# VISVESVARAYA TECHNOLOGICAL UNIVERSITY
# BELAGAVI

Scheme of Teaching and Examinations and Syllabus

**M.Tech AERONAUTICAL ENGINEERING (MAE)**

**(Effective from Academic year 2020 - 21)**

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
## Scheme of Teaching and Examinations – 2020 - 21
## M.Tech AERONAUTICAL ENGINEERING(MAE)
### Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

**I SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours per Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical | Skill Development Activities (SDA) | Duration in hours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 20MAE11 | Mathematical Modeling in Engineering. | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 20MAE12 | Aerodynamics | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 3 | PCC | 20MAE13 | Introduction to Aerospace Vehicles and Systems | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 4 | PCC | 20MAE14 | Computational Fluid Dynamics | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 5 | PCC | 20MAE15 | Finite Element Methods | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 6 | PCC | 20MAEL16 | Aerodynamic Laboratory | -- | 04 | -- | 03 | 40 | 60 | 100 | 2 |
| 7 | PCC | 20RMI17 | Research Methodology and IPR | 02 | -- | -- | 03 | 40 | 60 | 100 | 2 |
| | | | **TOTAL** | **17** | **04** | **10** | **21** | **280** | **420** | **700** | **24** |

**Note: PCC: Professional core.**

**Skill development activities:**

Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills.

The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem.

The students shall

(1) Gain confidence in modelling of systems and algorithms.

(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.

(3) Handle advanced instruments to enhance technical talent.

(4) Involve in case studies and field visits/ field work.

(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.

All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

**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 fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

**Note:** (i) Four credit courses are designed for 50 hours Teaching – Learning process.
(ii) Three credit courses are designed for 40 hours Teaching – Learning process.

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI**
**Scheme of Teaching and Examinations – 2020 - 21**
**M.Tech AERONAUTICAL ENGINEERING(MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**

**II SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/ seminar | Skill Development Activities (SDA) | Duration in hours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 20MAE21 | Aircraft Performance and Flight Mechanics | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 2 | PCC | 20MAE22 | Aerospace Propulsion | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 3 | PCC | 20MAE23 | Airframe Structures and Structural Design | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 4 | PEC | 20MAE24X | Professional elective 1 | 04 | -- | -- | 03 | 40 | 60 | 100 | 4 |
| 5 | PEC | 20MAE25X | Professional elective 2 | 04 | -- | -- | 03 | 40 | 60 | 100 | 4 |
| 6 | PCC | 20MAEL26 | Propulsion Laboratory | -- | 04 | -- | 03 | 40 | 60 | 100 | 2 |
| 7 | PCC | 20MAE27 | Technical Seminar | -- | 02 | -- | -- | 100 | -- | 100 | 2 |
| **TOTAL** | | | | **17** | **06** | **06** | **18** | **340** | **360** | **700** | **24** |

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

| **Professional Elective 1** | | **Professional Elective 2** | |
|---|---|---|---|
| **Course Code under 20MAE24X** | **Course title** | **Course Code under 20MAE25X** | **Course title** |
| 20MAE241 | Avionics | 20MAE251 | Space Mechanics |
| 20MAE242 | Helicopter Dynamics | 20MAE252 | Introduction to Data Science |
| 20MAE243 | Artificial Intelligence and Robotics | 20MAE253 | Introduction to System Engineering |
| 20MAE244 | Cryogenics | 20MAE254 | Space Craft Technology |

**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 fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI
## Scheme of Teaching and Examinations – 2020 - 21
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**III SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/ Mini –Project/ Internship | Skill Development activities (SDA) | Duration in hours | CIE Marks | SEE Marks | Total Marks | |
| 1 | PCC | 20MAE31 | Aircraft Flight Dynamics and Automatic Flight Control | 03 | -- | 02 | 03 | 40 | 60 | 100 | 4 |
| 2 | PEC | 20MAE32X | Professional elective 3 | 03 | -- | -- | 03 | 40 | 60 | 100 | 3 |
| 3 | PEC | 20MAE33X | Professional elective 4 | 03 | -- | -- | 03 | 40 | 60 | 100 | 3 |
| 4 | Project | 20MAE34 | Project Work phase -1 | -- | 02 | -- | -- | 100 | -- | 100 | 2 |
| 5 | PCC | 20MAE35 | Mini-Project | -- | 02 | -- | -- | 100 | -- | 100 | 2 |
| 6 | Internship | 20MAE36 | Internship | (Completed during the intervening vacation of I and II semesters and /or II and III semesters.) | | | 03 | 40 | 60 | 100 | 6 |
| **TOTAL** | | | | **09** | **04** | **02** | **12** | **360** | **240** | **600** | **20** |

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

| Professional elective 3 | | Professional elective 4 | |
|---|---|---|---|
| **Course Code under 20XXX32X** | **Course title** | **Course Code under 20XXX33X** | **Course title** |
| 20MAE321 | Flight Vehicle Design | 20MAE331 | Fatigue and Fracture Mechanics |
| 20MAE322 | Theory of Aeroelasticity | 20MAE332 | Aero Engine Testing and Performance Evaluation |
| 20MAE323 | Hypersonic Aerodynamics | 20MAE333 | Theory of Combustion |
| 20MAE324 | New Product Development | 20MAE334 | Introduction to Artificial intelligence and machine learning. |

**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 fail in internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI**
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**IV SEMESTER**

| Sl. No | Course | Course Code | Course Title | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/ Field work | Duration in hours | CIE Marks | SEE Marks Viva voce | Total Marks | |
| 1 | Project | 20MAE41 | 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.

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**MATHEMATICAL MODELING IN ENGINEERING**

| | | | |
|---|---|---|---|
| Course Code | 20MAE11 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Model fitting**

Introduction, Fitting models to data graphically - Analytic methods of model fitting - Chebyshev Approximation Criterion, Minimizing the Sum of the Absolute Deviations, Least-Squares Criterion, Relating the Criteria. Applying the least squares criterion- Fitting a Straight Line, Fitting a Power Curve, Transformed Least Squares Fit, Example: Vehicular stopping distance

**Module-2**

**Modelling with a differential equations**

Introduction- Population growth, Prescribing Drug Dosage, Breaking distance revisited. Graphical solutions of Autonomous differential equations, Example: Drawing a phase line and sketching solution curves, Numerical approximation methods - First-Order Initial Value Problems, Approximating Solutions to Initial Value Problems: Example 1: Using Euler's method, Example 2: A saving certificate revisited.

**Module-3**

**Ordinary Differential Equations:** Solving ODE"s using: Picard's method, Runge Kutta fourth order, Runge Kutta Fehlberg method, Stiffness of ODE using shooting method, Boundary value problems.

**Module-4**

**Partial Differential Equations:** Classification of second order Partial Differential Equations. Solution of One dimensional wave equation,(Schmidt`s explicit formula), One dimensional heat equation by Schmidt method, Crank- Nicholson method, and Du Fort-Frankel method.

**Module-5**

**Sampling Theory:** Testing of hypothesis using t and $\chi^2$ test, Goodness of fit. F-test, Analysis of Variance: One – way with/without interactions, problems related to ANOVA, Design of experiments, RBD.

**Course outcomes:**

At the end of the course the student will be able to:

1. Acquire the idea of significant figures, types of errors during numerical computation.
2. Develop the mathematical models of thermal system using ODE's and PDE's.
3. Learn the deterministic approach for statistical problems by using probability distributions.
4. Demonstrate the validity of the hypothesis for the given sampling distribution using standard tests and understand the randomization on design of experiments.
5. Classify and analyze mathematical tools applied to thermal engineering study cases.

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | A First course in Mathematical modeling | Frank.R.Giordano, Maurice.D.Weir, Willium.P.Fox | China machine press | 2003 |
| 2 | Numerical methods for Scientific and Engg computation | M K Jain, S.R.K Iyengar, R K. Jain | New Age International | 2003 |
| Reference Books | | | | |
| 1 | Higher Engineering Mathematics | B.S. Grewal | Khanna Publishers | 2017 |
| 2 | Probability and Statistics for Engineers and Scientists | R.E, Walpole, R.H.Myres, S.L.Myres and Keying Ye | Pearson | 2012 |
| 3 | Probability and Statistics in Engineering | William W.H., Douglas C.M., David M.G.and Connie M.B | Wiley | 2008 |
| 4 | Advanced Engineering Mathematics | C. Ray Wylie and Louis C Barrett | McGraw-Hill | 1995 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**AERODYNAMICS**

| | | | |
|---|---|---|---|
| Course Code | 20MAE12 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Basics of Aerodynamics:** Properties of fluids, Characteristics of Atmosphere, Type of fluid flows, Generation of Lift, Drag and Moment, Incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution, Streamlined and bluff-body, Reynolds number and Mach number, Conservation law of mass and momentum, Euler and Bernoulli's equations, pitot-tube measurement of airspeed. Pressure coefficient. Streamlines, path lines and streak lines. Angular velocity, vorticity, circulation Stream function, velocity potential and their relationship. Governing equation for irrotational and incompressible fluid flow.

**Module-2**

**Aerodynamics of airfoils and wings:** Airfoil nomenclature and classification, Low speed aerodynamic characteristics of symmetric and cambered airfoils, Centre of pressure, aerodynamic centre and aerodynamic moment, Concept of point vortex, line vortex and vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory and symmetric airfoil. Finite wing nomenclature. Incompressible flow over wing, vortex filament, bound vortex, horse shoe vortex, downwash, induce angle of attack and drag. Type of drag.Biot-Savart law and Helmholtzs vortex theorem. Prandtls lifting line theory and limitations. Elliptic lift distributions, expression for induced angle of attack and induce drag. Two dimensional and three dimensional wings lift curve slope and effect of aspect ratio. High lift devices.

**Module-3**

**High speed Aerodynamics:** Fundamentals of thermodynamic concepts, conservation of energy. Speed of sound, Mach wave and Mach angle. Normal shock wave, Oblique shock wave, Expansion fan, Prandtl-Meyer expansion. Family of shocks. Flow through convergent divergent nozzle. Hodograph and pressure turning angle. Rankine-Hugoniot relation.

**Module-4**

**Compressible flow over airfoil:** Full velocity potential equation. Small perturbation theory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing.

**Module-5**

**One dimensional flow through constant area duct:** Fanno flow and fanno line, Rayleigh flow and Rayleigh line. Method of characteristics and its application. Flow past Wedge and cone.

**Course outcomes:**

At the end of the course the student will be able to:

1. Solve aerodynamic problems related to pressure distribution and pressure coefficients
2. Demonstrate knowledge of compressible flows to solve one dimensional flows through constant area ducts
3. Solve problems related to normal and oblique shock waves

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Fundamentals of Aerodynamics | John D. Anderson | McGraw-Hill publication | 5th edition and 2010 |
| 2 | Modern compressible flow | John D. Anderson | McGraw-Hill publication | 3rd edition and 2002 |
| **Reference Books** | | | | |
| 1 | Aerodynamics for Engineering students | E L Houghton and P W Carpenter | Edward Arnold publication | 7th edition and 2016 |
| 2 | Fundamentals of compressible flow | Yahya, S M. | New Age International | 5th edition and 2016 |
| 3 | Introduction to flight | John D. Anderson | McGraw-Hill publication | 6th Edition And 2008 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS**

| | | | |
|---|---|---|---|
| Course Code | 20MAE13 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**General introduction to aeronautics:** Fixed wing & Rotary wing aircraft: Light aircraft, Fighter aircraft, Passenger aircraft, and Cargo aircraft; Light helicopter, Large passenger and cargo helicopters Exploded views of various types of aircraft, identification of various structural parts and their functions and materials used.
**Aircraft Systems:** System design and development processes; **Mechanical systems:** Components and functions of Hydraulics & Landing Gear systems.

**Module-2**

**Aircraft Electrical Systems:** Generation, distribution and typical aircraft electrical systems and recent trends; **Avionic systems:** Flight control systems; Navigation system, Communication and radar systems their components and functions; Emergency systems and advanced systems. **Satellites & orbital dynamics:** Satellite missions, Different types of satellites and their applications, Spacecraft configurations.

**Module-3**

**Spacecraft Launch Vehicles:** Rocket propulsion principles and types and propellants; Sounding Rockets, Staging of rockets; major subsystems of launch vehicles and their functions; Different types of satellite launch vehicles, General description about Launch Vehicles of Indian origin.

**Module-4**

**Standards & Specifications and Testing & Certification Aspects:** Introduction to aircraft international and standards specifications for Military and Civil aircraft, Company standards; Airworthiness certification aspects aircraft; Ground testing and qualification testing.

**Flight testing:** Purpose and scope, Test plans and procedures; flight test instrumentation; general flying and handling characteristics of aircraft; Preparation, and conduct of tests, fault reporting.

**Module-5**

**Introduction to aerospace industries and institutions and their roles:** Aircraft design and production industries; Components and systems manufactures, Service industries, Research and Development organizations and Academic institutions.

**Introduction to Airport Engineering:** Development of air transportation, ICAO, IAAI,AAI, Aircraft characteristics which affect airport planning; Airport planning: Airport Master Plan, Regional Plan, Site selection; Terminal area and airport layout, Visual aids and ATC.

**Course outcomes:**
At the end of the course the student will be able to:

1. Apply the knowledge to aircraft system layouts
2. Demonstrate knowledge of standards and specifications for design of aircraft
3. Draw test plan and specify flight test instrumentation for flight test programs

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Aircraft Production Technology and Management | ChennaKeshu S and Ganapathy K K | Interline Publishing | 2nd edition & 1993 |
| 2 | Aircraft Systems, mechanical, electrical and avionics subsystems integration | Ian Moir and Allan Seabridge | Professional Engineering Publishing Limited | 3rd edition & 2011 |
| **Reference Books** | | | | |
| 1 | Flight Testing of Fixed wing Aircraft | Ralph D Kimberlin | AIAA Education Series | 1st Edition & 2003 |
| 2 | Principles of Helicopter Aerodynamics | J. G. Leishman | Cambridge Aerospace series | 2nd Edition & 2005 |
| 3 | Airport Planning and Design | K Khanna, M G Arora and S S Jain | NEM Chand and Brothers, Roorki | 6th Edition &1999 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**COMPUTATIONAL FLUID DYNAMICS**

| | | | |
|---|---|---|---|
| Course Code | 20MAE14 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction:** CFD ideas to understand, CFD Application, Governing Equations (no derivation) of flow; continuity, momentum, energy. Conservative & Non-conservative forms of equations, Integral vs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting, Physical Boundary conditions. **Mathematical Behavior of Partial Differential Equations and Discretization:** Classification of partial differential equations and its Impact on computational fluid dynamics; case studies. Essence of discretization, order of accuracy and consistency of numerical schemes, Lax's Theorem, convergence, Reflection Boundary condition.

**Module-2**

**Mathematical Behavior of Partial Differential Equations and Discretization:** Higher order Difference quotients. Explicit & Implicit Schemes. Error and analysis of stability, Error Propagation. Stability properties of Explicit & Implicit schemes. **Solution Methods of Finite Difference Equations:** Time & Space Marching. Alternating Direction Implicit (ADI) Schemes. Relaxation scheme, Jacobi and Gauss-Seidel techniques, SLOR technique. Lax-Wendroff first order scheme, Lax-Wendroff with artificial viscosity, upwind scheme, midpoint leap frog method**.**

**Module-3**

**Grid Generation:** Structured Grid Generation: Algebraic Methods, PDE mapping methods, use of grid control functions, Surface grid generation, Multi Block Structured grid generation, overlapping and Chimera grids. Unstructured Grid Generation: Delaunay-Voronoi Method, advancing front methods (AFM Modified for Quadrilaterals, iterative paving method, Quadtree & Octree method).

**Module-4**

**Adaptive Grid Methods:** Multi Block Adaptive Structured Grid Generation, Unstructured adaptive Methods. Mesh refinement methods, and Mesh enrichment method. Unstructured Finite Difference mesh refinement. **Approximate Transformation & Computing Techniques:** Matrices & Jacobian. Generic form of governing Flow Equations with strong conservative form in transformed space. Transformation of Equation from physical plane into computational Plane -examples. Control function methods. Variation Methods. Domain decomposition. Parallel Processing.

**Module-5**

**Finite Volume Techniques:** Finite volume Discritisation-Cell Centered Formulation. High resolution finite volume upwind scheme Runge-Kutta stepping, Multi-Step Integration scheme. Cell vertex Formulation. Numerical Dispersion. **CFD Application to Some Problems:** Aspects of numerical dissipation & dispersion. Approximate factorization, Flux Vector splitting. Application to Turbulence-Models. Large eddy simulation, Direct Numerical Solution. Post-processing and visualization, contour plots, vector plots etc.

**Course outcomes:**

At the end of the course the student will be able to:

1. Develop grids around given shapes and transform the physical domain in to computational domain
2. Develop adaptive structured and unstructured grids
3. Apply knowledge to solve CFD problems through finite difference and finite volume techniques

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

| **Textbook/ Textbooks** | | | | |
|---|---|---|---|---|
| **Sl No** | **Title of the book** | **Name of the Author/s** | **Publisher Name** | **Edition and year** |
| 1 | Computational Fluid Dynamics | John D Anderson Jr | McGraw Hill International | 2nd edition &1995 |
| 2 | Computational Fluid Dynamics | T J Chung | Cambridge University Press | 2nd edition &2008 |
| **Reference Books** | | | | |
| 1 | Computational Fluid Dynamics - An Introduction | F. Wendt | Springer | 3rd edition &2009. |
| 2 | Numerical Computation of Internal and External Flows, Vols. I and II | Charles Hirsch | John Wiley & Sons, New York | 1st edition &1988. |
| 3 | Computational Fluid Dynamics- A Practical Approach | JiyuanTu, Guan HengYeoh, and Chaoqun Liu | Elsevier Inc | 2008 |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**FINITE ELEMENT METHODS**

| | | | |
|---|---|---|---|
| Course Code | 20MAE15 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction to Finite Element Method, One-Dimensional Elements-Analysis of Bars:**
Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design., Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods. Basic Equations and Potential Energy Functional, 1-0 Bar Element, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, 2-D Bar Element.

**Module-2**

**Two-Dimensional Elements-Analysis, Three-Dimensional Elements-Applications and Problems:** Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8) . Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for Higher Order Elements.

**Module-3**

**Aero Structural analysis through FEM for Beams and Trusses:** 1–D Beam Element, 2–D Beam Element, shape functions and stiffness matrixes, Problems, trusses with one, two, three and four bar elements.

**Module-4**

**FEM analysis of Heat Transfer and Fluid Flow:** Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.

**Module-5**

**FEM for Dynamic:** Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

**Course outcomes:**
At the end of the course the student will be able to:

1. Demonstrate the ability to evaluate and interpret FEA analysis results
2. Solve structural applications like truss, beam, and frame
3. Apply and use of the FE method for heat transfer problems

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Finite Elements in engineering | Chandrupatla | PHI | 2nd Edition &2007 |
| 2 | Finite Elements Analysis | Lakshminarayana H. V | Universities Press, | 2004 |
| **Reference Books** | | | | |
| 1 | Finite Elements Method in Engineering | Rao S. S | Elsevier | 4th Edition, 2006. |
| 2 | Textbook of Finite Element Analysis | P.Seshu, | PHI, | 2004 |
| 3 | Finite Element Method | J.N.Reddy | McGraw -Hill International Edition | 3rd edition &2005 |
| 4 | Finite Elements Procedures | Bathe K. J | PHI | 2007 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**AERODYNAMICS LAB**

| | | | |
|---|---|---|---|
| Course Code | 20MAEL16 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 0:0:4 | SEE Marks | 60 |
| Credits | 02 | Exam Hours | 03 |

| Sl. NO | Experiments |
|---|---|
| 1 | Calibration of test section of a subsonic wind tunnel. |
| 2 | Smoke flow visualization on a wing model at different angles of incidence at low speeds. |
| 3 | Tuft flow visualisation on a wing model at different angles of incidences at low speeds: Identify zones of attached and separated flows |
| 4 | Surface pressure distribution around building models in multiple model arrangement |
| 5 | Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag. |
| 6 | Calculation of total drag of a cambered airfoil at a low incidence using pitot-static probe wake survey. |
| 7 | Measurement of typical boundary layer velocity profile on the wind tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness in the presence of a circular cylinder model. |
| 8 | Study the effect of Blockage ratio on drag & pressure distribution of a circular cylinder. |
| 9 | Determination of turbulence level in a low speed wind tunnel. |
| 10 | Study of pressure distribution on hemispherical objects. |
| 11 | Study on internal/external flow distribution of hollow tube structure. |
| 12 | Conduct a series of test to obtain the stagnation pressure response of pitot probe in a wind tunnel for varied yaw angle and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle. |
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| **Course outcomes:**<br>At the end of the course the student will be able to:<br>1. Demonstrate various experimental facilities<br>2. Explain the use of different sensors and measurement techniques<br>3. Perform the test, acquire the data and analyse and document<br>. |
| |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -I**

**RESEARCH METHODOLOGY AND IPR**

| | | | |
|---|---|---|---|
| Course Code | 20RMI17 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 2:0:0 | SEE Marks | 60 |
| Credits | 02 | Exam Hours | 03 |

**Module-1**

**Research Methodology:** Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.
**Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

**Module-2**

**Reviewing the literature:** Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.
**Research Design:** Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs.

**Module-3**

**Design of Sampling:** Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.
**Measurement and Scaling:** Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.
**Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

**Module-4**

**Testing of Hypotheses:** Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.
Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

**Module-5**

**Interpretation and Report Writing:** Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.
**Intellectual Property:** The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention onBiological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition,

Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

**Course outcomes:**

At the end of the course the student will be able to:

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

**Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Research Methodology: Methods and Techniques | C.R. Kothari, Gaurav Garg | New Age International | 4th Edition, 2018 |
| 2 | Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module 2) | Ranjit Kumar | SAGE Publications | 3rd Edition, 2011 |
| 3 | Study Material (For the topic Intellectual Property under module 5) | Professional Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament, September 2013. | | |
| **Reference Books** | | | | |
| 1 | Research Methods: the concise knowledge base | Trochim | Atomic Dog Publishing | 2005 |
| 2 | Conducting Research Literature Reviews: From the Internet to Paper | Fink A | Sage Publications | 2009 |

*** END ***

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**AIRCRAFT PERFORMANCE AND FLIGHT MECHANICS**

| | | | |
|---|---|---|---|
| Course Code | 20MAE21 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Aircraft Performance:** Aviation history. Principles of Flight. Aircraft aerodynamics; Drag and Thrust. Steady and level Flight. Variation of Thrust, Drag, Power available, and Power required with speed and altitude. Minimum drag, minimum power, Maximum and minimum level flight speeds. Simple problems.

**Module-2**

**Steady Performance:** Airplane Steady Performance: General equation of motion, Steady level flight performance, Steady Climbing, Gliding Flights; Minimum rate of sink and range in a glide. Range and Endurance of jet and piston prop airplanes.

**Accelerated Performance:** Estimation of take-off and landing distances. Ground effect, Balanced Field Length. Turn performance; Bank angle, load factor, pull-up & pull-down maneuver; accelerated climbing, V-n diagram.

**Module-3**

**Static Longitudinal Stability and Control:** Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- Propeller airplane and Jet airplane. Trim condition. Static margin. stick fixed neutral points. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing, Restriction on forward C.G. range, Hinge moment parameters, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G.

**Module-4**

**Static Directional Stability and Control:** Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition, Weather cocking effect.

**Static Lateral Stability and Control:** Introduction, definition of Roll stability. Estimation of dihedral effect., Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron.

**Module-5**

**Dynamic Longitudinal Stability:** Definition of Dynamic longitudinal stability: types of modes of motion: long or phugoid motion, short period motion. Airplane Equations of longitudinal motion, Derivation of rigid body equations of motion, Orientation and position of the airplane, gravitational and thrust forces, Small disturbance theory.

**Dynamic Lateral and Directional Stability:** Routh's criteria. Factors affecting period and damping of oscillations. Effect of wind shear.

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply knowledge to calculate steady and accelerated performance of airplanes
2. Solve problems of static stability for stick fix and stick free conditions
3. Model dynamic stability for rigid airframes

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Introduction to Flight | Anderson J.D | McGraw Hill | 7th edition &2011 |
| 2 | Airplane Performance, stability and Control | Perkins, C.D., and Hage, R.E | John Wiley & Sons Inc, New York, | 1988 |
| **Reference Books** | | | | |
| 1 | Aerodynamics, Aeronautics and Flight Mechanics | McCormick B.W., | John Wiley & Sons New York | 1979 |
| 2 | Flight Performance of Aircraft, | Ojha S.K. | AIAA Education Series | 1995. |
| 3 | Performance, Stability, Dynamics and Control of Airplanes | Bandu N. Pamadi | AIAA | 2nd Edition Series,2004 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**AEROSPACE PROPULSION**

| | | | |
|---|---|---|---|
| Course Code | 20MAE22 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction to propulsive devices:** Air breathing and non-air breathing systems. Atmospheric Properties. Reciprocating Engine Construction & Nomenclature; Engine Performance theory &Performance. Propeller theory. Aircraft engine health monitoring techniques**.**

**Module-2**

**Gas turbine engines:** turbojet, Turbofan, Turboprop, Turbo-shaft engine Construction and Nomenclature, theory and performance, dump diffusers for modern aircraft engines. Gas turbine engine fuel and fuel systems: Nomenclature, Operation and Control system. Description & Analysis of rotating components, Compressors, Turbines & matching.

**Module-3**

**Elements of Chemical Rocket Propulsion:** Classification & fundamentals. Fuels and propellants. Fuel cells for space mission. Rocket combustion processes.

**Module-4**

**Solid propellant rocket description:** performance & estimation, Flame spread and Ignition transient. Mechanical characterization of propellants. Grain design. Burn rate estimation.

**Module-5**

**Liquid propellant rocket description:** performance & estimation. Injectors. Cooling. Systems. Combustion instabilities.
**Hybrid propellant rocket description:** performance & estimation, Mission requirements & Power plant selection. Ramjet and Scramjet engines. Introduction to Space mission.

**Course outcomes:**
At the end of the course the student will be able to:

1. Explain construction and operation of various propulsion devices
2. Solve problems related to combustion
3. Specify space mission propulsion requirements

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Aircraft power plants | Michael J Kroes and Thomas W Wild, | Macmillan/McGraw Hill NY | 8th edition &2013 |
| 2 | Rocket Propulsion Elements | George P Sutton and Donald M Ross | John Wiley & Sons NY | 1957 |

| Reference Books | | | | |
|---|---|---|---|---|
| 1 | Aerospace Propulsion | Dennis G Shepherd | American Elsovier Publishing Co Inc | |
| 2 | Aircraft Gas Turbine Engine Technology | E. Irwin Treager | McGraw Hill Education | 3rd Edition 1995 |
| 3 | Mechanics & Thermodynamics of Propulsion | Hill, P.G. & Peterson | C.R. Addison – Wesley Longman INC | 1999 |
| 4 | Rocket Propulsion | Barrere et al | Elsevier Co | 1960 |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**AIRFRAME STRUCTURES AND STRUCTURAL DESIGN**

| | | | |
|---|---|---|---|
| Course Code | 20MAE23 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Fundamentals of structural analysis and structural components of aircraft:** Basic elasticity, Two dimensional problems in elasticity, Loads on structural components, function of structural components, fabrication of structural components, connections, numerical. **Statically determinate and indeterminate structures as applied to aircraft structures:** Statically determinate: Equilibrium of force systems, truss structures, externally braced wings, landing gear, beams – shear and moments, torsion-stresses and deflection. Statically indeterminate structures: Bending moment in frames and rings by elastic centre method, Continuous structure– moment distribution method. Numerical problems

**Module-2**

**Introduction to practical aircraft stress analysis:** Introduction to wing stress analysis by modifies beam theory, Introduction to fuselage stress analysis by modified beam theory, Loads and stresses on ribs and frames. numerical problems

**Module-3**

**Buckling and stability as applied to aircraft structures:** Introduction, columns and beam columns, crippling stress, buckling of this sheets, Thin skin-stringer panels, skin-stringer panels, Integrally stiffened panels, numerical problems, **Overview of structural design process:** Structural integrity, Material and mechanical properties, failure theories, Design criteria- safe life and fail safe, Designing against fatigue, prediction of aircraft fatigue life.

**Module-4**

**Wing box structure and Fuselage:** Introduction, wing box design, wing covers, spars, Ribs and bulkheads, wing root joints, variable swept wings, wing fuel tank design. Fuselage: Introduction, fuselage configuration, fuselage detail design, forward fuselage, wing and fuselage intersection, stabilizer and aft fuselage intersection, fuselage opening.

**Module-5**

**Empennage structure, Landing gear and engine mounts: Landing gear:** Empennage structure: introduction, Horizontal stabilizer, vertical stabilizer, elevator and rudder. Introduction, developments and arrangements, stowage and retraction, detail design. Engine mounts: Introduction, propeller driven engine mounts, inlet of jet engines, wing-pod (pylon) mounts, rear fuselage mounts and tail mounts, fuselage mounts (fighters)

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply fundamentals of structural analysis of airframe parts
2. Demonstrate knowledge of structural design process, and various failure theories
3. Model airframe life assessment and design against fatigue

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Aircraft structures for engineering | T.H.G.Megson, | Butterworth- | 4th edition |
| 2 | Analysis and design of flight vehicle structures | E.F.Bruhn | Jacobs Publishing, Inc, USA | 1973. |
| **Reference Books** | | | | |
| 1 | Airframe structural design | Michael Chun-Yung Niu | Lockheed Aeronautical | February 2002 |
| 2 | Aircraft Structures | D.J. Peery | Dover Publications | 2011 |
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**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**AVIONICS**

| | | | |
|---|---|---|---|
| Course Code | **20MAE241** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction:** Importance and role of avionics, avionic environment, Regulatory and advisoryagencies. **Displays and man-machine interaction:** Head up displays, helmet mount displays, discussion of HUDs vs. HMDs, Head down displays, data fusion, intelligent displays management, Displays technology, control and data entry, instrument placement.

**Module-2**

**Navigation and Air data Systems:** Types of Navigation systems, Inertial navigation principals, platform axis, gyro compassing, position determining using GPS, differential GPS.
**Inertial reference systems:** Gyros and accelerometers, attitude derivation. RMI, HIS, ADI.
**Air data and Air data systems:** Air data measurements-density altitude, pressure-altitude, pressure-speed, calibrated air speed, air data sensors.

**Module-3**

**Surveillance systems:** Air traffic control, Primary radar, Secondary radar, Replies, Various system modes, error checking, Transponders of ATCCRB & Mode S, Collision avoidance, Lightning detection, Weather radar. **Airborne communications systems:** VHF AM Communications, VHF Communications hardware, High frequency communications, ACARS, SELCAL, Digital Communications and Networking, VHF Digital communications, Data link Modes.

**Module-4**

**Auto Pilots and Flight Management Systems**: Autopilots, Height control, heading control, ILS coupled autopilot, ILS localizer coupling loop, satellite landing guidance system.
Flight management system-Accurate Navigation sources, flight planning, navigation and guidance, Flight –path optimization and prediction.

**Module-5**

**Avionic Systems Integration**: Avionics equipment fit. Data Bus Systems-Electrical data bus MIL-STD-1553 and optical data bus system. Integrated modular avionics architectures. Commercially off-the shelf (COTS) hardware. UAV avionics.

**Course outcomes:**
At the end of the course the student will be able to:

1. Apply knowledge of man-machine interface in newer designs.
2. Demonstrate application of avionics instruments & Communication equipments.
3. Model System integration.

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Introduction to Avionics Systems | R.P.G. Collinson | Springer | 3rd edition, 2011 |

| | | | | |
|---|---|---|---|---|
| 2 | Principals of Avionics | Albert Helfrick | Avionics Communications Inc; | 5 edition (2009) |
| **Reference Books** | | | | |
| 1 | Avionics Systems | Middleton,D.H.,Ed., | Longman Scientific and Technical | 1989 |
| 2 | Digital Avionic Systems | Spitzer,C.R | McGraw-Hill Inc | 2nd edition, 1992 |
| 3 | Aircraft Communications and Navigation Systems | Mike Tooley and David Wyatt | Butterworth Heinemann. | 2007 |
| 4. | Manual of Avionics | Brain Kendal | The English Book House, New Delhi, | 3rd Edition, 1993 |
| | | | | |

| **M.TECH AERONAUTICAL ENGINEERING (MAE)**<br>**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**<br>**SEMESTER -II** | | | |
|---|---|---|---|
| **HELICOPTER DYNAMICS** | | | |
| Course Code | **20MAE242** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction:** History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation.

**Blade Element Analysis:** Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, lead/lag hinge, and drag hinge.

**Module-2**

**Basic Helicopter Performance**: Forces acting on helicopters in forward flight. Methods of achieving translatory flight. Controlling cyclic pitch: Swash-plate system. Lateral tilt with and without conning. Lateral and longitudinal asymmetry of lift in forward flight. Forward flight performance- total power required, effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects.

**Module-3**

**Rotor Airfoil Aerodynamics:** Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range.

**Rotor Wakes and Blade Tip Vortices:** Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake.

**Module-4**

**Helicopter Stability and Control.** Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional and directional. Dynamic stability aspects. Main rotor and tail rotor control. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities.

**Flight Testing**- General handing flight test requirements and, basis of limitations.

**Module-5**

**Standards, and Specifications:** Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification.

**Conceptual Design of Helicopters:** Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply the basic concepts of helicopter dynamics.
2. Compute the critical speed by using various methods.
3. Distinguish the turborotor system stability by using transfer matrix and finite element formulation.

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Principles of Helicopter Aerodynamics | J. Gordon Leishman | Cambridge University Press | 2002 |
| 2 | Dynamics of Helicopter Flight | George H. Saunders | John Wiley & Sons, Inc, NY | 1975 |
| **Reference Books** | | | | |
| 1 | Rotary Wing Aerodynamics | W Z Stepniewski and C N Keys | Dover Publications Inc, New York | 1984 |
| 2 | Helicopter Dynamics | ARS Bramwell, George Done, and David Balmford | Butterworth-Heinemann Publication | 2nd Edition 2001 |
| 3 | Basic Helicopter Aerodynamics | John, M. Seddon and | Wiley | 2011 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**Artificial Intelligence and Robotics**

| | | | |
|---|---|---|---|
| Course Code | **20MAE243** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction & Propositional Logic:** History of AI, Propositional logic-Computability & Complexity, Applications, Ist Order Predicate logic, limitations of logic.

**Module-2**

**Logic Programming:** Prolog system & Implementation, Execution control, Constraint Logic programming, Planning and examples.

**Module-3**

**Machine Learning and Data Mining:** Data analysis, learning rule, nearest neighbor method, Decision tree learning, Clustering-Distance matrices, Hierarchical learning.

**Module-4**

**Neural Networks**: Mathematical Model, Neural anociative memory, spelling correction program, support vector machine, application of deep learning, application of neural network.

**Module-5**

**Robotics:** Introduction, Mathematical representation of robots, kinematics of serial manipulators, kinematics of parallel manipulators, Dynamics of manipulators.

**Course outcomes:**
At the end of the course the student will be able to:

1. Apply the propositional logic in Artificial Intelligence.
2. Perform Data Mining.
3. Model Neural Network and Robotic Kinematics

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Introduction to Artificial Intelligence | Wolfgang Ertel | Springer | 2017 |
| 2 | Robotics-Fundamental Concepts and Analysis | Ashitara Ghosal | Oxford Press | 2006 |
| **Reference Books** | | | | |
| 1 | Artificial Intelligence and Machine Learning | Vinod Chandra S.S., and Anand Hareendran S | PHI Learning Pvt. Ltd | 2014 |
| 2 | Introduction to Robotics-Analysis, Control, Application | Saeed B Niku | Wiley | 2011 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**CRYOGENICS**

| | | | |
|---|---|---|---|
| Course Code | **20MAE244** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction to Cryogenic Engineering:**
Thermophysicalandfluiddynamicpropertiesofliquidandgashydrogen,Thermophysicalandfluiddynamicpropertiesofliquidandgashelium,Liquefactionsystemsofhydrogenandheliumgases,Liquefactionsystemsofhydrogenandheliumgases, Refrigerationandliquefactionprincipals;JouleThomsoneffectandinversioncurve;Adiabaticandisenthalpicexpansionwiththeircomparison.

**Module-2**

**Properties:** Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative - Linde - Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative - Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.

**Module-3**

**Cryogenic Insulation:**
Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.

**Module-4**

**Storage and Instrumentation of Cryogenic liquids:**
Designconsiderationsofstoragevessel;Dewarvessels;Industrialstoragevessels;Storageofcryogenicfluidsinspace;TransfersystemsandLinesforcryogenicliquids;Cryogenicvalvesintransferlines;TwophaseflowinTransfersystem;Cool-downofstorageandtransfersystems,Measurementofstrain,pressure,flow,liquidlevelandTemperatureincryogenicenvironment;Cryostats.

**Module-5**

**Cryogenic Equipment:**
Cryogenic heat exchangers-recuperative and regenerative; Variables affecting heat exchanger and system performance; Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component inefficiencies; System Optimization, Magneto-caloric refrigerator; 3He-4He Dilution refrigerator; Cryopumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport.

**Course outcomes:**
At the end of the course the student will be able to:

1. Recognize the basic of cryogenic engineering.
2. Identify the storage and instrumentation required for cryogenic liquids.
3. Classify the types of cryogenic equipments.

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Cryogenic Engineering Intelligence | T.M.Flynn, MarcelDekker | CRC Press | 2nd edition, 2004 |

| | | | | |
|---|---|---|---|---|
| 2 | Cryogenics: Applications and Progress | A.Bose and P.Sengupta | Tata McGraw Hill | 1987 |
| **Reference Books** | | | | |
| 1 | Handbook of Cryogenic Engineering | J.G.Weisend | CRC Press | 1st edition,1998 |
| 2 | Cryogenic Systems | R.Barron | McGraw-Hill Inc | 1967 |
| 3. | Cryogenic Process Engineering | K.D.Timmerhaus and T.M.Flynn | Plenum Press, | 1st edition,2013 |
| 4. | Applied Cryogenic Engineering | R.W.Vance and W.M.Duke | John Wiley &sons | 1962 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**SPACE MECHANICS**

| | | | |
|---|---|---|---|
| Course Code | **20MAE251** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Space Environment:** Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite life time.

**Module-2**

**Basic Concepts and the General N-Body:** The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, the many body problem, Lagrange-Jacobi identity, the circular restricted three body problem, libration points, the general N-body problem, two body problem, relations between position and time.

**Module-3**

**Satellite Injection and Satellite Perturbations**: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

**Module-4**

**Interplanetary Trajectories**: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.

**Module-5**

**Ballistic Missile Trajectories:** Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights , time of flight, re-entry phase, the position of impact point, influence coefficients.

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply the basic concepts of space mechanics and the general N-body.
2. Explain satellite injection and satellite orbit perturbations.
3. Distinguish between interplanetary and ballistic missile trajectories

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Rocket Propulsion and Space Dynamics | Cornelisse, J.W. | W.H.Freeman&co | 1984 |
| 2 | Introduction to Space Dynamics | Thomson, | Dover Publications, Revised edition | 2012 |
| **Reference Books** | | | | |
| 1 | Elements of Astromechanics | Vande Kamp, P., | Pitman | 1979 |
| 2 | Space Flight Dynamics | Willian E. Wiesel | Create Space Independent Publishing Platform | 3rd Edition 2010 |
| 3 | Rocket Propulsion Elements | George P. Sutton and | Wiley India | 7th edition, |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**INTRODUCTION TO DATA SCIENCE**

| | | | |
|---|---|---|---|
| Course Code | **20MAE252** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Introduction**
What is Data Science? - Big Data and Data Science hype - Current landscape of perspectives - Skill sets needed, Statistical Inference - Populations and samples - Statistical modeling, probability distributions, fitting a model - Introduction to R

**Module-2**

**Exploratory Data Analysis and the Data Science Process**
Basic tools (plots, graphs and summary statistics) of EDA - Philosophy of EDA - The Data Science Process - Case Study, Three Basic Machine Learning Algorithms - Linear Regression - k-Nearest Neighbors (k-NN) - k-means , Data Wrangling

**Module-3**

**Feature Generation and Feature Selection** (Extracting Meaning from Data)
Feature Selection algorithms – Filters; Wrappers; Decision Trees; Random Forests, Recommendation Systems, Dimensionality Reduction - Singular Value Decomposition - Principal Component Analysis

**Module-4**

Mining Social-Network Graphs - Social networks as graphs - Clustering of graphs - Direct discovery of communities in graphs - Partitioning of graphs - Neighbourhood properties in graphs

**Module-5**

**Data Visualization**
Basic principles, ideas and tools for data visualization, Examples of inspiring (industry) projects, Data Science and Ethical Issues - Discussions on privacy, security, ethics - A look back at Data Science - Next-generation data scientists

**Course outcomes:**
At the end of the course the student will be able to:

1. To apply data science and related skill sets
2. To understand Statistical Inference, probability distributions commonly , statistical modeling and model fitting
3. Apply R to carry out basic statistical modeling and analysis.
4. Apply exploratory data analysis (EDA) in data science.
5. To Apply the data science process

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Doing Data Science, Straight Talk From The Frontline. | Cathy O'Neil and Rachel Schutt | O'Reilly Media | 2014 |
| 2 | Mining of Massive Datasets. v2.1 | Jure Leskovek, Anand Rajaraman and Jeffrey Ullman | Cambridge University Press | 2014 |
| **Reference Books** | | | | |
| 1 | Machine Learning: A Probabilistic Perspective | Kevin P. Murphy | MIT Press | 2012 |
| 2 | Data Science for Business | Foster Provost and Tom Fawcett | O'Reilly Media | 2013 |
| 3 | Foundations of Data Science | Avrim Blum, John Hopcroft and Ravindran Kannan | Cambridge University Press | 2020. |
| 4 | Data Mining and Analysis: Fundamental Concepts and Algorithms | Mohammed J. Zaki and Wagner Miera Jr | Cambridge University Press | 2014. |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**INTRODUCTION TO SYSTEM ENGINEERING**

| | | | |
|---|---|---|---|
| Course Code | **20MAE253** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

Systems engineering – what is, origin, and examples Systems engg as a profession Power of systems engg and examples Systems engg viewpoint, perspectives, domains Systems engg fields, approaches, activities, and products

Complex system structure-building bloc s, hierarchy, interfaces Complex system structure-environment, interactions, complexity System development process – life cycle, evolutionary characteristics Systems engg method Systems testing throughout development

**Module-2**

Managing systems development, risks, workbreak down structure (WBS), systems engg management plan (SEMP) Systems risk management, organizing for systems engg Need analysis – originating, operations, functional, and feasibility Need validation, systems ops requirement System requirements development, performance requirements

Implementing concept exploration, validating requirements Concept definition – selection and validation, functional analysis and allocation Systems architecture, system modeling languages, Model-Based Systems Engg (MBSE) Decision making, modeling for decisions Simulation, Trade-of analysis

**Module-3**

Engg development stage – program risk reduction, prototype development for risk mitigation Development testing, risk reduction Revision of functional analysis and design Overview of probability data analysis Hypothesis testing

Engineering design – implementing system building bloc s, component design, validation, change management Concepts of reliability, redundancy Concepts of maintainability, availability, reducibility User interface design and GUI

**Module-4**

Integration, testing and evaluating total system Test planning and preparation, system integration Developmental and operational test and evaluation Engineering for production, transition from development to production operations – 1

**Module-5**

Production operation - 2 Installation, maintenance and upgrading Installation testing In-service support Upgrades and modernization.

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply the concept to develop systems engineering plan for a realistic project.
2. Review the applicability of the proposed process, methodology for systems engineering using the fundamental concepts
3. Execute the system engineer's role and responsibilities.
4. Apply systems engineering tools to realistic problems
5. Recognize the value and limitations of modeling and simulation.

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Introduction to systems Engineering | Andrew P. Sage, James E. Armstrong Jr. | Wiley | 2001. |
| 2 | Systems Engineering: Principles and Practice | Alexander Kossiakoff | Wiley | 2002 |
| **Reference Books** | | | | |
| 1 | Introduction to systems Engineering | Ian Faulconbridge | Argos Press | 2015 |
| 2 | Systems Engineering and Analysis | Benjamin S. Blanchard, Wolter J. Fabrycky. | Prentice Hall | 1998 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**Spacecraft Technology**

| | | | |
|---|---|---|---|
| Course Code | 20MAE254 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Spacecraft Environment & Design Consideration:** Orbit definition /Mission Requirements of LEO, GEO, GTO & HEO, Lunar orbits, IPO with respect to Power Generation, Power System Elements, Solar aspect angle Variations.

**Power Generation:** Study of Solar spectrum, Solar cells, Solar Panel design, Solar Panel Realization, Solar Panel testing, Effects of Solar cells and panels (IR, UV, Particles)

**Module-2**

**Navigation Concepts:** Fundamentals of spacecraft navigation systems and Position Fixing, Geometric concepts of Navigation, Elements, The Earth in inertial space, Earth's Rotation, Revolution of Earth, Different Coordinate Systems, Coordinates Transformation, Euler angle formulations, Direction cosine formulation, Quaternion formulation.

**Module-3**

**Inertial Navigation Systems:** Accelerometers, Pendulous type, Force Balance type, MEMs Accelerometers, Basic Principles of Inertial Navigation, Types, Platform and Strap down, Mechanization INS system, Rate Corrections, Block diagram, Acceleration errors, Coriolis effect, Schuler Tuning, Cross coupling, Gimbal lock , Alignment

**Module-4**

**CONTROL ACTUATORS**
Thrusters, Momentum Wheel, Control Moment Gyros, reaction wheel, Magnetic Torquers, Reaction Jets, Ion Propulsion, Electric propulsion, solar sails.

**Module-5**

**Satellite Telemetry, Tracking and Telecommand:** Introduction to telemetry systems, Aerospace transducer, signal conditioning, multiplexing methods, Analog and digital telemetry, Command line and remote control system, Application of telemetry in spacecraft systems, Base Band Telemetry system, Computer command & Data handling, Satellite command system, Issues

**Course outcomes:**
At the end of the course the student will be able to:

1. Identify the spacecraft environment for design consideration.
2. Apply the navigation concepts and systems.
3. Classify the control actuators.

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Spacecraft Systems Engineering' | Fortescue Peter | Wiley-Blackwell England | 4th edition,2003 |

| | | | | |
|---|---|---|---|---|
| 2 | Spacecraft Power Systems | Patel Mukund R | CRC Press | 1st edition, 2005 |
| **Reference Books** | | | | |
| 1 | Satellite Communication Systems Engineering | Wilbur L. Pritchard and Joseph A.Sciulli | Prentice Hall, New Jersey | 1986 |
| 2 | Spacecraft Dynamics and control, A Practical Engineering Approach | Marcel j. sidi | Cambridge University Press | 2000 |
| 3 | Modern Spacecraft Dynamics and control | Kaplan m | Wiley Press | 1976 |
| 4. | Spacecraft navigation and guidance | Maxwell Noton | Springer | 1998 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -II**

**PROPULSION LABORATORY**

| | | | |
|---|---|---|---|
| Course Code | 20MAEL26 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 0:0:4 | SEE Marks | 60 |
| Credits | 02 | Exam Hours | 03 |

| Sl. NO | Experiments |
|---|---|
| 1 | Cascade testing of a model of turbine blade row and study of wake survey. |
| 2 | Estimation of propeller performance |
| 3 | Forced Convective heat transfer on a flat surface |
| 4 | Measurement of Burning Velocity of a Premixed Flame |
| 5 | Determination of heat of combustion of aviation fuels |
| 6 | Fuel - injection characteristics (spray cone geometry; spray speed etc. for various type of injectors) |
| 7 | Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit |
| 8 | Effect of inlet flow distortion on measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit . |
| 9 | Investigation of relationship between flame speed and air-fuel ratio for a slow burning gaseous fuel. |
| 10 | Construction of flame stability diagram through flame lift up and flame fall back |
| 11 | Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through counter rotating axial flow fan unit |
| 12 | Effect of inlet flow distortion on measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through counter rotating axial flow fan unit. |

**Course outcomes:**

At the end of the course the student will be able to:

1. Demonstrate various experimental facilities
2. Explain the use of different measurement techniques
3. Perform the test, acquire the data and analyse and document

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
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**SEMESTER -II**

**TECHHNICAL SEMINAR**

| | | | |
|---|---|---|---|
| Course Code | 20MAE27 | CIE Marks | 100 |
| Number of contact Hours/week (L:T:P) | 0:0:2 | SEE Marks | -- |
| Credits | 02 | Exam Hours | -- |

**Course objectives:**

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill,

**Marks distribution for CIE of the course 20MAE27 seminar:**

Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

*** END ***

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**AIRCRAFT FLIGHT DYNAMICS AND AUTOMATIC FLIGHT CONTROL**

| | | | |
|---|---|---|---|
| Course Code | **20MAE31** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 4:0:0 | SEE Marks | 60 |
| Credits | 04 | Exam Hours | 03 |

**Module-1**

**Review of feedback system analysis and aerodynamic fundamentals:** Mathematical models of linear open loop and closed loop systems, Transfer functions and Bode plot and root locus methods of analysis, analysis of multi-loop vehicular control systems; Definition of airframe parameters, coefficients and reference geometries, aerodynamic characteristics of plan forms and fuselage and effectiveness of control surfaces.

**Module-2**

**Vehicle equations of motion and axis systems:** Newton's Second Law and reference frames Expansion of inertial forces and moments, gravity forces and their linearization, Expansion of aerodynamic forces and moments and direct thrust forces, Complete linearized equations of motion, description of dimensional and non-dimensional stability axis derivatives.

**Module-3**

**Longitudinal dynamics:** Review of simplifying assumptions and derivation of simplified longitudinal equations of motion, longitudinal controls and control input transfer functions, two degrees of freedom short period approximations and typical example transfer functions of conventional aircraft and their responses Lateral dynamics: Simplified lateral equations of motion, lateral controls and control input transfer functions, two degrees of freedom Dutch roll approximations, typical example transfer functions of conventional aircraft and their responses

**Module-4**

**Longitudinal and lateral feedback control:** Longitudinal Feedback Control: Feedback of pitch angle and pitch rate to the elevator, feedback of speed error to elevator, feedback of angle of attack and normal acceleration to elevator, feedback of altitude to the elevator Lateral Feedback Control: Feedback of bank angle and rolling velocity to ailerons, feedback of other quantities to ailerons, feedback of heading angle to rudder, feedback of yawing velocity to rudder, feedback of sideslip to rudder, feedback of lateral acceleration to rudder.

**Module-5**

**Longitudinal and lateral autopilots:** Longitudinal Autopilots: Displacement autopilot, pitch orientational control system, acceleration control system, glide slope coupler and automatic flare control, flight path stabilization, attitude reference systems, effect of nonlinearities. **Lateral Autopilots:** Damping of Dutch roll, discussion on coordination techniques and methods of obtaining coordination, yaw orientational control system and other lateral autopilot configurations, automatic lateral beam guidance.

**Course outcomes:**

At the end of the course the student will be able to:

1. Model equations of motion
2. Design Preliminary feedback systems and autopilot design.
3. Distinguish longitudinal and lateral autopilots.

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Airplane flight dynamics and automatic flight controls, Part I & II | Jan Roskam | Design Analysis and Research Corporation (DAR Corporation) | 2003 |
| 2 | Aircraft Dynamics and Automatic Control | D McRuer, I Ashkenas and D Graham | Princeton University Press, Princeton, New Jersey | 1973 |
| **Reference Books** | | | | |
| 1 | Automatic Control of Aircraft and Missiles | Blake lock J H | John Wiley & Sons | 1991 |
| 2 | Aircraft dynamic Stability and Response | Babister, A. W | Pergamon Press | 1980. |
| 3 | | | | |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**FLIGHT VEHICLE DESIGN**

| | | | |
|---|---|---|---|
| Course Code | **20MAE321** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**Overview of Design Process:** Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation, **Thrust to Weight Ratio & Wing Loading:** Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.

**Module-2**

**Configuration Layout & loft:** Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Delectability. Crew station, Passenger, and Payload arrangements. **Design of Structural Components:** Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.

**Module-3**

**Engine Selection & Flight Vehicle Performance:** Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices:- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking. Enhanced lift design -Passive & Active.

**Module-4**

**Static Stability & Control:** Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.

**Module-5**

**Design Aspects of Subsystems:** Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurisation and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.

**Course outcomes:**

At the end of the course the student will be able to:

1. Define a configuration for given specifications i.e. thrust to weight ratio and wing loading
2. Solve problems related to configuration layout & airframe components sizing
3. Workout engine selection and perform stability analysis
4. Model subsystems

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Aircraft Design - A Conceptual Approach | Daniel P. Raymer | AIAA Education Series | 4th Edition 2006 |
| 2 | Design of Aircraft | Thomas C Corke | Pearson Edition. Inc. | 2003 |
| **Reference Books** | | | | |
| 1 | Aeroplane Design -VOL 1 to 9 | J Roskam | DAR corporation | 1985 |
| 2 | Introduction to Aircraft Design | John Fielding | Cambridge University Press | 2009 |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**THEORY OF AEROELASTICITY**

| | | | |
|---|---|---|---|
| Course Code | **20MAE322** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**INTRODUCTION**

**Aeroelasticity - Aeroelastic phenomenon:** flutter, buffeting, dynamic loads problems, load distribution, divergence, control effectiveness & reversal. **Deformation of airplane structures under static loads:** Forces acting on aeroplane, Influence coefficients. Properties of influence coefficients. Deformation under distributed forces. Simplified elastic airplane. Bending, torsional and shear stiffness curves

**Module-2**

**Static aeroelastic phenomena:** Load distribution and divergence-wing torsional divergence (two-dimensional case, & finite wing case). Prevention of aeroelastic instabilities. **Control effectiveness and reversal :** Aileron effectiveness and reversal -2 dimensional case, and finite wing case. Strip theory. Aileron effectiveness in terms of wing -tip helix angle. Critical aileron reversal speed. Rate of change of local pitching moment coefficient with aileron angle.

**Module-3**

**Deformation of airplane structures under dynamic loads:** Differential and Integral forms of equations of motions of vibrations. Natural modes and frequencies of complex airplane structures - introduction. Dynamic response phenomenon. **Dynamic problems of Aeroelasticity:** Determination of critical flutter speed. Aeroelastic modes. Wing bending and torsion flutter. Coupling of bending and torsion oscillations and destabilizing effects of geometric incidences. Flutter prevention and control.

**Module-4**

**Test model similarities:** Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity law. Scale factors. Structural simulation:-shape, mass and stiffness.

**Module-5**

**Testing techniques:** Measurement of structural flexibility, natural frequencies and mode shapes. Polar plot of the damped response. Identification and measurement of normal modes. Steady state and dynamic Aeroelastic model testing.

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply knowledge of aeroelasticity towards aircraft design
2. Demonstrate deformation of airframe parts under static and dynamic loads
3. Model wind tunnel test similarities & Perform wind tunnel testing

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| 1 | Aeroelasticity | Dowell, E. H., Crawley, E. F., Curtiss Jr., H. C., Peters, D. A., Scanlan, R. H., and Sisto | Kluwer Academic Publishers | 3rd Edition, 1995 |
| 2 | Aeroelasticity | Bisplinghoff, R., Ashley, H., and Halfman, R. L. | Dover | 1955 |
| **Reference Books** | | | | |
| 1 | Introduction to the Theory of Aeroelasticity | Fung, Y. C | Dover | 1955 |
| 2 | Aircraft structures for Engineering students | Megson THG | Edward Arnold. | 5th edition &2012 |
| 3 | Principles of Aeroelasticity | Bisplinghoff, R. and Ashley, H., | Dover | 1962 |
| | | | | |

| **M.TECH AERONAUTICAL ENGINEERING (MAE)**<br>**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**<br>**SEMESTER -III** | | | |
|---|---|---|---|
| **HYPERSONIC AERODYNAMICS** | | | |
| Course Code | **20MAE323** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**General Considerations.** Characteristics General features of hypersonic flow field. Assumptions underlying inviscid hypersonic theory. Normal shock waves, oblique & curved shocks. Mach number independence principles. General strip theory.

**Small Disturbance Theory.** Introduction to basic equations. Hypersonic Similitude, United supersonic-hypersonic similitude. Slender – body strip theory.

**Module-2**

**Small Disturbance Theory.** Slightly blunted slender bodies, large incidence & correlation of Similitude. Unsteady flow theory. Non equilibrium effects.

**Newtonian Theory.** Two-dimensional axis symmetric bodies, simple shapes & free layers. Optimum shapes, shock layer structure.

**Module-3**

**Newtonian Theory.** Shock layer structure with cross flow. Conical flow, bodies of revolution at small incidences.

**Theory of Thin Shock Layers.** Basic concepts, successive approximation schemes. Constant stream tube-area approximation. Two-dimensional axis symmetric blunt faced bodies.

**Module-4**

**Viscous Flows.** Hypersonic Viscous effects, Boundary Layer equations. Similar laminar boundary layer solutions. Local similarity concept. Viscous interactions - flow models and interaction parameters. Weak pressure interaction. Strong pressure interaction. General features of rarified gas flows.

**Module-5**

**Hypersonic Testing.** Hypersonic Scaling, high enthalpy & high speed, types of hypersonic facilities. Shock tunnels & expansion tubes. Features of Hypersonic wind tunnel design. Instrumentation to hypersonic vehicle testing. Test model similarity laws.

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply knowledge of oblique and curved shock waves and shock wave structure
2. Solve problems related to hypersonic viscous effects
3. Model hypersonic wind tunnel testing.

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Hypersonic Inviscid Flows | Wallace D Hayes & Ronald F Probstein | Dover Publication | 2004. |
| 2 | Hypersonic Flow Theory | Wallace Hayes | Academic Press Inc | 1959. |
| **Reference Books** | | | | |
| 1 | Hypersonic and High Temperature Gas Dynamics | John D Anderson Jr. | AIAA | 2000 |
| 2 | Advanced Hypersonic Test Facilities | Frank K.Lu and Dart E. Marran, | AIAA | 2002 |
| 3 | Introduction to Hypersonic Flow | Cherynl C.G. | Academic Press | 1961 |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**NEW PRODUCT DEVELOPMENT**

| | | | |
|---|---|---|---|
| Course Code | **20MAE324** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**The Business Objective**

The fit, the strategy, consistency, differentiating research and development, leverage, continuity, flow, symbiosis, pursuit, singularity versus plurality, market investigation, understanding the marketplace, global product and business development.

**The market opportunity:**

The business concept embodied in the new product idea, solving the customer's problem in the product, the product as a business, the competitive game, idea evaluation within the framework of the business, playing the game well, it's faster changing world, winning the game, new product development as a competitive weapon, the strategic difference between large and small companies, the product evolution flow chart.

**Module-2**

**Refinement of the product concept into a new product and business:**

The idea, competitive analysis, the route to market, strategy and tactics in operational planning, background/format, reducing the risk of new product failure, the assignment, the configuration, mass customization and generic platforms, creeping functionalism, designing to cost, development engineer's influence on factory cost, manufacturing, global marketing, requirements specification

**The product and Business Plan:**

The plan, program timing, structuring the business plan, product mix/offering, pricing policy, facilitating change in the business to execute the plan, management focus, the importance of the accounting function, trading time saved for technology, selling the plan.

**Module-3**

**Justifying a program: The accounting viewpoint**

Accounting and finance as partners, financial and economic analysis, timing and lost opportunity cost, critical unit volume during amortization, generating cash and profit, profit in backlog, cost, volume, and profit-breakeven, financial models for the sales transactions, financial impact of lack of continuity,

**Stating Out:**

A statement about teamwork, identifying the requirements, assembling the team members, organizational form, apprenticeship and mentoring, management of the team, culture of the group, incentives for the development group, management reporting, communicatios systems, the program initiation.

**Module-4**

**Executing the plan:**

Mechanics of product development, managing people, executing the product development plan, product development phases, tracking performance, obstacle removal, key players and backup, dealing with shiting linking objectives, problem solving, issues review, cause assesment, decision management, planning architecture, quality management systems, intellectual property protection.

**Manufacturing Development:**

Concurrency of development phases, design for manufacturing, manufacturing, process, layout, product configuration, manufacturing process control, certification of manufacturing personnel, procurement and parts configuration, certification of vendors, information retention and recordkeeping, field problems and event status monitoring, forecasting, cycle time managament, sychronization.

**Module-5**

**The prelaunch checklist: Setting up the organization**

Preflight checklist, confirming agency certification, pilot run manufacturing, beta testing program, literature, setting up the infrastructure, training for personnel, applications support, field organization set-up, final pricing.

**The Launch:**

The product rollout, initial monitoring of results, early modifications for success, the myth of the hockey stick forecast, forecasting and building inventory, product promotion and customer visits, tools, measurements, sales channel and launch objectives, communication, agreement and commitment to objectives.

New product development records format: organizational format.

**Course outcomes:**
At the end of the course the student will be able to:

1. Apply the new product development process
2. Execute product development program to grow business
3. Solve the complexities of planning, execution, timing, problem solving skills

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | New Product Development: From Initial Idea to Product Management | Marc Annacchino | Elsevier | 2003. |
| 2 | Product Design and Development | Karl Ulrich and Steven Eppinger | McGraw-Hill | 2011. |
| **Reference Books** | | | | |
| 1 | Handbook of New Product Development Management | Christoph Loch, Stylianos Kavadias | Elsevier | 2007 |
| 2 | New Product Development: Successful Innovation in the Marketplace | Erdener Kaynak, Nicholas Mills, Michael Z | Routledge, T&F | 2012 |
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**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**FATIGUE AND FRACTURE MECHANICS**

| | | | |
|---|---|---|---|
| Course Code | **20MAE331** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**Fracture Mechanics Principles:** Introduction, Mechanisms of Fracture, a crack in a structure, the Graffiti's criterion, modem design, - strength, stiffness and toughness. Stress intensity approach. **Stress Analysis for Members with Cracks:** Linear elastic fracture mechanics, Crack tip stress and deformations; Relation between stress intensity factor and fracture toughness, Stress intensity based solutions. Crack tip plastic zone estimation, Plane stress and plane strain concepts. The Dugdale approach, the thickness effect.

**Module-2**

**Elastic - Plastic Fracture Mechanics:** Introduction, Elasto-plastic factor criteria, crack resistance curve, I-integral, Crack opening displacement, crack tip opening displacement. Importance of R-curve in fracture mechanics, Experimental determination of I-integral, COD and CTOD.

**Module-3**

**Dynamic and Crack Arrest:** Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest, and the dynamic fracture toughness.

**Module-4**

**Fatigue and Fatigue Crack Growth Rate:** Fatigue loading, Various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws.

**Fracture Resistance of Materials**: Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature, closure.

**Module-5**

**Computational Fracture Mechanics:** Overview of numerical methods, traditional methods in computational fracture mechanics – stress and displacement marching, elemental crack advance, virtual crack extension, the energy domain integral, finite element implementation. Limitations of numerical fracture analysis.

**Fracture Toughness testing of metals:** Specimen size requirements, various test procedures, effects of temperature, loading rate and plate thickness on fracture toughness. Fracture testing in shear modes, fatigue testing, NDT methods.

**Course outcomes:**
At the end of the course the student will be able to:

1. Apply principles of fracture mechanics
2. Solve problems related to plastic fracture mechanics
3. Model Computational fracture mechanics

**Question paper pattern:**
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Introduction to Fracture Mechanics | Karen Helen | McGraw Hill Pub | 2000 |
| 2 | Fracture of Engineering Brittle Materials | Jayatilake | Applied Science, London | 2001 |
| **Reference Books** | | | | |
| 1 | Fracture Mechanics Application | T. L. Anderson | CRC press | 1998 |
| 2 | Elementary Engineering Fracture of Mechanics | David Broek | ArtinusNijhoff, London | 1999. |
| 3 | | | | |
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**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**AERO-ENGINE TESTING AND PERFORMANCE EVALUATION**

| | | | |
|---|---|---|---|
| Course Code | **20MAE332** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**Introduction:** Need For Gas Turbine Engine Testing And Evaluation, Philosophy Of Testing, Rationale Of Testing. Types of tests: Proof of Concepts, Design Verification, Design Validation, and Formal Tests. **Aero Thermodynamic Tests: Compressor:** Compressor scaling parameter Groups, Compressor MAP. Inlet distortions. Surge margin stack up. Testing and Performance Evaluation, Test rig.

**Module-2**

**Combustor:** Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation. **Aero Thermodynamic Tests: Turbines:** Turbine MAP. Turbine Testing and Performance Evaluation. Component model scaling. **Inlet duct & nozzles:** Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation.

**Module-3**

**Engine performance:** Design & off-design Performance. Transient performance. Qualitative characteristics quantities. Transient working lines. Starring process & Wind milling of Engines. Thrust engine start envelope. Calculations for design and off-design performance from given test data – (case study for a Jet Engine).

**Module-4**

**Qualification Tests:** Tests used to evaluate a design. Environment ingestion capability. Preliminary flight rating tests, Qualification testing, acceptance tests, Reliability figure of merit. Structural integrity tests: Design Verification Tests, Durability and Life Assessment Tests, Reliability Tests, Failure Simulation Tests, Functional and Operability Tests. **Types of engine tests:** Normally Aspirated Testing, Ram Air Testing, Altitude Testing, Flying Test Bed, Mission Oriented Tests, Open Air Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing.

**Module-5**

**Test cell:** Air breathing engine test facility. Direct connect altitude cell, propulsion wind tunnels. Types of engine test beds. Factors for design of engine test beds. Altitude test facility. Steps in test bed cross calibration. Engine testing with simulated inlet distortions. Surge test. Cell Calibration and Correction. Performance Reduction Methodology. Instrumentation: Data Acquisition, Measurement of Thrust, Pressure, Temperature, Vibration, etc. Accuracy and Uncertainty in Measurements. Experimental Stress Analysis.

**Course outcomes:**

At the end of the course the student will be able to:

1. solve problems related to aerothermodynamics of compressors, combustors, and turbines
2. Apply knowledge to test engines
3. Specify engine performance requirements

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Gas Turbine Performance | P.P Walsh and P. Peletcher | Blackwell Science | 1998 |
| 2 | Experimental methods for Engineers | J P Holman | Tata McGraw –Hill Publishing Co. Ltd | 2007 |
| **Reference Books** | | | | |
| 1 | Advance Aero-Engine Testing | | AGARD-59 Publication | |
| 2 | An inventory of Aeronautical Ground Research Facilities | | NASA CR | 1875 |
| 3 | Military Specifications: Engine Aircraft, Turbo Jet & Turbofan General Specification for Advance Aero Engine testing | | MIL –5007 E | 1973 |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**THEORY OF COMBUSTION**

| | | | |
|---|---|---|---|
| Course Code | **20MAE333** | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

**Basics of Combustion theory:** Combustion Stochiometry and Thermo chemical Calculation, Chemical Kinetics and Equilibrium, Transport Phenomena-Theory of Viscosity, conductivity and diffusivity

**Module-2**

**Pre-Mixed Flames:** Description of premixed flames, Burning velocity and parametric dependences, Experimental methods of measuring burning velocity, Simple one-dimensional thermal theory of flame, concepts of minimum ignition energy, quenching distance, stability limits and flame stabilization. Turbulent premixed flame

**Module-3**

**Diffusion Flame:** Jet flame physical description, theoretical analysis-Burke-Schumann's analysis, mechanism of soot formation, Difference between premixed and diffusion flames, Liquid fuel combustion, Difference between premixed and diffusion flames, Liquid fuel combustion, Difference between premixed and diffusion flames, Liquid fuel combustion- Conservation equations, calculation of mass burning rate, Droplet burning time, Droplet combustion in convective environment.

**Module-4**

**Combustion in Reciprocating and Gas- Turbine Engines:** Description of the combustion process in piston engines, Combustion efficiency and factors affecting it, Rankine-Hugoniot curves, Deflagration and Detonation in reciprocating engines and preventive methods. Description of different types of combustion chambers in gas-turbine engines, primary requirements of the combustor, Flow structure, recirculation and flame stabilization in main combustion chamber, afterburners.

**Module-5**

**Combustion in Rocket Engines and Emission:** Types of Rockets based on combustion, Solid fuel combustion, combustion of carbon particle-simplified analysis, boundary layer combustion, combustion of carbon sphere with CO burning gas phase. Chemical Emission from combustion and its effects, Exhaust gas analysis, Emission control methods

**Course outcomes:**

1. Apply basic combustion theory
2. Solve problems related diffusion flame
3. Describe combustion process in engines

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | An Introduction to combustion Concepts and Application, | Stephen R Turns | TMH Publication | 3rd edition &2011 |
| 2 | Fundamentals and Technology of combustion | Fawzy El-Mahallawy, Saad El-Din Habik, | Elsevier. | 2018 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| 1 | Industrial Combustion | Charles E. Baukal | CRC Press | 1st edition &2010 |
| 2 | Fundamentals of combustion | D P Mishra | PHI Publication | 2008 |
| 3 | Combustion, Fossil Power Systems | G. Singer | Ed Pub | 3rd edition &1981 |
| | | | | |

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**Introduction to Artificial intelligence and machine learning**

| | | | |
|---|---|---|---|
| Course Code | 20MAE333 | CIE Marks | 40 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 60 |
| Credits | 03 | Exam Hours | 03 |

**Module-1**

Introduction to Data Science and AI & ML, Data Science, AI & ML, Essential Concepts in AI and ML Data Understanding, Representation and Visualisation

**Module-2**

Machine Learning: Linear Methods, Linear Regression, Multiple Linear Regression, Non-Linear Regression, Clustering, Forecasting models, Perceptron and Neural Network, Decision Trees, Support Vector Machines.

**Module-3**

Probabilistic Models, Dynamic programming and Reinforcement Programming, Evolutionary Algorithms, Time Series Models, Deep Learning, Emerging Trends in ML, Unsupervised Learning

**Module-4**

Foundations for AI, AI Basics , AI Classification, Supervised Learning, Feature Engineering Regression, Model Selection, Model Performance , Ranking

**Module-5**

Introduction to ML with R and using Python, Python and R for Artificial Intelligence, Machine Learning, and Data Science, AI/ML in aerospace industry

**Course outcomes:**

At the end of the course the student will be able to:

1. Apply the concepts of Artificial Intelligence and Machine Learning
2. Develop the knowledge to understand, represent and visualise the data that form the foundation to AI and ML
3. Apply different ML algorithms to different situations in Aerospace Industry

**Question paper pattern:**

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

**Textbook/ Textbooks**

| Sl No | Title of the book | Name of the Author/s | Publisher Name | Edition and year |
|---|---|---|---|---|
| 1 | Machine Learning and Artificial Intelligence | Ameet V Joshi | Springer | 2019 |
| 2 | Artificial Intelligence and Machine Learning fundamentals | Zsolt Nagy | Packt Publishing | 2018 |
| **Reference Books** | | | | |
| 1 | Artificial Intelligence and Machine Learning | Vinod Chandra SS | PHI Learning | 2014 |
| 2 | Basics of Artificial Intelligence and Machine Learning | Dheeraj Mehrotra | Notion Press | 2019 |
| 3 | | | | |
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**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**PROJECT WORK PHASE – 1**

| | | | |
|---|---|---|---|
| Course Code | 20MAE34 | CIE Marks | 100 |
| Number of contact Hours/Week (L:T:P) | 0:0:2 | SEE Marks | -- |
| Credits | 02 | Exam Hours | -- |

**Course objectives:**

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

**Project Phase-1** Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

**Seminar:** Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

| | |
|---|---|
| **Revised Bloom's Taxonomy Level** | $L_3$ – Applying, $L_4$ – Analysing, $L_5$ – Evaluating, $L_6$ – Creating. |

**Course outcomes:**

At the end of the course the student will be able to:

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.
- Demonstrate the knowledge, skills and attitudes of a professional engineer.

**Continuous Internal Evaluation**

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**MINI PROJECT**

| | | | |
|---|---|---|---|
| Course Code | 20MAE35 | CIE Marks | 40 |
| Number of contact Hours/Week (L:T:P) | (0:0:2) | SEE Marks | 60 |
| Credits | 02 | Exam Hours/Batch | 03 |

**Course objectives:**

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

**Mini-Project:** Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

**Course outcomes:**

At the end of the course the student will be able to:

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

**CIE procedure for Mini - Project:**

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

**Semester End Examination**

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University.

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -III**

**INTERNSHIP / PROFESSIONAL PRACTICE**

| | | | |
|---|---|---|---|
| Course Code | 20MAE36 | CIE Marks | 40 |
| Number of contact Hours/Week | 0:0:2 | SEE Marks | 60 |
| Credits | 06 | Exam Hours | 03 |

**Course objectives:**
Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

- To put theory into practice.
- To expand thinking and broaden the knowledge and skills acquired through course work in the field.
- To relate to, interact with, and learn from current professionals in the field.
- To gain a greater understanding of the duties and responsibilities of a professional.
- To understand and adhere to professional standards in the field.
- To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.

**Internship/Professional practice:** Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.
**Seminar:** Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

**Course outcomes:**
At the end of the course the student will be able to:

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.

**Continuous Internal Evaluation**
CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

**Semester End Examination**
SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.

**M.TECH AERONAUTICAL ENGINEERING (MAE)**
**Choice Based Credit System (CBCS) and Outcome Based Education(OBE)**
**SEMESTER -IV**

**PROJECT WORK PHASE -2**

| | | | |
|---|---|---|---|
| Course Code | 20MAE41 | CIE Marks | 40 |
| Number of contact Hours/Week(L:T:P) | 0:0:4 | SEE Marks | 60 |
| Credits | 20 | Exam Hours | 03 |

**Course objectives:**

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

**Project Work Phase - II:** Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

**Course outcomes:**

At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

**Continuous Internal Evaluation:**

**Project Report:** 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.

**Project Presentation:** 10 marks.

The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

**Question and Answer:** 10 marks.

The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.

**Semester End Examination**

SEE marks for the project report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.