# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
# CHOICE BASED CREDIT SYSTEM (CBCS)
## SCHEME OF TEACHING AND EXAMINATION 2015-2016
## Aeronautical Engineering
## VII Semester

| Sl. No | Subject Code | Title | | Teaching Hours /Week | | Examination | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical/Drawing | Duration | I.A. Marks | Theory/ Practical Marks | Total Marks | |
| 1 | 15AE71 | CONTROL ENGINEERING | | 04 | | 03 | 20 | 80 | 100 | 4 |
| 2 | 15AE72 | COMPUTATIONAL FLUID DYNAMICS | | 04 | | 03 | 20 | 80 | 100 | 4 |
| 3 | 15AE73 | AIRCRAFT STABILITY AND CONTROL | | 04 | | 03 | 20 | 80 | 100 | 4 |
| 4 | 15AE74X | PROFESSIONAL ELECTIVE | | 03 | | 03 | 20 | 80 | 100 | 3 |
| 5 | 15AE75X | PROFESSIONAL ELECTIVE | | 03 | | 03 | 20 | 80 | 100 | 3 |
| 6 | 15AEL76 | FLIGHT SIMULATION LAB | | | 1I+2P | 03 | 20 | 80 | 100 | 2 |
| 7 | 15AEL77 | MODELING AND ANALYSIS LAB | | | 1I+2P | 03 | 20 | 80 | 100 | 2 |
| 8 | 15AEP78 | Project Phase –I + Project Seminar | | - | | - | 100 | - | 100 | 2 |
| **TOTAL** | | | | **18** | **6** | **21** | **240** | **560** | **800** | **24** |

| Professional Elective (15AE74X) | | Professional Elective (15AE75X) | |
|---|---|---|---|
| 15AE741 | FATIGUE AND FRACTURE MECHANICS | 15AE751 | OPERATIONS RESEARCH |
| 15AE742 | HIGH PERFORMANCE COMPUTING | 15AE752 | WIND TUNNEL TECHNIQUES |
| 15AE743 | HELICOPTER DYNAMICS | 15AE753 | NUMERICAL METHODS |
| 15AE744 | AERO-ELASTICITY | 15AE754 | GUIDANCE, NAVIGATION & CONTROL |

1. **Core subject:** This is the course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch
3. **Project Phase –I + Project Seminar:** Literature Survey, Problem Identification, objectives and Methodology. Submission of synopsis and seminar.

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
# CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2015-2016

## CONTROL ENGINEERING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII

| | | | |
|---|---|---|---|
| Subject Code | **15AE71** | 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 basic concepts of control systems and mathematical models.
2. Acquire the knowledge on block diagrams and signal flow graphs.
3. Understand the frequency response analysis and various types of plots.

| **Modules** | **Teaching Hours** | **Revised Bloom's Taxonomy (RBT) Level** |
|---|---|---|
| **Module -1**<br><br>**Introduction to Control Systems and Mathematical Models**<br><br>**Introduction:** Concept of controls, Open loop and closed loop systems with examples, Concepts of feedback and basic structure of feedback control system, requirements of an ideal control system.<br><br>**Mathematical Models:** Transfer function models of mechanical systems, electrical circuits, DC and AC motors in control systems, Analogous systems: Force voltage and Force current analogy. | **10 Hours** | **L1, L2** |

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| | | |
| **Module -2**<br><br>**Block Diagrams and Signal Flow Graphs**<br>Transfer functions definition and its properties, block representation of control systems and terminologies, block diagram algebra and reduction of block diagrams, Signal flow graph method, Mason's gain formula and its applications<br><br>**Transient and Steady State Response Analysis**<br>Introduction, type and order of systems, time response specifications, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response. | **10 Hours** | **L1, L2** |
| **Module -3**<br><br>**System stability** analysis using Routh's – Hurwitz Criterion<br><br>**Root Locus Plots**<br>Definition of root loci, General rules for constructing root loci, Analysis using root locus plots, Determination of desired gain, limit gain, gain margin and conditional stability.<br><br>**Frequency Response Analysis Using Bode Plots:**<br>Bode attenuation diagrams for first and second order systems, | **10 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| Simplified Bode diagrams, Stability analysis using Bode plots and determination of phase margin and gain margin and gain<br>. | | |
| **Module -4**<br><br>**Frequency Response Specification and Analysis using Polar plots:**<br>**Specification:** Frequency response definition, frequency response specifications and its relationship with time response specifications.<br><br>**Analysis:** Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin, M&N circles. | **10 Hours** | **L1, L2, L3** |
| **Module -5**<br><br>**Feedback control systems:**<br>Types of controllers – Proportional, Integral, Derivative controllers, Proportional – Integral, Proportional – Integral – Derivative controllers; Compensation methods – Series and feedback compensation, Lead, Lag and Lead-Lag Compensators.<br><br>**State Variable Characteristics of Linear Systems:**<br>Introduction to concepts of states and state variable representation of linear systems, Advantages and Disadvantages over conventional transfer function representation, state equations of linear continuous data system. Matrix representation of state equations, Solution of state equation, State transition matrix and its properties, controllability and observability, Kalman and Gilberts test. | **10 Hours** | **L1, L2, L3** |
| **Course Outcomes:**<br>After studying this course, students will be able to:<br>1. Apply the concepts of control systems. | | |

2. Reduce the block diagrams and signal flow graphs.
3. Determine the frequency response analysis by using various types of plots.

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

1. U.A. Bakshi and V.U. Bakshi, Control Engineering, Technical Publications, ISBN: 978-93-5099-657-7.
2. A. Nagoor Kani, Control Systems Engineering, RBA Publications, 2014.

Reference Books:

1. Katsuhiko Ogatta, Modern Control Engineering, Pearson Education,2004.
2. I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age Publishers, 2017.
3. Richard. C. Dorf and Robert.H. Bishop, Modern Control Systems, Addison Wesley, 1999.
4. N.S. Nise, Control Systems

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|---|
| Engineering, 6th Edition, Wiley, 2012. |

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
## CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2015-2016

<table>
<tr><td colspan="4" align="center">COMPUTATIONAL FLUID DYNAMICS<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – VII</td></tr>
<tr><td>Subject Code</td><td>15AE72</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>04</td><td>Exam Hours</td><td>03</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>50</td><td>Exam Marks</td><td>80</td></tr>
<tr><td colspan="4" align="center">CREDITS – 04</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to<br>1. Know the basic equations of fluid dynamics, boundary layer and discretization.<br>2. Understand the source and vortex panel method.<br>3. Know about FDM, FVM and FEM.</td></tr>
</table>

| **Modules** | **Teaching Hours** | **Revised Bloom's Taxonomy Level** |
|---|---|---|
| **Module -1**<br>**Introduction:** CFD Applications. Need for Parallel Computers in CFD algorithms. Models of flows. Substantial derivative, Divergence of velocity. Continuity, Momentum, and Energy Equations-Derivation in various forms. Integral versus Differential form of equations. Comments on governing equations. Physical boundary conditions. Forms of equations especially suitable for CFD work. Shock capturing, and shock fitting. | **10 Hours** | **L1, L2** |
| **Module -2**<br><br>**Mathematical Behaviour of Partial Differential Equations:** Classification of partial differential equations. Cramer Rule and Eigen value methods for classification. Hyperbolic, parabolic, and elliptic forms of equations. Impact of classification on physical and | **10 Hours** | **L1, L2** |

| | | |
|---|---|---|
| computational fluid dynamics. Case studies: steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow, and unsteady thermal conduction, steady subsonic inviscid flow. | | |
| **Module -3**<br>**Grid Generation and Adaptive Grids:** Need for grid generation and Body-fitted coordinate system. Structured Grids-essential features. Structured Grid generation techniques- algebraic and numerical methods. Unstructured Grids-essential features. Unstructured Grid generation techniques- Delaunay-Voronoi diagram, advancing front method. Surface grid generation, multi-block grid generation, and meshless methods. Grid quality and adaptive grids. Structured grids adaptive methods and unstructured grids adaptive methods. | **10 Hours** | **L1, L2, L3** |
| **Module -4**<br><br>**Discretisation & Transformation:**<br>Discretisation: Finite differences methods, and difference equations. Explicit and Implicit approaches. Unsteady Problem -Explicit versus Implicit Scheme. Errors and stability analysis. Time marching and space marching. Reflection boundary condition. Relaxation techniques. Alternating direction implicit method. Successive over relaxation/under relaxation. Second order Lax-Wendroff method, mid-point Leap frog method, upwind scheme, numerical viscosity, and artificial viscosity.<br><br>**Transformation:** Transformation of governing partial differential equations from physical domain to computational domain. Matrices and Jacobians of transformation. Example of transformation. Generic form of the Governing flow equations in Strong Conservative form in the Transformed Space. | **10 Hours** | **L1, L2** |
| **Module -5**<br>**Finite Volume Technique and Some Applications:** Spatial discretisation- cell centered and cell vertex techniques (overlapping control volume, duel control volume). Temporal discretisation- Explicit time stepping, and implicit time stepping. Time step calculation. | **10 Hours** | **L1, L2** |

| | | |
|---|---|---|
| Upwind scheme and high resolution scheme. Flux vector splitting, approximate factorisation. Artificial dissipation and flux limiters. Unsteady flows and heat conduction problems. Upwind biasing. | | |

**Course outcomes:**

After studying this course, students will be able to:

1. Differentiate the FDM, FVM and FEM
2. Perform the flow, structural and thermal analysis.
3. Utilize the discretization methods according to the application.

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

1. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics", Springer, Berlin,2nd edition, 2002,ISBN-13: 978-3540543046
2. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill, 2013, **ISBN-13:** 978-0070016859.

**Reference Books:**

1. John F. Wendt, "Computational Fluid Dynamics - An Introduction", Springer, 3rd edition,2013
2. Charles Hirsch, "Numerical Computation of Internal and External Flows", Elsevier,1st edition, 2007, ISBN-13: 978-9381269428.
3. Klaus A Hoffmann and Steve T. Chiang. "Computational Fluid Dynamics for Engineers", Vols. I & II Engineering Education System, P.O. Box 20078, W. Wichita, K.S., 67208 - 1078 USA, 1993.

4. Tapan K. Sengupta, Fundamentals of CFD, Universities Press, 2004.

**VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM**
**CHOICE BASED CREDIT SYSTEM (CBCS)**
SCHEME OF TEACHING AND EXAMINATION 2015-2016

<table>
<tr><td colspan="4" align="center">AIRCRAFT STABILITY AND CONTROL<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – VII</td></tr>
<tr><td>Subject Code</td><td>15AE73</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>04</td><td>Exam Hours</td><td>03</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>50</td><td>Exam Marks</td><td>80</td></tr>
<tr><td colspan="4" align="center">CREDITS – 04</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to<br>1. Understand the basics of aircraft stability and control.<br>2. Understand the static longitudinal and static directional stability.<br>3. Acquire the knowledge on dynamic lateral and directional stability.</td></tr>
</table>

| Modules | Teaching Hours | Revised Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br><br>**Static Longitudinal Stability and Control-Stick Fixed**<br>Historical perspective, Aerodynamic Nomenclature, 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 Introduction, 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. | **10 Hours** | **L1, L2** |

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| **Module -2**<br><br>**Static Longitudinal Stability& Static Directional Stability and Control-Stick free**<br>Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim tabs, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G.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** |
| **Module -3**<br>**Static lateral dynamic & longitudinal stability and control**<br>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. Coupling between rolling and yawing moments. Adverse yaw effects. Aileron reversal. Definition of Dynamic longitudinal stability. Types of modes of motion: long or phugoid motion, short period motion. Airplane Equations of longitudinal motion. | **10 Hours** | **L1, L2, L3** |
| **Module -4** | **10 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| **Estimation of Dynamic Derivatives**<br>Derivation of rigid body equations of motion, Orientation and position of the airplane, gravitational and thrust forces, Small disturbance theory. Aerodynamic force and moment representation, Derivatives due to change in forward speed, Derivatives due to the pitching velocity, Derivatives due to the time rate of change of angle of attack, Derivatives due to rolling rate, Derivatives due to yawing rate. | | |
| **Module -5**<br>**Dynamic Lateral and Directional Stability**<br>Routh's criteria. Factors affecting period and damping of oscillations. Effect of wind shear. Flying qualities in pitch. Cooper-Harper Scale. Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for lateral and directional dynamics. | **10 Hours** | **L1, L2, L3** |

**Course outcomes:**
After studying this course, students will be able to:
1. Apply the basic concepts of aircraft stability and control.
2. Differentiate the static longitudinal and static directional stability.
3. Estimate the dynamic derivatives.

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

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

**Text Books:**

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.

**Reference Books:**

1. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.
3. W.J. Duncan, The Principles of the Control and Stability of Aircraft, Cambridge University Press, 2016.

## PROFESSIONAL ELECTIVES

### FATIGUE AND FRACTURE MECHANICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE741** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course objective:**
This course will enable students to

1. Understand the basics of fatigue of structures.
2. Comprehend the fracture mechanics.
3. Acquire the knowledge of fatigue design and testing.

| Modules | Teaching Hours | Revised Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br>**Fatigue of Structures:** S.N. curves, Endurance limit, Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams, Notches and stress concentrations, Neuber's stress concentration factors, plastic stress concentration factors – Notched S-N curves | **10 Hours** | **L1, L2** |
| **Module -2**<br><br>**Statistical Aspects Of Fatigue Behaviour:** Low cycle and high cycle fatigue, Coffin-Manson's relation, Transition life, Cyclic Strain hardening | **8 Hours** | **L1, L2** |

| | | |
|---|---|---|
| and softening, Analysis of load histories, Cycle counting techniques, Cumulative damage, Miner's theory, other theories. | | |
| **Module -3**<br>**Physical Aspects Of Fatigue:** Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Dislocations, Fatigue fracture surfaces. | **6 Hours** | **L1, L2, L3** |
| **Module -4**<br><br>**Fracture Mechanics:** Strength of cracked bodies, potential energy and surface energy, Griffith's theory, Irwin – Orwin extension of Griffith's theory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries. | **8 Hours** | **L1, L2** |
| **Module -5**<br>**Fatigue Design And Testing:** Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to composite materials and structures. | **8 Hours** | **L1, L2** |

**Course outcomes:**

After studying this course, students will be able to:

1. Evaluate the fatigue of structures.
2. Determine the strength of cracked bodies.
3. Distinguish the safe life and fail safe design.

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

1. D. Brock, "Elementary Engineering Fracture Mechanics", Noordhoff International Publishing Co., London, 1994.
2. J.F.Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London,1983.

**Reference Books:**

1. W. Barrois and L. Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.
2. C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

## HIGH PERFORMANCE COMPUNTING

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

SEMESTER – VII

| | | | |
|---|---|---|---|
| Subject Code | **15AE742** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course objective:**

This course will enable students to

1. Understand the concepts of high performance computing
2. Acquire the knowledge of various algorithms required for parallel computing.
3. Understand the concepts of architecture.

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

| | | |
|---|---|---|
| **Module -1**<br>**Computational Science and Engineering Introduction**: Computational Science and Engineering Applications; characteristics and requirements, Review of Computational Complexity, Performance: metrics and measurements, Granularity and Partitioning, Locality: temporal/spatial/stream/kernel, Basic methods for parallel programming, Real-world case studies (drawn from multi-scale, multi-discipline applications) | **8 Hours** | **L1, L2** |
| **Module -2**<br>**High-End Computer Systems: Memory Hierarchies, Multi-core Processors**: Homogeneous and Heterogeneous, Shared-memory Symmetric Multiprocessors, Vector Computers, Distributed Memory Computers, Supercomputers and Petascale Systems, Application Accelerators / Reconfigurable Computing, Novel computers: Stream, multithreaded, and purpose-built | **8 Hours** | **L1, L2** |
| **Module -3**<br>**Parallel Algorithms**: Parallel models: ideal and real frameworks, Basic Techniques: Balanced Trees, Pointer Jumping, Divide and Conquer, Partitioning, Regular Algorithms: Matrix operations and Linear Algebra, Irregular Algorithms: Lists, Trees, Graphs, Randomization: Parallel Pseudo-Random Number Generators, Sorting, Monte Carlo techniques. | **8 Hours** | **L1, L2, L3** |
| **Module -4**<br>**Parallel Programming**: Revealing concurrency in applications, Task and Functional Parallelism, Task Scheduling, Synchronization Methods, Parallel Primitives (collective operations), SPMD Programming (threads, Open MP, MPI), I/O and File Systems, Parallel Matlabs (Parallel Matlab, Star-P, Matlab MPI), Partitioning Global Address Space (PGAS) languages (UPC, Titanium, Global Arrays). | **8 Hours** | **L1, L2** |

| | | |
|---|---|---|
| **Module -5**<br>**Achieving Performance**: Measuring performance, Identifying performance bottlenecks, Restructuring applications for deep memory hierarchies, Partitioning applications for heterogeneous resources, Using existing libraries, tools, and frameworks. | **8 Hours** | **L1, L2** |

**Course outcomes:**

After studying the course the students will be able to

1. Apply the concepts of high performance computing
2. Develop various algorithms required for parallel computing.
3. Compare architectures for high performance computing.

**Graduate Attributes :**

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Modern tools

**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. Grama, A. Gupta, G. Karypis, V. Kumar, An Introduction to Parallel Computing, Design and Analysis of Algorithms,Pearson Education India,2nd edition, 2004,ISBN-13: 978-8131708071.
2. G.E. Karniadakis, R.M. Kirby II, Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and their Implementation, Cambridge University Press, 2003.

**Reference Books:**

1. Wilkinson and M. Allen, Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, Pearson,2nd edition, 2006, ISBN-13: 978-8131702390.
2. M.J. Quinn, Parallel Programming in C with MPI and Open MP, McGraw-Hill, 1st edition,2003, ISBN-13: 978-0070582019.

3. G.S. Almasi and A. Gottlieb, Highly Parallel Computing, 2/E, Addison-Wesley, 1994.
4. J. Dongarra, I. Foster, G. Fox, W. Gropp, K. Kennedy, L. Torczon, A. White, editors, The Sourcebook of Parallel Computing, Morgan Kaufmann, 2002.

# AEROELASTICITY

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE744** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course objective:**
This course will enable students to
1. Understand the basic aero elastic phenomena.
2. Comprehend the steady state aero elastic problems and flutter phenomena.
3. Acquire the knowledge on the aero elastic problems.

| Modules | Teaching Hours | Revised Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br><br>**Aeroelastic Phenomena**: Stability versus response problems, The aeroelastic triangle of forces, Aeroelasticity in Aircraft Design, Prevention of aeroelastic instabilities. Influence and stiffness | **8 Hours** | **L1, L2** |

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| coefficients. Flexure, torsional oscillations of beam, Differential equation of motion of beam. | | |
| **Module -2**<br><br>**Divergence of a Lifting Surface:** Simple two dimensional idealizations -Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semi rigid' assumption and approximate solutions – Generalized coordinates – Successive approximations – Numerical approximations using matrix equations. | **8 Hours** | **L1, L2** |
| **Module -3**<br><br>**Steady State Aeroelastic Problems:** Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory and successive approximations – Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability. | **8 Hours** | **L1, L2, L3** |
| **Module -4**<br><br>**Flutter Phenomenon**: Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasi steady aerodynamic derivatives. Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control. | **9 Hours** | **L1, L2** |
| **Module -5**<br>**Examples of Aeroelastic Problems**: Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges | **7 Hours** | **L1, L2** |
| **Course outcomes:**<br>After studying this course, students will be able to: | | |

1. Apply the aero elastic phenomena.
2. Evaluate the steady state aero elastic problems and flutter phenomena.
3. Classify the types of aero elastic problems.

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", Dover Publications Inc, 2008,ISBN-13: 978-0486469362
2. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986

**Reference Books:**

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
2. R.H. Scanlan and R. Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
3. R.D. Blevins, "Flow Induced Vibrations", Krieger Pub Co., 2001

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
# CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2015-2016

## HELICOPTER DYNAMICS
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE743** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course Objectives:** This course will enable students to
1. Comprehend the basic concepts of helicopter dynamics.
2. Acquire the knowledge of critical speed and rotor bearing system.
3. Understand the turborotor system and blade vibration.

| Modules | Teaching Hours | Revised Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br>**Introduction:** History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation.<br>**Blade Element Analysis:** Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, lead/lag hinge, and drag hinge. | **8 Hours** | **L1, L2** |
| **Module -2**<br>**Basic Helicopter Performance**: Forces acting on helicopters in forward flight. Methods of achieving translatory flight. Controlling | **8 Hours** | **L1, L2** |

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|---|---|---|
| cyclic pitch: Swash-plate system. Lateral tilt with and without conning. Lateral and longitudinal asymmetry of lift in forward flight. Forward flight performance- total power required, effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects. | | |
| **Module -3**<br><br>**Rotor Airfoil Aerodynamics:** Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range.<br>**Rotor Wakes and Blade Tip Vortices:** Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake. | **8 Hours** | **L1, L2, L3** |
| **Module -4**<br>**Helicopter Stability and Control.** Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional and directional. Dynamic stability aspects. Main rotor and tail rotor control. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities.<br>**Flight Testing-** General handing flight test requirements and, basis of limitations. | **8 Hours** | **L1, L2, L3** |
| **Module -5**<br>**Standards, and Specifications:** Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. | **8 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification.<br>**Conceptual Design of Helicopters:** Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft. | | |

**Course outcomes:**

After studying this course, students will be able to:

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

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

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

**Reference Books:**

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

## OPERATIONS RESEARCH

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE751** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |
| CREDITS – 03 | | | |

**Course objective:**
This course will enable students to
1. Understand the basic of operations research.
2. Comprehend the PERT-CPM techniques, queuing theory and game theory.
3. Acquire the knowledge on sequencing.

| **Modules** | **Teaching Hours** | **Revised Bloom's Taxonomy** |
|---|---|---|

| | | **(RBT) Level** |
|---|---|---|
| **Module -1**<br>**Introduction**: Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR, linear programming (LP) problem-formulation and solution by graphical method.<br>**Solution Of Linear Programming Problems**: The simplex method-canonical and standard form of an LP problem, slack, surplus and artificial variables, big M method and concept of duality, dual simplex method. | **9 Hours** | **L1, L2** |
| **Module -2**<br>**Transportation Problem:** Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases. Assignment Problem-formulation, types, application to maximization cases and travelling salesman problem | **7 Hours** | **L1, L2** |
| **Module -3**<br>**Integer Programming:** Pure and mixed integer programming problems, solution of Integer programming problems-Gomory's all integer cutting plane method and mixed integer method, branch and bound method, Zero-One programming.<br>**Pert-CPM Techniques:** Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects | **8 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| **Module -4**<br><br>**Queuing Theory:** Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), empirical queuing models – M/M/1 and M/M/C models and their steady state performance analysis.<br><br>**Game Theory:** Formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games. | **9 Hours** | **L1, L2** |
| **Module -5**<br>**Sequencing:** Basic assumptions, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing 2 jobs on 'm' machines using graphical method. | **7 Hours** | **L1, L2** |

**Course outcomes:**

After studying this course, students will be able to:

1. Apply the basic of operations research.
2. Classify the PERT-CPM techniques, queuing theory and game theory.
3. Identify the sequencing techniques.

**Graduate Attributes :**

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

**Question paper pattern:**

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

Text Books:

1. P K Gupta and D S Hira ,Operations Research, Chand Publications, New Delhi , Revised

edition,2007,ISBN-13: 978-8121902816
2. Taha H A ,Operations Research,Pearson Education,9th edition,2014,ISBN-13: 978-9332518223

Reference Books:
1. A P Verma ,Operations Research, S K Kataria &Sons, 2012,ISBN-13: 978-9350142400
2. Paneerselvan ,Operations Research, PHI,2nd edition,2009,ISBN-13: 978-8120329287
3. A M Natarajan, P Balasubramani, Operations Research, Pearson Education, 1st edition,2011,ISBN-13: 978-8131767764
4. Hillier and Liberman, Introduction to Operations Research, 8th Ed., McGraw Hill
5. S.D. Sharma ,Operations Research, , Kedarnath Ramanath & Co, 2012,ISBN-13: 978-9380803388

## WIND TUNNEL TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE752** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course objective:**
This course will enable students to
1. Understand the basic of wind tunnel testing.
2. Understand the types and functions of wind tunnel.
3. Acquire the knowledge on conventional measurement techniques and special wind tunnel techniques.

| | | |
|---|---|---|
| | | **Revised** |

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
# CHOICE BASED CREDIT SYSTEM (CBCS)
## SCHEME OF TEACHING AND EXAMINATION 2015-2016

| Modules | Teaching Hours | Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br>**Principles Of Model Testing**: Buckingham Theorem, Non dimensional numbers, Scale effect, Geometric Kinematic and Dynamic similarities. | **8 Hours** | **L1, L2** |
| **Module -2**<br>**Types And Functions Of Wind Tunnels**: Classification and types, special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions, Layouts, sizing and design parameters. | **7 Hours** | **L1, L2** |
| **Module -3**<br>**Calibration Of Wind Tunnels**: Test section speed, Horizontal buoyancy, Flow angularities, Flow uniformity & turbulence measurements, Associated instrumentation, Calibration of subsonic & supersonic tunnels. | **8 Hours** | **L1, L2, L3** |
| **Module -4**<br>**Conventional Measurement Techniques**: Force measurements and measuring systems, Multi component internal and external balances, Pressure measurement system, Steady and Unsteady Pressure, single and multiple measurements, Velocity measurements, Intrusive and Non-intrusive methods, Flow visualization techniques, surface flow, oil and tuft, flow field visualization, smoke and other optical and nonintrusive techniques | **9 Hours** | **L1, L2** |
| **Module -5**<br>**Special Wind Tunnel Techniques**: Intake tests, store carriage and separation tests, Unsteady force and pressure measurements, wind tunnel | **8 Hours** | **L1, L2** |

| | | |
|---|---|---|
| model design | | |

**Course outcomes:**

After studying this course, students will be able to:

1. Apply the principles and procedures for model testing in the wind tunnel.
2. Classify the types and functions of wind tunnel.
3. Distinguish the conventional measurement techniques and special wind tunnel techniques

**Graduate Attributes :**

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

**Question paper pattern:**

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

**Text Books:**

1. Rae, W.H. and Pope, A., "Low Speed Wind Tunnel Testing", John Wiley Publication, 3rd edition, 2010, ISBN-13: 978-8126525683.

2. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.

**Reference Books:**

1. E. Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, CRC Press, 2007.
2. Bradsaw "Experimental Fluid Mechanics", Pergamon Press, 2nd Revised edition,1970, ISBN-13: 978-0080069814
3. Short term course on Flow visualization techniques, NAL, 2009
4. Lecture course on Advanced Flow diagnostic techniques 17-19 September 2008 NAL, Bangalore

5. NAL-UNI Lecture Series 12:" Experimental Aerodynamics", NAL SP 98 01 April 1998

# NUMERICAL METHODS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE753** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course Objectives:** This course will enable students to

1. Comprehend the basic concepts of numerical methods.
2. Acquire the knowledge of interpolation and approximation.
3. Understand about the curve fitting, root finding and optimization.

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

| | | |
|---|---|---|
| **Module -1**<br><br>**Numerical Computation**<br>Motivation and Objectives/ Number Representation/ Machine Precision/ Round-of Error/ Truncation Error/ Random Number Generation.<br><br>**Linear Algebraic Systems:**<br>Motivation and Objectives/ Gauss-Jordan Elimination/Gaussian Elimination/LU Decomposition/ III- Conditioned Systems/ Iterative Methods. | **6 Hours** | **L1, L2** |
| **Module -2**<br><br>**Interpolation and Approximation**<br>Lagrangian Polynomials - Divided differences Interpolating with a cubic spline - Newton's forward and backward difference formulas.<br><br>**Eigen Values and Eigenvectors**<br>Motivation and Objectives/ The characteristics Polynominal/ Power Methods / Jacobi's Method/ Householder Transformation/ QR Method/ Danilevsky's Method/ Polynominal Roots. | **6 Hours** | **L1, L2** |
| **Module -3**<br><br>**Numerical Differentiation and Integration**<br>Derivative from difference tables - Divided differences and finite differences - Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rules - Two and Three point Gaussian quadrature formulas - Double integrals using trapezoidal and Simpson's rules. | **8 Hours** | **L1, L2, L3** |
| **Module -4** | **10 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| **Curve Fitting**<br>Motivation and objectives/ Interpolation/ Newton's Difference Formula/ Cubic Splines/ Least Square/ Two-Dimensional Interpolation. | | |
| **Module -5**<br><br>**Root Finding**<br>Motivation and Objectives/ Bracketing methods/ Contraction Mapping Method/ Se cant Method/ Muller's Method/ Newton's Method/ Polynomial Roots/ Nonlinear Systems of Equations.<br><br>**Optimization**<br>Motivation and Objectives/ Local and Global Minima/ Line Searches/ Steepest Descent Method/ Conjugate-Gradient Method/ Quasi-Newton Methods/ Penalty Functions/ Simulated Annealing. | **10 Hours** | **L1, L2, L3** |

**Course outcomes:**

After studying this course, students will be able to:

1. Apply the basic concepts of numerical methods.
2. Compute the Eigen values, Eigen vectors, numerical differentiation and integration.
3. Perform the curve fitting and root finding.

**Graduate Attributes:**

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

**Question paper pattern:**

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

**Text Books:**

1. Robert Schilling and Sandra Harris, Applied Numerical methods for Engineers Using Mat Lab and C-Thomson Learning, 2002.
2. Gerald and Wheatley, Applied Numerical Analysis –Pearson Education, 2002.

**Reference Books:**

1. Mahinder Kumar Jain, Numerical Methods: For Scientific and Engineering Computation, New Age Publishers, 2012.
2. Rajesh Srivastava and Saumyen Guha, Numerical Methods for Engineering and Science, Oxford University Press, 2010.
3. P. Kandasamy, K. Thilagavathy and K. Gunavathi, Numerical Methods, S. Chand Publishers, 2006.

## GUIDANCE, NAVIGATION & CONTROL

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

| | | | |
|---|---|---|---|
| Subject Code | **15AE754** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 40 | Exam Marks | 80 |

CREDITS – 03

**Course Objectives:** This course will enable students to

1. Comprehend the basic concepts of navigation, guidance and control.
2. Acquire the knowledge of radar systems and other guidance systems.
3. Understand the missile guidance and control system.

| Modules | Teaching Hours | Revised Bloom's Taxonomy (RBT) Level |
|---|---|---|
| **Module -1**<br><br>**Introduction**<br><br>Concepts of navigation, guidance and control. Introduction to basic principles. Air data information.<br>**Radar Systems**<br>Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI). | **6 Hours** | **L1, L2** |
| **Module -2**<br><br>**Tracking With Radar**<br>Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT).<br><br>**Other Guidance Systems**<br>Gyros and stabilised platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS. | **6 Hours** | **L1, L2** |
| **Module -3**<br><br>**Transfer Functions**<br>Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop.<br><br>**Missile Control System** | **8 Hours** | **L1, L2, L3** |

| | | |
|---|---|---|
| Guided missile concept. Roll stabilisation. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus. | | |
| **Module -4**<br><br>**Missile Guidance**<br>Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance | **10 Hours** | **L1, L2, L3** |
| **Module -5**<br>**Integrated Flight/Fire Control System**<br>Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle , Auto Pilot. | **10 Hours** | **L1, L2, L3** |

**Course outcomes:**
After studying this course, students will be able to:
1. Apply the basic concepts of navigation, guidance and control.
2. Compare the different types of missile guidance system performance.
3. Integrate the flight and fire control system.

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

**Question paper pattern:**

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

- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

1. P.T. Kabamba and A.R. Girard, Fundamentals of Aerospace Navigation and Guidance, Cambridge Aerospace Series, 2014.
2. John H Blakelock,` Automatic control of Aircraft & Missiles`, Wile –Inter Science Publication, 2nd edition, May 1990.

**Reference Books:**

1. R.B. Underdown & Tony Palmer, `Navigation`, Black Well Publishing; 2001.
2. Merrilh I. Skolnik,` Introduction to Radar Systems`, 3rd edition, Tata Mc Graw Hill , 2001.
3. George M. Siouris, Missile Guidance and Control Systems, Springer, 2004.

**FLIGHT SIMULATION LAB**

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

| | | | |
|---|---|---|---|
| Subject Code | **15AEL76** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 42 | Exam Marks | 80 |
| CREDITS – 04 | | | |

**Course Objectives:** This course will enable students to

- Understand the root locus and bode plot.
- Understand the spring mass damper system and the servo mechanism system with feedback.

- Acquire the knowledge to use computational tools to model aeronautical vehicle dynamics.

| **Modules** | **Revised Bloom's Taxonomy (RBT) Level** |
|---|---|
| 1. Draw Pole-Zero map of dynamic system model with plot customization option | **L1, L2, L3** |
| 2. Plot root locus with variables in transfer function through MATLAB | **L1, L2, L3** |
| 3. Plot root locus for a dynamic system though MATLAB | **L1, L2, L3** |
| 4. Draw Bode plot from a transfer function in MATLAB and explain the gain and phase margins | **L1, L2, L3, L4** |
| 5. Simulate a spring- mass- damper system with and without a forcing function though SIMULINK | **L1, L2, L3** |
| 6. Simulate a simple servo-mechanism motion with feedback- in the time domain, and in \`s\` domain | **L1, L2, L3** |
| 7. Simulate a bomb drop from an aircraft on a moving tank in pure pursuit motion | **L1, L2, L3** |
| 8. Develop a straight and level flight simulation program using MATLAB | **L1, L2, L3** |
| 9. Simulate aircraft Take-off and Landing with trajectory tracing | **L1, L2, L3** |
| 10. Simulate stall of aircraft and show the effect of variation in static margin on stalling characteristics | **L1, L2, L3** |

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|---|---|
| 11. Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a pulse input in pitch that is intended to bleed the airspeed. | **L1, L2, L3** |
| 12. Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a doublet input in pitch | **L1, L2, L3** |
| 13. Given a Quartic characteristic equation, determine two quadratics that shall result in poles of short-period oscillations and poles of Phugoid. Vary the coefficients of polynomial to study the movement of poles. | **L1, L2, L3** |
| 14. Given a Quartic characteristics equitation, determine Poles and Time constants for Roll mode, Spiral motion, and Dutch roll. Vary the coefficients of polynomial to study the movement of poles | **L1, L2, L3** |

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

1. Plot the root locus and bode plot.
2. Calculate the dynamics response of aircraft.
3. Use computational tools to model aircraft trajectory.

**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 :**

- Engineering Knowledge.
- Problem Analysis.

- Design / development of solutions (partly)
- Interpretation of data.

| **MODELING & ANALYSIS LAB**<br>[As per Choice Based Credit System (CBCS) scheme]<br>SEMESTER – VII | | | |
|---|---|---|---|
| Subject Code | **15AEL77** | IA Marks | 20 |
| Number of Lecture Hours/Week | 03 | Exam Hours | 03 |
| Total Number of Lecture Hours | 42 | Exam Marks | 80 |
| CREDITS – 02 | | | |

**Course Objectives:** This course will enable students to

- Understand the procedure to draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Acquire the knowledge of types of meshing.
- Understand the basics of flow and stress analysis.

| **Modules** | **Revised Bloom's Taxonomy (RBT) Level** |
|---|---|
| 1. Modeling of Symmetrical/Cambered Aerofoil Geometry , and Generation of Body Fitting Adaptive Mesh. | **L1, L2, L3** |
| 2. Modeling of 2-D Incompressible and Invisicd Flow over Symmetrical/Cambered Aerofoil, and Plotting of Pressure distribution and Velocity vectors for Subsonic/Supersonic Mach numbers. | **L1, L2, L3,L4** |
| 3. Modeling of 2-D Compressible and Viscid Flow over Symmetrical/Cambered Aerofoil, and Plotting of Pressure distribution and Velocity vectors for Subsonic Mach numbers. | **L1, L2, L3, L4** |

| | |
|---|---|
| 4. Isentropic Flow Analysis in a 2-D Subsonic Diffuser and a Subsonic Nozzle. | **L1, L2, L3, L4** |
| 5. Isentropic Flow Analysis in a 2-D Supersonic Diffuser and a Supersonic Nozzle. | **L1, L2, L3, L4** |
| 6. Geometric Modeling and Mesh Generation of a 2-D Convergent-Divergent Nozzle and Analyses of flow for Adiabatic Conditions ( Fanno Flow). | **L1, L2, L3, L4** |
| 7. Geometric Modeling and Mesh Generation of a 2-D Pipe and Modeling of Steady/Unsteady Heat Convection and Conduction (Rayleigh Flow). | **L1, L2, L3,L4** |
| 8. Structural Modeling of Sandwich Beam of Rectangular Cross-section and Analyses for Stress for Unsymmetrical bending case. | **L1,L2,L3,L4** |
| 9. Structural Modeling and Stress Analysis of a Torsion Box of a Wing. | **L1,L2,L3,L4** |
| 10. Structural Modeling and Stress Analysis of a Fuselage Frame. | **L1,L2,L3,L4** |
| 11. Structural Modeling and Stress Analysis of a Tapered I-Section Spar. | **L1, L2, L3,L4** |
| 12. Determine the Natural frequency and Mode shapes of a Cantilever beam under UDL. | **L1, L2, L3** |
| 13. A Plate fixed at one end has a hole in centre and has varying thickness, Determine | **L1, L2, L3** |

| | |
|---|---|
| stresses developed due to applied static loads in vertical direction. | |
| 14. A Tapered Plate fixed at one end has a hole in centre and has varying thickness, Determine stresses developed due to applied static loads in vertical direction. | **L1, L2, L3** |

Course outcomes: After studying the course the students will be able to

- Draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Apply different types of meshing.
- Perform the flow and stress analysis.

**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 :**

- Engineering Knowledge.
- Problem Analysis.
- Team work
- Communication