Visvesvaraya Technological University, Belagavi Tentative Scheme of Teaching and Evaluation PG Programmes (w. e. f. Academic year 2018-19) (Computer Aided Engineering)

31-07-2018

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
Scheme of Teaching and Examination – 2018 - 19
M.Techin Computer Aided Engineering (CAE)
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				
						Durationinhours	Marks	Marks	Total Marks	Credits
1	PCC	18CAE11	Applied Mathematics	04	--	03	40	60	100	4
2	PCC	18MDE12	Advanced Theory of Vibrations	04	--	03	40	60	100	4
3	PCC	18CAE13	CIM & Robotics for Automation	04	--	03	40	60	100	4
4	PCC	18CAE14	Advanced Fluid Dynamics	04	--	03	40	60	100	4
5	PEC	18CAE15	Composite Materials Technology	04	--	03	40	60	100	4
6	PCC	18CAEL16	Computer Aided Engineering Laboratory-I	-	04	03	40	60	100	2
7	PCC	18RMI17	Research Methodology and IPR	02	--	03	40	60	100	2
			TOTAL	**22**	**04**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
									Total Marks	
1	PCC	18MEA21	Finite Element Methods	04	--	03	40	60	100	4
2	PCC	18MDE22	Advanced Machine Design	04	--	03	40	60	100	4
3	PCC	18CAE23	Computer Graphics	04	--	03	40	60	100	4
4	PEC	18XXX24X	Professional elective 1	04	--	03	40	60	100	4
5	PEC	18XXX25X	Professional elective 2	04	--	03	40	60	100	4
6	PCC	18CAEL26	Computer Aided Engineering Laboratory-II	--	04	03	40	60	100	2
7	PCC	18CAE27	Technical Seminar	--	02	--	100	--	100	2
		TOTAL		**20**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		Professional Elective 2	
Course Code under 18XXX24X	**Course title**	**Course Code under 18XXX25X**	**Course title**
18CAE241	Vehicle Crash and Occupant Safety	18CAE251	Design Optimization
18CAE242	Design for Manufacture and Assembly	18MEA252	Automobile System Design
18CAE243	Continuum Mechanics	18MEA253	Computational Fluid Dynamics

Note:

1. Technical Seminar:CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.

The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as failed and have to complete during the subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
									TotalMarks	
1	PCC	18CAE31	Advanced Manufacturing Process Simulation	04	--	03	40	60	100	4
2	PEC	18XXX32X	Professional elective3	04	--	03	40	60	100	4
3	PEC	18XXX33X	Professional elective 4	04	--	03	40	60	100	4
4	Project	18CAE34	Evaluation of Project phase -1	--	02	--	100	--	100	2
5	Intenship	18CAEI35	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)		03	40	60	100	6
TOTAL				12	02	12	**260**	**240**	**500**	**20**

Note: **PCC: Professional core, PEC: Professional Elective.**

Professional elective 3		Professional elective 4	
Course Code under 18XXX32X	**Course title**	**Course Code under 18XXX32X**	**Course title**
18CAE321	Experimental Mechanics	18CAE331	Smart Materials and Structures
18MDE322	Mechatronics System Design	18CAE332	Finite Element Methods for Heat Transfer and Fluid Flow
18MEA323	Robust Design	18MDE333	Acoustics and Noise Control Engineering

Note:

1. Project Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as failed and have to complete during subsequent University examinations after satisfying the internship requirements.

Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Duration in hours	Examination		Total Marks	Credits
1	Project	18CAE41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	**--**	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

I SEMESTER

APPLIED MATHEMATICS

(Common to CAE/MST)

Course Code	**18CAE11**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives

The main objectives of the course are to enhance the knowledge of various methods in finding the roots of an algebraic, transcendental or simultaneous system of equations and also to evaluate integrals numerically and differentiation of complex functions with a greater accuracy. These concepts occur frequently in their subjects like finite element method and other design application oriented subjects.

Course Content

Module 1:

Approximations and round off errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving: Simple mathematical model, Conservation Laws of Engineering.

06 Hours

Module 2:

Roots of Equations: Bracketing methods-Graphical method, Bisection method, False position method, Newton- Raphson method, Secant Method. Multiple roots, Simple fixed point iteration. Roots of polynomial-Polynomials in Engineering and Science, Muller’s method, Bairstow’s Method Graeffe’s Roots Squaring Method.

12 Hours

Module 3:

Numerical Differentiation and Numerical Integration: Newton –Cotes and Guass Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae.

06 Hours

Module 4:

System of Linear Algebraic Equations And Eigen Value Problems: Introduction, Direct methods, Cramer’s Rule, Gauss Elimination Method, Gauss-Jordan Elimination Method, Triangularization method, Cholesky Method, Partition method, error Analysis for direct methods, Iteration Methods. Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Householder’s method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method.

14 Hours

Module 5:

Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-schmidt process, Least Square problems, Inner product spaces. **12 Hours**

Text Books:

1. S.S.Sastry, Introductory Methods of Numerical Analysis, PHI, 2005.
2. Steven C. Chapra, Raymond P.Canale, Numerical Methods for Engineers, Tata Mcgraw Hill, 4th Ed, 2002.
3. M K Jain, S.R.K Iyengar, R K. Jain, Numerical methods for Scientific and engg computation, New Age International, 2003.

Reference Books:

1. Pervez Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, 2010.
2. David. C. Lay, Linear Algebra and its applications, 3rd edition, Pearson Education, 2002.

Course Outcome

The Student will be able to

1. Model some simple mathematical models of physical Applications.
2. Find the roots of polynomials in Science and Engineering problems.
3. Differentiate and integrate a function for a given set of tabulated data, for Engineering Applications

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

ADVANCED THEORY OF VIBRATIONS

(Common toMDE, MEA, MMD, CAE)

Course Code	**18MDE12**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To understand the theoreticalprinciplesof vibration,andvibrationanalysistechniquesfor thepracticalsolutionof vibration problems.
To understand theimportanceofvibrations in design ofmachineparts subject to vibrations. To understand the concepts of Transient and Non-linear vibrations.
To understand concepts of vibration measurements and its applications. To understand the principles of Transient and Non linear vibrations.

Course Content:

Module 1:ReviewofMechanicalVibrations:Basicconcepts;freevibrationofsingledegreeoffreedomsystemswith andwithoutdamping,forced vibration ofsingleDOF-systems, Natural frequency. VibrationControl:Introduction,Vibrationisolationtheory,Vibrationisolationandmotionisolationforharmonicexcitation,practical aspects ofvibration analysis, vibration isolation, Dynamicvibration absorbers, and Vibration dampers. **12 Hours**

Module 2: VibrationMeasurementandapplications: Introduction,Transducers,Vibrationpickups,Frequencymeasuringinstruments,Vibration exciters, Signal analysis.
Modal analysis &Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Conditionmonitoring anddiagnosis. **10 Hours**

Module 3:TransientVibrationofsingleDegree-offreedomsystems:Impulseexcitation,arbitraryexcitation,Laplacetransformformulation,Pulse excitation and risetime, Shock responsespectrum, Shock isolation.
RandomVibrations:Randomphenomena,Timeaveragingandexpectedvalue,Frequencyresponsefunction ,Probabilitydistribution, Correlation, Powerspectrum and powerspectral density,Fouriertransforms and response. **10 Hours**

Module 4:NonLinearVibrations:Introduction,Sourcesofnonlinearity,Qualitativeanalysisofnonlinear systems.Phaseplane,Conservativesystems,Stabilityofequilibrium,Methodofisoclines,Perturbationmethod,Methodofiteration, Self-excited oscillations. **10 Hours**

Module 5: Continuous Systems: Vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. **8 Hours**

CourseOutcomes:

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

ApplyNewtons equation of motion and energy methods to model basic vibrating mechanical system, model undamped and damped mechanical systems and structures for free and harmonically forced vibrations.

Model single-and multi-degree of freedom for free and forced vibrations and determine response to vibration, natural frequencies and modes of vibration.

Apply the fundamentals of vibration to its measurement and analysis.

Solverealisticvibrationproblems in mechanicalengineeringdesign that involves application ofmost ofthe coursesyllabus.

TextBooks

1. S. S. Rao, "MechanicalVibrations", Pearson Edu cati on, 4th edition.
2. S. Graham Kelly,"Fundamentals ofMechanicalVibr atio n"-McGraw-Hill, 2000
3. Theoryof Vibration with Application, -William T. Thomson, Marie Dillon Dahleh, ChandramouliPadmanabhan, 5th edition PearsonEducation.

ReferenceBooks

1. S. Graham Kelly,"Mechanical Vibrations", Schau m'sO utlines, TataMcGraw Hill, 2007.
2. C Sujatha,"Vibrationsand Acoustics – Measureme nts and signalanalysis", Tata McGraw Hill, 2010.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

CIM & ROBOTICS for AUTOMATION

Course Code	**18CAE13**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives

1. To impart the basic concepts in manufacturing systems and fundamentals of NC & CNC system
2. Knowledge enhancement in design consideration and increasing productivity with NC machine tools, machining centers and tooling for CNC machines
3. Understanding the robotic system, available tools and technique for kinematics and its applications to industry

Course Content

Module 1:

Introduction to Computer integrated Manufacturing Systems: Manufacturing Systems, Types of Manufacturing Systems, , Machine Tools and related equipment's, Material Handling Systems, Computer monitoring and control, Manufacturing support systems, The Product Cycle and CAD/ CAM, Functions of computers in CIMS: CIMS Data Files, System Reports, Benefits of Computer integrated Manufacturing Systems, NC/ CNC Machine Tools: General architecture of CNC Machine, Components of the CNC Systems: Machine Control Unit , CNC Driving system components: Hydraulic, Servo Motors, Stepper Motors, Feedback Devices: Encoder, Resolver, Inductors, Tachometers, Counting devices, Digital to analog converters.

10 Hours

Module 2:

part programming: Introduction, NC/ CNC programming methods: Manual part programming for turning and milling centers, G codes, M codes, canned cycles, Programming with CAD/CAM integration, CAM packages for CNC part program generation, Practical Exercises on CNC part programming. Computer Controls in NC: CNC Technology: Functions of CNC Control in Machine Tools, Advantages of CNC, Direct Numerical Control (DNC Systems): Configuration of DNC system, Functions of DNC, Communication between DNC computer & MCU, Advantages of DNC, Adaptive control machining systems. Adaptive control optimization system, adaptive control constraint system, applications to machining processes, Benefits of Adaptive control machining.

10 Hours

Module 3:

Introduction to Robotics: Automation and Robotics, Historical Development, Definitions, Basic Structure of Robots, Robot Anatomy, Complete Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, Types of Drive Systems and their Relative Merits, the Wrist & Gripper Subassemblies. Concepts and Model about Basic Control System, Transformation and Block Diagram of Spring Mass System, Control Loops of Robotic Systems, PTP and CP Trajectory Planning, Different Types of Controllers, Control Approaches of Robots.

10 Hours

Module 4:

Kinematics of Robot Manipulator: Introduction, General Description of Robot Manipulator, Mathematical Preliminaries on Vectors & Matrices, Homogenous Representation of Objects, Robotic Manipulator Joint Co-Ordinate System, Euler Angle & Euler Transformations, Roll-Pitch-Yaw(RPY) Transformation, Relative Transformation, Direct & Inverse Kinematics' Solution, D H Representation & Displacement Matrices for Standard Configurations, Geometrical Approach to Inverse Kinematics. Homogeneous Robotic Differential Transformation: Introduction, Jacobian Transformation in Robotic Manipulation. **10 Hours**

Module 5:

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

Industrial Applications: Automation in Manufacturing, Robot Application in Industry, Task Programming, Goals of AI Research, AI Techniques, Robot Intelligence and Task Planning, Modern Robots, Future Application and Challenges and Case Studies. **10 Hours**

Text Books:

1. GROOVER M P, Automation, Production Systems and Computer Integrated Manufacturing - , Prentice Hall India (P) Ltd, 1989.
2. Mikell P. Groover and Emory W. Zimmer, Jr., CAD/CAM Computer Aided Design and Manufacturing, Prentice Hall India (P) Ltd, 1992.
3. M.Koren ―Computer Controls of Manufacturing Systems, McGrawHill, 1983
4. "A Robot Engineering Textbook "– Mohsen Shahinpoor – Harper & Row publishers, New York, 1987.
5. "Robotics, control vision and intelligence," Fu, Le e and Gonzalez. McGraw Hill International,1987.
6. "Introduction to Robotics:Mechanics and Control", J ohn J. Craig, Pearson, 3e, 2009.
7. Reference Books:
8. Martin J. ―Numerical control of machine tools".
9. P.N. Rao – CAD/CAM Principles and ApplicationsMcGra whill 2002

10. Y. Koren&J.Benuri -"Numerical control of machine to ols-Khanna, 1992
11. Wilson F.M —Numerical control in manufacturing- McGraw Hill Newyork
12. Suk-Hwan Suh, Seong-Kyoon Kang, Dea-Hyuk Chung and Ian Stroud, Theory and Design of CNC Systems, , Springer, 2008.
13. "Robotics for Engineers", YoramKoren, McGraw Hill I nternational, 1985.
14. "Industrial Robotics",Groover, Weiss, Nagel, McGraw Hill International, 1986.
15. "Robot Technology Fundaments"- Keramas, Thomson Vik as Publication House, 1999.

Course Outcome

Students will get clear understanding of

1. CIM, NC/CNC machines, various elements of CNC machines and its uses
2. Constructional features of CNC machine Tools
3. Robots & its industrial applications.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

ADVANCED FLUID DYNAMICS

Course Code	18CAE14	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives

The student will gain knowledge of dynamics of fluid flow under different conditions.

Module 1:

Review of undergraduate Fluid Mechanics : Differential Flow analysis- Continuity equation (3D Cartesian, Cylindrical and spherical coordinates) Navier Stokes equations (3D- Cartesian, coordinates) Elementary inviscid flows; superposition (2D).

10 Hours

Module 2:

Integral Flow Analysis: Reynolds transport theorem, Continuity, momentum, moment of momentum, energy equations with applications such as turbo machines, jet propulsion &propellors; Exact solution of viscous flow equations: Steady flow: Hagen Poiseuille problem, plane Poiseuille problem, Unsteady flow: Impulsively started plate.

10 Hours

Module 3:

Low Reynolds number flows: Lubrication theory (Reynolds equation), flow past rigid sphere, flow past cylinder. Boundary Layer Theory:Definitions, Blasius solution, Von-Karman integral, Separation.

10 Hours

Module 4:

Thermal Boundary layer and heat transfer, (Laminar & turbulent flows); **Experiments in fluids:** Wind tunnel, Pressure Probes, Anemometers and flow meters.

10 Hours

Module 5:

Special Topics: Stability theory; Natural and forced convection; Rayleigh Benard problem; Transition to turbulence; Introduction to turbulent flows.

10 Hours

Text Books:

1. “Foundations of fluid mechanics” - S. W. Yuan,SI Un it edition, 1988.
2. “Advanced Engineering Fluid Mechanics”- K. Muralidh ar& G. Biswas, Narosa Publishers, 1999.

Reference Books:

1. “Physical Fluid Dynamics” 2nd edition – D.J. Tritto n, Oxford Science Publications, 1988.
2. “Boundary Layer Theory”8th edition, H. Schlichting , McGraw Hill, New York., 1999.

Course Outcome

The student will be able to apply concepts of fluid dynamics in solving real time problems.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

COMPOSITE MATERIALS TECHNOLOGY

Course Code	**18CAE15**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course LearningObjectives:

To impart a basic understanding of micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.

To uunderstand the principles, matrix and reinforcement material options, advantages and disadvantages of different manufacturing techniques of composites.

To comprehend recent developments in composites, including metal, ceramic and polymer matrix composites.

To know the use of composites in engineering applications.

Course Content:

Module 1: Introduction to Composite Materials:Definition, Classification, Types of matrices material and reinforcements, Characteristics &selection, Fiber composites, laminated composites, Particulate composites, Prepegs, and sandwich construction.
Metal Matrix Composites: Reinforcement materials, Types, Characteristics and selection, Base metals, Selection, Applications. Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants fororthotropic material, Two - dimensional relationship of compliance and stiffness matrix. Hooke's law fortwo-dimensional angle lamina, engineering constants - Numerical problems. Invariant properties. Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

10 Hours

Module 2: Micro Mechanical Analysis of aLamina: Introduction, Evaluation of the four elastic moduli, Rule of mixture, Numerical problems.Experimental Characterization of Lamina- Elastic Moduli and Strengths. Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsa-Hill theory, Tsai, Wu tensortheory, Numerical problem, practical recommendations.

10 Hours

Module 3: Macro Mechanical Analysis of Laminate: Introduction, code, Kirchhoff hypothesis, Classical Lamination Theory, A, B, and D matrices (Detailed derivation), Special cases of laminates, Numerical problems. Shear Deformation Theory, A, B, D and E matrices (Detailed derivation)

10 Hours

Module 4: Analysis of Composite Structures: Optimization of Laminates, composite laminates of uniform strength, application of optimal compositestructures, composite pressure vessels, spinning compositedisks, composite lattice structures.
Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.

10 Hours

Module 5: Manufacturing and Testing: Layup and curing - open and closed mould processing,Hand lay-up techniques, Bag moulding and filamentwinding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair.
NDT tests – Purpose, Types of defects, NDT method - Ultrasonicinspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

10 Hours

CourseOutcomes:

At the end of the course, students should be able to:

Understand the use of fibre -reinforced composites in structural applications.

Develop a basic understanding of the use of composite materials, micro-mechanics of layered composites, analysis and design of composite structures and failure analysis of laminated panels.

Apply the basic micro-mechanics theories in the design of fibre reinforced composites.

Analyze the performance of composites in engineering applications.

Text Books:

1. Autar K. Kaw, Mechanics of Composite materials, CRC Press, 2nd Ed, 2005.
2. Madhijit Mukhopadhay, Mechanics of Composite Material s & Structures, Universities Press, 2004.

Reference Books:

1. J. N. Reddy, Mechanics of Laminated Composite Plates & Shells, CRD Press, 2nd Ed, 2004.
2. Mein Schwartz, Composite Materials handbook, McGraw Hill, 1984.
3. Rober M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1998.
4. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009.
5. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012.
6. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993.
7. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

COMPUTER AIDED ENGINEERING LABORATORY –I

Course Code	**18CAEL16**	**CIE Marks**	**40**
Number of Practical Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Note:
These are independent laboratory exercises.

Student must submit a comprehensive report on the problems solved and give a presentation on the same for Internal Evaluation.

Any one of the experiments done from the following list has to be set in the examination for conduction and evaluation.

Experiment #1Experimental and Numerical Analysis of Tensile Test

Part A: Experimental study of Tensile Test
Part B: Numerical Analysis of Tensile Test.

Experiment #2 Experimental and Numerical Analysis of Flexural Test

Part A: Experimental study of Flexural Test
Part B: Numerical Analysis of Flexural Test

Experiment #3 Numerically Calculation and MATLAB Simulation

Part A: Invariants, Principal stresses and strains with directions
Part B: Maximum shear stresses and strains and planes, Von-Mises stress
Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #4Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. Shear

Part A: Mat lab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate
Part B: Modeling of plate geometry under chosen load conditions and study the effect of plate geometry. Part C: Numerical Analysis using FEA package.

Experiment #5Single edge notched beam in four point bending.

Part A: Modeling of single edge notched beam in four point bending.
Part B: Numerical Studies using FEA.
Part C: Correlation Studies.

Experimental #6Torsion of Prismatic bar with Rectangular cross-section.

Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry. Part C: Correlation studies.

Experiment #7 Contact Stress Analysis of Circular Disc under diametrical compression

Part A: 3-D Modeling of Circular Discs with valid literature background, supported with experimental results on contact stress.
Part B: Numerical Analysis using any FEA package.
Part C: 2D Photo Elastic Investigation.

Experiment #8 Vibration Characteristics of a Spring Mass Damper System.

Part A: Analytical Solutions.
Part B: MATLAB Simulation. Part C: Correlation Studies.

II SEMESTER

FINITE ELEMENT METHOD
(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA21**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

- To present the Finite element method (FEM) as a numerical method for engineering analysis of continua and structures.
- To present Finite element formulation using variational and weighted residual approaches
- To present Finite elements for the analysis of bars & trusses, beams & frames, plane stress& plane strain problems and 3-D solids, for thermal and dynamics problems.
- Learn to model complex geometry problems and technique of solutions.

Course Content:

Module 1: Introduction to finite element method: basic steps in finite element method to solve mechanical engineering problems (solid, fluid and heat transfer). Functional approach and Galerkin approach. Displacement approach: admissible functions. Convergence criteria: conforming and nonconforming elements, C0, C1 and Cn continuity elements. Basic equations, element characteristic equations, assembly procedure, boundary and constraint conditions. **10 Hours**

Module 2: Solid Mechanics: One-dimensional finite element formulations and analysis – bars-uniform, varying and stepped cross section. Basic (Linear) and higher order elements formulations for axial, torsional and temperature loads with problems.
Beams- basic (linear) element formulation-for uniform, varying and stepped cross section- for different loading and boundary conditions, numericals.
Trusses, Plane frames and Space frame – basic (Line ar) elements formulations for different boundary conditions -axial, bending, torsional, and temperature loads, numericals. **10 Hours**

Module 3: Two dimensional finite element formulations for solid mechanics problems: triangular membrane (tria 3, tria 6, tria 10) element, fournoded quadrilateral membrane (quad 4, quad 8) element formulations for in-plane loading with simple problems.
Triangular and quadrilateral axi-symmetric basic and higher order elements formulation for axi-symmetric loading with simple numericals.
Three dimensional finite element formulations for solid mechanics problems: finite element formulation of tetrahedral element (tet 4, tet 10), hexahedral element (hexa 8, hexa 20), for different loading conditions. Serendipity and Lagrange family elements. **10 Hours**

Module 4: Finite element formulations for structural mechanics problems: Basics of plates and shell theories: classical thin plate theory, shear deformation theory and thick plate theory. Finite element formulations for triangular and quadrilateral plate elements.
Finite element formulation of flat, curved, cylindrical and conical shell elements. **10 Hours**

Module 5: Dynamic analysis: finite element formulation for point/lumped mass and distributed masses system, finite element formulation of one dimensional dynamic analysis: bar, truss, frame and beam element. Finite element formulation of two dimensional dynamic analysis: triangular membrane and axi-symmetric element, quadrilateral membrane and axi-symmetric element. Evaluation of eigen values and eigen vectors applicable to bars, shaft, beams, plane and space frame. **10 Hours**

Course Outcomes:
At the end of this course, students should be able to:

Understand the concepts of Variational methods and Weighted residual methods.

Identify the application and characteristics of FEA elements such as bars, beams,

plane and isoparametric elements, and 3D element.
Develop element characteristic equations and generate global stiffness equations.

Apply suitable boundary conditions to a global structural equation, and

reduce it to a solvable form.
Identify how the finite element method expands beyond the

structural domain, for problems involving dynamics and heat transfer.

Text Books:

1. T. R. Chandrupatla and A. D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 3rd Ed, 2002.
2. Lakshminarayana H. V., Finite Elements Analysis– Pr ocedures in Engineering, Universities Press, 2004.

Reference Books:

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

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

ADVANCED MACHINE DESIGN

(Common toMDE, MEA, MMD, CAE)

Course Code	18MDE22	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives:

To identify failure modes and evolve design by analysis methodology.

To understand the theories of failure relating to different ductile and brittle materials.

To understand the concept of fatigue testing of materials including criteria for fatigue design and different fatigue life models.

To understand the concepts of the stress life behavior, strain life behavior and factors influencing stress life behavior and strain life behavior.

To understand the concept of crack nucleation, crack growth and fracture of materials using fundamentals of linear elastic fracture mechanics.

To gain the knowledge of various cumulative damage theories and different cycle counting methods relating to fatigue from variable amplitude loading.

To understand the different surface failure mechanisms with stress distribution of various contact surfaces.

To learn fundamental approaches to failure prevention for static and repeated loading.

Course Content:

Module 1: Introduction: Roleoffailurepreventionanalysisinmechanicaldesign,Modesofmechanicalfailure,Reviewoffailuretheoriesfor ductile and brittlematerials includingMohr's theoryand modified Mohr'stheory.Numerical examples.
FatigueofMaterials:Introductory concepts,Highcycleandlowcyclefatigue,Fatiguedesignmodels,Fatiguedesignmethods,Fatigue designcriteria,Fatiguetesting,Testmethodsandstandardtestspecimens,Fatigue fracture surfacesandmacroscopic features,Fatiguemechanisms and microscopic features.

10 Hours

Module 2: Stress-Life(S-N)Approach:S-Ncurves,Statisticalnatureoffatiguetestdata,GeneralS-Nbehavior,Meanstresseffects,Different factorsinfluencing S-N behaviour,S-Ncurve representationandapproximations,Constantlifediagrams,Fatiguelifeestimationusing S- N approach.
Strain-Life(ε-N)approach:Monotonic stress-strainbehavior ,Straincontrolledtestmethods,Cyclicstress-strainbehavior,Strainbased approachtolife estimation,Determinationofstrainlife fatigue properties,Meanstresseffects,Effectofsurface finish,Life estimationby ε-N approach.

10 Hours

Module 3:LEFMApproach:LEFMconcepts,Cracktipplasticzone,Fracturetoughness,Fatiguecrackgrowth,Mea

nstresseffects,Crackgrowth lifeestimation.
Notchesandtheireffects:Concentrationsandgradientsinstressandstrain,S-Napproachfornotchedmembranes,mean StresseffectsandHaighdiagrams,Numerical examples.
10 Hours

Module 4:
FatiguefromVariableAmplitudeLoading: Spectrumloadsandcumulativedamage,Damagequantificationandtheconceptsofdamage fractionandaccumulation,Cumulativedamagetheories,Loadinteractionandsequence effects,Cyclecounting methods,Lifeestimation usingstress lifeapproach. Numerical examples.
Notchstrainanalysis: Strain–lifeapproach,Neuber'srule,Glinka'srule,app l icationsof fracturemechanics to crack growth at notches. Numerical examples.

10 Hours

Module 5:SurfaceFailure: Introduction,Surfacegeometry,Matingsurface,Friction,Adhesivewear,Abrasivewear ,Corrosionwear.

Surface fatigue: spherical contact, Cylindrical contact, General contact, Dynamiccontact stresses, Surfacefatiguestrength, Surface fatigue failure modes, Design to avoid Surface failures.

10 Hours

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

Apply stateofthe art design methodologynamelydesign byanalysisand damagetolerant design to mechanical components.
Distinguish different design criteria and their procedure to carry out the design of mechanical components.

Design machine components which are subjected to fluctuating loads.

Design machine components using techniques like stress life approach, Strain life approach and Fracture mechanics approach.

Define the various statistical aspects of fatigue using different probability distribution plots.

Explain the contact stresses and implementation of Hertz contact phenomenon to the real field problem.

Explain surface failure mechanisms.

TextBooks:

1. RalphI. Stephens,Ali Fatemi, Robert, Henryo. Fuchs, "MetalFatiguein engineering", John wileyNewyork, Second edition. 20 01.
2. FailureofMaterials in Mechanical Design, Jack.A. Collins,John Wiley,Newyork 1992.
3. RobertL.Norton ,"Machine Design", Pearson Educ atio nIndia, 2000.

ReferenceBooks:

1. S.Suresh ,"FatigueofMaterials", Cambridge Uni versi tyPress, -1998
2. Julie.A.Benantine,"Fundamentals ofMetalFatigue Anal ysis", PrenticeHall,1990
3. Fatigue andFracture, ASM Hand Book, Vol 19,2002.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

COMPUTER GRAPHICS

Course Code	18CAE23	CIE Marks	40
Number of Lecture Hours/Week	04	SEE Marks	60
Total Number of Lecture Hours	50(10 Hours per Module)	Exam Hours	03

Course Learning Objectives

This course will help the student to be knowledgeable of concepts, principles, processes and techniques essential to all areas of computer graphics

Course Content

Module 1:

Transformations : Representation of points, Transformations: Rotation, Reflection, Scaling, Shearing, Combined Transformations, Translations and Homogeneous Coordinates, A geometric interpretation of homogeneous coordinates, Over all scaling, Points at infinity, Rotation about an arbitrary point, Reflection through an arbitrary line, Rotation about an axis parallel to coordinate axis, Rotation about an arbitrary axis in space, Reflection through an arbitrary plane.

10 Hours

Module 2:

Types and Mathematical Representation of Curves: Curve representation, Explicit, Implicit and parametric representation. Nonparametric and parametric representation of Lines, Circles, Ellipse, Parabola, Hyperbola, Conics. Parametric representation of synthetic curve, Hermite cubic splines, , Bezier curves: Blending function, Properties, generation, B-spline curves- Cox-deBoor recursive formula, Properties, Open uniform basis functions, Non-uniform basis functions, Periodic B-spline curve.

Types and Mathematical Representation of Surfaces Surface entities and parametric representation- Plane, Ruled, surface of revolution, Offset surface, Coons patch, Bezier surface, B-spline surface. **10 Hours**

Module 3:

Types and Mathematical Representation Solids: Solid entities: Block, Cylinder, Cone, Sphere, Wedge, Torus, Solid representation, Fundamentals of solid modeling, Set theory, Regularized set operations, Set membership classification, Half spaces, Basic elements, Building operations, Boundary representation and Constructive solid geometry, Basic elements, Building operations.

Scan Conversion and Clipping: Representation of points, lines, Drawing Algorithms: DDA algorithm, Bresenham's integer line algorithm, Bresenham's circle algorithm, Polygon filling algorithms: Scan conversion, Seed filling, Scan line algorithm. Viewing transformation, Clipping - Points, lines, Text, Polygon, Cohen-Sutherland line clipping, Sutherland-Hodgmen algorithm.

10 Hours

Module 4:

Visual Realism: Introduction, Hidden line removal, Visibility of object views, Visibility techniques: Minimax test, Containment test, Surface test, Silhouttes, Homogeneity test, Sorting, Coherence, Hidden surface removal- Z-buffer algorithm, Warnock's algorithm, Hidden solid removal - ray tracing algorithm, Shading, Shading models, Diffuse reflection, Specular reflection, Ambient light, Shading of surfaces: Constant shading, Gourand shading, Phong shading, Shading enhancements, Shading Solids, Ray tracing for CSG, Z-buffer algorithm for B-rep and CSG

10 Hours

Module 5:

Applications: Colouring- RGB, CMY, HSV, HSL colour models, Data Exchange: Evolution of Data exchange, IGES, PDES, Animation: Conventional animation-key frame, In between, Line testing, Painting, Filming, Computer animation, Entertainment and Engineering Animation, Animation system hardware, Software architecture, Animation types, Frame buffer, Colour table, Zoom- pan-scroll, Cross bar, Real time play back, Animation techniques- key frame, Skelton. Path of motion and p-curves. **10 Hours**

TextBooks:

1. IbrahamZeid, CAD/CAM-Theory and Practice-McGraw Hill, 2006.
2. David Rogers & Alan Adams, Mathematical Elements for Computer Graphics-Tata McGraw Hill, 2002.

ReferenceBooks:

1. Xiang Z, Plastock, R. A, Computer Graphics- Schaum's Outline, McGraw Hill, 2007.
2. Foley, van Dam, Feiner and Hughes, Computer Graphics- Principles and Practice-Addison Wesley, 1996.
3. Sinha A N., Udai A D., Computer Graphics- Tata McGraw Hill, 2008.

Course Outcome

This course will enable students to:

1. Recognize how a visual image can be an effective means of communication
2. Acquire and develop the skills needed to creatively solve visual communication problems.
3. Understand, develop and employ visual hierarchy using images and text.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-1

VEHICLE CRASH & OCCUPANT SAFETY

Course Code	**18CAE241**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives

This course will help the student to understand Importance of Vehicle Safety, Preliminary consideration in vehicle design, driving safety and the importance of Computer aided Engineering for Industrial application for Crash and Safety.

Module 1:

Basic Concepts of Vehicle Safety: Importance of Vehicle Safety, Global priority for vehicle safety and underlying principles, Fail-safe, Survivability and injury reduction. Design considerations: Preliminary consideration in vehicle structural design, Structural design for occupant protection,

Passenger car body structure for energy absorption, Design of front end system for pedestrian safety, Design of bumpers, Concept of crumble zone **10 Hours**

Module 2:

Safety Concepts: Active safety: Driving safety, Conditional safety, Perceptibility safety, Operating safety, Passive safety: Exterior safety, Interior safety.
CAE Methods: For Vehicle Crashworthiness and Occupant Safety, Deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact. **10 Hours Module 3:**

CAE Analysis Process: Industrial application of CAE for Crash and Safety, Expectations from CAE specific to Crash and Safety.
Mapping: Mapping Physical vehicle to Virtual CAE model, Dummies and injury criteria. **10 Hours**

Module 4:

Safety Equipments: Seat belt, Regulations, Collapsible steering column, Air bags, Electronic system for activating air bags, Antilock braking systems, Traction control devices, ESC devices. **10 Hours**

Module 5:

Collision Warning and Avoidance: Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions. **10 Hours**

Text Book:

1. Bosch, "Automotive Handbook" - 5th edition - SAE pu blication - 2000.
2. J.Powloski, "Vehicle Body Engineering", Business Bo oks limited, London - 1969.

References:

1. Ronald. K. Jurgen, "Automotive Electronics Handbook " - Second edition- McGraw-Hill Inc., - 1999
2. Automotive vehicle safety (George Peters and Barbara Peters)
3. ECE Regulations
4. Vehicle safety by Limpert

Course Outcome

The student will be able to analyse and simulate real time engineering problems related to vehicles Crash and Safety though computers.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-1

DESIGN FOR MANUFACTURE AND ASSEMBLY

Course Code	**18CAE242**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

CourseLearning Objectives:

- To understand various general design rules for manufacturability and criteria for material selection.
- To study various machining process and tolerance aspects in machining.
- To know the design considerations for casting, forging and welding process.
- To study the general design guidelines for manual assembly and development of DFA Methodology.

CourseContent:

Module 1: EffectofMaterials AndManufacturing ProcessOnDesign:Majorphasesofdesign.Effectofmaterial propertiesondesignEffectof manufacturing processesondesign.Materialselectionprocess- costperunitproperty,Weightedpropertiesandlimitsonproperties methods. TolerenceAnalysis:Processcapability,mean,varience,skewness,kurtosis,Processcapabilitymetrics,Cp, Cpk,Costaspects,Feature tolerances relevant to manufacturing and assembly, tolerance stacks,effects on assembly,methods of eliminating tolerance stacks, Geometriestolerances,Geometrictolerances,Surfacefinish,Reviewof relationshipbetweenattainabletolerancegradesand differentmachiningprocess.Cumulativeeffectoftolerance-Surefitlawandtruncatednormallaw.

10Hours

Module 2: Selective Assembly: Interchangeable part manufacture and selective assembly, Deciding the number of groups -Model-1 : Group toleranceof matingpartsequal,Modeltotalandgrouptolerancesof shaftequal.Controlofaxialplay-Introducingsecondarymachining operations,Laminatedshims,examples. DatumFeatures:Functionaldatum,Datumformanufacturing,Changingthedatum.Examples.

10Hours

Module 3: DesignConsiderations:Designofcomponentswithcastingconsideration.Pattern,Mould, andPartingline.CoredholesandMachined holes.Identifyingthepossibleandprobablepartingline.Castingrequiringspecialsandcores.Designingtoobviatesandcores.Welding considerations: requirements and rules, redesign of components for welding; case studies.

Component Design:Component designwithmachining considerations linkdesignforturningcomponents-milling, Drillingandother relatedprocessesincludingfinish-machiningoperations.

12Hours

Module 4: Forging considerations -Requirements and rules -Redesign of components for forging and Case studies.

True positional theory :Comparison between co-ordinate and convention method offeature location. Tolerance and true position tolerancing,virtualsize concept,floatingandfixedfasteners.Projectedtolerancezone.Assemblywith gasket,zeropositiontolerance. Functionalgauges,and Paperlayoutgauging.

10Hours

Module 5: Approaches to design for assembly-Qualitative evaluation procedures, knowledge based approach, Computer aided DFA methods. Assemblability measures. Boothroyd-Dewhurst DFA method -Redesign of a simple product-Case studies.

08 Hours

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

Describe the different types of manufacturing systems and comparetheir suitability foreconomic production of various components and products.

Identify factors and causing mechanisms of the defects likely to occur with different manufacturing processes in producing mechanical products and the relevant design approaches to rectify them.

Select proper materials and manufacturing processes for designing products/components by applying the relevant principles for ease and economic production.

Reference Books:

1. HarryPeck, “DesigningforManufacturing”,PitmanPu bli cations,1983.
2. Dieter,“MachineDesign”- McGraw-HillHigherEducat ion , -2008
3. R.K.Jain, "EngineeringMetrology",KhannaPublishers,1986
4. Productdesignformanufacture andassembly-GeoffreyBoothroyd, Peterdewhurst, WinstonKnight,Merceldekker. Inc.CRCPress, ThirdEdition
5. MaterialselectionandDesign,Vol.20-ASMHandbook.
6. Alan Redford and Chal, (1994) Design for Assembly-Principles and Procedures. McGraw Hill International.
7. James G. Bralla, (1986) Hand Book of Product Design for Manufacturing. McGraw Hill Co

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-1

CONTINUUM MECHANICS

Course Code	**18CAE243**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To expose the students to the field of Continuum Mechanics.

To understand elastic behavior of materials (hyper elasticity, linear elasticity) and plasticity (basic concepts of small strain and large strain plasticity).

Introduce student to basic notion and rules of tensor calculus as well as basic idea and laws of continuum mechanics.

To learn the fundamentals of analysis of stresses, deformation and strain, generalised Hooke's law, two dimensional problems, and viscoelastic equations.

Course Content:

Module 1:Analysis of Stress: Definition and Notation for forces and stresses. Body force, surface force, components of stresses, equations of equilibrium, specification of stress at a point. Principal stresses, maximum and minimum shear stress, Mohr's diagram in three dimensions. Boundary conditions. Stress components on an arbitrary plane, stress invariants, octahedral stresses, decomposition of state of stress, deviator and spherical stress tensors, stress transformation.

10 Hours

Module 2:Deformation and Strain: Deformation, strain Displacement relations, strain components, The state of strain at a point, , Principal strain, strain invariants, Strain transformation, Compatibility equations, Cubical dilatation, spherical and deviator strains, plane strain, Mohr's circle, and compatibility equation

Relations and the General Equations of Elasticity: Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems.

10 Hours

Module 3: Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation of simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems.

Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem.

10 Hours

Module 4: Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate.

Thermal Stresses: Introduction, Thermo-elastic stress -strain relations, thin circular disc, long circular cylinder.

10Hours

Module 5: Torsion of Prismatic Bars: Introduction, Torsion of circular cross section bars, Torsion of elliptical cross section bars, Soap film analogy, Membrane analogy, Torsion of thin walled open tubes.

Elastic Stability: Axial compression of prismatic bars, Elastic stability, buckling load for column with constant cross section.

Viscoelasticity: Linear Viscoelasticbehavior. Simple viscoelastic models-generalized models, linear differential operator equation. Creep and Relaxation- creep function, relaxation function, hereditary integrals. Complex modulii and compliances. (Note: No numericals)

10 Hours

Course Outcomes:

At the end of the course, students should be able to:

- Treat general stresses and deformations in continuous materials.
- Formulate and solve specific technical problems of displacement, strain and stress.
- Perform experiments with stresses and deformations.
- Model and analyse the stresses and deformations of simple geometries under an arbitrary load in solids.

Text Books:

1 Timoshenko and Goodier, "Theory of Elasticity"-'Tata McGraw Hill, New Delhi,3rd edition , 1970
2. L S Srinath "Advanced Mechanics of Solids"- Tat a McGraw Hill, New Delhi, 3rd edition, 2010
3 G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press,Boca Raton, 2010

References:

1. Batra, R. C., Elements of Continuum Mechanics, Reston, 2006.
2. George E. Mase, Schaum's Outline of Continuum Mechanics, McGraw-Hill, 1970
3. Dill, Ellis Harold, Continuum Mechanics: Elasticity, Plasticity, Viscoelasticity, CRC Press , 2006.
4. Sadhu Singh," Theory of Elasticity"- Khanna publisher, 4th edition, 2013

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-2

DESIGN OPTIMIZATION

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MDE251**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course LearningObjectives:

To understand the fundamentals of optimisation methods and their applications to manufacturing process and product design.

To learn optimisation models including design objectives, constraints and variables. To learn appropriate optimisation techniques and programs.

To understand the limitations of solutions obtained from optimisation, and to use optimal design tools/software.

Course Content:

Module 1:EngineeringDesignPractice: EvolutionofDesignTechnology,IntroductiontoDesignandtheDesignProcess,DesignversusAnalysis, RoleofComputers in Design Cycle,Impact ofCAE on Design, Numerical Modelingwith FEAand Correlation with Physical Tests.

Applications ofOptimizationinEngineering Design: Automotive, Aerospaceand GeneralIndustryApplications, Optimization ofMetallic and CompositeStructures, Minimization and MaximizationProblems, MDO and MOO.

10 Hours

Module 2: OptimumDesignProblemFormulation:TypesofOptimizationProblems,TheMathematicsofOptimization,DesignVariablesand DesignConstraints,FeasibleandinfeasibleDesigns,Equality andInequality Constraints,DiscreteandContinuousOptimization,Linearand NonLinear Optimization.

OptimizationTheory– FundamentalConcepts,GlobalandLocalMinimum,GradientVectorandHessianMatrix,ConceptofNecessary and Sufficient Conditions, Constrained and Unconstrained Problems,LagrangeMultipliers and Kuhn TuckerConditions.

10 Hours

Module 3:SensitivityAnalysis: Linear andNonLinear Approximations. Gradient Based Optimization Methods– Dual and Direct.

OptimizationDisciplines: Conceptual DesignOptimizationandDesignFine Tuning, CombinedOptimization,Optimizationof Multiple Static andDynamicLoads,Transient Simulations,Equivalent StaticLoadMethods.InternalandExternal Responses,DesignVariablesin Each Discipline.

10 Hours

Module 4:ManufacturabilityinOptimizationProblems: DesignForManufacturing,ManufacturingMethodsandRules,ApplyingManufacturingConstraints to Optimization Problems.

DesignInterpretation: UnboundProblems,OverConstrainedProblems,ProblemswithNoofMultipleSolutions,ActiveandInactiveConstraints, Constraint Violations and Constraint Screening, Design MoveLimits,Local and Global Optimum.

10 Hours

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

10 Hours

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

Identify and apply relevant problem solving methodologies.
Design components, systems and/ or processes to meet required specification.
Optimizeanexistingdesignwithsingleormultipleobjectivefunctions.
Apply decision-making methodologies to evaluate solutions for efficiency, effectiveness and sustainability.

TextBooks:

1. S.S.Rao, Engineering Optimization: Theoryand Practice, John Wiley, 2009
2. JasbirArora,Introduction to Optimum Design, McGrawHill, 2011.

ReferenceBooks:
1. Optimisation and Probabilityin System Engg-Ram, Van Nostrand.
2. Optimization methods -K. V. Mitaland C. Mohan, NewageInternationalPublishers, 1999.
3. Optimization methods forEngg.Design -R.LFox, Addison – Wesley, 1971.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-2

AUTOMOBILE SYSTEMDESIGN

(Commonto MDE, MMD, MEA, CAE)

Course Code	**18MEA252**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Objective:

To understanding of the stages involved in automobile system design.
To expose the to industrialpractices in design of various systems of an automobile.
To study importance and features of different systems like axle, differential, brakes, Steering, suspension, and balancing etc.

To study working of various Automobile Systems.

To know some modern trends in Automotive Vehicles.

Course Content:

Module 1: Body Shapes: Aerodynamic Shapes, drag forces for small family cars.
Fuel Injection: Spray formation, direct injection for single cylinder engines (both SI & CI), energy audit.

12 Hours

Module 2: Design of I.C. Engine I: Combustion fundamentals, combustion chamber design, cylinder head design for both SI & C. I. Engines.

08 Hours

Module 3: Design of I.C. Engine II: Design of crankshaft, camshaft, connecting rod, piston & piston rings for small family cars (max up to 3 cylinders).

10 Hours

Module 4: Transmission System: Design of transmission systems – gearbox (max of 4-speeds), differential.
Suspension System: Vibration fundamentals, vibration analysis (single & two degree of freedom, vibration due to engine unbalance, application to vehicle suspension.

10 Hours

Module 5:Cooling System: Heat exchangers,application todesign ofcoolingsystem(watercooled).
EmissionControl: Common emission control systems, measurement ofmissions, exhaust

gasemission testing.

10 Hours

CourseOutcomes:

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

Gain an insight into aspects of vehicle design, operation and maintenance, which will be useful for taking up a position in the automotive industry.

Applytheknowledgeincreatingapreliminarydesign of automobilesub systems.

Identify construction, working, preventive maintenance, trouble shooting and diagnosis of various Automobile Systems.

Identify Modern technology and safety measures used in Automotive Vehicles

TextBooks:

1. DesignofAutomotiveEngines, -A.Kolchin&V. Demidov, MIR Publishers, Moscow.
2. Themotorvehicle, Newtonsteeds &Garratte-Iliffee&sonsLtd.,London.
3. I.C. Engines -Edward FObert,International text book company.

ReferenceBooks:

1. Introductionto combustion-Turns.
2. AutomobileMechanic-, N.K.Giri, KhannaPublications, 1994
3. I.C. Engines -Maleev, McGrawHill book company, 1976
4. Diesel enginedesign-HeldtP.M.,ChiltoncompanyNew York.
5. Problems on designofmachine elements-V.M. Faires&Wingreen, McMillan Company., 1965
6. DesignofI.C.Engines -John Heywood, TMH.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-2

COMPUTATIONAL FLUID DYNAMICS
(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA253**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

This course would create awareness about the theory behind fluid dynamics computations as applied in analysis tools.

This course provides core knowledge of the fundamentals of CFD, and an introduction to the methods and analysis techniques used in CFD.

Course Content:

Module 1: Basic Concepts: Dimensionless form of equations; Simplified mathematical models; Hyperbolic, Parabolic & Elliptic systems; Properties of numerical solutions (Consistency, Stability, Conservation, Convergence and Accuracy).

10 Hours

Module 2: Finite Difference Methods: Discretisation; Boundary conditions; error propagation; Introduction to spectral methods; examples.

10 Hours

Module 3: Finite volume method: Surface & volume integrals; Interpolation & differentiation; Boundary conditions; Examples.

10 Hours

Module 4: Gausian Elimination; LU decomposition; Tridiagonal Systems; Iterative methods; convergence; ADI & other splitting methods.
Multi-grid method - Coupled equations; Simultaneous solutions, sequential solutions & under relaxation.Non linear systems.

10 Hours

Module 5: Initial value problem & Boundary value problems; Implicit & Explicit schemes; 2D and 3D examples.Heat and Mass transfer Problems; Multi Phase Flows.

10 Hours

Course Outcomes:

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

Understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, specifying solution parameters, and visualising and analysing the results.
Apply CFD analysis to real engineering designs.

Text Books:

1. Computational Methods for Fluid Dynamics, 3rd edition - J.H. Ferziger& M. Peric, Springer, 2002.
2. Numerical Solutions of Partial Differential Equations, Finite Difference methods, 3rd ed., G.D. Smith, Oxford University Press. 1986.

Reference Books:

1. Computational Fluid Dynamics - T. J. Chung, Cambridge Univ. Press, 2002.
2. Partial Differential Equations for Scientists and Engineers - Farlow, John Wiley, 1982.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

COMPUTER AIDED ENGINEERING LABORATORY – II

Course Code	**18CAEL26**	**CIE Marks**	**40**
Number of Practical Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Hours	**50**	**Exam Hours**	**03**

Note:
These are independent laboratory exercises.

Student must submit a comprehensive report on the problems solved and give a

presentation on the same for Internal Evaluation.
Any one of the experiments done from the following list has to be set in the examination

for conduction and evaluation.

Course Content:

Experiment #1 Structural Analysis

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

Experiment #2Design Optimization

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

Experiment #3 Thermal analysis

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

Experiment #4 Thermal Stress Analysis

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

Experiment#5 CFD Analysis

Part A: Modeling and simulation of Flow mix and heat transfer (3D), turbulence models.
Modeling and simulation of periodic flow and heat transfer.
Part B: Modeling and simulation of Natural convection and radiation heat transfer.

Experiment #6CFD Analysis

Part A: Modeling and simulation of turbulent Flow in compact heat exchanger
Part B: Modeling and simulation of flow bet between two parallel plates, flow inside cylinder and Couette flow.

Experiment #7 Bolted Joints.

Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

Experiment #8Adhesive Bonded Joints.

Part A : Fabrication and Testing.
Part B : FE Modeling and Failure Analysis .
Part C : Correlation Studies.

III SEMESTER

ADVANCED MANUFACTURING PROCESS SIMULATION

Course Code	**18CAE31**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Objectives

The course aims at bringing in clear understanding of finite element modeling for simulation of various manufacturing processes.

Course Content

Module 1:

Finite Element Models of Sheet Metal Forming Processes: Introduction, fundamentals of continuum mechanics- strain and stress measurement, Material Models , FE-Equations for Small Deformations, FE-Equations for Finite Deformations, Flow Approach- Eulerian FE-Formulations for Rigid-Plastic Sheet Metal Analysis, The Dynamic, Explicit Method, Historical Review of Sheet Forming Simulation. Plastic Behaviour of Sheet Metal: Anisotropy of Sheet Metals- Uniaxial and biaxial Anisotropy Coefficients, Yield Criteria for Isotropic Materials, Classical Yield Criteria for Anisotropic Materials.

10 Hours

Module 2:

Advanced Anisotropic Yield Criteria: Banabic-Balan-Comsa (BBC) 2005 Yield Criterion, Banabic-Balan-Comsa (BBC) 2008 Yield Criterion, Recommendations on the Choice of the Yield Criterion, Modeling of the Bauschinger Effect. Formability of Sheet Metals: Evaluation of the Sheet Metal Formability-method based on simulation test and limit dome height diagram, Forming Limit Diagram-definition, experimental determination, methods of determining the limit strain, factors influencing the forming limit, Theoretical Predictions of the Forming Limit Curves, Semi-empirical Model.

10 Hours

Module 3:

Numerical Simulation of the Sheet Metal Forming Processes: Simulation of the Elementary Forming Processes. Simulation of the Industrial Parts Forming Processes, Robust Design of Sheet Metal Forming Processes, the Spring-back Analysis, Computer Aided Spring- back Compensation. Forging, Classification, various stages during forging, forging equipment, brief description, deformation in compression, forging defects. Residual stresses in forging.

10 Hours

Module 4:

Rolling: Classification forces and geometrical relationships in rolling. Deformation in rolling, Defects in rolled products, Residual stresses in rolled products. Torque and Horse power. Drawing and Extrusion: Principles of Rod and wire drawing, variables in wire drawing, Residual stresses in rod, wire and tube drawing, Defects in Rod and wire drawing. Extrusion equipment, Classification, variables in extrusion, Deformation in extrusion, Extrusion defects, Work done in extrusion.

10 Hours

Module 5:

Composite Materials and Honeycomb Structures: Manufacturing processes and environmental requirements for manufacturing of composite components, NDT methods and quality control, sandwich structures and adhesive bonding. Heat Treatment Processes: Purpose of heat treatment and theory of heat treatment processes, heat treatment of alloys of aluminum, magnesium, titanium, steel and case hardening. **10 Hours**

Text Books:

1. Dorel Banabic,Sheet Metal Forming Processes: Constitutive Modeling and Numerical Simulation, Springer, 2010.
2. Dieter G.E. Mechanical Metallurgy, McGraw Hill, 1986.
3. ASM Metals Handbook –Volume II.

Reference Books:

1. Aircraft Materials and Manufacturing Process - George F.Titterton, published by Himalayan books, New Delhi, 1968.
2. Aircraft Production Technology and Management - ChennaKeshu S and Ganapathy K K, Interline Publishing, Bangalore, 1993.
3. SachG "Fundamentals of working of metals" Pergamon Press.
4. N Bhatnagar, T S Srivatsan, "Processing and Fabrica tion of Advanced Materials", IK International
5. Phillip F. Ostwald, Jairo Muñoz, "Manufacturing processes and systems", John Wiley, 1997.
6. Stephen F. Krar, Arthur Gill, "Exploring advanced m anufacturing technologies", Industrial Press, 2003.
7. Kobayashi "Metal forming and finite element methods ", Oxford, 1989.
8. PrakashMahadeo Dixit, Uday S. Dixit, "Modeling of m etal forming and machining processes", Springer, 2008.
9. Dorel Banabic,"Advanced Methods in Material Forming ", Springer, 2007.
10. Schuler GmbH., "Metal forming handbook", Springer, 1998.

Course Outcome:
Students will be able to analyse the behaviour of materials during forming.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-3

EXPERIMENTAL MECHANICS

(Common to MDE, MEA, MMD, CAE)

Course Code	**18CAE321**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course LearningObjectives:

To introduce the concepts of dynamic measurements and analysis of experimental data.
To expose them to the techniques of Data Acquisition, Signal conditioning and processing.
To introduce students to different aspects of measuring deformation, strains, and stresses for developing a mechanistic understanding of both the material and the structure behavior.
Tofamiliarizethestudentwithstateoftheartexperimentaltechniquesnamelystraingauges,photoelasticity, Moiréinteroferometry,brittlecoating,Moiréfringesandholography.

CourseContent:

Module 1:Introduction:Definitionofterms,calibration,standards,dimensionandunits,generalizedmeasurementsystem,Basicconceptsindynamic measurements,systemresponse,distortion,impedancematching,experimentplanning.
Analysisof ExperimentalData: Causeandtypesof experimentalerrors,erroranalysis.Statisticalanalysisof experimentaldata-probabilitydistribution, Ga u s s i a n , Normaldistribution. Chi-square test, methodof least square, correlation coefficient, multivariable regression, standarddeviationofmean,graphicalanalysisandcurvefitting,generalconsiderationindataanalysis.

10Hours

Module 2: DataAcquisition andProcessing: Generaldataacquisition system,signalconditioning revisited,datatransmission, Analog-to-Digital and Digital-to- Analogconversion. Basiccomponents (storageanddisplay)ofdataacquisition system.Computerprogramasasubstitute forwiredlogic.
Force,TorqueandStrainMeasurement: Massbalancemeasurement,elasticelementfor forcemeasurement,torquemeasurement.Strain gages- strainsensitivityofgagemetals,gageconstruction,gagesensitivityandgagefactor,performancecharacteristics,environmentaleffects,Straingagecircuits,Potentiometer, WheatStone'sbridges,Constantcurrentcircuits.Strainanalysismethods-two elementand threeelement,rectangularanddeltarosettes,correctionfortransversestraineffects,stressgage-planesheargage,stressintensityfactor gage.

10Hours

Module 3: StressAnalysis: TwoDimensionalPhotoelasticity-natureoflight,-wavetheoryoflight,-opticalinterference-Polariscopesstressopticlaw effect ofstressed modelinplaneandcircularpolariscopes, Isoclinics, Isochromaticsfringeorder determination -Fringe multiplicationtechniques- Calibrationphotoelasticmodelmaterials.Separationmethodssheardifferencemethod,Analyticalseparatio nmethods,Model toprototypescaling.

10Hours

Module 4: ThreeDimensionalPhotoelasticity: Stressfreezingmethod,Generalslice,Effectivestresses,Stressesseparation,Shear deferencemethod, Obliqueincidencemethod,secondaryprincipalsstresses,scatteredlightphotoelasticity,Polariscopeandstressdataanalyses.

10 Hours

M o d u l e 5 : Coating Methods: a)PhotoelasticCoating Method-Birefringence coating techniques,Sensitivity Reinforcing and thickness effects -data reduction-Stressseparation techniques,Photoelasticstraingauges.

b) BrittleCoatingsMethod:BrittlecoatingtechniquePrinciplesdata analysis-coatingmaterials,Coatingtechniques.

c) MoireTechnique-Geometricalapproach,Displacementapproach-sensitivityofMoiredatareduction,InplaneandoutplaneMoiremethods,Moirephotography,Moiregridproduction.

Holography: Introduction, Equation forplane waves andspherical waves, Intensity, Coherence,

process),Hurter,Driffeldcurves,Reconstructionprocess,Holograpicinterferomerty, Realtimeanddoubleexposuremethods,Displacement measurement,Isopachics.

10Hours

CourseOutcomes:

At the end of this course, students should be able to:

Mount strain gages, take measurements and analyze the obtained data.
Design strain gage-based transducers for measuring specific loads.
Describe the different methods photo elasticity for strain measurement viz, stress freezing , and Moirés method
Undertakeexperimentalinvestigationstoverifypredictionsbyothermethods.
Apply the principles and techniques of brittle coating analysis
Apply the principles and techniques of holographic interferometry.

TextBooks:

1 . Holman,“ExperimentalMethodsforEngineers”7th Edition,TataMcGraw-Hill Companies,Inc,NewYork,2007.
2. R.S.Sirohi,H.C.RadhaKrishna,“Mechanicalmeasurements”NewAgeInternationalPvt. Ltd.,NewDelhi,2004
3. ExperimentalStressAnalysis-Srinath,Lingaiah,Raghavan,Gargesa,Ramachandraand Pant,TataMcGrawHill,1984.
4. . Instrumentation,MeasurementAndAnalysis-Nakra&Chaudhry,BCNakraKKChaudhry, TataMcGraw-HillCompanies,Inc,NewYork, SeventhEdition,2006.

ReferenceBooks:

1. MeasurementSystemsApplicationandDesign-DoeblinE.A.,4th(S.I.)Edition,McGraw Hill,NewYork.1989
2. DesignandAnalysisofExperiments- MontgomeryD.C.,JohnWiley&Sons,1997.

3. ExperimentalStressAnalysis-DallyandRiley,McGrawHill,1991.
4. ExperimentalStressAnalysis-SadhuSingh,Khannapublisher,1990.
5. PhotoelasticityVolIandVolII-M.M.Frocht,.JohnWileyandsons,1969.
6. StrainGaugePrimer-PerryandLissner,McGrawHill,1962.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-3

MECHATRONICS SYSTEM DESIGN

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MDE322**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To educate the student regarding integration of mechanical, electronics, electrical and computer systems in the design of CNC machine tools, Robots etc.

To provide students with an understanding of the Mechatronic design process, actuators, sensors, transducers, signal conditioning, MEMS and Microsystems and also the advance applications in Mechatronics.

Course Content:

Module 1: Introduction: Definition and introduction to Mechatronic Systems. Modeling & Simulation of physical systems. Overview of Mechatronic products and their functioning. Measurement systems, control systems, simple controllers. Study of sensors and transducers, Pneumatic and Hydraulic Systems, Mechanical actuation systems, Electrical actuation systems, Real time interfacing and hardware components for Mechatronics.

10 Hours

Module 2: Electrical Actuation Systems: Electrical systems, mechanical switches, solid state switches, solenoids, DC & AC motors, Stepper motors. System Models: Mathematical models, mechanical system building blocks, electrical system building blocks, thermal system building blocks, electro-mechanical systems, hydro-mechanical systems, pneumatic systems.

10 Hours

Module 3: Signal Conditioning: Signal conditioning, the operational amplifier, protection, filtering, Wheatstone Bridge, Digital signals, Multiplexers, Data Acquisition, Introduction to digital system processing, Pulse-modulation.

MEMS and Micro systems: Introduction, working principle, materials for MEMS and Micro systems, Micro system fabrication process, overview of Micro Manufacturing, Micro system Design, and Micro system packaging.

10 Hours

Module 4: Data Presentation Systems: Basic System Models, System Models, Dynamic Responses of System.

10 Hours

Module 5: Advanced Applications in Mechatronics: Fault Finding, Design arrangements and practical case studies, Design for manufacturing, User- friendly design.

10 Hours

Course Outcomes:
At the end of the course,students will be able to:

Describe mechatronic systems and overview of control systems & actuators.

Identify and describe the different types of actuators used in mechatronic systems

Differentiate between various sensors, transducers and actuators and their applications.

Identify and describe the different types of speed- and position-feedback devices.

Relate various signal conditioning units, amplifiers, logic gates and their role in programmable logic controllers.

Discuss the importance of feedback in controlling physical systems with the use of examples. Explain the principle of operation of ac induction motor, dc motor, servomotor, and stepper motor.

Identify and describe the types of controllers used in mechatronic systems.

Select the suitable type of controller for an application.

Text Books:

1. W. Bolton, "Mechatronics" **-** Addison Wesley Longman Publication, 1999

2. HSU "MEMS and Microsystems design and manufact ure" **-** Tata McGraw-Hill Education, 2002

Reference Books:

1. Kamm, "Understanding Electro-Mechanical Engine erin g an Introduction to Mechatronics"-IEEE Press, 1 edition ,1996

2. Shetty and Kolk "Mechatronics System Design"- Cenga ge Learning, 2010

3. Mahalik "Mechatronics"- Tata McGraw-Hill Educa tion , 2003

4. HMT "Mechatronics"- Tata McGraw-Hill Education , 19 98

5. Michel .B. Histand& David. Alciatore, "Introdu ctio n to Mechatronics & Measurement Systems"–. Mc Grew Hill, 2002

6. "Fine Mechanics and Precision Instruments"- Pe rgam on Press, 1971.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-3

Robust Design

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MEA323**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To impart a holistic view of the fundamentals of experimental designs, analysis tools and techniques, interpretation and applications.

To cover the statistical design of experiments for systematically examining functioning of the system.

To understandTaguchi's orthogonal array techniques which are predominantly used in optimization of parameters.

To understand the applications of statistical models in analysing experimental data.

Course Content:

Module 1: Quality by Experimental Design : Quality, western and Taguchi quality philosophy, elements of cost, noise factors causes of variation,quadratic loss function and variation of quadratic loss functions. Robustdesign :steps in robust design,parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.

Experimental design: classical experiments,factorial experiments, terminology, factor levels, interactions, treatment combination, randomization, 2-levelexperimental design for two factors and three factors, 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, fractional factorial design, saturated design, central composite designs, and illustration through numerical examples.

10 Hours

Module 2: Measures of Variability: Measures of variability, concept of confidence level.Statisticaldistributions :normal, log normal and Weibull distributions. Hypothesis testing, probability plots, choice of sample size illustration through numerical examples. Analysis and interpretation of experimental data: Measures of variability, ranking method, column effect method and plotting method.Analysis of Variance (ANOVA) in factorial experiments: Yate's algorithm for ANOVA, regression analysis, mathematical models from experimental data, illustration through numerical examples.

10 Hours

Module 3: Taguchi's Orthogonal Arrays : Types orthogonal arrays, selection of standard orthogonal arrays, linear graphs and interaction assignment, dummy level technique, compound factor method, modification of linear graphs, column merging method, branching design, strategies for constructing orthogonal arrays. Signal to Noise ratio (S-N ratios): Evaluation of sensitivity to noise, signal to noise ratios for static problems, smaller – the – better types, nominal – the –better – type , larger – the- better – type. Signal to Noise ratios for dynamic problems, illustrations through numerical examples.

10 Hours

Module 4: Parameter Design and Tolerance Design : Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples.

10 Hours

Module 5: Reliability Improvement Through Robust Design : Role of S-N ratios inreliability improvement ; Case study; Illustrating the reliability improvement ofrouting process of a printed wiring boards using robust design concepts.

10 Hours

Course Outcome:

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

Apply methods to analyze and identify opportunities to improve design processes for robustness.

Set up full and fraction Factorial experiment design.

Perform ANOVA and Hypothesis Testing.

Apply statistical models in analysing experimental data.

Lead product development activities that include robust design techniques.

Text Books:

1.Madhav S. Phadake , "Quality Engineering using Ro b ust Design", Prentice Hall,1989.
2. Douglas Montgomery, "Design and analysis of expe ri ments", Willey India Pvt.Ltd., 2007.
3. Phillip J. Ross, Taguchi , "Techniques for Quali ty Engineering",McGraw Hill Int. Ed., 1996

Reference Books:

1. Thomas B. Barker , "Quality by Experimental Desi gn ", Marcel Dekker Inc, ASQC Quality Press, 1985
2. C.F. Jeff Wu, Michael Hamada , "Experiments plan ni ng, analysis and parameter design optimization", John Willey Ed., 2002
3. W.L. Condra, Marcel Dekker , "Reliability improv em ent by Experiments", MarcelDekkerInc, ASQC Quality Press, 1985

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-4

SMART MATERIALS AND STRUCTURES

(Common to MDE, MEA, MMD,CAE)

Course Code	**18CAE331**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To understand the concepts of functional material, smart material and smart systems.

To expose the students to design smart structures for advanced engineering applications.

To introduce the concepts of shape memory alloys, ER and MR fluids, and MEMS.

Course Content:

Module 1: Smart Structures: Types of smart structures, potential feasibility of smart structures, key elements of smart structures, applications of smart structures. Piezoelectric materials, properties, piezoelectric constitutive relations, depoling and coersive field, field strain relation. Hysteresis, creep and strain rate effects, inchworm linear motor. Beam modeling: Beam modeling with induced strain rate effects, inchworm linear motor beam modeling with induced strain actuation-single actuators, dual actuators, pure extension, pure bending harmonic excitation, Bernoulli-Euler beam model, problems, piezo-electrical applications.

10 Hours

Module 2: Shape memory Alloy: Experimental phenomenology, shape memory effect, phase transformation, Tanaka's constitutive model, testing of SMA wires, vibration control through SMA, multiplexing. Applications of SMA and problems. ER and MR fluids: Mechanisms and properties, fluid composition and behavior, the Bingham plastic and related models, pre-yield response, post-yield flow applications in clutches, dampers and others.

08 Hours

Module 3:Vibration absorbers: Series and parallel damped vibrations (overview), active vibration absorbers, fiber optics, physical phenomena,characteristics, sensors, fiber optics in crack detection, applications. Control of structures: Modeling, control strategies and limitations, active structures in practice.

10 Hours

Module 4: MEMS: Mechanical Properties of MEMS Materials, Scaling of Mechanical Systems, Fundamentals of Theory, The Intrinsic Characteristics of MEMS, Miniaturization, Microelectronics Integration.

10 Hours

Module 5: Devices: Sensors and Actuators, conductivity of Semiconductors, crystalplanes and orientation, Stress and Strain Relations, Flexural Beam Bending Analysis undersimpleloading conditions, polymers in MEMS, optical MEMS applications.

10 Hours

Course Outcomes:

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

Understand the behavior and applicability of various smart materials.
Design simple models for smart structures & materials.
Perform simulations of smart structures & materials application.
Devise experiments to verify the predictions.
Judge the appropriate application of smart materials with respect to the feasibility of their fabrication and implementation, and to the economic aspects.

Text Books:

1. Smart Materials and Structures - M. V. Gandhi and B. So Thompson, Chapman and Hall, London; New York, 1992 (ISBN: 0412370107).
2. Smart Structures and Materials - B. Culshaw, ArtechHouse, Boston, 1996 (ISBN :0890066817).
3. Smart Structures: Analysis and Design - A. V. Srinivasan, Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267).

Reference Books:

1. Electroceramics: Materials, Properties and Applications - A. J. Moulson and J. M. Herbert. John Wiley & Sons, ISBN: 0471497429
2. Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors. Materials and Amplifiers, Springer, Berlin;New York, 2002 (ISBN: 3540422595).
3. Piezoelectric Actuators and Wtrasonic Motors - K. Uchino, Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114).
4. Handbook of Giant Magnetostrictive Materials - G. Engdahl, Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X).
5. Shape Memory Materials - K. Otsuka and C. M. Wayman, Cambridge University Press, Cambridge; New York, 199~ (ISBN:052144487X).

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

<u>**Professional Elective-4**</u>

FINITE ELEMENT METHODS FOR HEAT TRANSFER AND FLUID FLOW

Course Code	**18CAE332**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives

The student will learn finite element formulation of various modes of heat transfer and fluid flow and to solve numerical examples.

Course Content

Module 1:

Introduction to Heat Transfer and Fluid Mechanics: Mathematical Preliminaries, Governing equations of a continuum, Governing equation in terms of primitive variables, porous equations, low speed compressible flow equations, auxiliary transport equations, chemically reacting systems, boundary conditions, change of phase, enclosure radiation. Finite Element Methods: Introduction, model differential equation, finite element approximations, interpolation functions, library of finite elements, modeling considerations, assembly of elements, numerical integration, discussion of results with some practical examples, time dependent problems.

10 Hours

Module 2:

Steady State Conduction Heat Transfer: Introduction, one dimensional linear, quadratic element. Homogeneous, composite wall with uniform and varying cross sectional area. Radial heat flow in a cylinder. Conduction –convection systems. Numerical examples. Conduction Heat Transfer: Interpolation functions for tetrahedral, hexahedral, pyramid and prism elements. Numerical integration, computation of surface flux, semi-discrete finite element model, solution of nonlinear equations for transient problems. Radiation solution algorithms, variable properties.

10 Hours

Module 3:

Advanced topic in Conduction: specialty elements, computation of boundary conditions, bulk nodes, reactive materials, and material motions. Example problems on conduction, radiation, temperature dependent conductivity, anisotropic conduction, brazing and welding, investment casting.

08 Hours

Module 4:

Flows of Viscous Incompressible Fluids: Governing equation mixed finite element model, penalty finite element models. Finite element models of porous flow

Computational consideration: Interpolation functions for triangular, quadrilateral, tetrahedral and hexahedral elements. Evaluation of element matrices in penalty model. Pressure calculation and traction boundary conditions, numerical examples.

10 Hours

Module 5:

Coupled Fluid Flow and Heat Transfer: Introduction to non-isothermal incompressible flows, governing equations and boundary condition. Mixed, penalty finite element model. Finite element model for porous flow. Non-isothermal low speed compressible flows: governing equation, boundary conditions, and mixed finite element model and solution methods. Convection with change of phase, convection with enclosure radiation, turbulent heat transfer, chemically reacting systems. Numerical examples. **10 Hours**

Text Books:

1. JNReddy, David K. Gartling,"The finite element meth od in heat transfer and fluid dynamics" , CRC, 2004.
2. Roland Wynne Lewis, PerumalNithiarasu, K. N. Seetharamu," Fundamentals of the finite element method for heat and fluid flow" John Wiley, 2004

Reference Books:

1. Ching Jen Chen, R. A. Bernatz, "Finite analytic met hod in flows and heat transfer" Taylor & Francis.
2. Gianni Comini, Stefano Del Giudice, Carlo Nonino, " Finite Element Analysis in Heat Transfer: Basic Formulation and Linear problems" Ta ylorand Francis, 1994.

Course Outcome:

This course enables the student to use numerical methods for solving problems of fluid flow and heat transfer.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.

Professional Elective-4

ACOUSTICS AND NOISE CONTROL ENGINEERING

(Common to MDE, MEA, MMD, CAE)

Course Code	**18MDE333**	**CIE Marks**	**40**
Number of Lecture Hours/Week	**04**	**SEE Marks**	**60**
Total Number of Lecture Hours	**50(10 Hours per Module)**	**Exam Hours**	**03**

Course Learning Objectives:

To provide introduction to students the fundamentals of acoustics related to generation, transmission and control techniques.

To provide basic knowledge and understanding of noise and vibration control necessary for professional practice as a noise control engineer.

To expose them to acoustic instrumentation and techniques of sound measurement.

To understand Noise reduction and control techniques in Machinery, auditorium, and HVAC systems.

Course content:

Module 1: Introduction to Acoustics: Basics of acoustics - speed of sound, wavelength, frequency, and wave number, acoustic pressure and particle velocity, acoustic intensity and acoustic energy density, spherical wave, directivity factor and directivity index, levels and the decibel, combination of sound sources, octave bands, weighted sound levels. Sound sources and Propagation – Plane and spherical waves, near and far field, free and reverberant field - Anechoic and Reverberant chambers.

10 Hours

Module 2: Acoustics Evaluation Techniques: Room Acoustics ,Reverberation time, Acoustic materials, Absorption and Absorption Coefficient, Evaluation techniques.

10 Hours

Module 3:Noise and physiological effects: Noise and physiological effects , Acoustic criteria, the human ear, hearing loss, industrial noise criteria, speech interference level, noise criteria for interior spaces , Loudness, hearing, hearing loss, hearing protectors, Mechanism - Weighted Networks -Noise standards for traffic - Community noise -Aircraft -Environmental noise, Articulation index, and Machinery acoustics.

10 Hours

Module 4: Acoustic Instrumentation: Sound level and intensity meters - Octave analyzers, octave band filters, acoustic analysers, dosimeter, measurement of sound power, sound power measurement in a reverberant room, sound power measurement in an anechoic chamber, sound power survey measurements, measurement of the directivity factor, calibration, noise measurement procedures.

Sound power estimation - Instruments for building acoustics -Speech Interference - Sound systems and Auditorium acoustics.

10 Hours

Module 5: Noise control techniques: At source and transmission path-Barriers and Enclosures-HVAC system noise, Machinery acoustics and levels- Near field monitoring and diagnostics -Active noise control techniques. Noise control in rooms, sound absorption.

10 Hours

Course Outcomes:
After studying this course, students will:

Distinguish among different sound generation and propagation mechanisms and their representations, understand different categories of noise effects on humans.

Understand how to use pressure wave expressions to describe sound transmission in different media.

Analyze complex noise environments and predict sound levels in desired locations.

Evaluate acoustic enclosures, barriers and walls for effective noise control.

Students will become familiar with sound measurement instrumentation.

Select appropriate noise control techniques for the solution of practical noise problems and evaluate their performance.

Apply the noise control techniques considered in an integrated way to a practical design case.

Text Books:

1. J.D. Irwin and E.R.Graf, (2001), Industrial Noise and Vibration control, Prentice Hall Inc.

Reference books:

1. Bies and Colin. H. Hanson, (2001): Engg. Noise Control, E &FN SPON.
2. Noise Control Hand Book of Principles and Practices, David M.Lipsdomls Van Nostrand Reinhold Company.
3. Acoustic and Noise Control, (2000), B.J. Smith, R.J.Peters, Stephanie Owen.

4. Harris, C.K.–Handbook of Noise Control.
5. Petrusowicz and Longmore –Noise and Vibration co nt rol for industrialists
6. Thumann and Miller- Secrets of Noise control
7. R. D. Ford–Introduction to Acoustics.

8. Douglas P. Reynolds –Engineering Principles of A co ustics.

Scheme of Examination:

Two questions to be set from each module. Students have to answer five full questions, choosing one full question from each module.