VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2018-2019

M.Tech. Aeronautical Engineering

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -I

APPLIED MATHEMATICS
(Professional Core Course)

Subject Code	**18MAE11**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand principles of vector operations
2. Analyze integrals
3. Find numerical solutions to equations
4. Determine finite difference approximate in various forms

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 Review of Fourier series and Applications, Review of Laplace Transforms and Applications. Classification of second order linear partial differential equations, Canonical forms for hyperbolic, parabolic and elliptic equations, Homogeneous and Non Homogeneous equations with constant coefficients. Applications	**10 Hours**	**L1, L2**
Module -2 Vector Functions, General rules for differentiation, Velocity and Acceleration, Gradient of a scalar field, Directional Derivative, Properties of Gradient, Divergence of vector point function, Curl of a vector point function, Properties of Divergence and Curl. Applications Integration of vector functions, Line integral, Circulation, Work done by a force, Surface integrals, Volume integrals, Divergence Theorem of Gauss, Green's Theorem in the plane, Stoke's Theorem, problems on all the three theorems and Applications.	**10 Hours**	**L1, L2**
Module -3 Review of Complex analysis, Complex analysis applied to potential theory, Electrostatic fields, conformal mapping, Heat problems, Fluid flow, General properties of Harmonic functions, Complex Integration, Cauchy's Theorem, Cauchy's Integral Formula, Cauchy's Integral Formula for Derivatives, Taylor's and Laurent's series. Applications. Singular point, Residue, Method of finding Resides, Residue Theorem,	**10 Hours**	**L1, L2, L3**

Contour Integration, Integration round the unit circle, Rectangular contour. Applications.		
Module -4 Numerical Solutions algebraic and transcendental equations: False position method, Newton – Raphson method, Iteration method, Aitken's method, Solution of linear simultaneous equations. Gauss elimination method, Inverse of a matrix , Gauss-Seidal method, Crout's method. Solution of Ordinary Differential Equations: Taylor's Series method, Picard's method, Euler's method, Euler's Modified method, Runge-Kutta 4thorder method. Predictor and corrector method (Milen's and Adams-Bashfourth) Applications.	**10 Hours**	**L1, L2, L3**
Module -5 Finite differences, Interpolation, Newton's Forward & Backward Interpolation formulae, Lagrange's formula, Newton's Divided difference, Central difference formulae (all formulae with proof). Numerical Differentiation, Numerical Integration (all rules with proof). Applications.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Apply principles of vector operations to engineering problems
2. Solve close form solutions
3. Apply finite difference approximate to solve elliptic, hyperbolic and parabolic form of equations

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Erwin Kreyszing: **"Advanced Engineering Mathematics"**- John Wiley &Sons(Asia) Pvt. Ltd. 8th edition.
2. H K Dass: **"Advanced Engineering Mathematics"**- S Chand and Company Ltd. 12thedition.

Reference Books:
1. Bali and Iyengar: **"Engineering Mathematics"**- Laxmi Publications (P) Ltd. 6thedition.
2. C. Ray Wylie and Louis C Barret: **"Advanced Engineering"**. Mathematics Tata McGraw Hill Publishing Co. Ltd. 6th edition.
3. Michael D Greenberg: **"Advanced Engineering Mathematics"**- Pearsons India Ltd. 2nd edition.
4. B S Grewal: **"Higher Engineering Mathematics"**- 12th edition.

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -I

AERODYNAMICS
(Professional Core Course)

Subject Code	**18MAE12**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Analyze incompressible flows over aerofoils
2. Understand aerofoil and wing aerodynamic characteristics and theory of lift generation
3. Analyze airfoils at subsonic, transonic and supersonic flight conditions.
4. Acquire knowledge of basic compressible gas dynamics

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**

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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Fundamentals of Aerodynamics: John D. Anderson, McGraw-Hill publication.
2. Modern compressible flow: John D. Anderson, McGraw-Hill publication.

Reference Books:

1. Aerodynamics for Engineering students: E L Houghton and P W Carpenter, Edward Arnold publication, 1993
2. Fundamentals of compressible flow: Yahya, S M. Wiley Eastern. 1991
3. Introduction to flight: John D. Anderson, McGraw-Hill publication.6th Edition.

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M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -I

INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS
(Professional Core Course)

Subject Code	**18MAE13**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. To understand the configuration features of fixed wing and rotary wing aircraft
2. Acquire the knowledge of various aircraft systems and flight testing
3. Gain knowledge of standards and specifications used in aircraft and system designs
4. Understand spacecraft launch vehicles

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**

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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. ChennaKeshu S and Ganapathy K K: Aircraft Production Technology and Management, Interline Publishing, Bangalore 1993
2. Ian Moir and Allan Seabridge: Aircraft Systems, mechanical, electrical and avionics subsystems integration, Professional Engineering Publishing Limited, UK, 2001

Reference Books:

1. Ralph D Kimberlin: Flight Testing of Fixed wing Aircraft, AIAA Education Series, 2003
2. J. G. Leishman: Principles of Helicopter Aerodynamics, Cambridge Aerospace series, 2000
3. S K Khanna, M G Arora and S S Jain, Airport Planning and Design NEM Chand and Brothers, Roorki, 6th Edition, 2001.

M.Tech Aeronautical Engineering
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SEMESTER -I

COMPUTATIONAL FLUID DYNAMICS
(Professional Core Course)

Subject Code	**18MAE14**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand CFD ideas and Mathematical behavior of PDEs
2. Acquire the knowledge to solve CFD problems through finite difference discritisation
3. Gain knowledge for grid generation and optimize grids
4. Transform the grids to computational domain
5. Acquire the knowledge to solve CFD problems through finite volume technique

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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 vrs 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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**

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).	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. John D Anderson Jr. - Computational Fluid Dynamics, The Basics with Applications, McGraw Hill International Edn;1995.
2. T J Chung - Computational Fluid Dynamics, Cambridge University Press, 2008

Reference Books:

1. F. Wendt (Editor), Computational Fluid Dynamics - An Introduction, Springer – Verlag, Berlin; 1992.
2. Charles Hirsch, Numerical Computation of Internal and External Flows, Vols. I and II. John Wiley & Sons, New York; 1988.
3. JiyuanTu, Guan HengYeoh, and Chaoqun Liu, Computational Fluid Dynamics- A Practical Approach, Elsevier Inc; 2008.

M.Tech Aeronautical Engineering
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SEMESTER -I

FINITE ELEMENT METHODS
(Professional Core Course)

Subject Code	**18MAE15**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand the fundamental theory of the FEA
2. Develop the ability to generate the governing FE equations for systems governed by partial differential equations
3. Use the basic finite elements for structural applications like truss, beam, and frame
4. Understand the application and use of the FE method for heat transfer problems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level

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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students 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

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Chandrupatla T. R.,“Finite Elements in engineering”- 2nd Edition, PHI, 2007.
2. Lakshminarayana H. V.,“Finite Elements Analysis”– Procedures in Engineering, Universities Press, 2004.

Reference Books:
1. Rao S. S. “Finite Elements Method in Engineering”- 4th Edition, Elsevier, 2006.
2. P.Seshu, “Textbook of Finite Element Analysis” -PHI, 2004.
3. J.N.Reddy, “Finite Element Method”- McGraw -Hill International Edition.
4. Bathe K. J. “Finite Elements Procedures”- PHI.

M.Tech Aeronautical Engineering
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SEMESTER -I

AERODYNAMICS LAB
(Professional Core Course)

Subject Code	**18MAEL16**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	56	SEE Marks	60
CREDITS – 02			

Course objectives: This course will enable students to

1. Familiarization with various wind tunnel experimental facilities
2. Familiarize with different sensors and measurement techniques and model set up system
3. Conduct the test, acquire the data and analyse and document

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Calibration of test section of a subsonic wind tunnel.	**L1, L2, L3, L4**
2. Smoke flow visualization on a wing model at different angles of incidence at low speeds.	**L1, L2, L3, L4**
3. Tuft flow visualisation on a wing model at different angles of incidences at low speeds: Identify zones of attached and separated flows	**L1, L2, L3, L4**
4. Surface pressure distribution around building models in multiple model arrangement	**L1, L2, L3, L4**
5. Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag.	**L1, L2, L3, L4, L5**
6. Calculation of total drag of a cambered airfoil at a low incidence using pitot-static probe wake survey.	**L1, L2, L3, L4**
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.	**L1, L2, L3, L4**
8. Study the effect of Blockage ratio on drag & pressure distribution of a circular cylinder.	**L1, L2, L3**
9. Determination of turbulence level in a low speed wind tunnel.	**L1, L2, L3**

10. Study of pressure distribution on hemispherical objects.	**L1, L2, L3**
11. Study on internal/external flow distribution of hollow tube structure.	**L1, L2, L3**
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.	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

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

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Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -I

RESEARCH METHODOLOGY AND IPR
(Professional Core Course) and (Common to all M.Tech Programmes)

Course Code	18RMI17	CIE Marks	40
Number of Lecture Hours/Week	02	Exam Hours	03
Total Number of Lecture Hours	25	SEE Marks	60
CREDITS – 02			

Course objectives:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections.
- To explain several parametric tests of hypotheses and Chi-square test.
- To explain the art of interpretation and the art of writing research reports.
- To explain various forms of the intellectual property, its relevance and business impact in the changing global business environment.
- To discuss leading International Instruments concerning Intellectual Property Rights.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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	**5 Hours**	**L1, L2**
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	**5 Hours**	**L1, L2**

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	**5 Hours**	**L1, L2**
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. .	**5 Hours**	**L1,L2, L3,L4**
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 on Biological 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,	**5 Hours**	**L1,L2, L3,L4**

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		

Revised Bloom's Taxonomy Level	L1 – Remembering, L2 – Understanding ,L3 – Applying , L4 – Analysing.

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 and their characteristics.
- Explain the details of sampling designs, measurement and scaling techniques and also different methods of data collections
- Explain several parametric tests of hypotheses and Chi-square test.
- Explain the art of interpretation and the art of 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

Graduate Attributes (As per NBA): Problem analysis, Investigation, Design, Individual and teamwork, Communication skills, Professionalism.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Research methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International,4th Edition, 2018.
2. ResearchMethodologyastep-by-stepguideforbeginners. (For the topic Reviewing the literature under module 2) , Ranjit Kumar, SAGE Publications Ltd.,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.An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002

2.An Introduction to Multivariate Statistical Analysis Anderson T.W,Wiley 3rd Edition, 2003

3.Research Methodology, Sinha, S.C, Dhiman ,EssEss Publications2002

4.Research Methods: the concise knowledge base ,Trochim ,Atomic Dog Publishing ,2005

5.How to Write and Publish a Scientific Paper, Day R.A ,Cambridge University Press ,1992

6.Conducting Research Literature Reviews: From the Internet to Paper ,Fink A ,Sage Publications ,2009

7.Proposal Writing ,Coley S.M. Scheinberg, C.A ,Sage Publications ,1990 8.Intellectual Property Rights in the Global Economy ,Keith Eugene Maskus ,Institute for International Economics ,2000

Semester – II

M.Tech Aeronautical Engineering **Outcome Based Education(OBE) and Choice Based Credit System (CBCS)** **SEMESTER -II**			
AIRCRAFT PERFORMANCE AND FLIGHT MECHANICS **(Professional Core Course)**			
Subject Code	**18MAE21**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand the steady and accelerated performance of airplanes
2. Acquire knowledge of static longitudinal, directional, and lateral stability of airplanes
3. Analyses dynamic longitudinal stability of airplanes

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
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	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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-	**10 Hours**	**L1, L2, L3**

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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Anderson J.D.: Introduction to Flight, McGraw Hill, 1987
2. Perkins, C.D., and Hage, R.E.: Airplane Performance, stability and Control, John Wiley & Sons Inc, New York, 1988.

Reference Books:

1. McCormick B.W., Aerodynamics, Aeronautics and Flight Mechanics, John Wiley & Sons New

York, 1979.
2. Anderson J.D., Foundation of Aerodynamics, McGraw Hill Book Co, New York,1985
3. Ojha S.K., Flight Performance of Aircraft, AIAA Education Series. Editor in Chief, J.S. Przemieniecki 1995.
4. Bandu N. Pamadi, ` Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

AEROSPACE PROPULSION

(Professional Core Course)

Subject Code	**18MAE22**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the construction and operation of turbojet, turboprop and reciprocating engines
2. Acquire knowledge of chemical rocket propulsion
3. Acquire knowledge on space mission propulsion requirement

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
Module -3 **Elements of Chemical Rocket Propulsion:** Classification & fundamentals. Fuels and propellants. Fuel cells for space mission. Rocket combustion processes.	**10 Hours**	**L1, L2, L3**
Module -4 **Solid propellant rocket description:** performance & estimation, Flame spread and Ignition transient. Mechanical characterization of propellants. Grain design. Burn rate estimation.	**10 Hours**	**L1, L2, L3**
Module -5	**10 Hours**	**L1, L2, L3**

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:
After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Aircraft power plants - Michael J Kroes and Thomas W Wild, Macmillan/McGraw Hill NY.
2. Rocket Propulsion Elements - George P Sutton and Donald M Ross, John Wiley & Sons NY.

Reference Books:

1. Aerospace Propulsion - Dennis G Shepherd, American Elsovier Publishing Co Inc NY.
2. Aircraft Gas Turbine Engine Technology, 3rd Edition - E. Irwin Treager, 1995 'ISBN-02018281.
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
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

AIRFRAME STRUCTURES AND STRUCTURAL DESIGN (Professional Core Course)

Subject Code	**18MAE23**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the fundamentals of structural analysis of airframe parts
2. Acquire knowledge of structural design process, and various failure theories
3. Know the airframe life assessment and design against fatigue

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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	**10 Hours**	**L1, L2**
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	**10 Hours**	**L1, L2**
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	**10 Hours**	**L1, L2, L3**

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.	**10 Hours**	**L1, L2, L3**
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)	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. T.H.G.Megson, 'Aircraft structures for engineering students', fourth edition, Butterworth-Heinemann, USA, 2007.
2. E.F.Bruhn, 'Analysis and design of flight vehicle structures', Jacobs Publishing, Inc, USA, 1973.

Reference Books:
1. Michael Chun-Yung Niu, 'Airframe structural design', Lockheed Aeronautical systems company, Burbank, California, Hong Kong Conmilt Press Ltd, USA, February 2002.
2. D.J. Peery, 'Aircraft Structures', Dover Publications, 2011.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2018-2019

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

AVIONICS

(Professional Elective Course)

Subject Code	**18MAE241**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the man-machine interface.
2. Acquire the knowledge of aircraft sensors and avionics instruments.
3. Gain the knowledge of onboard communication systems and know the integration of avionics systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Importance and role of avionics, avionic environment, Regulatory and advisory agencies. **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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**

Module -3	10 Hours	L1, L2, L3
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	**10 Hours**	**L1, L2**
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	**10 Hours**	**L1, L2**
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:

After studying this course, students 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.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.

- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. R.P.G. Collinson., "Introduction to Avionics Systems", Springer, 3rd edition, 2011, ISBN-13: 978-9400707078
2. **Albert Helfrick**, Principals of Avionics 2nd Edition, Avionics Communication Inc.

Reference Books:

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989, ISBN-13: 978-0582018815.
2. Spitzer, C.R., "Digital Avionic Systems", McGraw-Hill Inc., US, 2nd edition, 1992, ISBN-13: 978-0070603332.
3. Mike Tooley and David Wyatt, Aircraft Communications and Navigation Systems, Butterworth Heinemann, 2007.
4. **Brain Kendal**, "Manual of Avionics", The English Book House, 3rd Edition, New Delhi, 1993.

M.Tech Aeronautical Engineering **Outcome Based Education(OBE) and Choice Based Credit System (CBCS)** **SEMESTER -II**			
HELICOPTER DYNAMICS (Professional Elective Course)			
Subject Code	**18MAE242**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course Objectives: This course will enable students to

1. Comprehend the basic concepts of helicopter dynamics.
2. Acquire the knowledge of critical speed and rotor bearing system.
3. Understand the turborotor system and blade vibration.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**8 Hours**	**L1, L2**
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.	**8 Hours**	**L1, L2**
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	**8 Hours**	**L1, L2, L3**

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.	**8 Hours**	**L1, L2, L3**
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.	**8 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge University Press, 2002.
2. George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons, Inc, NY,1975.

Reference Books:

1. W Z Stepniewski and C N Keys, Rotary Wing Aerodynamics, Dover Publications, Inc, New York, 1984.
2. ARS Bramwell, George Done, and David Balmford, Helicopter Dynamics, 2nd Edition, Butterworth-Heinemann Publication, 2001.
3. John, M. Seddon and Simon Newman, Basic Helicopter Aerodynamics, Wiley, 2011.
4. Gareth D. Padfield, Helicopter Flight Dynamics, 2nd Edition, Wiley, 2011.

M.Tech Aeronautical Engineering
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

Artificial Intelligence and Robotics
(Professional Elective Course)

Subject Code	**18MAE243**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course Objectives: This course will enable students to
1. Understand the propositional logic in Artificial Intelligence.
2. Acquire the knowledge of Machine Learning and data mining.
3. Learn the mathematical modeling of Neural Network.
4. Gain Knowledge of robotics kinematics.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction & Propositional Logic:** History of AI, Propositional logic- Computability & Complexity, Applications, Ist Order Predicate logic, limitations of logic.	**6 Hours**	**L1, L2**
Module -2 **Logic Programming:** Prolog system & Implementation, Execution control, Constraint Logic programming, Planning and examples.	**6 Hours**	**L1, L2**

Module -3 **Machine Learning and Data Mining:** Data analysis, learning rule, nearest neighbor method, Decision tree learning, Clustering-Distance matrices, Hierarchical learning.	**8 Hours**	**L1, L2, L3**
Module -4 **Neural Networks**: Mathematical Model, Neural anociative memory, spelling correction program, support vector machine, application of deep learning, application of neural network.	**10 Hours**	**L1, L2, L3**
Module -5 **Robotics:** Introduction, Mathematical representation of robots, kinematics of serial manipulators, kinematics of parallel manipulators, Dynamics of manipulators.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

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

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Wolfgang Ertel,** Introduction to Artificial Intelligence, Springer, 2017.
2. **Ashitara Ghosal,** Robotics-Fundamental Concepts and Analysis ,Oxford Press, 2006

Reference Books:

1. **Vinod Chandra S.S., and Anand Hareendran S ,** Artificial Intelligence and Machine Learning, PHI Learning Pvt. Ltd., 2014.
2. **Saeed B Niku,** Introduction to Robotics-Analysis, Control, Application, Wiley, 2011.

M.Tech Aeronautical Engineering
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

SPACE MECHANICS
(Professional Elective Course)

Subject Code	**18MAE251**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course Objectives: This course will enable students to
1. Understand the basic concepts of space mechanics and the general N-body.
2. Study satellite injection and satellite orbit perturbations.
3. Acquire the knowledge of interplanetary and ballistic missile trajectories.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**08 Hours**	**L1, L2**
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.	**08 Hours**	**L1, L2**
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.	**08 Hours**	**L1, L2, L3**
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.	**08 Hours**	**L1, L2**

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.	**08 Hours**	**L1, L2**

Course Outcomes:

At the end of this 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.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, W.H. Freeman&co,1984.
2. Thomson, Introduction to Space Dynamics, Dover Publications, Revised edition,2012.

Reference Books:

1. Vande Kamp, P., "Elements of Astromechanics", Pitman,1979
2. Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition , 2010, ISBN-13: 978-1452879598
3. George P. Sutton and Oscar Biblarz, Rocket Propulsion Elements, Wiley India Pvt Ltd,7th edition, 2010, ISBN-13: 978-8126525775.

M.Tech Aeronautical Engineering **Outcome Based Education (OBE) and Choice Based Credit System (CBCS)** **SEMESTER -II**			
UNMANNED AERIAL VEHICLES **(Professional Elective Course)**			
Subject Code	**18MAE252**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course Objectives: This course will enable students to

1. Comprehend the basic aviation history and UAV systems.
2. Acquire the knowledge of basic aerodynamics, performance, stability and control.
3. Understand the propulsion, loads and structures.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction** Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV	**6 Hours**	**L1, L2**
Module -2 **The Air Vehicle** **Basic Aerodynamics:** Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag **Performance:** Overview, climbing flight, Range and Endurance – for propeller-driven aircraft, range- a jet-driven aircraft, Guiding Flight	**6 Hours**	**L1, L2**
Module -3 **Stability and Control** Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.	**8 Hours**	**L1, L2, L3**

Module -4 **Propulsion** Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power **Loads and Structures** Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques	**10 Hours**	**L1, L2, L3**
Module -5 **Mission Planning and Control:** Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs	**10 Hours**	**L1, L2, L3**

Course Outcomes:
After studying this course, students will be able to:
1. Apply the basic concepts of UAV systems.
2. Explain the basic aerodynamics, performance, stability and control required for UAV.
3. Select the propulsion system and materials for structures.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd
2. Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions, ISBN13: 9789385505034.

Reference Books:
1. Unmanned Aerial Vehicles: DOD's Acquisition Efforts, Publisher: Alpha Editions, ISBN13: 9781297017544.
2. Valavanis, Kimon P., Unmanned Aerial Vehicles, Springer, 2011.

3. Valavanis, K., Vachtsevanos, George J., Handbook of Unmanned Aerial Vehicles, Springer, 2015.

M.Tech Aeronautical Engineering
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

FLIGHT TESTING
(Professional Elective Course)

Subject Code	**18MAE253**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand the Concept of flight testing and requirement of flight test instrumentation
2. Acquire knowledge of flight test techniques
3. Know the standards, and specifications of handling qualities

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Method of reducing data uncertainty in flight test data -sources and magnitudes of error, avoiding and minimizing errors. **Flight test instrumentation:** Planning flight test instrumentation, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry.	**10 Hours**	**L1, L2**
Module -2 **Performance flight testing - range, endurance and climb:** Airspeed – in flight calibration. Level flight performance for propeller driven aircraft and for Jet aircraft - Techniques and data reduction. Estimation of range, endurance and climb performance. **Performance flight testing - take-off, landing, turning flight:** Maneuvering performance estimation. Take-off and landing - methods, procedures and data reduction.	**10 Hours**	**L1, L2**
Module -3 **Stability and control - longitudinal and maneuvering:** Static & dynamic longitudinal stability: - methods of flight testing and data reduction techniques. Maneuvering stability methods & data reduction.	**10 Hours**	**L1, L2, L3**

Stability and control - lateral & directional: Lateral and directional static & dynamic stability:-Coupling between rolling and yawing moments. definition of Roll stability. Adverse yaw effects. Aileron reversal. Regulations, test techniques and method of data reduction.		
Module -4 **Flying qualities:** MIL and FAR regulations. Cooper-Harper scale. Pilot Rating. Flight test procedures. **Hazardous flight testing:** Stall and spin- regulations, test and recovery techniques. Test techniques for flutter, vibration and buffeting.	**10 Hours**	**L1, L2, L3**
Module -5 **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.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:

1. Apply the Concept of flight testing and specify the requirement of flight test instrumentation
2. Estimate aircraft performance , and stability from flight test data
3. Evaluate handling qualities from flight test data

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Ralph D Kimberlin, Flight Testing of Fixed Wing Aircraft, AIAA educational Series,2003.
2. Perkins, C.D., Hege R.E, Airplane performance, stability and control, John wiley&sons inc, Newyork, 1988.

Reference Books:

1. AGARD, Flight Test Manual Vol. I to IV.

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -II

PROPULSION LAB
(Professional Core Course)

Subject Code	**18MAEL26**	CIE Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Familiarization with various propulsion experimental facilities
2. Familiarize with different propulsion experiments and measurement techniques
3. Conduct the test, acquire the data and analyse and document

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Cascade testing of a model of turbine blade row and study of wake survey.	**L1, L2, L3, L4**
2. Estimation of propeller performance	**L1, L2, L3, L4**
3. Forced Convective heat transfer on a flat surface	**L1, L2, L3, L4**
4. Measurement of Burning Velocity of a Premixed Flame	**L1, L2, L3, L4**
5. Determination of heat of combustion of aviation fuels	**L1, L2, L3, L4, L5**
6. Fuel - injection characteristics (spray cone geometry; spray speed etc. for various typer of injectors)	**L1, L2, L3, L4**
7. Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit	**L1, L2, L3, L4**
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 .	**L1, L2, L3**
9. Investigation of relationship between flame speed and air-fuel ratio for a slow burning gaseous fuel.	**L1, L2, L3**
10. Construction of flame stability diagram through flame lift up and flame fall back	**L1, L2, L3**

11. Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through counter rotating axial flow fan unit	**L1, L2, L3**
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.	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

M.Tech Aeronautical Engineering **Outcome Based Education(OBE) and Choice Based Credit System (CBCS)** **SEMESTER -III**			
AIRCRAFT FLIGHT DYNAMICS AND AUTOMATIC FLIGHT CONTROL **(Professional Core Course)**			
Subject Code	**18MAE31**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand the Concept of application of control and airframe parameters
2. Acquire knowledge of vehicles equations of motion
3. Know the feedback systems and autopilot for pitch, roll, and yaw control

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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	**10 Hours**	**L1, L2, L3**

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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Model equations of motion
2. Do Preliminary feedback systems and autopilot design.

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Jan Roskam: Airplane flight dynamics and automatic flight controls, Part I & II, Published by Design Analysis and Research Corporation (DAR Corporation), 2003, USA.
2. D McRuer, I Ashkenas and D Graham: Aircraft Dynamics and Automatic Control, Princeton University Press, Princeton, New Jersey, 1973

Reference Books:
1. Blake lock J H: Automatic Control of Aircraft and Missiles, John Wiley & Sons, Inc, 1991

2. Babister, A. W: Aircraft dynamic Stability and Response, Pergamon Press, Oxford, 1980.

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -III

FLIGHT VEHICLE DESIGN
(Professional Elective Course)

Subject Code	**18MAE321**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60

CREDITS – 04

Course objectives: This course will enable students to
1. Understand the overview of aircraft design process
2. Acquire knowledge of configuration layout and design of structural components
3. Analyses engine selection and carry out control surface sizing
4. Understand design aspects of subsystems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**10 Hours**	**L1, L2**

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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Aircraft Design - A Conceptual Approach- Daniel P. Raymer, AIAA Education Series, IVth Edition © 2006
2. Design of Aircraft-Thomas C Corke, Pearson Edition. Inc. © 2003.

Reference Books:

1. Aeroplane Design -VOL 1 to 9 - J Roskam
2. Introduction to Aircraft Design - John Fielding, Cambridge University Press, 2009

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Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -III

THEORY OF AEROELASTICITY
(Professional Elective Course)

Subject Code	**18MAE322**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the various aeroelastic phenomenon
2. Acquire knowledge of deformation of airframe parts under static and dynamic loads
3. Develop the wind tunnel test model similarities
4. Understand wind tunnel test techniques

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level

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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Dowell, E. H., Crawley, E. F., Curtiss Jr., H. C., Peters, D. A., Scanlan, R. H., and Sisto, F., A Modern Course in Aeroelasticity, Kluwer Academic Publishers, 3rd Edition, 1995. (TL574.A37.M62)
2. Bisplinghoff, R., Ashley, H., and Halfman, R. L., Aeroelasticity, Dover, 1955. (TL570.B622)

Reference Books:

1. Fung, Y. C., An Introduction to the Theory of Aeroelasticity, 1955 (Dover, 1969).
2. Megson THG,` Aircraft structures for Engineering students`, Edward Arnold.
3. Bisplinghoff, R. and Ashley, H., Principles of Aeroelasticity, Dover, 1962. (TL570.B623)

M.Tech Aeronautical Engineering
Outcome Based Education(OBE) and Choice Based Credit System (CBCS)
SEMESTER -III

HYPERSONIC AERODYNAMICS
(Professional Elective Course)

Subject Code	**18MAE323**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand oblique and curved shock waves and shock wave structure
2. Acquire knowledge of hypersonic viscous effects
3. Know the hypersonic wind tunnel test techniques

		Revised

Modules	Teaching Hours	Bloom's Taxonomy (RBT) Level
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
Course outcomes: After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Wallace D Hayes & Ronald F Probstein, `Hypersonic Inviscid Flows`, Dover Publication 2004.
2. Wallace Hayes,` Hypersonic Flow Theory`, Academic Press Inc., 1959.

Reference Books:

1. John D Anderson Jr. `Hypersonic and High Temperature Gas Dynamics`, AIAA, 2000.
2. Frank K.Lu and Dart E. Marran,` Advanced Hypersonic Test Facilities, AIAA 2002.
3. Cherynl C.G.,` Introduction to Hypersonic Flow`, Academic Press,1961.

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Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER -III

FATIGUE AND FRACTURE MECHANICS
(Professional Elective Course)

Subject Code	**18MAE331**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand the principles of fracture mechanics
2. Acquire knowledge of plastic fracture mechanics
3. Know the computational fracture mechanics

Modules	Teaching Hours	Revised Bloom's Taxonomy

		(RBT) Level
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Apply principles of fracture mechanics
2. Solve problems related to plastic fracture mechanics
3. Model Computational fracture mechanics

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

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, Artinus Nijhoff, London 1999.

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SEMESTER -III

AERO-ENGINE TESTING AND PERFORMANCE EVALUATION
(Professional Elective Course)

Subject Code	**18MAE332**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand aerothermodynamics of compressors, combustors, and turbines
2. Acquire the knowledge design and off-design engine performance
3. Gain knowledge of engine qualification tests, and test cells

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
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.	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2**
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).	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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	**10 Hours**	**L1, L2, L3**

Measurements. Experimental Stress Analysis.

Course outcomes:

After studying this course, students 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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. P.P Walsh and P. Peletcher, Gas Turbine Performance, Blackwell Science, 1998, ISBN 0632047843.
2. J P Holman, Experimental methods for Engineers, Tata McGraw –Hill Publishing Co. Ltd ., 2007

Reference Books:

1. Advance Aero-Engine Testing, AGARD-59 Publication
2. NASA CR-1875,`An inventory of Aeronautical Ground Research Facilities.
3. MIL –5007 E , `Military Specifications: Engine , Aircraft, Turbo Jet & Turbofan General Specification for Advance Aero Engine testing`, 15th Oct 1973.

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Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

SEMESTER -III

THEORY OF COMBUSTION

(Professional Elective Course)

Subject Code	**18MAE333**	CIE Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	SEE Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Understand basic combustion theory
2. Acquire knowledge of diffusion flame
3. Know the combustion process in engines

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Basics of Combustion theory:** Combustion Stochiometry and Thermo chemical Calculation, Chemical Kinetics and Equilibrium, Transport Phenomena-Theory of Viscosity, conductivity and diffusivity	**10 Hours**	**L1, L2**
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	**10 Hours**	**L1, L2**
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.	**10 Hours**	**L1, L2, L3**
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.	**10 Hours**	**L1, L2, L3**
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	**10 Hours**	**L1, L2, L3**

carbon sphere with CO burning gas phase. Chemical Emission from combustion and its effects, Exhaust gas analysis, Emission control methods		

Course outcomes:
After studying this course, students will be able to:

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

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. An Introduction to combustion Concepts and Application, Stephen R Turns, TMH Publication
2. Fundamentals and Technology of combustion, Fawzy El-Mahallawy, Saad El-Din Habik, Elsevier.

Reference Books:

1. Industrial Combustion by Charles E. Baukal.
2. Fundamentals of combustion, D P Mishra, PHI Publication
3. Combustion, Fossil Power Systems by G. Singer. 4th Ed. 1966 Ed Pub.
4. Sharma, S.P., and Chandra Mohan "Fuels and Combustion", Tata Me. Graw Hill Publishing Co.,Ltd., New Delhi, 1987.