYMMETRICAL BENDING 9 + 0

Concept of shear centre in symmetrical and unsymmetrical bending - Stress and deflections in beams subjected to unsymmetrical bending - Shear centre for thin wall beam cross section - Open section with one axis of symmetry - General open section and closed section.

UNIT IV PLATE BENDING 9 + 0

Bending of plate to cylindrical surface - Bending of a long uniformly loaded rectangular plate - Pure bending in two perpendicular directions - Bending of circular plates loaded symmetrically w. r. t. center - Bending of circular plates of variable thickness - Circular plate with circular hole at centre symmetrically loaded and load distributed along inner and outer edges.

UNIT V PRESSURIZED CYLINDERS AND ROTATING DISKS 9 + 0

Governing equations - Stress in thick walled cylinder under internal and external pressure - Shrink fit compound cylinders- Stresses in rotating flat solid disk - Flat disk with central hole -Disk with variable thickness - Disk of uniform strength - Plastic action in thick walled cylinders and rotating disc**.**

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : To explain the concept of elasticity and the difference between stress and strain

CO2 : Explain the term as plane stress and plane strain

CO3 : Conduct the transformation of plane stress or plane strain components using Mohr's circle, the method of Eigen values and eigenvectors, the method of quadratic form of ellipsoids, and the method of stress or strain trajectories

CO4 : Apply basic concepts of elastic stability and buckling of elastic

TEXT BOOKS:

1. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill, 1970.
2. Timoshenko, "Advanced Strength of Materials", Vol. 1,2, CBS publishers, 2004.

REFERENCE BOOKS:

1. Den Harteg, "Advanced Strength of Materials",Dover Publications Inc., 1987.
2. Dally & Riley, "Experimental Stress Analysis", McGraw-Hill College, 1991.
3. Timoshenko, "Theory of Plates and Shells", McGraw Hill, 1964.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	1	2	2	1	2	1	1	-	-	-
CO2	2	2	2	2	1	2	2	1	3	1	1	1	-	1
CO3	1	2	3	1	2	2	2	-	1	1	1	-	2	-
CO4	1	1	1	2	1	3	1	-	1	1	1	1	-	-

1- Faintly
2- Moderately
3- Strongly

PROGRAMME ELECTIVE-II

18CDE21	ADVANCED KINEMATICS OF MECHANISMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To develop a thorough understanding of the various mechanisms
2. To understand the layout of linkages in the assembly of a system/machine.
3. To study the principles involved in assessing the displacement, velocity and acceleration at any point in a link of a mechanism.

UNIT I INTRODUCTION **9 + 0**

Basic Concepts- Definitions and assumptions- planar and spatial mechanisms- kinematic pairs-Degree of freedom-equivalent mechanisms-Kinematic Analysis of Planar Mechanisms. Review of graphical and analytical methods of velocity and acceleration analysis of kinematically simple mechanism-analysis of complex mechanisms by the normal acceleration and auxiliary-point methods.

UNIT II CURVATURE THEORY **9 + 0**

Fixed and moving centrodes- inflection circle-Euler-Savary equation-Bobillier constructions, cubic of stationary curvature- Ball's point- Applications in dwell-mechanisms.

UNIT III SYNTHESIS OF MECHANISMS **9 + 0**

Number synthesis-degrees of freedom of planar kinematic chains, dimensional synthesis graphical methods-pole and relative pole of four bar and slider crank mechanism-design of slider crank and four bar mechanism, analytical method Chebyshev's spacing of accurate points-function generation by mechanism-Freudenstein equation for four bar slider crank chain for three accuracy points, mechanism for position guidance-body guidance- Bloch's method-cognate linkages.

UNIT IV SPATIAL MECHANISMS AND KINEMATICS OF ROBOT **9 + 0**

Introduction – Mobility - Position analysis - Velocity analysis -Acceleration analysis - Eulerian angles - Denavit-Hartenberg parameters – Kinematic analysis of spatial RSSR mechanism- Forward and inverse kinematics of robotic manipulators - Study and use of Mechanism using simulation software packages.

UNIT V COUPLER CURVES **9 + 0**

Four bar linkage-Equation of coupler curve- double points and symmetry- Robert-Chebyshev theorem-straight line mechanism-approximate and exact.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Develop an analytical equation describing the relative velocity and acceleration of links.
CO2 : Solve constrained equation to design the linkages for a specified application.
CO3 : Select configure and synthesize mechanical components into complete systems.
CO4 : Select the topological arrangements of a robotic arm for specific applications.

TEXT BOOKS:

1. R.L. Norton , "Design of Machinery", Tata McGraw Hill, 2004
2. J. J.Uicker, G. R. Pennock&J.E.Shigley, "Theory of Machines and Mechanisms", Oxford University Press, New York, 2003.

REFERENCE BOOKS:

1. R.S. Hartenberg and J. Denavit, "Kinematic Synthesis of Linkages", McGraw-Hill, New York, 1980.

2. J. Kenneth, Waldron, L.Gary&Kinzel, “Kinematics, Dynamics and Design of machinery”, John Wiley& Sons, 2003.
3. J.S. Rao, “The Theory of Machines Through Solved Problems”, New Age International Publishers, 2006.
4. N.G. Sandor& G.A. Erdman, “Advanced Mechanism Design”, Volume-I, Prentice Hall India Pvt. Ltd, 2001.
5. Michael J.Rider,”Design and analysis of Mechanism”,John Wiley & Sons,2015.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	3	1	-	-	-	2	-	1	2	2	3
CO2	2	3	2	2	3	-	1	-	-	-	1	3	1	2
CO3	2	1	1	2	2	1	-	-	-	-	1	-	-	-
CO4	1	1	1	1	2	-	-	-	1	-	1	1	-	-

1- Faintly
2- Moderately
3- Strongly

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18CDE22	ADVANCED TOOL DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To reveal the essential properties, selection and recent progress in cutting tool materials.
2. To select suitable single point cutting tool and multipoint cutting tool for the machining process.
3. To address the underlying concepts, methods and application of Machine Tool Design.

UNIT I TOOL-DESIGN METHODS 9 + 0

Introduction – The Design Procedure – Statement of the problem – The Needs Analysis – Research and Ideation – Tentative Design Solutions – The Finished Design – Drafting and Design Techniques in Tooling drawings – Screws and Dowels – Hole location – Jig-boring practice – Installation of Drill Bushings – Punch and Die Manufacture – Electro-discharge machining – Electro-discharge machining for cavity. Concepts of aesthetic and ergonomics applied to machine tools- latest trends in Machine Tool Design- Introduction to CAD techniques.

UNIT II SELECTION OF TOOL MATERIALS AND HEAT TREATMENT 9 + 0

Properties of Materials – Ferrous Tooling Materials – Tool steels – Cast Iron – Mild- or low-carbon Steel – Nonmetallic Tooling Materials – Nonferrous Tooling Materials – Metal-cutting Tools – Single-point cutting tools – Milling cutters – Drills and Drilling – Reamer classification – Taps – Tap classification- the selection of carbide cutting tools – Determining the insert thickness for carbide tools- advanced heat treatment methods for composite materials, cryo treatment of steels, plasma equipment.

UNIT III DESIGN OF SPINDLES AND SPINDLE BEARINGS 9 + 0

Analysis of Spindles, Bearing and Power Screws: Design of spindles subjected to combined bending and torsion. The layout of bearings. Pre-loading. Anti-friction slideways. Rolling contact, hydrodynamic, hydrostatic, aerostatics and magnetic bearings, their relative performance. Power Screws, Recirculating ball screws. Hydrodynamic design of journal bearings.

UNIT IV MACHINE TOOL VIBRATIONS 9 + 0

Effect of vibration on the machine tool; Forced vibrations. Machine tool chatter. Self-excited vibration and dynamic stability single and two-degree freedom analysis. Completely coefficient. Elimination of vibration. Vibration analysis of machine tool structures.

UNIT V TOOL DESIGN FOR NC MACHINES 9 + 0

Introduction to numerical control machine tools— Fixture design for numerically controlled machine tools – Cutting tools and Tool holding methods for numerical control – Automatic tool changers and tool positioners – Tool presetting – Introduction – General explanation of the Brown and sharp machine – tooling for Automatic screw machines. Types of Jigs and Fixtures- Design consideration of jigs and Fixtures.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Identify the properties of tool material, tool nomenclature and to classify the cutting tools.
CO2 : Apply design principles for tool design and to create economically viable products
CO3 : Can find the applications of all the areas in the day to day life.
CO4 : Synthesize the principles of Tool design and Design of Jigs and Fixtures as per modern industrial requirement.

TEXT BOOKS:

1. Cyril Donaldson, George H.LeCain and V.C. Goold, “Tool Design”, Tata McGraw Hill, 2000.
2. Prakash Hiralal Joshi, “Tooling data”, Wheeler Publishing, 2000.

REFERENCE BOOKS:

1. Mehta- N.K, “Machine Tool Design”, Tata McGraw Hill, 1989.
2. Koenisbergaer F, “Design Principles of Metal Cutting Machine Tools”, Pergamon Press, 1964.
3. Acherkan N, “Machine Tool Design- Vol. 3 & 4”, MIR Publishers, Moscow, 1968.
4. Sen. G and Bhattacharya A, “Principles of Machine Tools Vol.2”, NCB, Calcutta, 1973.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	2	1	2	-	-	-	-	-	-	1	-	-	3
CO2	-	1	3	1	-	-	-	-	-	-	1	3	1	2
CO3	1	1	1	3	-	-	-	1	-	-	1	-	-	-
CO4	1	1	1	1	1	-	-	-	-	-	1	1	2	-

1- Faintly
2- Moderately
3- Strongly

18CDE23	ADVANCED STRENGTH OF MATERIALS	L	T	P	C
	(Use of approved databook is permitted)	3	0	0	3

COURSE OBJECTIVES:

1. To understand the analysis of stresses, strains, and shear center of different sections.
2. To gain the knowledge of the effect of torsion in different types of bars.

UNIT I ELASTICITY **9 + 0**

Stress-Strain relation and the General equation of elasticity in Cartesian- polar and spherical coordinates- the differential equation of equilibrium – compact ability –boundary conditions- representations of three-dimensional stress of a tension –generalized Hooke's law – St.Vennant's principle – Plane strain- plane stress – Airy's stress function. Shear Centre- Location of the shear center for various sections – shear flow.

UNIT II UNSYMMETRICAL BENDING **9 + 0**

Stresses and deflection in beams subjected to unsymmetrical loading – Kern of a section. Curved flexural members - circumferential and radial stresses – deflection and radial curved beam with re-strained ends – closed ring subjected to concentrated load and uniform load – chain link and crane hooks.

UNIT III THICK CYLINDERS AND ROTATING DISKS **9 + 0**

Thick walled cylinder subjected to internal and external pressures – Shrink fit joints – Stresses due to the rotation – Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness – allowable speed. – Rotating shafts and cylinder

UNIT IV TORSION OF NON-CIRCULAR SECTIONS **9 + 0**

Torsion of the rectangularcross-section – St.Vennant Theory – elastic membrane analogy – Prandtl's stress function – Torsional stresses in hollow thin walled tubes.

UNIT V CONTACT STRESSES **9 + 0**

Theory of contact stresses – Geometry of the contact surface- Methods of computing contact stresses – deflection of bodies in point and line contact – applications.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 **:** Relate the mechanical properties of materials to their structure.
CO2 **:** Select materials for structural applications which can withstand the bending.
CO3 **:** Solve realistic and/or fundamental problems relating to the mechanical behavior of materials for individual solutions and tests.
CO4 **:** Design the problems related to designing the pressure vessels and piping systems.

TEXT BOOKS:

1. Srinath.L.S, "Advanced Mechanics of Solids", Tata McGraw Hill ublishing Company Limited, 2003.
2. Arthur P.Boresi and Richard J.Schmidt, "Advanced Mechanics of Materials", 6th Edition, John Wiley &Sons-Inc., 2003.

REFERENCE BOOKS:

1. Robert D.Cookand Wareen.C.Yound, "Advanced Mechanics of Materials", 2ndEdition, Macmilon Publishers Company, 1985.
2. KrishnaRaju- N and Guru raja-D.R., "Advanced Mechanics of Solids and Structures", Narosa Publishing House, 1997.
3. U.C.Jindal, "Advanced Topics of Strength of materials", Galgotia Publications, 1st Edition, 1997.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	2	-	-	-	-	-	-	1	-	-	-
CO2	1	1	1	1	-	-	-	-	-	-	1	-	-	1
CO3	1	1	3	1	-	-	-	1	-	-	1	-	-	-
CO4	1	1	1	1	1	-	-	-	-	-	1	1	2	-

1- Faintly
2- Moderately
3- Strongly

18CDE24	MECHANICS OF FRACTURE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on mechanics of cracked components of different modes by which these components fail under static load and fatigue load conditions.
2. To understand about the fundamental of fracture mechanics and fatigue.
3. To consider fatigue and fracture aspects in design

UNIT I INTRODUCTION 9 + 0

Theory of Elasticity - Stress Concentration Factor – Notch Strengthening – External variables affecting fracture – Nomenclature of the fracture process - Griffith Crack Theory – Irwin's modification - Strain-Energy Release Rate – Crack resistance curves, Plane stress and plane strain cases - Crack stability and instability conditions - Grain-Size Refinement.

UNIT II LINEAR ELASTIC FRACTURE MECHANICS 9 + 0

Modes of Loading – Crack tip stress (mode I, II, III) –Stress Intensity Factor –Crack tip plasticity – Fracture Toughness – Fatigue crack growth – Crack growth life Integration – Mean stress effect – Cyclic Plastic zone – Crack Closure –Irwin's correction - Small fatigue cracks and LEFM limitations

UNIT III ELASTIC-PLASTIC FRACTURE MECHANICS 9 + 0

Plastic zone models – J integral – crack tip opening displacement - Path independence, Stress-Strain relation, Engineer Approach. Crack Tip Plasticity – Crack tip opening displacement Relationship between CTOD, K_I, G_I for small scale yielding, Equivalence between CTO D and J.

UNIT IV FATIGUE CRACKAND CREEP CRACK 9 + 0

Fatigue regimes – S-N, P-S-N curves – Fatigue crack growth models – crack initiation, crack propagation - effect of overload, variable amplitude fatigue load - paris law –Fracture Toughness. Dynamics of moving crack tip, process zone size, crack speed – crack path instabilities. Creep crack growth, failure at high temperatures.

UNIT V EXPERIMENTAL METHODS AND NUMERICALAPPROACHES 9 + 0

Test methods to measure material fracture toughness and critical J integral value –Correlations between impact energy and fracture toughness - Finite element modelling of crack and evaluation of J integral and stress intensity parameter-Direct and indirect methods.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Use any one of the four parameters for finding out damage tolerance: stress intensity factor, energy release rate, J integral, Crack tip opening displacement.

CO2 : Manage singularity at crack tip using complex variable.

CO3 : Learn modern fatigue and to calculate the fatigue life of a component with or without crack in it.

CO4 : Learn modern sophisticated experimental techniques to determine fracture toughness and stress intensity factor.

TEXT BOOKS:

1. T.L. Anderson, "Fracture mechanics: Fundamentals and Applications", 4th Edition. CRC Press, Taylors& Francis, 2017.
2. Kare Hellan, "Introduction of Fracture Mechanics", McGraw Hill Book Company, 1985.

REFERENCE BOOKS:

1. Richard W.Hertzberg, "Deformation and Fracture Mechanics of Engineering Materials" John wiley& sons, Inc., 1996
2. Nestor Perez, "Fracture Mechanics", Kluwer Academic Publishers, 2004
3. David Broek, "Elementary Engineering Fracture Mechanics", Fifthoff and Noerdhoff International Publisher, 1978.

4. M.F. Kanninen and C.H. Popelar, Advanced Fracture Mechanics, Oxford Press, 1985.
5. S. Murakami, Continuum Damage Mechanics, Springer Netherlands, Dordrecht, 2012.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	2	2	1	-	-	-	-	-	-	-	-
CO2	2	2	2	2	2	1	-	-	-	-	-	-	1	-
CO3	2	2	2	3	3	1	-	-	-	-	-	1	-	-
CO4	2	2	2	3	3	1	-	-	-	-	-	-	-	1

1. **Faintly**
2. **Moderately**
3. **Strongly**

18CDE25	RAPID PROTOTYPING AND TOOLING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Generating a good understanding of RP history, its development and applications.
2. Expose the students to different types of Rapid prototyping processes, materials used in RP systems.
3. To understand the design steps involved in evaluating the dimensions of a component to satisfy functional operation and also learn standard practices by using RP software.

UNIT I INTRODUCTION 9 + 0

Need for time compression in product development- Product development - conceptual design - development - detail design - prototype - tooling -History of RP systems- Survey of applications- Growth of RP industry- classification of RP systems.

UNIT II STEREO LITHOGRAPHY SYSTEMS 9 + 0

Stereo lithography systems (SLA) – Principle – process parameters – process details – machine details- Applications. Selective laser sintering (SLS) – Principle – process parameters – process details – machine details – Applications. Direct Metal Laser Sintering (DMLS) system – Principle – process parameters – process details – machine details- Applications.

UNIT III FUSED DEPOSITION MODELING 9 + 0

Fusion Deposition Modeling (FDM) – Principle – process parameters – process details – machine details- Applications. Laminated Object Manufacturing (LOM) – Principle – process parameters – process details – machine details- Applications.

UNIT IV SOLIDGROUND CURING AND CONCEPT MODELERS 9 + 0

Solid Ground Curing (SGC) – Principle – process parameters – process details – machine details- Applications. 3-Dimensional printers (3DP) – Principle – process parameters – process details – machine details – Applications- and other concept modelers like thermo jet printers - Sander's model maker - JP system 5-Objects Quadra system. Laser Engineering Net Shaping (LENS) - Ballistic Particle Manufacturing (BPM) -Principle.

UNIT V RAPID TOOLING AND SOFTWARES 9 + 0

Introduction to rapid tooling – direct and indirect method- Indirect Rapid Tooling - Silicone rubber tooling- Aluminum filled epoxy tooling- Spray metal tooling- etc. Direct Rapid Tooling - Direct AIM- Quick cast process- Copper polyamide. Rapid Tool – DMILS –ProMetal- Sand casting tooling- Laminate tooling- soft tooling vs hard tooling. Software for RP – STL files –Magics and Mimics. Application of Rapid prototyping in Medical field.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Identify the intended modelling process for a particular product.

CO2 : Improves the scope of application in the field of manufacturing products

CO3 : Familiar on iterative prototyping techniquesfor working out the details of the online interaction, includingsoftware development tools and software environments.

CO4 : Designing of existing product into variety of attractive designed product and new interactive devices with low cost and ever more challenging

TEXT BOOKS:

1. Pham, D.T., Demov, S.S., "Rapid Manufacturing: Springer Verlag London, 2001.
2. Noorani, R., Rapid Prototyping: Principles and Applications, John Wiley & Sons, Inc., New Jersey, 2006

REFERENCE BOOKS:

1. Paul F Jacobs, "Rapid Prototyping and manufacturing – Fundamentals of Streolithography", Society of Manufacturing Engineering, Dearborn, USA 1992.

2. Terry wohlers, “Wohlers Report 2007”, Wohlers Associates, USA 2007.
3. “Rapid Prototyping and Tooling”, Industrial Design Centre, IIT Mumbai, 1998
4. Patri, K. V., Weiyin, Ma, Rapid Prototyping - Laser-based and Other Technologies, Kluwer Academic Publishers, U.S.A., 2003.
5. Chua, C.K., Leong, K.F., “Rapid Prototyping: Principles and Applications in Manufacturing”, John Wiley and Sons Inc., 2000.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	-	1	-	-	-	-	-	1	1	2	3
CO2	1	1	1	-	-	-	-	-	-	-	1	3	-	2
CO3	1	1	3	1	-	-	-	1	-	-	1	-	1	-
CO4	1	1	1	1	1	-	-	-	-	-	1	3	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE26	NANOMATERIALS TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the concepts of Nanotechnology and behaviour of nanomaterial and their properties.
2. To learn about the different routes for the synthesis and consolidation of nanoparticles and Nano crystalline materials.
3. To study about the various field of applications of Nano-materials.

UNIT I INTRODUCTION 9 + 0

Importance of Nano-Technology - Emergence of Nano-Technology - Bottom-Up and Top-down approaches-challenges in Nano-Technology. Properties of materials and Nano-materials- role of size in Nano-materials- Electronic Properties- Magnetic Properties- Thermal Properties- Mechanical Properties- Optical Properties.

UNIT II SYNTHESIS 9 + 0

Physical methods - Inert gas condensation - Arc discharge - RF plasma - Plasma arc technique - Ion sputtering - Laser ablation - Laser pyrolysis - Ball Milling - Molecular beam epitaxy - Chemical vapour deposition method and Electro deposition. Chemical Methods - Metal Nano-crystals by reduction – Solvothermal, Photochemical, Electrochemical synthesis - Nano crystals of semiconductors - Thermolysis routes - Sonochemical routes - Liquid-liquid interface - Hybrid methods - Solvated metal atom dispersion - Post-synthetic size-selective processing. Sol-gel- Micelles and micro emulsions - Cluster compounds.

UNIT III CHARACTERIZATIONS 9 + 0

Scanning Electron Microscopy (SEM) - Scanning Probe Microscopy (SPM) - TEM and EDAX analysis - X-ray diffraction-Optical Microscope - Operational principle and application for analysis of Nano-materials- UV-VIS-IR Spectrophotometers- Principle of operation and application for band gap measurement. M based nanolithography and Nano-manipulation- E beam lithography and SEM based nanolithography and Nano-manipulation- Ion beam lithography- oxidation and metallization- Mask and its application. UV lithography- X-ray based lithography.

UNIT IV APPLICATIONS 9 + 0

Micro and Nano-sensors - Fundamentals of sensors – biosensor- micro fluids- MEMS and NEMS - Packaging and characterization of sensors - Method of packaging at zero level - dye level and first level. Sensors for aerospace and defense: Accelerometer - Pressure Sensor- Night Vision System - Nano tweezers - Nano-cutting tools - Integration of sensor with actuators and electronic circuitry.

UNIT V NANO FLUIDS 9 + 0

Preparation of Nano-fluids – Properties – Characterization of Nano-fluids - Role of Brownian Motion – Constraints for nano-fluids -Models for the measurements of thermal conductivities of Nano-fluids –Current applications – Issues with the Environment.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand processing techniques for nanomaterials.
CO2 : Knowledge about various properties of nano-materials and to optimize the methods for specific material application
CO3 : Use various nano-fluids in the fields of engineering.
CO4 : Use of Nano particles for the health, ecological and environmental hazards

TEXT BOOKS:

1. B.S.Murthy, P.Shankar, Baldevraj, B.B.Rath and James Murday, “Text Book of Nanoscience and Nanotechnology”, Universities Press (India) Private Limited, 2013
2. Mark Ratneer, Daniel Ratner, “Nanotechnology” Pearson Education, Inc, 2003

REFERENCE BOOKS:

1. Guozhong Cao , “Nanostructures &Nanomaterials: Synthesis- Properties and Applications”, Imperial College Press, 2004
2. Bharat Bhusan (Ed.), “Springer Handbook of Nanotechnology”, Springer Verlag Berlin- Heidelberg, 2004.
3. Rainer Wasser (Ed.), “Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices” Wiley-VchVerlag GmbH & Co, 2003.
4. Charles P. Poole- Jr. and Frank J. Owens , “Introduction to Nanotechnology”, Wiley Interscience, 2003
5. M.J. Madou, “Fundamentals of Microfabrication: Science of Miniaturization”, CRC Press- 2nd Edition, 2002.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	3	3	1	1	-	1	-	-	-	-	-
CO2	1	1	2	1	-	1	1	-	2	1	1	1	2	-
CO3	2	2	1	2	3	1	1		2	1	1	-	-	-
CO4	1	1	1	1	-	-	-	2	2	2	2	-	-	1

1- Faintly
2- Moderately
3- Strongly

ELECTIVE-III

18CDE31	PRODUCTIVITY MANAGEMENT AND RE-ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To gain an understanding and appreciation of the principles and applications relevant to the planning, design, and operations of manufacturing/service firms.
2. To develop skills necessary to effectively analyze and synthesize the many inter-relationships inherent in complex socio-economic productive systems
3. To gain some ability to recognize situations in a production system environment that suggests the use of certain quantitative methods to assist in decision making on operations management and strategy
4. To understand the managerial responsibility for Operations, even when production is outsourced, or performed in regions far from corporate headquarters
5. To recognize the need for, and problems associated with, change in organizations.

UNIT I PRODUCTIVITY **9 + 0**

Productivity Concepts - Macro and Micro factors of productivity - Dynamics of Productivity - Productivity Cycle Productivity Measurement at International - National and Organization level - Productivity measurement models.

UNIT II SYSTEMS APPROACH TO PRODUCTIVITY MANAGEMENT **9 + 0**

Conceptual frame work, Management by Objectives (MBO) - Performance objectivities- Productivity (POP) - Methodology and application to manufacturing and service sector.

UNIT III ORGANISATIONAL TRANSFORMATION **9 + 0**

Elements of Organizational Transformation and Reengineering-Principles of organizational transformation and re-engineering, fundamentals of process reengineering, preparing the workforce for transformation and re-engineering, methodology, guidelines, LMI CIP Model – DSMC Q and PMP model.

UNIT IV RE-ENGINEERING PROCESS AND IMPROVEMENT MODELS **9 + 0**

PMI models - PASIM Model - Moen and Nolan Strategy for process improvement - LMICIP Model - NPRDC Model.

UNIT V TOOLS FOR RE-ENGINEERING **9 + 0**

Analytical and process tools and techniques - Information and Communication Technology-Implementation of Reengineering Projects – Success Factors and common implementation Problem - Cases.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : understand the need for change in organizations and be able to apply appropriate strategies to affect change in an appropriate manner

CO2 : Creating a layout of a manufacturing department that integrates both production equipment and office accommodation

CO3 : Use the techniques, skills, and modern engineering tools necessary for engineering practice.

TEXT BOOKS:

1. Handbook on Industrial Engineering equations, formulas and calculations, Adedeji B. Badiru and Olufemi A. Omitaomu, 2011, CRC Press.
2. "Industrial Engineering and Management", O.P.Khanna, 17th edition, DhanpatRai publications.

REFERENCE BOOKS:

1. "Productivity Engineering and Management', Sumanth, D.J. TMH, New Delhi, 1994.
2. "Organisational Transformation and Process Re-engineering", Edosomwan, J.A.,Library Cataloging in Pub.Data, 1995.
3. "Productivity Management – A, Systems Approach", Premvrat, Sardana, G.D. and Sahay, B.S., Narosa Publishing House. New Delhi, 1998.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	1	1	1	1	1	-	1	-	1	-	-	-
CO2	1	-	1	-	3	2	-	2	1	-	1	-	1	-
CO3	1	1	1	1	1	1	-	-	-	-	3	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE32 **THEORY OF PLATES AND SHELLS** **L T P C**

(Use of approved Data Book and Charts may be permitted) **3 0 0 3**

COURSE OBJECTIVES:

1. To understand the concepts of rectangular plates, shells and frames and their analyzation techniques.
2. To apply the FEM in analyzing the Plates and shells.
3. To understand the creation of Frames with basic principle.

UNIT I INTRODUCTION **9 + 0**

Thin Plates with small deflection. Laterally loaded thin plates- governing differential equation- various boundary conditions

UNIT II PLATES **9 + 0**

Rectangular plates. Simply supported rectangular plates- Navier solution and Levy's method- Rectangular plates with various edge conditions- plates on elastic foundation. Symmetrical bending of circular plates.

UNIT III ANALYSIS METHODS **9 + 0**

Energy methods- Finite difference and Finite element methods – Plates and Shells

UNIT IV SHELLS **9 + 0**

Classification of shells- types of shells- structural action- membrane theory- shells of revolution and shells of translation- examples- limitations of membrane theory. Folded Plate structures- structural behavior- types- design by ACI - ASCE Task Committee method

UNIT V FRAMES **9 + 0**

Space frames - configuration - types of nodes - general principles of design Philosophy - Behavior.

Total = 45Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Apply design principles and to create economically viable products.

CO2 : Develop the ability to obtain the various deflections in plates and shells.

CO3 : Synthesize the principles of analysis of finite difference and finite element methods

TEXT BOOKS:

1. Szilard R, “Theory and Analysis of Plates”, Prentice Hall Inc., 1995.
2. Timoshenko S and Krieger S.W, “ Theory of Plates and Shells”, McGraw Hill Book Company- New York 1990.

REFERENCE BOOKS:

1. Timoshenko S, “Theory of Plates and Shells”, McGraw Hill, 1990.
2. Wilhelm Flügge, “Stresses in shells”, Springer ,Verlag.
3. Ramasamy G.S, “Design and Construction of Concrete Shells Roofs”, CBS Publishers, 1986.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	3	3	3	1	1	-	1	-	1	-	-	-
CO2	1	3	1	2	1	2	-	-	-	-	1	-	-	2
CO3	1	3	1	2	1	2	-	-	-	-	1	1	1	-

1- Faintly

2- Moderately

3- Strongly

18CDE33	OPTIMIZATION TECHNIQUES IN DESIGN	L	T	P	C
	(Use of approved Data Book and Charts may be permitted)	3	0	0	3

COURSE OBJECTIVES:

1. To create awareness about optimization techniques.
2. To understand and apply optimization techniques to real life problems.
3. To understand the fundamentals constrained and un constrained optimization and their static and dynamic application.

UNIT I INTRODUCTION **9 + 0**

General Characteristics of mechanical elements- adequate and optimum design- principles of optimization- formulation of objective function- design constraints – Classification of optimization problem

UNIT II UNCONSTRAINED OPTIMIZATION **9 + 0**

Single variable and multivariable optimization- Techniques of unconstrained minimization – Golden section- pattern and gradient search methods – interpolation methods.

UNIT III CONSTRAINED OPTIMIZATION **9 + 0**

Optimization with equality and inequality constraints – Indirect methods using penalty functions- Lagrange multipliers- Geometric programming- Constrained- mixed inequality and unconstrained minimization- Genetic algorithms

UNIT IV STATIC APPLICATIONS **9 + 0**

Structural applications – Design of simple truss members. Design applications – Design of simple axial- transverse loaded members for minimum cost- maximum weight – Design of shafts and torsionally loaded members – Design of springs.

UNIT V DYNAMIC APPLICATIONS **9 + 0**

Dynamic Applications – Optimum design of single- two degree of freedom systems- vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

Total = 45Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Know the different optimization techniques.
CO2 : Apply these techniques to solve static and dynamic problems of day to day applications.
CO3 : Develop the ability to obtain the optimal solution for engineering problems.

TEXT BOOKS:

1. SingiresuS.Rao, “Engineering Optimization Theory and Practice”, New Age International (P) Limited, 1996.
2. Johnson Ray C, “Optimum design of mechanical elements”, Wiley John & Sons, 1990.

REFERENCE BOOKS:

1. Kalyanamoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt, 1995.
2. Goldberg D.E, “Genetic algorithms in search- optimization and machine”, Barnen Addison-Wesley New York, 1989.
3. Saravanan.R, “Manufacturing optimization through intelligent techniques”, Taylor and Francis Publications, CRC Press, 2006.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	1	-	-	1	1	-	1	-	-	-
CO2	1	3	1	1	2	2	-	2	2	-	1	1	3	-
CO3	1	3	1	1	2	2	-	2	2	-	1	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE34 **COMPUTATIONAL FLUID DYNAMICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To develop finite difference and finite volume discredited forms of the CFD equations.
2. To formulate explicit & implicit algorithms for solving the Euler Eqns & Navier Stokes Eqns.

UNIT I INTRODUCTION AND GOVERNING EQUATIONS 9 + 0

Basics of computational fluid dynamics–Governing equations of fluid dynamics–Continuity, Momentum and Energy equations– Chemical species transport–Physical boundary conditions–Time-averaged equations for Turbulent Flow–Turbulent–Kinetic Energy Equations–Mathematical behaviour of PDEs on CFD-Elliptic, Parabolic and Hyperbolic equations.

UNIT II FINITE DIFFERENCE AND FINITE VOLUME METHODS FOR DIFFUSION 9 + 0

Derivation of finite difference equations–Simple Methods–General Methods for first and second order accuracy–Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems–Parabolic equations–Explicit and Implicit schemes–Example problems on elliptic and parabolic equations–Use of Finite Difference and Finite Volume methods.

UNIT III CONDUCTION AND CONVECTIVE HEAT TRANSFER 9 + 0

One-Dimensional and Two-Dimensional Conduction - Convection – Diffusion problems, Unsteady one-dimensional convection – Diffusion, Unsteady two-dimensional convection – Diffusion – Introduction to finite element method – Solution of steady heat conduction by FEM

UNIT IV FLUID FLOW 9 + 0

Governing Equations, Stream Function – Verticity method, Determination of pressure for viscous flow, SIMPLE Procedure of Patankar and spalding, Computation of Boundary layer flow, Finite difference approach, Finite volume methods-Representation of the pressure gradient term and continuity equation–Staggered grid–Momentum equations–Pressure and Velocity corrections– Pressure Correction equation, SIMPLE algorithm and its variants–PISO Algorithms.

UNIT V TURBULENCE MODELS 9 + 0

Algebraic Models – One equation model, K - ε Models, Standard, Reynolds number models, Prediction of fluid flow.

Total = 45Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Ability to Write the mathematical representation of governing equation for fluid flow and heat transfer scenarios.
CO2 : Solve one dimensional and two-dimensional heat transfer problems
CO3 : Ability to identify, formulate, and solve conduction type problems using appropriate CFD technique.
CO4 : Ability to understand different turbulence model and able to apply appropriate models to various practical applications.

TEXT BOOKS:

1. Muralidhar, K., and Sundararajan, T., “Computational Fluid Flow and Heat Transfer”, Narosa Publishing House, New Delhi, 1995.

2. Ghoshdasdidar, P.S., “Computer Simulation of flow and heat transfer” Tata McGraw-Hill Publishing Company Ltd., 1998.

REFERENCE BOOKS:

1. Subas, V.Patankar “Numerical heat transfer fluid flow”, Hemisphere Publishing Corporation, 1980.
2. Taylor, C and Hughes, J.B. “Finite Element Programming of the Navier Stock Equation”, Pineridge Press Limited, U.K., 1981.
3. Anderson, D.A., Tannehill, J.I., and Pletcher, R.H., “Computational fluid Mechanics and Heat Transfer “ Hemisphere Publishing Corporation, Newyork, USA, 1984.

4. Donald R. Honra, “Co-ordinate measurement and reverse Engineering”, American Gear Manufacturers Association.1997.
5. Fletcher, C.A.J. “Computational Techniques for Fluid Dynamics 1” Fundamental and General Techniques, Springer – Verlag, 1987.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	-	-	-	-	-	1	-	-	3
CO2	1	2	2	2	1	-	-	-	1	-	1	1	-	-
CO3	1	3	1	3	1	-	-	1	2	-	1	3	2	-
CO4	1	1	1	1	1	-	-	-	-	-	1	-	1	1

1- Faintly
2- Moderately
3- Strongly

18CDE35 COMPUTER INTEGRATED MANUFACTURING SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To simplify production process, production designs, and factory organization
2. To automate production process and the business functions
3. To integrate all production and support processes

UNIT I INTRODUCTION **9 + 0**

Objectives of a manufacturing system - Identifying business opportunities and problems classification production systems - Linking manufacturing strategy and systems analysis of manufacturing operations.

UNIT II COMPUTER AIDED PROCESS PLANNING **9 + 0**

Introduction - Part families - Parts classification and coding - Group technology machine cells - Benefits of group technology - Process planning function CAPP - Computer generated time standards.

UNIT III COMPUTER AIDED PLANNING AND CONTROL **9 + 0**

Production planning and control – Cost planning and control - Inventory management - Material requirements planning (MRP) - Shop floor control - Factory data collection system - Automatic identification system - Barcode technology - Automated data collection system.

UNIT IV COMPUTER MONITORING **9 + 0**

Types of production monitoring systems-Structure model of manufacturing process-Process control & strategies-Direct digital control-Supervisory computer control-Computer in QC - Contact inspection methods non-contact inspection method – Computer aided testing - Integration of CAQC with CAD/CAM.

UNIT V INTERNET WORKING DEVICES **9 + 0**

LAN & ACCESS TECHNIQUES: Topologies - star, ring, bus. Ethernet, transmission media, protocols, polling, contention, ALOHA, CSMA, CSMA/CD, token ring protocols, performance comparisons. INTERNETWORKING DEVICES: Principles, repeaters, bridges, routing with bridges, routers, brouters, gateways, hubs and switches, TCP/IP protocol structure, internet protocol, transmission protocol, applications

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : It helps the students to get familiarized with the computer aided process planning, group technology, process planning and control and computer integrated manufacturing systems

CO2 : The student shall be comfortable with using CAD/CAM systems with programming and operating of CNC machine tools

CO3 : To apply the concept of computer aided planning and control

TEXT BOOKS:

1. Groover, M.P., "Automation, Production System and CIM", Prentice-Hall of India, 1998.
2. David Bedworth, "Computer Integrated Design and Manufacturing", TMH, New Delhi, 1998.

REFERENCE BOOKS:

1. YoremKoren, "Computer Integrated Manufacturing Systems", McGraw Hill, 1983.
2. Ranky, Paul G., "Computer Integrated Manufacturing", Prentice Hall International 1986.
3. R.W. Yeomamas, A. Choudry and P.J.W. Ten Hagen, "Design rules for a CIM system", North Holland Amsterdam, 1985.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	-	2	1	2	1	-	1	-	1	3	2	3
CO2	1	2	1	2	1	2	1	-	2	-	1	3	3	-
CO3	2	2	1	1	1	3	1	1	1	-	1	2	2	1

1- Faintly
2- Moderately
3- Strongly

18CDE36 **INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. Students will explore the broad scope of robotic applications.
2. To learn the basic components and building blocks of robots
3. To Interface various hardware components and controller-based projects with function on multidisciplinary teams
4. To acquire fundamental knowledge and competences on how to simulate and program industrial robots.
5. To understand the impact of engineering solutions in a global, economic, environmental, and societal context with the help of Robotics

UNIT I INTRODUCTION **9 + 0**

Introduction - Scope of Industrial robots – structure of a Robot and Classification –Robot Kinematics – Direct and inverse kinematics – Robot dynamics - Newton Euler formulation, Lagrange – Euler formulation, problems- Robot trajectories – Control of robot manipulators

UNIT II DRIVES AND CONTROL **9 + 0**

Controlling the Robot motion – Position and velocity – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Mechanical, Vacuum, magnetic grippers.

UNIT III SENSORS **9 + 0**

Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing – Image processing and analysis

UNIT IV WORK CELL LAYOUT AND APPLICATION **9 + 0**

Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis.

UNIT V PROGRAMMING AND ARTIFICIAL INTELLIGENCE **9 + 0**

Methods of Robot Programming – VAL-II programming-basic commands- AML Language-General description-Program control statements -Artificial intelligence – AI techniques – problem representation in AI

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : identify a Robot for a specific application
CO2 : interface various Servo and hardware components with Controller based projects
CO3 : access the machine vision capabilities of the robot to select objects based upon shape, orientation and color
CO4 : design and critically evaluate: a safe system in a robot cell
CO5 : implement and present a basic automation task with an industrial robot, including online and offline programming and evaluation of the results, based on a given specification

TEXT BOOKS:

1. "Robotics Control, Sensing, Vision and Intelligence", K.S.Fu, R.C. Gonzalez and C.S.G. Lee McGraw Hill, 1987.

REFERENCE BOOKS:

1. "Robotics for Engineers", YoramKoren, McGraw-Hill, 1987.
2. "Industrial Robots–Technology, Programming and Applications", Groover M.P., McGrawHill, 2001.
3. "Robotics Engineering – An Integrated Approach", Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, Prentice-Hall of India Pvt. Ltd., 1989.

4. “Robotics Technology and Flexible Automation”, Deb, S.R. Tata McGraw-Hill, 2010.
5. “Expert Systems and Robotics”, Timothy Jordanides et al , Springer –Verlag, New York, May 2012.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	-	1	1	1	-	-	-	1	-	-	-
CO2	1	2	2	-	1	3	1	-	2	-	1	-	-	2
CO3	1	1	-	3	-	-	1	-	2	-	1	-	2	-
CO4	-	-	1	-	-	1	-	-	-	-	1	1	3	3
CO5	1	2	1	-	3	-	-	-	1	-	-	3	-	-

1- Faintly
2- Moderately
3- Strongly

ELECTIVE-IV

18CDE41	EXPERIMENTAL TECHNIQUES AND DATA ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1 To understand the working principle of instruments used for cutting forces, temperature measure mentand metallurgical studies.
2 Familiar to collection and analysis of data with scientific approach.
3 Understand the concept of design of experiment and Taguchi method.

UNIT I MEASUREMENT OF CUTTING FORCES 9 + 0

Strain gauge and piezoelectric transducers – characteristics - Dynamometer construction, Bridge circuits - Instrumentation and calibration - Displacement and strain measurements by photo elasticity - Holography, interferometer, Moir techniques, strain gauge rosettes – Calibration of instruments.

UNIT II TEMPERATURE AND FLOW MEASUREMENT 9 + 0

Circuits and instrumentation for different transducers - bimetallic, expanding fluid, electrical resistance, thermistor, thermocouples and pyrometers. Flow Measurement - Transducers for Non-compressible and compressible fluids - Obstruction and drag methods - Vortex shredding flow meters - Ultrasonic, Laser Dopler and Hotwire anemometer - Flow visualization techniques - Shadow graphs, Schlieren photography, Interferometer

UNIT III CHARACTERIZATION TECHNIQUES 9 + 0

Optical and electron microscopy - X-Ray diffraction, Bragg's Law and its application for studying crystal structure and residual stresses - Electron spectroscopy, electron microprobe. Surface Measurements - Micro hardness, roughness, accuracy of dimensions and forms - 3-D co-ordinate measuring machines – Scanning Electron Microscope.

UNIT IV EXPERIMENT DESIGN AND DATA ANALYSIS 9 + 0

Statistical methods - Randomized block design, Latin and orthogonal squares, factorial design - Replication and randomization - Data Analysis - Deterministic and random data, uncertainty analysis - Tests for significance - Chi-square, student's't' test - Regression modeling - direct and interaction effects - ANOVA, F-test - Time Series analysis - Autocorrelation and autoregressive modeling – RSM Technique.

UNIT V DESIGN OF EXPERIMENTS 9 + 0

Types of Experiments – Experiment Design Factor – Experiment design protocol and examples. Taguchi Methods - Experiment design and planning with Orthogonal arrays and linear graphs - Additive cause effect model - Optimization of response level - Identification of Design and noise factors - Performance evaluation and Optimization by signal to noise ratios - Concept of loss function and its application. Introduction to Response surface methodology (RSM).

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Develop an appropriate experimental research design for an engineering case study taking into account practical limitations.
CO2 : Apply knowledge of statistical analysis to assess a hypothesis by selecting appropriate statistical tests and by correctly interpreting the results of these tests.
CO3 : Propose an appropriate statistical model for a given dataset and interpret the goodness of fit.
CO4 : Optimize the experimental result and correlated with analytical data by using taughi method.

TEXT BOOKS:

1. Holman, J.P., "Experimental Methods for Engineers", McGraw Hill Int., New York.
2. Venkatesh, V.C., and Chandrasekharan, "Experimental Methods in Metal Cutting", Prentice Hall of India, Delhi.

REFERENCE BOOKS:

1. Davis, O.V., “The Design and Analysis of Industrial Experiments”, Longman, London.
2. Box and Jenkins; “Time Series analysis, Forecasting and control”, Holden Day, Sanfrancisco
3. Dove and Adams, “Experimental stress analysis and motion measurement”, Prentice Hall of India, Delhi.
4. Tapan P. Bagchi, “Taguchi Methods Explained”, Prentice Hall of India, Delhi.
5. Gerry P.Quinn, Michael J.Keough “Experimental Design and Data Analysis for Biologists”, Cambridge University Press.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	3	3	1	-	-	1	-	1	1	2	1
CO2	2	2	1	2	1	-	-	-	-	-	1	3	1	-
CO3	2	2	1	2	1	-	-	-	-	-	1	3	-	-
CO4	2	2	1	2	1	-	-	-	-	-	1	2	3	3

1- Faintly
2- Moderately
3- Strongly

18CDE42	CAD/CAM TOOLS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the basics of industrial automation.
2. To understand nature & significance of Machine tools
3. To develop skills for programming skills required for manufacturing.

UNIT I COMPUTER AIDED MANUFACTURING 9 + 0

Manufacturing Processes – Removing, Forming, Deforming and joining – Integration Requirements. Integrating CAD, NC and CAM – Machine tools – Point to point and continuous path machining, NC, CNC and DNC – NC Programming – Basics, Languages, G Code, M Code, APT – Tool path generation and verification – CAD/CAM NC Programming – Production Control – Cellular Manufacturing

UNIT II CAD/CAM HARDWARE 9 + 0

Introduction – Types of systems – CAD/CAM system evaluation criteria – Input devices – Output devices – Hardware integration and Networking – Programmable logic controllers – Hardware trends.

UNIT III INSPECTION METHODS 9 + 0

Engineering Tolerances – Need for Tolerances – Conventional Tolerances – FITS and LIMITS – Tolerance Accumulation and Surface quality – Geometric Tolerances – Tolerances Practices in design, Drafting and manufacturing – Tolerance Analysis – Tolerance synthesis – Computer Aided Quality control – Contact Inspection Methods – Non Contact Inspection Methods - Non optical.

UNIT IV REVERSE ENGINEERING 9 + 0

Scope and tasks of Reverse Engineering – Domain Analysis – Process Duplicating – Tools for RE – Developing Technical data – Digitizing techniques – Construction of surface model – Solid part model – Characteristic evaluation – Software's and its application – CMM and its feature capturing – surface and solid modeling.

UNIT V DATA MANAGEMENT 9 + 0

Strategies for Reverse Engineering Data management – Software application – software components – Recycling real time embedded software – Design experiments to evaluate a RE tools – Rule based detection for RE user interface – RE of assembly programs.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : To get familiarized with computer aided tools for various industrial applications which includes manufacturing, process planning, inspection, data management and reverse engineering.
CO2 : To apply the concept of geometric modelling and create new objects.
CO3 : To evaluate the principle of synthesis of curves and create new 3D Objects.

TEXT BOOKS:

1. Ibrahim Zeid and R. Sivasubramanian, "CAD/CAM Theory and Practice", Revised 1stEdition, Tata McGraw Hill Publication, 2007.
2. Catherine A. Ingle, "Reverse Engineering", Tata McGraw Hill Publication, 1994.

REFERENCE BOOKS:

1. Ibrahim Zeid, "Mastering CAD/CAM", special Indian Edition, Tata McGraw Hill Publication, 2007.
2. David D. Bedworth, Mark R. Henderson and Philp M. Wolfe, "Computer Integrated Design and Manufacturing", McGraw Hill International series, 1991.
3. Linda Wills, "Reverse Engineering", Kluwer Academic Press, 1996.
4. Donald R. Honra, "Co-ordinate measurement and reverse Engineering", American Gear Manufacturers Association.1997.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	1	2	2	1	2	-	1	3	2	2
CO2	2	2	2	2	-	2	2	1	3	1	1	3	3	2
CO3	1	3	3	1	2	2	2	2	1	-	1	3	3	3
CO4	2	3	2	2	1	2	2	1	2	-	1	3	2	2

1- Faintly
2- Moderately
3- Strongly

18CDE43 **CONTACT MECHANICS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the concepts of mechanical properties of materials, elastic and brittle fracture of materials.
2. To understand elastic-plastic indentation and testing methods

UNIT I INTRODUCTION **9 + 0**

Mechanical Properties of Materials- Elasticity -Hooke's law - Strain energy - Surface energy- Stress-Strain -Linear sticity - 2-D Plane stress- plane strain -Principal stresses- Equations of equilibrium and compatibility- Saint-nant's principle-Hydrostatic stress and stress deviation -Visualizing stresses- Plasticity -Equations of plastic flow - ess Failure Criteria - Tresca failure criterion - Von Mises failure criterion.

UNIT II LINEAR ELASTIC FRACTURE AND BRITTLE FRACTURE **9 + 0**

Introduction- Stress Concentrations- Energy Balance Criterion - Linear Elastic Fracture Mechanics - Stress intensity factor - Determining Stress Intensity Factors- Calculating stress intensity factors from prior stresses - Determining stress intensity factors using the finite-element method -Delayed Fracture in Brittle Solids-Static Fatigue - The Stress Corrosion Theory of Charles and Hillig - Sharp Tip Crack Growth Model - Strength and failure probability - Effect of biaxial stresses - Determining the probability of delayed failure.

UNIT III ELASTIC INDENTATION **9 + 0**

Introduction- Hertz Contact Pressure Distribution - Analysis of Indentation Stress Fields -Line contact -Point contact- Analysis of stress and deformation - Indentation Stress Fields- Uniform pressure- Spherical indenter - Cylindrical roller (2-D) contact -Cylindrical flat punch indenter - Rigid cone-Elastic Contact- Hertz Contact Equations - Impact –Friction -Hertzian Fracture- Hertzian Contact Equations - Auerbach's Law- Auerbach's Law and the Griffith Energy Balance Criterion- Energy Balance.

UNIT IV ELASTIC –PLASTIC INDENTATION **9 + 0**

Elastic-Plastic Indentation Stress Fields –Introduction- Pointed Indenters - Indentation stress field - Indentation fracture- Fracture toughness- Berkovich indenter- Spherical Indenter-Elastic and Elastic-Plastic Contact.- Introduction- Geometrical Similarity- Indenter Types - Spherical- conical- and pyramidal indenters - Sharp and blunt indenters -Elastic-Plastic Contact - Elastic recovery –Compliance- The elastic-plastic contact surface.

UNIT V DEPTH-SENSING INDENTATION TESTING METHODS **9 + 0**

Indenter-Load-Displacement Curve-Unloading Curve Analysis-Experimental and Analytical Procedures - Corrections to the experimental Data-Application to Thin-Film Testing-Indentation Test Methods- Bonded-Interface Technique - Indentation Stress-Strain Response – Compliance Curves- Hardness Testing - Vickers hardness -Berkovich indenter -Depth-sensing (nano) Indentation - instruments - techniques -data analysis- test standards.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Gain knowledge about the couplings between normal- and tangential loads and deformations.
CO2 : Understand the mechanism of elastic fracture and brittle fracture.
CO3 : Understand the elastic problems with tangential, sliding or rolling contacts and plastic contact problem.
CO4 : Applying the relations for thermo-elastic contact, contact of rough surfaces, adhesion.

TEXT BOOKS:

1. Fischer Cripps and Anthony C, "Introduction to Contact Mechanics", 2nd Edition, Springer Mechanical Engineering series, 2007.

2. Johnson.K.L, “Contact Mechanics”, Cambridge University Press, Cambridge, 1985

REFERENCE BOOKS:

1. Valentin L. Popov,”Contact Mechanics and Friction”,2nd Edition, Springer Mechanical Engineering series, 2007
2. I.G.Goryacheva,”Contact Mechanics in Tribology”, Springer-Science+Business Media, B.V.1998
3. K.L. Johnson, K. Kendall, A.D. Roberts ,"Surface Energy and the Contact of Elastic Solid", *Proc. R. Soc. London, Ser. A* 1971, *324*, 301-313.
4. M.K. Chaudhury, T. Weaver, C.Y. Hui and E.J. Kramer "Adhesive contact of Cylindrical lens and a Flat Sheet”, J. Appl.Phys. 1996, 80(1), 30-37

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	-	-	-	-	-	1	1	-	-	-
CO2	1	1	1	1	-	-	1	-	-	1	1	-	-	1
CO3	1	1	1	1	-	-	-	-	-	-	1	1	2	-
CO4	1	2	1	1	-	-	-	-	-	-	1	1	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE44	ADVANCED AUTOMOTIVE SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Introduction to engineering analysis of the automobile and its sub-systems
2. To understand the fundamental design concepts in clutch, Transmission, brakes, suspension, steering and electronic systems.
3. Learn about application of engineering principles to automotive design.

UNIT I INTRODUCTION 9 + 0

Fundamentals of designing automobiles - performance of automobiles - general layout of the automobile - Types of chassis layout - various types of frames, constructional details, materials, unitized frame body construction - Design conditions - loading conditions.

UNIT II ENGINE COMPONENTS 9 + 0

Choice of material for various engine components - design of cylinder, design of piston assembly, design of connecting rod, design of crankshaft under bending and twisting, balancing weight calculations - design of valves, valve springs and design of flywheel.

UNIT III CLUTCH AND BRAKES 9 + 0

Introduction - design diagrams of clutch - calculation of critical parameters of clutches- design calculation of standard elements of friction clutches - torsional vibration dampers - clutch control drives. Pressure distribution along shoe length - determining braking torque - design of drum and disk brakes - fundamentals of designing brake force regulators - anti-locking system.

UNIT IV TRANSMISSION, SUSPENSION, STEERING SYSTEMS 9 + 0

Determining main parameters of transmission and its design - gear shift mechanisms – differential - differential housings - axle shafts - gear box - universal joint - propeller shaft. Suspension system - Oscillation and smoothness of ride - elastic elements of suspension - shock absorbers. Fundamentals of designing and calculating steering control linkage - steering gears - hydraulic booster.

UNIT V AUTOMOTIVE ELECTRONIC SYSTEMS 9 + 0

Sensors in automobiles - Classification - sensors for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant and exhaust temperature, air mass flow for engine application. Solenoids, stepper motors and relay - engine management system - Gasoline / diesel systems – Electronic transmission control vehicle safety system – braking and traction.

Total = 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Apply design principles for manufacturing to create eco-friendly automobiles

CO2 : Enhanced knowledge on automobile design and its innovation with greater concern towards environmental issues.

CO3 : Apply the electronic technology in automotive, for improving performance or reduce cost

CO4 : Apply the automotive electronics to control the engine in order to reduce the emission level

TEXT BOOKS:

1. David A.Crolla, “Automotive Engineering, Powertrain, Chassis System and Vehicle Body”, 2009
2. William B. Ribbens, “Understanding Automotive Electronics”, 1998

REFERENCE BOOKS:

1. Lukin P Gasparyants G and Rodionov V, “Automobile Chassis Design and Calculations”, Mir Publishers, 1989
2. Heinz Heisier, “Vehicle and Engine technology”, SAE New York, 1999.
3. Gillespie T D, “Fundamentals of Vehicle Dynamics”, SAE Inc. New York, 1992.
4. Schwaller A E, “Motor Automotive Technology” ,3rd Edition, Delman Publishers, New York.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	3	3	2	1	-	-	1	1	-	-	3	-
CO2	2	1	2	-	1	-	-	-	1	1	1	3	1	-
CO3	2	1	2	-	2	-	-	-	-	-	1	-	-	-
CO4	2	1	1	-	2	1	1	-	1	1	-	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE45	DESIGN OF MATERIAL HANDLING EQUIPMENT	L	T	P	C
	(Use of approved Data Book and Charts may be permitted)	3	0	0	3

COURSE OBJECTIVES:

1. To impart students on the need, use, application and design of different material handling techniques, equipment's and machines used in common use and in industrial sector
2. To briefly discuss about load handling equipment and brakes.

UNIT I FLEXIBLE HOISTING APPLIANCES 9 + 0

Type- selection and applications of material handling equipment- choice of material handling equipment – hoisting equipment – components and theory of hoisting equipment – chain and ropes – selection of ropes- pulleys- pulley systems- sprockets and drums.

UNIT II LOAD HANDLING EQUIPMENTS AND BRAKES 9 + 0

Forged standard hooks – forged Ramshorn hooks – solid triangular eye hooks –crane grabs- electric lifting magnetic– grabbing attachments for loose materials. arresting gear – brakes: shoe- band and cone types – elements of shoe brakes –thermal calculation in shoe brakes.

UNIT III SURFACE AND OVERHEAD TRANSPORTATION EQUIPMENTS 9 + 0

Hand operated trucks – powered trucks – tractors – electronically controlled tractors - hand truck on rails – industrial railroad equipments: locomotives - winches – capstans – turntables – monorail conveyors –pipe rail systems – flat bar monorails. Rail traveling mechanism- cantilever and monorail cranes- cogwheel drive- monocable tramways-reversible tramways.

UNIT IV ELEVATING EQUIPMENTS 9 + 0

Continuous-motion vertical conveyors – reciprocating-motion vertical conveyors – stackers – work levelers and tail gates – industrial lifts – passenger lifts – freight elevators – mast type elevators – vertical skip hoist elevators- bucket elevators: design- loading and bucket arrangements.

UNIT V CONVEYING EQUIPMENTS 9 + 0

Belt conveyors - chain conveyors – apron conveyors – escalators – flight conveyors – roller conveyors - oscillating conveyors - design of belt conveyors- screw conveyors and pneumatic conveyors.

Total 45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Describe the importance of proper material handling techniques and regarding hoisting and conveying equipment.

CO2 : List hazards associated with hoisting and conveying.

CO3 : Learn about various hoisting gear drives used in various applications.

TEXT BOOKS:

1. Rudenko. N, "Materials Handling Equipment", MIR Publishers, 1969.
2. Spivakovsky. A.O and Dyachkov. V.K, "Conveying Machines- Volume I and II", MIR Publishers, 1985.

REFERENCE BOOKS:

1. Alexandrov M, " Materials Handling Equipments", MIR Publishers, 1981.
2. Boltzharol A, " Materials Handling Handbook", The Ronald Press Company,1958.
3 P.S.G Tech, "Design Data Book", KalaikathirAchchagam, 2008.
4 Lingaiah. K and Narayanalyengar, "Machine Design Data Hand Book- Vol. 1 & 2", Suma Publishers,1983.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	2	1	1	1	-	-	1	1	1	-	-
CO2	1	1	3	2	1	1	2	1	1	3	1	-	1	-
CO3	1	2	1	1	3	3	1	-	-	1	1	-	-	2

1- Faintly
2- Moderately
3- Strongly

18CDE46	PLASTICITY AND METAL FORMING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on theory of plasticity, analysis of various metal forming processes that arise in engineering applications.
2. To understand Plastic deformation during forming processes

UNIT I THEORY OF PLASTICITY 9 + 0

Theory of plastic deformation - Engineering stress and strain relationship – Stress tensor - Strain tensor - Yield criteria's - Plastic stress strain relationship – Plastic work - Equilibrium conditions - Incremental plastic strain.

UNIT II STUDY OF PLASTIC DEFORMATION 9 + 0

Forging, Rolling, Extrusion, rod/wire drawing and tube drawing – Effect of friction. Classification of forming process- Temperature in metalworking- Forging defects- Hydrostatic.

UNIT III CONSTITUTIVE RELATIONSHIPS AND INSTABILITY 9 + 0

Uniaxial tension test - Mechanical properties - Work hardening, Compression test, bulge test, plane strain compression stress, plastic instability in uniaxial tension stress, plastic instability in biaxial tension stress.

UNIT IV DEFECTS IN METAL FORMING PROCESS 9 + 0

Slab analysis - Slip line method, upper bound solutions, statistically admissible stress field, numerical methods, contact problems, effect of friction, thermo elastic Elasto plasticity, elastovis coplasticity - Thermo mechanical coupling – Analysis of forging, rolling, extrusion and wire drawing processes - Experimental techniques for the evaluation of metal forming.

UNIT V SHEET METAL FORMING PROCESS 9 + 0

Bending theory - Cold rolling theory - Hill's anisotropic theory, Hill's general yield theory - Sheet metal forming - Elements used - Mesh generation and formulation Equilibrium equations - Consistent full set algorithm - Numerical solutions procedures - examples of simulation of simple parts - Bench mark tests – Forming limit diagrams.

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Understand the stress and strain tensor field
CO2 : Apply the concepts to evaluate the theory of plasticity
CO3 : Formulate the concepts for plasticity and plastic deformation analysis
CO4 : Recognize the various metal forming techniques

TEXT BOOKS:

1. Hansford. W. F and Cad dell. RM., Metal Forming Mechanics and Metallurgy, Prentice Hall Eaglewood Cliffs, 1993.
2. Surrender Kumar, " Technology of Metal Forming Processes", Prentice Hall of India, New Delhi, 2008

REFERENCE BOOKS:

1. Narayanaswamy. R, Theory of Metal Forming Plasticity, Narosa Publishers, 1999.
2. Shiro Kobayashi, Altan. T, Metal Forming and Finite Element Method, Oxford University Press, 1989.
3. Slater. R A. C., Engineering Plasticity - Theory & Applications to Metal Forming, John Wiely and Sons, 1987.
4. Wagoner. R H. and Chenot. J.J., Metal Forming analysis, Cambridge University Press, 2002.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	1	2	2	1	1	1	-	-	1	1	-	-	-
CO2	1	1	3	2	1	1	2	1	1	3	1	-	1	2
CO3	1	2	1	1	3	3	1	-	-	1	1	-	-	-
CO4	1	1	2	1	2	1	1	-	-	2	1	1	1	1

1- Faintly
2- Moderately
3- Strongly

ELECTIVE-V

18CDE51	TRIBOLOGY IN DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVE:

1. To impart knowledge in the friction, wear and lubrication aspects of machine components
2. To understand the material properties which influence the tribological characteristics of surfaces.
3. To understand the analytical behavior of different types bearings and design of bearings based on analytical /theoretical approach

UNIT I SURFACES- FRICTION AND WEAR 9 + 0

Topography of Surfaces – Surface features – Surface interaction – Theory of Friction – Sliding and Rolling Friction- Friction properties of metallic and non-metallic materials – friction in extreme conditions – wear- types of wear – mechanism of wear – wear resistance materials – surface treatment – Surface modifications – surface coatings

UNIT II LUBRICATION THEORY 9 + 0

Lubricants and their physical properties lubricants standards – Lubrication Regimes Hydrodynamic lubrication – Reynolds Equation- Thermal- inertia and turbulent effects – Elasto hydrodynamic and plasto hydrodynamic and magnetohydrodynamic lubrication – Hydrostatic lubrication – Gas lubrication.

UNIT III DESIGN OF FLUID FILM BEARINGS 9 + 0

Design and performance analysis of thrust and journal bearings – Full- partial- fixed and pivoted journal bearings design – lubricant flow and delivery – power loss- Heat and temperature rotating loads and dynamic loads in journal bearings – special bearings – Hydrostatic Bearing design.

UNIT IV ROLLING ELEMENT BEARINGS 9 + 0

Geometry and kinematics – Materials and manufacturing processes – contact stresses – Hertzian stress equation – Load divisions – Stresses and deflection – Axial loads and rotational effects- Bearing life capacity and variable loads – ISO standards – Oil films and their effects – Rolling Bearings Failures.

UNIT V TRIBO MEASUREMENTS 9 + 0

Surface Topography measurements – Electron microscope and friction and wear measurements – Laser method – instrumentation - International standards – bearings performance measurements – bearing vibration measurement.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student shall be able to:

CO1	**:**	Understand friction, wear and lubrication
CO2	**:**	Analyze properties of lubrication on hydrodynamic, hydrostatic, Elasto hydrodynamic condition
CO3	**:**	Develop processes of lubrication in all regimes, Suggest an explanation to the cause of a tribological failure
CO4	**:**	Understand the friction phenomena and select a suitable lubricant for a specific application
CO5	**:**	Understand and determine wear processes in contacts between metallic and non-metallic surfaces

TEXT BOOKS:

1. Cameron A, “Basic Lubrication Theory”, Ellis Herward Ltd. UK, 1981.
2. Hulling J, “Principles of Tribology”, MacMillan, 1984.

REFERENCE BOOKS:

1. Williams J.A, “Engineering Tribology”, Oxford University Press, 2005.
2. Neale M.J, “Tribology Handbook”, 2nd Edition, Butterworth Heinemann, 1995.
3. Bharat Bhushan, “Modern Tribology Handbook Vol. I & II”, CRC Press, 2001.

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	2	3	-	-	-	-	1	1	1	1	1	1
CO2	2	1	1	1	1	-	1	-	-	1	1	3	2	2
CO3	2	1	1	1	1	1	1	-	1	1	1	1	1	-
CO4	1	1	1	1	1	1	1	-	-	1	1	1	-	-
CO5	1	1	3	1	1	-	1	-	-	1	1	1	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE52 ENTERPRISE RESOURCE PLANNING L T P C
3 0 0 3

COURSE OBJECTIVE :

1. To understand the concepts of various resource planning technique and ERP system packages

UNIT I ENTERPRISE RESOURCE PLANNING 9 + 0

Principle – ERP framework – Business Blue Print – Business Engineering vs. Business process Re-Engineering – Tools – Languages – Value chain – Supply and Demand chain – Extended supply chain management – Dynamic Models –Process Models

UNIT II TECHNOLOGY AND ARCHITECTURE 9 + 0

Client/Server architecture – Technology choices – Internet direction – Evaluation framework – CRM – CRM pricing – chain safety – Evaluation framework.

UNIT III ERP SYSTEM PACKAGES 9 + 0

SAP - People soft- Baan and Oracle – Comparison – Integration of different ERP applications – ERP as sales force automation – Integration of ERP and Internet – ERP Implementation strategies – Organizational and social issues.

UNIT IV ORACLE 9 + 0

Overview – Architecture – AIM – applications – Oracle SCM. SAP: Overview – Architecture – applications -Before and after Y2k – critical issues – Training on various modules of IBCS ERP Package-Oracle ERP and MAXIMO-including ERP on the NET

UNIT V ERP PROCUREMENT ISSUES 9 + 0

Market Trends – Outsourcing ERP – Economics – Hidden Cost Issues – ROI –Analysis of cases from five Indian Companies.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student shall be able to:

CO1 Understand the risks and benefits of ERP.
CO2 Understand the technologies needed for ERP implementation.
CO3 Understand the implementation process..
CO4 Analyze the role of Consultants, Vendors and Employees.
CO5 Analyze the role of PLM, SCM and CRM in ERP.

TEXT BOOKS:

1. Sadagopan. S, “ERP-A Managerial Perspective”, Tata McGraw Hill, 1999.
2. Jose Antonio Fernandez, “The SAP R/3 Handbook”, Tata McGraw Hill, 1998.

REFERENCE BOOKS:

1. Vinod Kumar Crag and Venkitakrishnan, N.K., “Enterprise Resource Planning Concepts and Practice”, Prentice Hall of India, 1998.
2. Garg and Venkitakrishnan, “ERPWARE- ERP Implementation Framework”, Prentice Hall, 1999.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	3	1	-	1	1	2	1	1	1	1	1	1	2
CO2	1	2	1	-	1	2	1	-	1	-	1	1	1	2
CO3	1	2	2	1	1	2	2	1	2	1	1	1	1	-
CO4	-	1	2	-	2	2	1	2	1	-	1	3	2	-
CO5	1	1	1	1	1	1	1	1	1	-	1	3	2	-

1- Faintly
2- Moderately
3- Strongly

18CDE53 **MECHATRONICS SYSTEM DESIGN** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1 To understand the interdisciplinary applications of Electronics, Electrical, Mechanical and Computer Systems for the Control of Mechanical and Electronic Systems.

UNIT I INTRODUCTION **9 + 0**

Introduction to Mechatronics - Systems - Mechatronics in Products – Measurement Systems - Control Systems - Traditional design and Mechatronics Design- Advanced applications in Mechatronics -Measurement systems- Control Systems- PID Controllers

UNIT II SENSORS AND TRANSDUCERS **9 + 0**

Introduction - Performance Terminology - Displacement- Position and Proximity -Velocity and Motion - Fluid pressure - Temperature sensors - Light sensors -Selection of sensors - Signal processing - Servo systems.

UNIT III MICROPROCESSORS IN MECHATRONICS **9 + 0**

Introduction - Architecture - Pin configuration - Instruction set - Programming of Microprocessors using 8085 instructions - Interfacing input and output devices - Interfacing D/A converters and A/D converters –Applications - Temperature control - Stepper motor control - Traffic light controller

UNIT IV PROGRAMMABLE LOGIC CONTROLLERS **9 + 0**

Introduction - Basic structure - Input and Output processing - Programming –Mnemonics Timers- Internal relays and counters - Data handling - Analog input and output - Selection of PLC.

UNIT V DESIGN AND MECHATRONICS **9 + 0**

Designing - Possible design solutions - Case studies of Mechatronics systems: Data Acquisition and control-Car engine management systems, Pick and place robot – automatic Car Park Systems – Engine Management Systems- Mechatronic Control in Automated Manufacturing.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student shall be able to:

CO1 Generate conceptual design for Mechatronics products based on potential customer requirements
CO2 Select appropriate sensors and transducers and devise an instrumentation system for collecting information about processes
CO3 Design a control system for effective functioning of Mechatronics systems using digital electronics, microprocessors, microcontrollers and programmable logic controllers
CO4 Determine the performance of a Mechatronics system
CO5 Understand MEMS fabrication techniques

TEXT BOOKS :

1. Michael B.Histand and David G. Alciatore, “Introduction to Mechatronics and Measurement Systems”, McGraw Hill International Editions, 1999.
2. Bradley- D.A, Dawson D, Buru N.C and Loader A J, “Macaronis”, Chapman and Hall, 1993.

REFERENCE BOOKS:

1. Ramesh.SGaonkar, “Microprocessor Architecture- Programming and Applications”, Wiley Eastern, 1998.
2. Lawrence J.Kamm, “Understanding Electro-Mechanical Engineering- An Introduction to Mechatronics”, Prentice Hall, 2000.
3. Ghosh- P.K. and Sridhar- P.R. “0000 to 8085- Introduction to Microprocessors for Engineers and Scientists”, 2nd Edition, Prentice Hall, 1995.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	3	2	2	2	-	-	1	2	-	1	1	2	-
CO2	1	-	2	2	-	1	-	1	2	-	1	1	2	-
CO3	2	2	2	-	2	-	-	1	1	-	-	3	3	1
CO4	-	2	3	2	1	-	-	1	1	-	1	-	-	-
CO5	1	1	1	-	-	1	1	-	-	-	-	-	1	-

1- Faintly
2- Moderately
3- Strongly

18CDE54 **FAILURE ANALYSIS** **L T P C**
3 0 0 3

COURSE OBJECTIVE :

1. To Introduce The Basic Concept Of Fracture Mechanics And Failure Analysis
2. Import Knowledge On Mechanics Of Fracture During Static And Dynamic Loading
3. Understanding The Failure Mechanism Of Creep Rupture.
4. Understand The Mechanism Of Wear And Corrosion And Knowledge On Prevention

UNIT I INTRODUCTION **9 + 0**

Stages of failure analysis, classification and identification of various types of fracture. Overview of fracture mechanics, characteristics of ductile and brittle fracture.

UNIT II COCEPTS OF FAILURE **9 + 0**

General concepts, fracture characteristics revealed by microscopy, factors affecting fatigue life Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure. Some case studies failures.

UNIT III TYPES OF FAILURE **9 + 0**

Types of wear, analyzing wear failure. Corrosion failures- factors influencing corrosion failures, an overview of various types of corrosion stress corrosion cracking, sources, characteristics of stress corrosion cracking. Procedure for analyzing stress corrosion cracking, various types of hydrogen damage failures

UNIT IV CAUSES OF FAILURE **9 + 0**

Causes of failure in forging, failure of iron and steel castings, improper heat treatment, stress concentration and service conditions. Failure of weldments - reasons for failure procedure for weld failure analysis.

UNIT V RELIABILITY **9 + 0**

Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability, bathtub curve, parallel and series system, mean time between failures and life testing

Total =45 Periods

COURSE OUTCOMES :

At the end of the course, the student shall be able to:

CO1 Understand an overview of mechanical behavior includes tensile, fatigue and creep behavior of materials.
CO2 Understand the micro mechanisms of brittle and ductile fracture
CO3 Analyze the fatigue and fracture behavior of materials
CO4 Apply the knowledge for failure analysis and case studies

REFERENCE BOOKS:

1. Bradley- D.A, Daws ASM Metals Handbook “Failure Analysis and Prevention”, ASM Metals Park. Ohio, Vol.10, 10th Edition, 1995.
2. Colangelo.V.J. and Heiser.F.A. “Analysis of Metallurgical Failures”, John Wiley and Sons Inc. New York, USA, 1974. On D, Buru N.C and Loader A J, “Macaronis”, Chapman and Hall, 1993.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	-	-	-	-	1	1	-	-	1
CO2	3	2	2	2	1	-	-	-	-	1	-	-	-	1
CO3	2	3	2	1	1	1	-	-	-	1	-	3	2	-
CO4	2	3	2	1	1	1	1	-	-	1	1	3	2	-

1- Faintly
2- Moderately
3- Strongly

18CDE55	MAINTENANCE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the concepts productivity and availability based on reliability and effectiveness.
2. To prevent or reduce the likelihood or frequency of failures of engineering components and systems.
3. To increase the quality, quantity of the product with minimal cost.
4. To identify and correct the causes of failures that does occur in engineering system.

UNIT I INTRODUCTION **9 + 0**

Maintenance – Key to reliability & productivity. Basic elements of maintenance system – inspection, Planning & scheduling, job execution, record keeping, data analysis, learning & improvement. Preventive, operating and shutdown maintenance; Condition based maintenance and Application of Preventive maintenance for a system of equipment.

UNIT II VIBRATION AND SIGNATURE ANALYSIS **9 + 0**

Vibration and signature analysis; causes; remedy in rotating machinery. Fluid analysis for condition Monitoring, various methods of fluid analysis. Vibration monitoring – Data acquisition, Transducers, Time domain and frequency domain analysis, Phase signal analysis, Fault diagnosis of rotating Equipment, antifriction bearings and gears.

UNIT III NON-DESTRUCTIVE TESTING **9 + 0**

Non-destructive testing – Visual examination – optical aids, liquid penetrate testing, magnetic particle Testing, eddy current testing, radiography, ultrasonic testing, acoustic emission testing, thermography, leak testing, corrosion monitoring, standards for NDT.

UNIT IV LUBRICATION **9 + 0**

Lubrication: Introduction to lubrication engineering, types, classification of lubricants with their properties and characteristics. Bearing lubrication technique for minimization of friction and wear

UNIT V RELIABILITY **9 + 0**

The science of friction and wear; Different types of wear, such as abrasive, corrosive, seizure, scoring, Scuffing, pitting, spalling, adhesive, etc. and techniques for minimization of wear. Data collection and Analysis, Introduction to computer-aided maintenance management system.

Total =45 Periods

COURSE OUTCOMES :

Upon successful completion of this course, students will be able to:

CO1 Apply maintenance management skill and understand need of safety devices.
CO2 Apply Concept of tribology, conditioning monitoring.
CO3 Select and apply the concept of maintainability and availability of mechanical components and systems.
CO4 Increase the productivity of the plant at minimal cost by failure analysis of plant machineries.

TEXT BOOKS :

1. Industrial Maintenance – H.P.Garg
2. Industrial Maintenance Management – S.K.Srivastava

REFERENCE BOOKS:

1. Mishra, R. C. and Pathak, K., Maintenance Engineering and Management, Second Edition, Prentice Hall of India, New Delhi, 2004.
2. Dhillon B.S., Engineering Maintenance: A Modern Approach, Taylor & Francis Group, 2002.
3. Mobley R. K., An Introduction to Predictive Maintenance, Second Edition, Butterworth-Heinemann,

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	2	1	-	-	-	-	1	1	1	-	3
CO2	3	2	2	2	1	-	-	-	-	1	-	1	-	-
CO3	2	3	2	1	1	1	-	-	-	1	-	-	1	-
CO4	2	3	2	1	1	1	1	-	-	1	1	-	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE56	DESIGN OF PRESSURE VESSELS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To impart knowledge on stresses in pressure vessels
2. To understand and apply the design considerations for pressure vessels.
3. To understand the need for support structures and their design.

UNIT I INTRODUCTION TO PRESSURE VESSELS 9 + 0

Definition-uses-methods of fabrication –materials of constructions –different specifications with special reference to BIS. Methods for determining stresses – Terminology and Ligament Efficiency – Applications.

UNIT II DESIGN OF PRESSURE VESSELS 9 + 0

Criteria for internal and external pressures-accessories to pressure vessels-connections to shell details-design criteria for pressure vessel access-inspection, tests and nondestructive examinations-supports.

UNIT III STRESSES IN PRESSURE VESSELS 9 + 0

Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.

UNIT IV THICK WALLED HIGH PRESSURE VESSELS 9 + 0

Definition-methods of fabrication and materials of construction-stresses in thick cylinder-theories of failure-prestressing methods-design-high pressure vessels and its accessories – support.

UNIT V BUCKLING AND FRACTURE ANALYSIS IN VESSELS 9 + 0

Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – the collapse of thick-walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

Total =45 Periods

COURSE OUTCOMES :

Upon successful completion of this course, students will be able to :

CO1 Apply the fundamental principles of loads and stresses as applied to pressure vessels.
CO2 Select and apply appropriate failure theories in the design of pressure vessels.
CO3 Design a variety of different pressure vessels using standard codes.
CO4 Design support members of pressure vessels.

TEXT BOOKS:

1. John F. Harvey, “Theory and Design of Pressure Vessels”, CBS Publishers and Distributors, 1987.
2. Henry H. Bedner, “Pressure Vessels, Design Hand Book”, CBS Publishers and Distributors, 1987.

REFERENCE BOOKS:

1. Stanley, M. Wales, “Chemical process equipment, selection and Design”, Butterworths series in Chemical Engineering, 1988.
2. William. J., Bees, “Approximate Methods in the Design and Analysis of Pressure Vessels and Piping”, Pre ASME Pressure Vessels and Piping Conference, 1997.
3. Hesse.H.C and Rushto J.H, “Process equipment design”, D.vanNostran Co. Inc, N.Y, 1945.
4. Brownell, L.E and Yound.E.H, “Process Equipment Design”, McGraw Hill Co. Inc, N.Y, 1959.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	2	1	-	-	-	-	-	1	2	1	1
CO2	1	2	2	2	1	-	-	-	1	-	1	1	1	1
CO3	1	3	1	3	1	-	-	1	2	-	1	3	2	1
CO4	1	1	1	1	1	-	-	-	-	-	1	3	2	2

1- Faintly
2- Moderately
3- Strongly

ELECTIVE-VI

18CDE61	INTEGRATED PRODUCT AND PROCESSES DEVELOPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Process planning and cost estimation, Concept of Engineering design, Industrial Management and Engineering.

UNIT I INTRODUCTION **9 + 0**

Characteristics of Successful Product Development-Interdisciplinary activity-Duration and Costs of Product Development- Challenges of Product Development –Development Processes and Organizations-A Generic Development Process-Concept Development: The Front-End Process Adapting the Generic Product Development Process- The AMF Development Process-Product Development Organizations-The AMF Organization

UNIT II PRODUCT PLANNING **9 + 0**

Product Planning Process- Identifying Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs-Reflecting on the Results and the Process

UNIT III PRODUCT SPECIFICATIONS **9 + 0**

Specifications - Specifications Established - Establishing Target Specifications-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation-Clarify the Problem- Search Externally-Search Internally-Explore Systematically- Reflect on the Results and the Process.

UNIT IV CONCEPT SELECTION **9 + 0**

Concept Selection- Overview of Methodology-Concept Screening-Concept Testing- Define the Purpose of the Concept Test- Choose a Survey Population- Choose a Survey Format- Communicate the Concept- Measure Customer Response-Interpret the Results- Reflect on the Results and the Process..

UNIT V PRODUCT ARCHITECTURE **9 + 0**

Product Architecture-Implications of the Architecture-Establishing the Architecture- Delayed Differentiation-Platform Planning-Related System-Level Design Issues

Total =45 Periods

COURSE OUTCOMES:

Upon completion of this course the students will be able to

CO1 Impart knowledge on product development processes and organizations.

CO2 Identify customer needs, product planning processes and allocating resources and timing, Apply knowledge on product specifications.

CO3 Define the concept selection and measure customer response, Provide product architecture and level design issues.

TEXT BOOK:

1. Product Design and Development, Karl T. Ulrich and Steven .D Epinger, McGraw-Hill International Edns. 4th edition 2013. ISBN-13: 978-0070658110.
2. Kevien Otto and Kristin Wood, “Product Design” Pearson Publication,3rd Edition, 2012, ISBN-13: 9780130212719.

REFERENCE BOOKS:

1. Tuart Pugh, “Tool Design – Integrated Methods for successful Product Engineering”, Addison Wesley Publishing, Neyork, 1991,ISBN: 020141639.
2. Tephen Rosenthal, Business One Orwin “Effective Product Design and Development”, Homewood, 1992,ISBN:1-55623-603-4

3. KemnnethCrow,"ConcurrentEngg. /Integrated Product Development", DRM Associates, 26/3, ViaOlivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	1	-	-
CO2	1	1	1	-	-	-	2	1	-	3	1	1	-	1
CO3	1	1	1	-	-	-	1	-	-	3	1	-	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE62	INDUSTRIAL SAFETY MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To achieve an understanding of principles of safety management.
2. To enable the students to learn about various functions and activities of safety department.
3. To enable students to conduct safety audit and write audit reports effectively in auditing situations.
4. To have knowledge about sources of information for safety promotion and training.
5. To familiarize students with evaluation of safety performance.

UNIT I SAFETY MANAGEMENT 9 + 0

Evaluation of modern safety concepts - Safety management functions - safety organization, safety department - safety committee, safety audit - performance measurements and motivation - employee participation in safety - safety and productivity.

UNIT II OPERATIONAL SAFETY 9 + 0

Hot metal Operation - Boiler, pressure vessels - heat treatment shop - gas furnace operation - electroplating-hot bending pipes - Safety in welding and cutting. Cold-metal Operation - Safety in
Machine shop - Cold bending and chamfering of pipes - metal cutting - shot blasting, grinding, painting - power press and other machines.

UNIT III SAFETY MEASURES 9 + 0

Layout design and material handling - Use of electricity - Management of toxic gases and chemicals - Industrial fires and prevention - Road safety - highway and urban safety - Safety of sewage disposal and cleaning - Control of environmental pollution - Managing emergencies in Industries - planning, security and risk assessments, on-site and off site. Control of major industrial hazards.

UNIT IV ACCIDENT PREVENTION 9 + 0

Human side of safety - personal protective equipment - Causes and cost of accidents. Accident prevention programmes - Specific hazard control strategies - HAZOP - Training and development of employees - First Aid-Fire fighting devices - Accident reporting, investigation.

UNIT V SAFETY, HEALTH, WELFARE & LAWS 9 + 0

Safety and health standards - Industrial hygiene - occupational diseases prevention - Welfare facilities - History of legislations related to Safety-pressure vessel act-Indian boiler act - The environmental protection act - Electricity act - Explosive act.

Total =45 Periods

COURSE OUTCOME:

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

CO1 To understand the functions and activities of safety engineering department.
CO2 To carry out a safety audit and prepare a report for the audit.
CO3 To prepare an accident investigation report, To estimate the accident cost using supervisors report and data.
CO4 To evaluate the safety performance of an organization from accident records.
CO5 To identify various agencies, support institutions and government organizations involved in safety training and promotion.

TEXT BOOKS :

1. Industrial safety and the law by P.M.C. Nair Publisher's, Trivandrum.
2. John V. Grimaldi and Rollin H. Simonds, "Safety Management", All India Travellers bookseller, New Delhi-1989.
3. Krishnan N.V., "Safety in Industry", Jaico Publisher House, 1996

REFERENCE BOOKS:

1. Managing emergencies in industries, Loss Prevention of India Ltd., Proceedings,1999.
2. Occupational Safety Manual BHEL.

3. Safety security and risk management by U.K. Singh & J.M. Dewan, A.P.H. Publishing company, New Delhi, 1996.
4. Singh, U.K. and Dewan, J.M., "Safety, Security and risk management", APH Publishing Company, New Delhi, 1996.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	1	1	1	2	1	-	-	1	-	1	-
CO2	1	1	1	1	1	1	-	-	-	-	1	-	-	-
CO3	1	1	1	1	3	-	1	-	-	-	1	1	-	1
CO4	1	1	1	-	3	1	-	2	-	2	1	1	-	-
CO5	1	1	1	1	2	-	1	-	-	-	1	1	-	1

1- Faintly
2- Moderately
3- Strongly

18CDE63 RELIABILITY IN ENGINEERING SYSTEMS L T P C
3 0 0 3

COURSE OBJECTIVE

The objectives of this course are:

1. The ability to use statistical tools to characterize the reliability of an item
2. The working knowledge to determine the reliability of a system and suggest approaches to enhancing system reliability;
3. The ability to select appropriate reliability validation methods

UNIT I RELIABILITY CONCEPT 9 + 0

Reliability definition – Quality and Reliability– Reliability mathematics – Reliability functions – Hazard rate – Measures of Reliability – Design life –A priori and posteriori probabilities – Mortality of a component –Bath tub curve – Useful life.

UNIT II FAILURE DATA ANALYSIS 9 + 0

Data collection –Empirical methods: Ungrouped/Grouped, Complete/Censored data – Time to failure distributions: Exponential, Weibull – Hazard plotting – Goodness of fit tests.

UNIT III RELIABILITY ASSESSMENT 9 + 0

Different configurations – Redundancy – m/n system – Complex systems: RBD – Baye's method – Cut and tie sets – Fault Tree Analysis – Standby system.

UNIT IV RELIABILITY MONITORING 9 + 0

Life testing methods: Failure terminated – Time terminated – Sequential Testing –Reliability growth monitoring – Reliability allocation – Software reliability.

UNIT V RELIABILITY IMPROVEMENT 9 + 0

Analysis of downtime – Repair time distribution – System MTTR – Maintainability prediction – Measures of maintainability – System Availability – Replacement theory.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student should be able to

CO1: Analyse the interference between strength and stress, or life data for estimating reliability;

CO2: Apply the appropriate methodologies and tools for enhancing the inherent and actual reliability of components and systems, taking into consideration cost aspects; specify life test plans for reliability validation

TEXT BOOKS :

1. Charles E. Ebeling, "An introduction to Reliability and Maintainability engineering", TMH, 2000.

REFERENCE BOOKS:

1. Roy Billington and Ronald N. Allan, "Reliability Evaluation of Engineering Systems", Springer, 2007.

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	1	2	-	2	-	1	1	-	-
CO2	1	1	1	1	1	-	-	-	2	1	1	1	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE64 **NEURAL NETWORKS AND FUZZY LOGIC** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This purpose of this course is to provide the students with the following capabilities

1. Design of Experiments in neural network
2. To purpose of recurrent networks and fuzzy logic relations

UNIT II INTRODUCTION TO NEURAL NETWORKS 9 + 0

Artificial Neural Networks, Basic properties of Neurons, Neuron Models, Learning Paradigmand Rule, single unit mapping and the perception. Feed forward networks – Perceptions, widrow-Hoff LMS algorithm; Multilayer networks – Exact and approximate representation, back propagation algorithm, variants of Back propagation.

UNIT II RECURRENT NETWORKS 9 + 0

Unsupervised and Reinforcement learning; Symmetric Hopfield networks and Associative memory; Competitive learning and self-organizing networks, Boltzmann machine, Adaptive Resonance Networks PCA, SOM, LVQ, Hopfield Networks, Associative Memories, RBF Networks, Applications of Artificial Neural Networks to Function Approximation, Regression, Classification, Blind Source Separation, Time Series and Forecasting, Hybrid Learning; Computational complexity of ANNs.

UNIT III CLASSICAL AND FUZZY SETS 9 + 0

Overview of Classical Sets, Membership Function, a-cuts, Properties of a-cuts, Decomposition Theorems, Extension Principle. Operations on Fuzzy Sets: Compliment, Intersections, Unions, Combinations of Operations, Aggregation Operations.

UNIT IV FUZZY ARITHMETIC AND RELATIONS 9 + 0

Fuzzy Numbers, Linguistic Variables, Arithmetic Operations on intervals & Numbers, Lattice of Fuzzy Numbers, Fuzzy Equations, Crisp & Fuzzy Relations, Projections &Cylindric Extensions, Binary Fuzzy Relations, Binary Relations on single set, Equivalence, Compatibility & Ordering Relations, Morphisms, Fuzzy Relation Equations, Possibility Theory - Fuzzy Measures, Evidence & Possibility Theory, Possibility versus Probability Theory.

UNIT V FUZZY LOGIC 9 + 0

Classical Logic, Multivalued Logics, Fuzzy Propositions, Fuzzy Qualifiers, Linguistic Hedges. Uncertainty based Information: Information & Uncertainty, Non specificity of Fuzzy &Crispsets, Fuzziness of Fuzzy Sets.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course, the student should be able to

CO1 Understand and explain about neural networks.
CO2 Discuss artificial Intelligence methods, algorithms and results.
CO3 Classify the classical and fuzzy sets.
CO4 Solve the issues involved in simulations.
CO5 Apply the fuzzy logic concept in the analysis and evaluation of complicated systems.

TEXT BOOKS :

1. GunjanGoswami., “An Introduction to Neural Networks”, S.K. Kataria& Sons, 2012.
2. Bose and Liang, Artificial Neural Networks, Tata Mcgraw Hill, 1996.

REFERENCE BOOKS:

1. Kosco B, Neural Networks and Fuzzy Systems: A Dynamic Approach to Machine Intelligence, Prentice Hall of India, New Delhi, 1992.
2. Timothy J. Ross, “Fuzzy Logic: With Engineering Applications”, Wiley, 2nd Ed, July 2007.
3. Klir G.J and Folger T.A, Fuzzy sets, Uncertainty and Information, Prentice Hall of India, New Delhi 1994.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	2	2	1	1	-	-	-	1	1	1	1	1	-	-
CO2	1	1	1	1	-	-	-	1	1	-	1	-	-	-
CO3	1	3	2	1	1	-	-	1	1	1	1	-	-	1
CO4	1	1	1	2	1	1	1	-	-	1	1	-	-	-
CO5	1	1	1	1	3	-	-	1	1	-	1	-	-	-

1- Faintly
2- Moderately
3- Strongly

18CDE65 **ERGONOMICS IN MANUFACTURING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVE:

1. To process of manufacturing Technology or equivalent
2. To develop the work space design and enviroments
3. To understand the types and manufacturing methods

UNIT I INTRODUCTION: **5 + 0**

Interdisciplinary nature of ergonomics, modern ergonomics.

UNIT II HUMAN PERFORMANCE **10 + 0**

Information input and processing, factors affecting human performance, physical work load andenergy expenditure, heat stress, manual lifting.

UNIT III WORK SPACE DESIGN **10 + 0**

Anthropometry, Work-space design for standing and seated workers, arrangement of components within a physical space, interpersonal aspect of workplace design.

UNIT IV DESIGN OF EQUIPMENT **10 + 0**

Ergonomic factors to be considered, design of displays and controls, design for maintainability.

UNIT V DESIGN OF ENVIRONMENT **10 + 0**

Illumination – Climate – Noise – Motion.

Total =45 Periods

COURSE OUTCOMES:

At the end of the course the students will be in position to

CO1 Recognize the need, requirements and applications of ergonomics in design
CO2 Summarize the requirements and applications of ergonomics and design
CO3 Illustrate the importance of work space design
CO4 Contrast influence of human performance over ergonomics
CO5 Identify methodology for best job production.

TEXT BOOK:

1. Martin Helander, “A Guide to Ergonomics of Manufacturing”, CRC Press, 2 edition, December 2005.
2. Bridger, R.S., “Introduction to Ergonomics, CRC Press, 3 edition, August 2008.

REFERENCE BOOKS:

1. McCormick, J., “Human Factors in Engineering and Design”, McGraw-Hill, 7 edition, January 1993.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	-	-	1	2	-	2	-	1	1	-	1
CO2	1	1	1	1	1	-	-	-	2	1	1	1	-	-
CO3	1	3	1	1	1	1	-	-	-	-	1	-	1	-
CO4	1	2	1	1	1	-	1	-	-	1	1	2	1	-
CO5	1	1	2	1	1	-	1	-	-	2	1	2	1	-

1- Faintly
2- Moderately
3- Strongly

AUDIT COURSE 1 & 2 (18AC01 TO 18AC02)

18AC01	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	-	-	0

COURSE OBJECTIVES: Students will be able to:

1. Understand that how to improve your writing skills and level of readability
2. Learn about what to write in each section
3. Understand the skills needed when writing a Title.
4. Ensure the good quality of paper at very first-time submission

UNIT I **4 + 0**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II **4 + 0**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

UNIT III **4 + 0**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV **4 + 0**

key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT V **4 + 0**

skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT VI **4 + 0**

useful phrases, how to ensure the paper is as good as it could possibly be the first- time submission

Total= 24 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Practice the unique qualities of a professional writing style
CO2 : Recognize, explain, and use the verbal strategies and the formal elements
CO3 : Collect, analyze, document, and report research clearly, concisely, logically, and ethically
CO4 : Participate actively in writing activities that model effective scientific and technical papers.

TEXT BOOKS

1. Adrian Wallwork (2011) English for Writing Research Papers, Springer New York Dordrecht Heidelberg London.
2. Goldbort R (2006) Writing for Science, Yale University Press

REFERENCE BOOKS:

1. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
2. Highman N (1998) Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.
3. McMurrey,David A. and Joanne Buckley (2008) Handbook for Technical Writing, New Delhi: Cengage Learning, 2008

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	1	1	-
CO2	1	1	1	-	-	-	2	1	-	3	1	-	1	-
CO3	1	1	1	-	-	-	1	-	-	3	1	2	2	-
CO4	1	2	1	1	1	-	1	-	-	1	1	-	-	-

1- Faintly
2- Moderately
3- Strongly

18AC02	DISASTER MANAGEMENT	L	T	P	C
		2	-	-	0

COURSE OBJECTIVES: Students will be able to:

1. Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
4. Critically understand the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 4 + 0

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 4 + 0

Economic Damage, Loss of Human And Animal Life, Destruction of Ecosystem. Natural Disasters: Earthquakes, Volcanism, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 4 + 0

Study of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 4 + 0

Preparedness: Monitoring of Phenomena Triggering A Disaster or Hazard; Evaluation of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

UNIT V RISK ASSESSMENT 4 + 0

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

UNIT VI DISASTER MITIGATION 4 + 0

Meaning, Concept And Strategies of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs of Disaster Mitigation In India.

Total= 24 Periods

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 : Develop an understanding of the key concepts and the significance of disaster management
CO2 : Understand the occurrences, reasons and mechanism for various types of disaster.
CO3 : Have a basic understanding of the Disaster Preparedness and Management
CO4 : Develop a basic under the understanding of Risk assessment, Prevention, Mitigation, Response and Recovery.

TEXT BOOKS:

1. R. Nishith, Singh AK 2012 Disaster Management in India:Perspectives, issues and strategies New Royal Book Company, Lucknow
2. Sahni, PardeepEt.Al. (Eds.) 2002 Disaster Mitigation Experiences And Reflections. Prentice Hall Of India, New Delhi.

REFERENCE BOOKS:

1. Goel S. L. 2007 Disaster Administration And Management Text And Case Studies Deep &Deep Publication Pvt. Ltd., New Delhi.
2. Mishra A 2012 New Dimensions of Disaster Management in India: Perspectives Approaches and Strategies (Set of 2 Vols) Serials publications, New Delhi.
3. Sharma, Kadambari C, Avina 2010 Disaster Management in India JnanadaPrakashan [P&D], New Delhi.

CO-PO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	1	1	1	1	-	-	1	-	-	2	1	1	1	-
CO2	1	1	1	-	-	-	2	1	-	1	1	-	1	-
CO3	1	1	1	-	-	-	1	-	-	1	1	-	-	1
CO4	1	1	1	1	1	-	1	-	-	1	1	-	-	-

1- Faintly
2- Moderately
3- Strongly