VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

M.Tech. Aeronautical Engineering

I SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16MAE11	Applied Mathematics	4	-	3	20	80	100	4
2	16MAE12	Aerodynamics	4	-	3	20	80	100	4
3	16MAE13	Introduction to Aerospace Vehicles and Systems	4	-	3	20	80	100	4
4	16MAE14	Computational Fluid Dynamics	4	-	3	20	80	100	4
5	16MAE15X	Elective-1	3	-	3	20	80	100	3
6	16MAEL16	Aerodynamics Lab	-	3	3	20	80	100	2
7	16MAE17	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective	
16MAE151	Introduction to Advanced Composites
16MAE152	Advanced Gas Turbine
16MAE153	Finite Element Methods
16MAE154	Aero Engine Testing & Performance Evaluation

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SCHEME OF TEACHING AND EXAMINATION 2016-2017

M.Tech. Aeronautical Engineering

II SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16MAE21	Aircraft Performance and Flight Mechanics	4	-	3	20	80	100	4
2	16MAE22	Aerospace Propulsion	4	-	3	20	80	100	4
3	16MAE23	Airframe Structures and Structural Design	4	-	3	20	80	100	4
4	16MAE24	Flight Vehicle Design	4	-	3	20	80	100	4
5	16MAE25X	Elective-2	3	-	3	20	80	100	3
6	16MAEL26	Propulsion Lab		3	3	20	80	100	2
7	16MAE27	Seminar	-	3	-	100	-	100	1
TOTAL			**19**	**6**	**18**	**220**	**480**	**700**	**22**

Elective	
16MAE251	Aircraft Navigation Systems
16MAE252	Theory of Aero-elasticity
16MAE253	Flight Testing
16MAE254	State Space Methods

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M.Tech. Aeronautical Engineering

III SEMESTER: Internship

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Field Work/Assignment	Duration	I.A. Marks	Theory/Practical Marks	Total Marks	
1	16XX31	Seminar / Presentation on Internship (After 8 weeks from the date of commencement)	-	-	-	25	-	25	
2	16XX32	Report on Internship	-	-	-	25	-	25	20
3	16XX33	Evaluation and Viva-Voce of Internship	-	-	-	-	50	50	
4	16XX34	Evaluation of Project phase -1	-	-	-	50	-	50	1
TOTAL			**-**	**-**	**-**	**100**	**50**	**150**	**21**

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IV SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Field Work/ Assignment	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	16MAE41	Aircraft Flight Dynamics and Automatic Flight Control	4	-	3	20	80	100	4
2	16MAE42X	Elective-3	3	-	3	20	80	100	3
3	16XX43	Evaluation of Project phase -2	-	-	-	50	-	50	3
4	16XX44	Evaluation of Project and Viva-Voce	-	-	-	-	100+100	200	10
TOTAL			**-**	**-**	**6**	**90**	**360**	**450**	**20**

Elective	
16MAE421	Fatigue and Fracture Mechanics
16MAE422	Missile Aerodynamics
16MAE423	Theory of Combustion
16MAE424	Rockets and Space Propulsion

Note:

1. Project Phase-1: 6-week duration shall be carried out between 2nd and 3rd Semester vacation. Candidates in consultation with the guide shall carry out literature survey/ visit industries to finalize the topic of Project.

2. Project Phase-2: 16-week duration during 4th semester**.** Evaluation shall be done by the committee constituted comprising of HoD as Chairman, Guide and Senior faculty of the department.

3. **Project Evaluation**: Evaluation shall be taken up at the end of 4th semester. Project work evaluation and Viva-Voce examination shall conducted

4**. Project evaluation:**

a. Internal Examiner shall carry out the evaluation for 100 marks.

b. External Examiner shall carry out the evaluation for 100 marks.

c .The average of marks allotted by the internal and external examiner shall be the final marks of the project evaluation.

d. Viva-Voce examination of Project work shall be conducted jointly by Internal and External examiner for 100 marks.

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APPLIED MATHEMATICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	**16MAE11**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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, Contour Integration, Integration round the unit circle, Rectangular contour. Applications.	**10 Hours**	**L1, L2, L3**
Module -4	**10 Hours**	**L1, L2, L3**

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.		
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.

AERODYNAMICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	**16MAE12**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

High speed Aerodynamics: Fundamentals of thermodynamic concepts, conservation of energy. Speed of sound, Mach wave and Mach angle. Normal shock wave, Oblique shock wave, Expansion fan, Prandtl-Meyer expansion. Family of shocks. Flow through convergent divergent nozzle. Hodograph and pressure turning angle. Rankine-Hugoniot relation.		
Module -4 **Compressible flow over airfoil:** Full velocity potential equation. Small perturbation theory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing.	**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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INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	**16MAE13**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

Standards & Specifications and Testing & Certification Aspects: Introduction to aircraft international and standards specifications for Military and Civil aircraft, Company standards; Airworthiness certification aspects aircraft; Ground testing and qualification testing. **Flight testing:** Purpose and scope, Test plans and procedures; flight test instrumentation; general flying and handling characteristics of aircraft; Preparation, and conduct of tests, fault reporting.		
Module -5 **Introduction to aerospace industries and institutions and their roles:** Aircraft design and production industries; Components and systems manufactures, Service industries, Research and Development organizations and Academic institutions. **Introduction to Airport Engineering:** Development of air transportation, ICAO, IAAI,AAI, Aircraft characteristics which affect airport planning; Airport planning: Airport Master Plan, Regional Plan, Site selection; Terminal area and airport layout, Visual aids and ATC.	**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. Gordon Leishman: Principles of Helicopter Aerodynamics, Cambridge Aerospace series, 2000
3. Jane's All The World Aircraft
4. S K Khanna, M G Arora and S S Jain, Airport Planning and Design NEM Chand and Brothers, Roorki, 6th Edition, 2001

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COMPUTATIONAL FLUID DYNAMICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	**16MAE14**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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 discritization, 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	**10 Hours**	**L1, L2, L3**

generation, Multi Block Structured grid generation, overlapping and Chimera grids. Unstructured Grid Generation: Delaunay-Voronoi Method, advancing front methods (AFM Modified for Quadrilaterals, iterative paving method, Quadtree & Octree method).		
Module -4 **Adaptive Grid Methods:** Multi Block Adaptive Structured Grid Generation, Unstructured adaptive Methods. Mesh refinement methods, and Mesh enrichment method. Unstructured Finite Difference mesh refinement. **Approximate Transformation & Computing Techniques:** Matrices & Jacobian. Generic form of governing Flow Equations with strong conservative form in transformed space. Transformation of Equation from physical plane into computational Plane -examples. Control function methods. Variation Methods. Domain decomposition. Parallel Processing.	**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.

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INTRODUCTION TO ADVANCED COMPOSITES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	**16MAE151**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand composite properties including longitudinal and lateral moduli, Poisson's ratio, and shear modulus
2. Acquire the knowledge to determine the generalized stiffness and compliance matrix relating in-plane stresses to strains for a composite layer assuming plane stiffness
3. Gain knowledge on composite materials application & know what are smart materials

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Science of composite materials:** Polymer-matrix composites, Carbon-matrix, Metal-matrix, Ceramic-matrix. **Advance processing techniques:** Filament winding, pultrusion, pulforming, thermoforming, injection, injection molding, liquid molding, blow molding. Application to aircraft, missiles & spacecraft.	**10 Hours**	**L1, L2**
Module -2 **Macro& microbehavior of a lamina:** Stress strain relationship for an orthotropic Lamina-Restriction on elastic constants-Strengths of an orthotropic lamina and failure theories for an orthotropic lamina. Determination of elastic constants-Rule of mixtures, **Macro-mechanical behavior of a laminate:** Classical plate theory-stress and strain variation in laminate. Strength analysis of a laminate.	**10 Hours**	**L1, L2**
Module -3 **Composite materials for thermal application, electrical/electro-magnetic application:** Materials for high thermal conductivity, thermal interface materials, materials for thermal insulation, materials for heat retention Application to micro-electronics, resistance heating Mechanism behind electromagnetic application, materials for electromagnetic application.	**10 Hours**	**L1, L2, L3**
Module -4 **Materials for thermoelectric, dielectric application, optical &**	**10 Hours**	**L1, L2, L3**

magnetic application: Non-structural & Structural composites, dielectric behavior, piezoelectric behavior, Piezoelectric/ferroelectric composite principles. Pyroelectric behavior. Materials for optical wave guide, materials for lasers. Metal-matrix composites for magnetic application**.**		
Module -5 **Smart structure application:** Polymer matrix composites for damage sensing, temperatures sensing& vibration reduction. **Introduction to testing:** Environmental effects testing, Design allowable & Damage tolerance Testing. Test Techniques.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Determine composite mechanical properties from constituent fiber and matrix material properties including longitudinal and lateral moduli, Poisson's ratio, and shear modulus.
2. Apply the generalized stiffness and compliance matrix relating in-plane stresses to strains for a composite layer assuming plane stiffness.
3. Model classical laminated plate theory to determine extensional, coupling, and bending stiffnesses of a composite laminate.
4. Fabricate composite laminates and built-up composite structures such as I-beams, box beams

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. Composite Materials-Functional Material for modern Technologies-Deborah D. L. Chung, Springer-Verlag London Ltd., 2004.
2. Mechanics of Composite Materials-R M Chawla, Springer Verlag, 1998.

Reference Books:

1. Composite materials-Testing & Design-Ravi B Deo& Charles R, Editor, ASTM STP

Publication, 1996.
2. Composite materials-Properties as Influenced by Phase geometry- Nielson, Springer-Verlag Berlin Heidelberg 2005.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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ADVANCED GAS TURBINES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	**16MAE152**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand jet propulsion cycles and thermodynamics of each component of a turbine engine
2. know the materials for various components and the manufacturing techniques of various parts
3. Gain knowledge on the performance of compressors and turbines

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **JET PROPULSION CYCLES AND ANALYSIS:** Introduction, Prime movers, simple gas turbine, energy equation, Dimensional analysis of rotating machine, Ram jet engine, pulse jet engine, turboprop engine, turbojet engine, thrust and thrust equation, specific thrust of turbojet engine, efficiencies, parameters affecting performance, thrust augmentation, problems.	**10 Hours**	**L1, L2**
Module -2 **Ideal cycles and their analysis:** Introduction, assumptions, Brayton Cycle, reheat cycle, reheat and regenerator, inter cooled cycle with heat exchanger, inter cooled and reheat cycle, comparison of varies cycles, ericsson cycle, compressor and turbine efficiency, performance of actual cycle.	**10 Hours**	**L1, L2**
Module -3 **Centrifugal and axial flow compressors:** essential parts of centrifugal and axial flow compressors, principles of operation, blade shape and velocity triangles, performance characteristics, surging and chocking, degree of reaction, compressor stage efficiency, mechanical loses, problems.	**10 Hours**	**L1, L2, L3**
Module -4 **Impulse and reaction turbine:** single impulse stage and reaction stage, velocity triangles of a single stage machines, expression for work output, blade and stage efficiencies, velocity and pressure compounding, multi stage reaction turbines, performance graphs, losses	**10 Hours**	**L1, L2, L3**

and efficiencies.		
Module -5 **Blade materials, cooling and environmental consideration:** Blade materials, manufacturing techniques, blade fixing, blade cooling, liquid cooling, air cooling, practical air cooled blades, NOX formation, noise standards, noise reduction, aircraft emission standards.	**10 Hours**	**L1, L2, L3**

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

1. Model jet propulsion cycles
2. Select the materials for various components and involve in manufacturing of various parts
3. Solve problems related to performance of compressors and turbines

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. Gas turbines - V Ganesan Tata McGraw-Hill Publishing company limited.
2. Gas turbine theory - H.I.H Saravanamuttoo, G.F.C. Rogers and H. Cohen PV Straznicky, Publisher: Pearson Education Canada.

Reference Books:

1. Mechanics & Thermodynamics of Propulsion - Hill, P.G. & Peterson, C.R. Addison – Wesley Longman INC, 1999.
2. Aerospace Propulsion - Dennis G Shepherd, American Elsevier Publishing Co Inc NY.
3. Aircraft Gas Turbine Engine Technology, 3rd Edition - E. Irwin Treager, 1995 ISBN-002018281.

FINITE ELEMENT METHODS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	**16MAE153**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

matrixes, Problems, trusses with one, two, three and four bar elements.		
Module -4 **FEM analysis of Heat Transfer and Fluid Flow:** Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.	**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.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

AERO-ENGINE TESTING AND PERFORMANCE EVALUATION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	**16MAE154**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

Reliability Tests, Failure Simulation Tests, Functional And Operability Tests. **Types of engine tests:** Normally Aspirated Testing, Ram Air Testing, Altitude Testing, Flying Test Bed, Mission Oriented Tests, Open Air Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing.		
Module -5 **Test cell:** Air breathing engine test facility. Direct connect altitude cell, propulsion wind tunnels. Types of engine test beds. Factors for design of engine test beds. Altitude test facility. Steps in test bed cross calibration. Engine testing with simulated inlet distortions. Surge test. Cell Calibration and Correction. Performance Reduction Methodology. Instrumentation: Data Acquisition, Measurement of Thrust, Pressure, Temperature, Vibration, etc. Accuracy and Uncertainty in Measurements. Experimental Stress Analysis.	**10 Hours**	**L1, L2, L3**

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. Pletcher, 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.

AERODYNAMICS LAB

[As per Choice Based Credit System (CBCS) scheme]

Semester I

Subject Code	**16MAEL16**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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	**L1, L2, L3**

wind tunnel for varied yaw angle and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle.

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

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.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2016-2017

AIRCRAFT PERFORMANCE AND FLIGHT MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE21**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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-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	**10 Hours**	**L1, L2, L3**

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.

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CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

AEROSPACE PROPULSION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE22**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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 **Liquid propellant rocket description:** performance & estimation. Injectors. Cooling. Systems. Combustion instabilities. **Hybrid propellant rocket description:** performance & estimation, Mission	**10 Hours**	**L1, L2, L3**

requirements & Power plant selection. Ramjet and Scramjet engines. Introduction to Space mission.		

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

4. Explain construction and operation of various propulsion devices
5. Solve problems related to combustion
6. 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

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

AIRFRAME STRUCTURES AND STRUCTURAL DESIGN

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE23**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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 against fatigue, prediction of aircraft fatigue life.	**10 Hours**	**L1, L2, L3**
Module -4	**10 Hours**	**L1, L2, L3**

Wing box structure and Fuselage: Introduction, wing box design, wing covers, spars, Ribs and bulkheads, wing root joints, variable swept wings, wing fuel tank design. Fuselage: Introduction, fuselage configuration, fuselage detail design, forward fuselage, wing and fuselage intersection, stabilizer and aft fuselage intersection, fuselage opening.		
Module -5 **Empennage structure, Landing gear and engine mounts: Landing gear:** Empennage structure: introduction, Horizontal stabilizer, vertical stabilizer, elevator and rudder. Introduction, developments and arrangements, stowage and retraction, detail design. Engine mounts: Introduction, propeller driven engine mounts, inlet of jet engines, wing-pod (pylon) mounts, rear fuselage mounts and tail mounts, fuselage mounts (fighters)	**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.
3. Michael Chun-Yung Niu, 'Airframe structural design', Lockheed Aeronautical systems company, Burbank, California, Hong Kong Conmilt Press Ltd, USA, February 2002,

Reference Books:

1. Aircraft structures by David Perry, McGraw Hill, 1982
2. Structural Analysis with Application to Aerospace Structures by O.A. Bauchau and J. I. Craig, Springer ,2009

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

FLIGHT VEHICLE DESIGN

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE24**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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-	**10 Hours**	**L1, L2, L3**

off, Landing & Enhanced Lift Devices:- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking. Enhanced lift design -Passive & Active.		
Module -4 **Static Stability & Control:** Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.	**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

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017

AIRCRAFT NAVIGATION SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE251**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the techniques of navigation
2. Acquire knowledge of air data system
3. Understand ILS and ATC management

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Guidance versus Navigation, categories of navigation, the vehicle, phases of flight, design trade-offs; Evolution of Air navigation, integrated avionics. The Navigation equations: Geometry of earth, coordinate frames, dead-reckoning computations, positioning, positioning, terrain-matching, course computation, errors, digital charts, software aspects and future trends.	**10 Hours**	**L1, L2**
Module -2 **Terrestrial Radio-Navigation Systems:** General principles, system design considerations, point source systems, hyperbolic systems, future trends. Terrestrial Integrated Radiocommunication - Navigation Systems: Inertial navigation: Introduction, JTIDS relative navigation, position location reporting system, future trends.	**10 Hours**	**L1, L2**
Module -3 **Inertial Navigation:** The system, Instruments, Platforms, Mechanization equations, error analysis, alignment. Satellite Radio Navigation: Basics, orbital mechanics and clock characteristics, atmospheric effects on satellite signals, NAVSTAR GPS, GLONASS, GNSS, future trends.	**10 Hours**	**L1, L2, L3**
Module -4 **Air data Systems:** Air-data measurements, equations, systems, specialty designs, calibration and system test, future trends. Attitude and Heading References: basic instruments, vertical references, heading references, initial alignment of heading references, future	**10 Hours**	**L1, L2, L3**

trends. **Doppler and Altimeter Radars:** Doppler radars, radar altimeters, future trends. **Mapping and Multimode Radars:** radar pilot age, semiautomatic position fixing, semiautomatic position fixing with synthetic, precision velocity update, terrain following and avoidance, multimode radars, signal processing, airborne weather radar, future trends.		
Module -5 **Celestial Navigation:** star observation geometry, theory of stellar-inertial navigation, stellar sensor design characteristics, Celestial Navigation system design, star catalog characteristics, system calibration and alignment, future trends. **Landing Systems:** the mechanics of landing; low-visibility operations, automatic landing systems: ILS, microwave-landing system, satellite landing system, carrier- landing system, future trends **Air Traffic Management:** flight rules and procedures, phases of flight, subsystems, facilities and operations, system capacity, airborne collision avoidance systems.	**10 Hours**	**L1, L2, L3**

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

1. Apply techniques of navigation
2. Use air data system
3. Demonstrate ILS and ATC management

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. Myron Kayton and Walter R. Fried: Avionics Navigation Systems, John Wiley & Sons Inc., 2nd Edition, 1996
2. Collinson RPG, Introduction to Avionics, Second Edition, Kluwer Academic Publishers, Chapman & Hall, 2003.

Reference Books:

3. Siouris G M: Aerospace avionic systems – A Modern Synthesis, Academic Press 1993

THEORY OF AEROELASTICITY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	**16MAE252**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

Flutter prevention and control.		
Module -4 **Test model similarities:** Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity law. Scale factors. Structural simulation:-shape, mass and stiffness.	**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)

FLIGHT TESTING

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	**16MAE253**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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

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.

STATE SPACE METHODS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	**16MAE254**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the concept of state space methods
2. Acquire knowledge of linear state space models and estimation of parameters though maximum likelihood method
3. Understand nonlinear state space modeling and smoothing of sampling

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction.** Basic idea of state space and its analysis. Linear state space model, local level model, non-Gaussian & nonlinear models. Prior knowledge, notations. Concept of filtering, forecast errors, error recursion, state smoothing. Disturbance smoothing parametric estimation –log likelihood method.	**10 Hours**	**L1, L2**
Module -2 **Linear State Space Model.** Univariate structural time series model. Introduction to multivariate structural time series models. Regression model. Space state models in continuous time. Spline smoothing. Filters, Smoothing & Forecasting. State smoothing, smoothened state error, state smoothing recursion, disturbance smoothing, weight functions, simulation smoothing state model in matrix form.	**10 Hours**	**L1, L2**
Module -3 **Maximum Likelihood Estimation of Parameters.** Likelihood qualification. Log likelihood when initial conditions are known. Diffuse log likelihood. Likely hood when model contains regression effects. Likelihood when large observation vector is collapsed. Numerical maximisation algorithm. Goodness of fit. Diagnostic checking. Illustrations of Use of Linear Model. Structural time series model. Bivariate structural time series analysis.	**10 Hours**	**L1, L2, L3**
Module -4	**10 Hours**	**L1, L2, L3**

Non-Gaussian & Nonlinear State Space Models. Special cases of nonlinear linear and non-Gaussian models. Models with linear Gaussian signals. Exponential family models. Heavy tailed distribution. Stochastic Volatility model. Filtering, and smoothing of non-Gaussian and nonlinear model.		
Module -5 **Approximate Model Filtering & Smoothing.** Multicaptive-Introduction. Trend cycle decomposition. Nonlinear Smoothing-Extended Smoothing. Unscetented smoothing. Approximate mode estimation. Improvement of sampling from smoothing. Filtering and smoothing in Dynamic systems.	**10 Hours**	**L1, L2, L3**

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

1. Apply the knowledge of state space methods
2. Demonstrate knowledge of linear state space models and estimation of parameters though maximum likelihood method
3. Model smoothing of sampling

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. J Durbin & SJ Koopman, Time series analysis-State Space Methods, 2nd Edition, Oxford 2012.

Reference Books:

1. Daniel Alpay & Israel Gohberg, State Space Method:- Generalisation & Applications, Springer

PROPULSION LAB

[As per Choice Based Credit System (CBCS) scheme]

Semester I

Subject Code	**16MAEL26**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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	**L1, L2, L3**

static pressure rise & fan overall efficiency through counter rotating axial flow fan unit.

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.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2016-2017

AIRCRAFT FLIGHT DYNAMICS AND AUTOMATIC FLIGHT CONTROL

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**16MAE41**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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:

4. Model equations of motion
5. 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.

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SCHEME OF TEACHING AND EXAMINATION 2016-2017

FATIGUE AND FRACTURE MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**16MAE421**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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, atigue 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 **o**f 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 (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. Introduction to Fracture Mechanics - Karen Helen, McGraw Hill Pub 2000.
2. Fracture of Engineering Brittle Materials - Jayatilake, Applied Science, London. 2001.

Reference Books:

1. Fracture Mechanics Application - T. L. Anderson, CRC press 1998.
2. Elementary Engineering Fracture of Mechanics - David Broek, ArtinusNijhoff, London 1999.

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MISSILE AERODYNAMICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**16MAE422**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand aerodynamic theory of bodies of revolution
2. Acquire knowledge of missile maneuvering flight
3. Know the air loads acting on missiles

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Theory of bodies of revolution. Lift and moment of slender bodies of revolution..Planar W-B Interference. Classes of missiles, Types of design and control; Wing, Canard, Tail, Tailless control; Dorsal, Jet control, Monowing, Triform, and Cruciform.	**10 Hours**	**L1, L2**
Module -2 **Aerodynamic Characteristics of Airframe Components & Missile Performance:** Forebody: conical, ogival, hemi-spherical, etc. Midsection: boat-tail. Characteristics of bodies of revolution. Aerodynamics of airfoil, Aspect-ratio, Wing Planform, Aerodynamic control: wing, canard and tail. **Missile Performance:** Introduction. Drag: Friction, pressure, interference, induced and boat tail drag. Boost glide trajectory: graphical and iterative method. Long range cruise trajectory; Maximum speed, rate of climb, time to climb, stall speed, maximum range. Long range ballistic trajectory: powered and unpowered flight and design consideration.	**10 Hours**	**L1, L2**
Module -3 **Longitudinal Stability and Control, Maneuvering Flight:** Introduction, Two-degree of freedom analysis, Complete missile aerodynamics: static stability margin, load factor capability for forward control and rear control, Flat turn: Cruciform, Triform, Pull ups; Relation between Maneuverability and load factor. Stability margin.	**10 Hours**	**L1, L2, L3**

Module -4 **Directional & Lateral Stability and Control:** Introduction, Cruciform configuration: wing, body and tail contribution, Directional Control. Introduction to lateral stability and control, Induced roll - cruciform, Lateral Control cruciform, Special design consideration, Damping in roll. Induced roll; Mono wing, Lateral Control- Mono wing.	**10 Hours**	**L1, L2, L3**
Module -5 **Air loads: Design criteria:** Forward Control, Rear control. Component Air loads: Body, Aerodynamic surfaces. Component load distribution: Body and lifting surfaces. Aerodynamic Hinge moments and Aerodynamic heating.	**10 Hours**	**L1, L2, L3**

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

1. Apply aerodynamic theory of bodies of revolution missile configuration
2. Solve problems related missile stability and control
3. Describe air loads acting on missile

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. S S Chin, “Missile Configuration Design”, McGraw Hill, 1961
2. Jack N Neilson, `Missile Aerodynamics`, McGraw hill Book Company, Inc 1960

Reference Books:

1. M.J. Hemsch, and J.N. Nielsen,” Tactical Missile Aerodynamics”, AIAA , 2006
2. J.H. Blacklock,” Automatic Control of Aircraft and Missiles”, John Wiley & Sons, II Edition, 1991.

THEORY OF COMBUSTION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**16MAE423**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

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 carbon sphere with CO burning gas phase. Chemical Emission from combustion and its effects, Exhaust gas analysis, Emission control methods	**10 Hours**	**L1, L2, L3**

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

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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ROCKET AND SPACE PROULSION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**16MAE424**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course objectives: This course will enable students to

1. Understand functioning of solid and liquid rocket propulsion
2. Acquire knowledge of launch vehicle dynamics
3. Know the futuristic rocket propulsion

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Types of rocket engines, Liquid and Solid Propellant rocket engines, Rocket Propulsion theory, Rocket dynamics- Vertical flight of rocket, the rocket equation, Altitude gain during vertical flight, Escape velocity.	**10 Hours**	**L1, L2**
Module -2 **Thermodynamics and Heat Transfer in Rocket Engines:** Thermodynamics of Rocket Propulsion, Nozzle Theory, Over and Underexpanded Nozzles, two-phase flow, variable thrust, High velocity flow with heating in the chamber. General steady state Heat transfer relation, Rocket thrust chamber heat transfer, uncooled combustion devices, Heat transfer to flying vehicles, Exhaust jet and atmospheric interaction.	**10 Hours**	**L1, L2**
Module -3 **Solid propellant and Liquid propellant rocket Engines :** Properties and design of solid motors, Integrity of the combustion chamber, Ignition, Hybrid rocket motors, modern solid booster motors Basic configuration and types of liquid propellant rocket engines, Combustion chamber and nozzle, Cooling of liquid-fuelled rocket engines, Choice of propellant and performance of Liquid fuelled rocket engines	**10 Hours**	**L1, L2, L3**

Module -4 **Combustion in Rocket Engines and launch vehicle dynamics:** Combustion of carbon particle-simplified analysis, boundary layer combustion, combustion of carbon sphere with CO burning gas phase. Problems. Vertical motion in earth's gravity field, inclined motion in earth's gravity field, motion in atmosphere, Gravity turn, typical earth-launch trajectories	**10 Hours**	**L1, L2, L3**
Module -5 **Electric and Nuclear Propulsion:** Principles of electric propulsion, electric, electromagnetic, and plasma thrusters, Electrical power generation, Nuclear reactor fundamentals, nuclear fission and chain reaction, Typical nuclear rocket system and Operational issues with the nuclear rocket engine	**10 Hours**	**L1, L2, L3**

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

1. Apply knowledge of solid and liquid rocket propulsion
2. Solve problems related to launch vehicle dynamics
3. Work towards newer concepts in rocket propulsion

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. Rocket Propulsion Elements by G. P. Sutton and O. Biblarz, 8th Edition, John Wiley and Sons, 2001
2. Rocket and Spacecraft Propulsion: Principles, Practice and New Developments by M. J. L. Turner, Third Edition, Springer, 2009

Reference Books:

1. Spacecraft Propulsion by C. D. Brown, AIAA Education Series, Mechanics and

Thermodynamics of Propulsion by P. Hill and C. Peterson, Second Edition, 1992, Addison-Wesley

2. Space Propulsion Analysis and Design, Revised Edition, by R. W. Humble, G. N. Henry and W. J. Larson, McGraw Hill, 1995