TULSIRAMJI GAIKWAD-PATIL COLLEGE OF ENGINEERING & TECHNOLOGY
Wardha Road, Nagpur - 441108
Accredited with NAAC A+ Grade
Approved by AICTE, New Delhi, Govt. of Maharashtra
(An Autonomous Institution Affiliated to Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur)

# DEPARTMENT OF AERONAUTICAL ENGINEERING

## Teaching Scheme & Syllabus (As per NEP_2020)

# SCHEME OF INSTRUCTION & SYLLABI

## Semester -Fifth

# Programme: Aeronautical Engineering

**From**

Academic Year 2025-26

## Institute Vision & Mission

**Vision:**

- To emerge as a learning Center of Excellence in the National Ethos in domains of Science, Technology and Management.

**Mission:**

- To strive for rearing standard and stature of the students by practicing high standards of professional ethics, transparency and accountability.
- To provide facilities and services to meet the challenges of Industry and Society.
- To facilitate socially responsive research, innovation and entrepreneurship.
- To ascertain holistic development of the students and staff members by inculcating knowledge and profession as work practices.

## Program Outcomes (POs)

1. Engineering Knowledge
2. Problem Analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and team work
10. Communication
11. Project management and finance
12. Lifelong learning

## Department Vision & Mission

**Vision:**

- To foster technically skilled Aeronautical Engineers of the utmost academic principles, to convene the needs of academia, industry and society.

**Mission:**

- Impart quality technical education and unique interdisciplinary experiences.
- Develop the analytical, computational and design capabilities to provide sustainable solutions.
- Expose the students to the current trends and opportunities in the Aerospace industry.
- Inculcate professional responsibility based on an innate ethical value system.

## Program Educational Objectives (PEOs)

1. Undergraduate students will acquire knowledge to investigate and solve Aeronautical Engineering problems using basics of applied science and engineering.
2. Undergraduate students will utilize the modern technology and techniques to explore new skills and ideas to satisfy the need of society as well as industry.
3. Undergraduate students will get finest employment opportunities in the field of Aeronautical Engineering.
4. To develop the environment of societal and ethical values to concern with engineering issues.
5. Undergraduate students will contribute in the domain specific and interdisciplinary research through the project based learning.

## Program Specific Outcomes (PSO)

- Develop profound working knowledge to solve combination of complex problems in aerodynamics, propulsion, structures, flight mechanics and allied courses.
- Be equipped to use CAE packages, simulation languages and advanced tools to solve practical design and analysis problems.
- Undergraduates will be able to utilize the extensive knowledge of design, manufacturing, testing or maintenance of systems and sub systems to pursue career in aeronautical engineering.

## Department of Aeronautical Engineering

## Scheme of Instructions: Second Year (V Sem) B. Tech in Aeronautical Engineering

| S N. | Sem | Type | BoS/ Dept | Sub Code | Subject | T/ P | Contact Hours | | | Credits | % Weightage | | | ESE Duration | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | L | P | Hrs | | CT/IA | CA | ESE | | |
| 1 | V | PCC | AE | BAE33501 | Mechanics of Machines | T | 3 | - | 3 | 3 | 30 | 10 | 60 | 3 Hrs | 100 |
| 2 | V | PCC | AE | BAE33502 | Aircraft Propulsion | T | 3 | - | 3 | 3 | 30 | 10 | 60 | 3 Hrs | 100 |
| 3 | V | PCC | AE | BAE33503 | Aerodynamics-II | T | 3 | - | 3 | 3 | 30 | 10 | 60 | 3 Hrs | 100 |
| 4 | V | PCC | AE | BAE33508 | Mechanics of Machines Lab | P | - | 2 | 2 | 1 | - | 25 | 25 | 2 Hrs | 50 |
| 5 | V | PCC | AE | BAE33509 | Aircraft Propulsion Lab | P | - | 2 | 2 | 1 | - | 25 | 25 | 2 Hrs | 50 |
| 6 | V | PCC | AE | BAE33510 | Aerodynamics Lab | P | - | 2 | 2 | 1 | - | 25 | 25 | 2 Hrs | 50 |
| 7 | V | OEC | - | BAE33511 | Open Elective-III | T | 2 | - | 2 | 2 | 14 | 6 | 30 | 2 Hrs | 50 |
| 8 | V | PEC | AE | BAE33504-07 | Program Elective-I | T | 4 | - | 4 | 4 | 30 | 10 | 60 | 3 Hrs | 100 |
| 9 | V | MDM | ME | BME33501 | Heat Transfer | T | 4 | - | 4 | 4 | 30 | 10 | 60 | 3 Hrs | 100 |
| **Total** | | | | | | | **19** | **06** | **25** | **22** | **164** | **131** | **405** | **23 Hrs** | **700** |

| Course Category | HSSM (Humanities Social Science & Management) | BSC (Basic Science Course) | ESC (Engg. Science Course) | PCC (Programme Core Courses) | PEC (Program Elective Courses) | OEC (Open Elective Courses) | MDM (Multi-disciplinary Courses) | SEC (Skill Course) | ELC/FP/CEP (Experiential Learning Courses) | CC (Liberal Learning Courses) |
|---|---|---|---|---|---|---|---|---|---|---|
| Credits | -- | -- | -- | 12 | 4 | 2 | 4 | -- | -- | -- |
| Cumu. Sum | 12 | 16 | 13 | 34 | 4 | 8 | 8 | 6 | 2 | 4 |

Progressive total credits:85+22=107

| | | | | | |
|---|---|---|---|---|---|
| Chairperson | Dean Academics | Vice Principal | Principal | June, 2025 | 1.00 |
| | | | | Date of Release | Version |

Applicable For AY 2025-26 Onwards

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Dr. Pragati Patil
Vice-Principal
Tulsiramji Gaikwad Patil College of
Engineering & Technology, Nagpur

Dr. Premanand Naktode
Principal
TGPCET, Nagpur

## Programme: B. Tech. Aeronautical Engineering

List of **Program Electives** offered by Department of Aeronautical Engineering

| Program Elective- I | Program Elective-II | Program Elective- III | Program Elective- IV |
|---|---|---|---|
| **Semester V** | **Semester VI** | **Semester VI** | **Semester VII/ VIII** |
| **BAE33504:** Boundary Layer Theory | **BAE33604:** High Speed Aerodynamics | **BAE33608:** Control Theory & Systems | **BAE34803:** Unmanned Aerial Vehicles & Systems |
| **BAE33505:** Aircraft Systems & Instruments | **BAE33605:** Spacecraft Technology | **BAE33609:** Aviation Management | **BAE34804:** Composite Materials & NDT |
| **BAE33506:** Space Flight Mechanics | **BAE33606:** Aircraft Navigation & Communication Systems | **BAE33610:** Helicopter Engineering | **BAE34805:** Vibrations and Aero-elasticity |
| **BAE33507:** Industrial Aerodynamics | **BAE33607:** Aircraft Maintenance & Repair | **BAE33611:** Finite Element Methods (FEM) | **BAE34806:** Computational Fluid Dynamics |

## Program: B. Tech. Aeronautical Engineering

List of **Open Electives** offered by Department of Aeronautical Engineering

| Open Elective-I | Open Elective-II | Open Elective-III |
|---|---|---|
| **Semester-III** | **Semester-IV** | **Semester-V** |
| **BAE32310:** Introduction to Aerospace Engineering | **BAE32406 :** Avionics | **BAE32511:** Unmanned Aerial Systems |

| | | | | | | |
|---|---|---|---|---|---|---|
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| | | | | Date of Release | Version | |

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Principal
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| Course Category | HSSM (Humanities Social Science & Manag.) | BSC (Basic Science Course) | ESC (EngineeringScience Course.) | PCC (ProgrammeCore Courses | PEC (Programme Elective Courses) | OEC (Open Elective Courses) | MDM (Multi-disciplinary Course) | SEC (Skill Course) | ELC/FP/CEP Experimential Learning Courses) | CC (Liberal Learning Courses) | Semester Wise Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Semester-I** | 04 | 08 | 05 | -- | -- | -- | -- | 02 | -- | 02 | **21** |
| **Semester-II** | 02 | 08 | 08 | -- | -- | -- | -- | 02 | -- | 02 | **22** |
| **Semester-III** | 02 | -- | -- | 11 | -- | 04 | 02 | -- | 02 | -- | **21** |
| **Semester-IV** | 04 | -- | -- | 11 | -- | 02 | 02 | 02 | -- | -- | **21** |
| **Semester-V** | | -- | -- | 12 | 4 | 02 | 4 | -- | -- | -- | **22** |
| **Semester-VI** | | -- | -- | 11 | 06 | -- | 02 | 01 | -- | -- | **20** |
| **Semester-VII** | | -- | -- | 04 | 04 | -- | -- | -- | 12 | -- | **20** |
| **Semester-VIII** | | -- | -- | 06 | 04 | -- | 03 | -- | 08 | -- | **21** |
| **Cumu. Sum** | **12** | **16** | **13** | **55** | **17** | **08** | **13** | **07** | **22** | **04** | **168** |

| | | | | | | |
|---|---|---|---|---|---|---|
| Chairperson | Dean Academics | Vice Principal | Principal | June, 2025 | 1.00 | Applicable For AY 2025-26 Onwards |
| | | | | Date of Release | Version | |

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## Third Year (Semester-V) B. Tech. Aeronautical Engineering

## BAE33501:Mechanics of Machines

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 3 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 3** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To introduce the fundamental concepts of mechanisms and linkages |
| **2.** | To develop competency in static force analysis for mechanical components |
| **3.** | To understand and analyze friction and energy losses in mechanical systems |
| **4.** | To explore the application of governors and gyroscopes in mechanical systems |
| **5.** | To enhance skills in gear system design and dynamic balancing |

**Course Contents**

| | |
|---|---|
| **Unit I** | **Simple Mechanism:** Introduction, Kinematic Link or Element, Types of Links, Structure, Difference Between a Machine and a Structure, Kinematic Pair, Types of Constrained Motions, Classification of Kinematic Pairs. Kinematic Chain, Types of Joints in a Chain, Mechanism, Number of Degrees of Freedom for Plane Mechanisms, Application of Kutzbach Criterion to Plane Mechanisms, Grubler's Criterion for Plane Mechanisms, Inversion of Mechanism, Types of Kinematic Chains, Four Bar Chain or Quadric Cycle Chain, Inversions of Four Bar Chain, Single Slider Crank Chain, Inversions of Single Slider Crank Chain, Double Slider Crank Chain, Inversions of Double Slider Crank Chain. |
| **Unit II** | **Kinematics of Machine:** Introduction, Plane Motion, Rectilinear Motion, Curvilinear Motion, Linear Displacement, Linear Velocity, Linear Acceleration, Equations of Linear Motion, Graphical Representation of Displacement with respect to Time, Graphical Representation of Velocity with respect to Time, Graphical Representation of Acceleration with respect to Time, Angular Displacement, Representation of Angular Displacement by a Vector, Angular Velocity, Angular Acceleration, Equations of Angular Motion, Relation Between Linear Motion and Angular Motion, Relation Between Linear and Angular Quantities of Motion, Acceleration of a Particle along a Circular Path.. |
| **Unit III** | **Friction:** Introduction, Types of Friction, Friction Between Lubricated Surfaces, Coefficient of Friction, Limiting Angle of Friction, Angle of Repose, Friction of a Body Lying on a Rough Inclined Plane, Efficiency of Inclined Plane. |
| **Unit IV** | **Rigid Body Mechanism:**<br>Rigid body motion in space. Euler's equation of motion, Gyroscope, angular velocity, angular acceleration, simple precession & gyroscopic couple. Gyroscopic effect on airplane. Speed governors, centrifugal & inertia type, Watt, Portal, Proell, Hartnell governors, Operating characteristics of governors. |
| **Unit V** | **Gear and Gear Trains:**<br>Gear terminology, law of gearing, Path of contact, Arc of contact, Contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference. Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains. Concepts of cam mechanism, comparison of cam mechanism with linkages. Types of cams and followers and applications. |

| | |
|---|---|
| **Text Books** | |
| **1** | Rattan S.S, "Theory of Machines", Tata McGraw-Hill Publishing Company Ltd., New Delhi,3rd edition, 2009. |
| **2** | J.J. Uicker, G.R. Pennock, J.E. Shigley, "Theory of Machines and Mechanisms", OXFORD, 3rd edition, 2009. |
| **3** | Ghosh. A, and A.K. Mallick, Theory and Machine, East-West Pvt. Ltd., New Delhi, 4th edition, 1988. |
| **Reference Books** | |
| **1** | Ramamurthi. V., "Mechanisms of Machine", Narosa Publishing House, 2nd edition, 2005. |
| **2** | Rao J. S. and Dukkipatti R.V. —Mechanisms and Machines, Wiley-Eastern Ltd., New Delhi, 1st edition,1998. |
| **3** | Robert L. Norton, "Design of Machinery", McGraw-Hill, 2nd edition, 2012. |
| **Useful Links** | |
| **1** | https://nptel.ac.in/courses/112/105/112105268/ |
| **2** | https://nptel.ac.in/courses/112/104/112104121/ |
| **3** | |

| **BAE33501** | **Course Outcomes** | **CL** | **Class Sessions** |
|---|---|---|---|
| **CO1** | **Identify** key concepts in simple mechanisms and kinematic elements. | **2** | **9** |
| **CO2** | **Apply** analytical methods to solve problems involving mechanisms and kinematic chains. | **3** | **9** |
| **CO3** | **Analyze** the effects of friction in mechanical systems to determine efficiencies. | **3** | **9** |
| **CO4** | **Apply** the knowledge of governors and gyroscope for understanding rigid body mechanism. | **3** | **9** |
| **CO5** | **Analyze** gear and cam mechanisms for motion transmission. | **3** | **9** |

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## B. Tech. V$^{th}$ Sem Aeronautical Engineering

## BAE33502: Aircraft Propulsion

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 3 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 3** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To familiarize students with the fundamental working principles of gas turbine engines |
| **2.** | To build a foundation in aerothermodynamics of air inlets for aerospace vehicles |
| **3.** | To provide analytical and conceptual understanding of inlets and nozzles in propulsion systems |
| **4.** | To introduce the principles of compressor and turbine operation and design |
| **5.** | To develop skills for evaluating the performance of combustion chambers and nozzles |

### Course Contents

| | |
|---|---|
| **Unit I** | **Introduction**<br>History of the Air breathing Jet Engine, Twentieth Century Inventions, The Beginning, Innovations in Gas Turbine Engines, Multi-spool Configuration, Variable Stator, Transonic Compressor, Low Emission Combustor, Turbine Cooling, Exhaust Nozzles Modern Materials and Manufacturing Techniques, New Engine Concepts, Advanced Turboprop (ATP) and Geared Turbofan (GTF), Advanced Air breathing Rocket Technology, Wave Rotor Topping Cycle, Pulse Detonation Engine (PDE), Millimeter-Scale Gas Turbine, Engines Combined Cycle Propulsion. |
| **Unit II** | **Fundamentals of Gas Turbine Engines**<br>Illustration of working of gas turbine engine, the thrust equation, Factors affecting thrust, Effect of pressure, velocity and temperature changes of air entering compressor, Propulsive efficiency, Specific fuel consumption, Thrust and power, Factors affecting thrust and power,<br>Characteristics of turboprop, turbofan and turbojet, Ram jet, Scram jet, Methods of Thrust augmentation, Gas Turbine, Engine Cycle Analysis. |
| **Unit III** | **Inlet and Nozzles**<br>Internal flow and Stall in Subsonic inlets, Inlet Diffuser performance, Supersonic inlets, Shock swallowing by area variation, Modes of inlet operation. Exhaust Nozzle, Nozzle Adiabatic Efficiency, Total Pressure Ratio, Pressure Ratio (NPR) and Critical Nozzle Pressure Ratio ($NPR_{crit}$). Relation Between Nozzle Figures of Merit, efficiency and pressureratio. The Effect of Boundary Layer on Nozzle, Nozzle Exit Flow, Effect of Flow Angularityon Gross Thrust Nozzle, Gross Thrust Coefficient Cfg, over expanded Nozzle Flow, Shock Losses, Nozzle Area Scheduling, Nozzle Cooling Thrust Reverser and Thrust<br>Vectoring, Nozzle-Turbine (Structural) Integration. |
| **Unit IV** | **Compressor and Turbine**<br>Introduction to centrifugal compressors, Axial flow compressor, geometry, twin spools,three spools, stage analysis, velocity polygons, degree of reaction, radial equilibrium theory,<br>performance maps. Axial flow turbines: Geometry, velocity polygons, stage analysis,performance maps, thermal limit of blades and vanes, cascade study of LP turbine. |
| **Unit V** | **Combustion Chamber and matching of component**<br>Classification of combustion chambers, Important factors affecting combustion chamber design, Combustion process, Combustion chamber performance, effect of operating variableson performance. Flame tube cooling, Flame stabilization, Use of flame holders, Numerical problems. Inlet, compressor, combustion chamber, |

| | |
|---|---|
| | turbine, and nozzle. Numerical problems on matching. |
| **Text Books** | |
| **1** | Hill, P. G. & Peterson, G. R., Mechanics of Thermodynamics of Propulsion, Addison – WesleyLongman JNC,2nd Edition, 1999. |
| **2** | Cohen, H., Rogers, G. F. C. and Saravanamuttoo, H. I. H., Gas Turbine Theory, Longman, 3rdEdition 1989. |
| **3** | Mathur, M. L., and Sharma, R. P., Gas Turbine, Jet and Rocket Propulsion, Standard Publishers andDistributors, Delhi, 3rd Edition 1988. |
| **Reference Books** | |
| **1** | Oates, G. C., Aerothermodynamics of Aircraft Engine Components, AIAA Education Series, NewYork, 1985. |
| **2** | |
| **3** | |
| **Useful Links** | |
| **1** | https://nptel.ac.in/courses/101/106/101106033/ |
| **2** | https://nptel.ac.in/courses/101/101/101101002/ |
| **3** | https://nptel.ac.in/courses/112/103/112103281/ |

| BAE33502 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Describe** the historical development, key innovations, and current advancements in air-breathing propulsion systems | **2** | **9** |
| **CO2** | **Apply** the principles of gas turbine engines and factors influencing thrust, propulsive efficiency, and fuel consumption. | **3** | **9** |
| **CO3** | **Evaluate** nozzle performance in terms of pressure ratios, adiabatic efficiency, and shock losses. | **4** | **9** |
| **CO4** | **Evaluate** axial turbine performance through stage analysis, cascade studies, and thermal limits of components. | **4** | **9** |
| **CO5** | **Analyze** the types and design considerations of combustion chambers based on combustion processes and flame stabilization methods. | **3** | **9** |

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## B. Tech. V$^{th}$ Sem Aeronautical Engineering

## BAE33503: Aerodynamics-II

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 3 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 3** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To get insight into the basic aspects of compressible flow. |
| **2.** | To arrive at the shock wave and expansion wave relations. |
| **3.** | To get exposure on potential equation for 2-dimensional compressible flow. |
| **4.** | To get knowledge on high-speed flow over airfoils, wings and airplane configuration. |
| **5.** | To gain basic knowledge on low and high-speed wind tunnels and model testing. |

### Course Contents

| | |
|---|---|
| **Unit I** | **One Dimensional Compressible Flow**: Energy, Momentum, continuity and state equations, velocity of sound, adiabatic steady state flow equations, Isotropic one dimensional flow, Flow through convergent- divergent passage, Performance under various back pressures, Effect of Mach number and compressibility effects, Flow in Constant-Area Ducts with Friction (Fanno Flow) & Constant-Area Ducts with heat (Raleigh Flow) |
| **Unit II** | **Concept of Waves in Fluid:** Mach waves, Compression waves, Expansion waves. Isentropic flow, Adiabatic flow, Shock waves, Prandtl equation and Rankine –Hugonoit relation, Normal Shock Waves and Equations, Oblique Shocks and Equations, Bow Shocks in 2D. Numericals, shock polar, flow past wedges and concave corners, strong, weak and detached shocks. |
| **Unit III** | **Compressible Flow and Shock Interaction:** Conical Shocks, Bow Shocks in 3D. Shock interactions, Shock reflection from boundaries, Shockwave Boundary Layer interaction. Prandtl-Meyer expansion fans. Shock Expansion Methods. Mach Number and Area rule, Flow through a Nozzle: Convergent Nozzle, Convergent Divergent Nozzle, Underexpanded and Over-expanded Nozzle flows. |
| **Unit IV** | **Differential Equation of motion**: Steady compressible flows, Small perturbation potential equations, Solution for subsonic and supersonic flow, Prandtl-Glauert transformation relation for subsonic flows. Linearized and exact 2-D supersonic flows theory and its application for calculation of lift and drag and pitching moments centre of pressure, Prandtl-Glauert correction. Compressibility effects on aerodynamic coefficients. |
| **Unit V** | **Principles of model testing:** Types of subsonic wind tunnels, Balances and measurements, Interference effects, transonic, Supersonic and hypersonic wind tunnels and characteristic features, their operation and performance, Smock Tunnel, Shock tubes and shock tunnels Free flight testing, Measurements of pressure, velocity, density and Mach number - Flow visualization methods of subsonic and supersonic flows. |

### Text Books


| | |
|---|---|
| **1** | Anderson, J. D., Modern Compressible Flow with Historical Perspective, 3rd Ed, McGraw Hill, 2003. |
| **2** | Yahya, S.M., Fundamentals of Compressible Flow, 3rd Ed., New Age International, 2003. |

| | |
|---|---|
| **3** | L.J. Clancy, "Aerodynamics" Sterling Book House, 3rd Ed, 2006. |
| **Reference Books** | |
| **1** | Rathakrishnan, E., "Gas Dynamics", 6th Edition, Prentice Hall of India, 2017. |
| **2** | Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press, Volume I, 1982. |
| **3** | Zucrow, M.J. and Anderson, J.D., "Elements of gas dynamics", McGraw-Hill Book Co., New York, 3rd Ed , 1989. |
| **Useful Links** | |
| **1** | https://nptel.ac.in/courses/101/101/101101079/ |
| **2** | https://nptel.ac.in/courses/101/105/101105059/ |
| **3** | https://onlinecourses.nptel.ac.in/noc19_ae05/preview |

| BAE33503 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Apply** the fundamental conservation equations to analyze one-dimensional compressible flow. | **3** | **9** |
| **CO2** | **Analyze** the behavior of normal and oblique shock waves, and their effects using shock relations | **3** | **9** |
| **CO3** | **Evaluate** complex shock interactions, expansion fans, and nozzle flows using area-Mach relations. | **4** | **9** |
| **CO4** | **Solve** linearized and exact 2D supersonic flow equations by Prandtl-Glauert transformation relations. | **4** | **9** |
| **CO5** | **Apply** wind tunnel test results and flow visualization techniques in flow regimes for aerodynamic model validation. | **3** | **9** |

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# PROGRAM ELECTIVE-I

## B. Tech. Vth Sem Aeronautical Engineering

## BAE33504: Boundary Layer Theory

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 4 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 4** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To understand the behavior of the fluid flow under static condition |
| **2.** | Introduce Navier-Stokes equations and some of the exact solutions; |
| **3.** | To understand the basics of Different types of flow such as Laminar, turbulent and compressible flow, Incompressible flow, Viscid and Inviscid flow |
| **4.** | To know about the basics of Boundary layer Control |
| **5.** | To know about the flow through pipe foe different types of flow |

### Course Contents

| | |
|---|---|
| **Unit I** | **Basic concepts of viscous flows:** Viscous flow characteristics, introduction to hydrodynamic and thermal boundary layer theory, governing equations with effect of viscosity, flow over the flat plate at zero incidences, boundary layer thickness, displacement thickness, momentum thickness, energy thickness, boundary layer equation and their general properties. Flat plate at zero angle of incidence, method of exact solution, Blassius solution to boundary layer problems, |
| **Unit II** | **Solutions to boundary layer flows:** Approximate solutions – Von-karman solution to boundary layer flows over the flat plate, flow with pressure gradient, flow over a cylinder, plane Couette flow, circular Couette flow, flow between parallel plates, numerical |
| **Unit III** | **Transition:** Pipe flow and flow over a flat plate, critical Reynolds number, turbulent spots, principles of theory of stability of Laminar flows, Summerfield equation, factors effecting transition, Laminar aero foils |
| **Unit IV** | **Turbulent boundary layers**: Fundamentals of turbulent flow, Mean motion fluctuations, Reynolds Equations, Reynolds stresses, wind tunnel turbulence, Prandtl mixing length theory, velocity distribution laws, numerical Flow thorough pipe, governing equations and velocity profile for fully developed flow through pipe, effect of roughness, smooth pipes, relation between laws of friction & velocity distribution, numerical |
| **Unit V** | **Boundary layer control:** Need of boundary layer control, causes of boundary layer separation, flow over the cylinder and airfoil for different flow conditions leads separation, unsteady viscous flow: Startup of plane Couette flow, unsteady flow over a cylinder |

### Text Books


| | |
|---|---|
| **1** | Boundary layer theory by h. Schlichting and Gersten, K., 8th ed., McGraw-Hill (2001). |
| **2** | Batchelor, G. K., Introduction to Fluid Dynamics, 2nd ed., Cambridge Univ. Press (2000). |
| **3** | White, F. M., Viscous Fluid Flow, 3rd ed., McGraw-Hill (2006). |

| Reference Books | |
|---|---|
| 1 | Cebeci, T. and Smith, A. M. O., Analysis of Turbulent Boundary Layers, Academic Press (1974). |
| 2 | Gatski, T. B. and Bonnet, J.-P. Compressibility, Turbulence and High Speed Flow, 2nd ed., Academic Press (2013). |
| 3 | |
| **Useful Links** | |
| 1 | https://nptel.ac.in/courses/101/101/101101079/ |
| 2 | https://nptel.ac.in/courses/101/105/101105059/ |
| 3 | https://onlinecourses.nptel.ac.in/noc19_ae05/preview |

| BAE33504 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| CO1 | **Explain** the fundamentals of viscous flow and boundary layer theory. | 3 | 9 |
| CO2 | **Apply** exact and approximate methods to solve laminar boundary layer flow problems. | 3 | 9 |
| CO3 | **Analyze** the transition from laminar to turbulent flow in pipes and over flat plates, and the role of Reynolds number. | 3 | 9 |
| CO4 | **Evaluate** turbulent boundary layer characteristics using Reynolds-averaged equations and velocity distribution laws. | 4 | 9 |
| CO5 | **Apply** boundary layer control methods to delay separation and unsteady viscous flows. | 3 | 9 |

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# PROGRAM ELECTIVE-I

## B. Tech. V$^{th}$ Sem Aeronautical Engineering

## BAE33505: Aircraft Systems and Instruments

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 4 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 4** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To introduce the fundamentals of aircraft control systems |
| **2.** | To provide knowledge of auxiliary aircraft systems |
| **3.** | To explain the subsystems of aircraft powerplants |
| **4.** | To explore environmental and safety systems in aircraft |
| **5.** | To develop an understanding of aircraft instrumentation |

**Course Contents**

| | |
|---|---|
| **Unit I** | **Airplane Control Systems**<br>Conventional Systems, Power assisted and fully powered flight controls, Power actuated systems, Engine control systems, Push pull rod system, flexible push pull rod system, Modern control systems, Digital fly by wire systems, Auto pilot system, Active control Technology, Communication and Navigation systems, Instrument landing systems, VOR - CCV case studies. |
| **Unit II** | **Aircraft Hydraulic Systems**<br>Hydraulic systems, Study of typical workable system, components, Hydraulic system controllers, Modes of operation. |
| **Unit III** | **Pneumatic and Hybrid Systems**<br>Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification, Shock absorbers, Retraction mechanism. |
| **Unit IV** | **Engine Systems**<br>Fuel systems for Piston and jet engines, Components of multi engines. Lubricating systems for piston and jet engines, Starting and Ignition systems, Typical examples for piston and jet engines. |
| **Unit V** | **Auxiliary System**<br>Basic Air cycle systems, Vapour Cycle systems, Boost-Strap air cycle system, Evaporative vapour cycle systems, Evaporative air cycle systems, Oxygen systems, Fire protection systems, Deicing and anti-icing systems.<br>**Aircraft Instruments**<br>Flight Instruments and Navigation Instruments, Gyroscope, Accelerometers, Air speed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles. |

**Text Books**


| | |
|---|---|
| **1** | McKinley, J.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw-Hill, 1993. |
| **2** | "General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995. |

| Reference Books | |
|---|---|
| **1** | Allan G. Seabridge and Ian Moir, "Design and Development of Aircraft Systems: An Introduction ", (AIAA Education Series), 2004. |
| **Useful Links** | |
| **1** | https://nptel.ac.in/courses/101/101/101101079/ |
| **2** | https://nptel.ac.in/courses/101/104/101104071/ |
| **3** | https://nptel.ac.in/courses/101/104/101104071/ |

| BAE33505 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Explain** the architecture and functioning of conventional and modern aircraft control systems | **3** | **9** |
| **CO2** | **Analyze** the configuration and operation of aircraft hydraulic systems and their components. | **3** | **9** |
| **CO3** | **Compare** pneumatic and hybrid systems used in aircraft, with emphasis on landing gear operations, shock absorption, and braking systems. | **3** | **9** |
| **CO4** | **Differentiate** between fuel, lubrication, ignition, and starting systems used in piston and jet engines | **3** | **9** |
| **CO5** | **Apply** the working principles of aircraft auxiliary systems, flight and engine instruments for performance monitoring. | **3** | **9** |

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# PROGRAM ELECTIVE-I

## B. Tech V$^{th}$ Sem Aeronautical Engineering

## BAE33506: Space Flight Mechanics

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 4 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 4** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To introduce the fundamentals of celestial mechanics and the Earth's atmospheric influence on space trajectories |
| **2.** | To develop a foundational understanding of orbital dynamics and N-body motion |
| **3.** | To provide knowledge of satellite launch and orbital insertion techniques |
| **4.** | To examine perturbations affecting satellite orbits |
| **5.** | To build analytical skills in interplanetary mission planning |

**Course Contents**

| | |
|---|---|
| **Unit I** | **Basic Concepts**<br>The solar system, Reference frames and coordinate systems, The celestial sphere, Theecliptic, Motion of vernal equinox, Sidereal time, Solar time, Standard time, The earth's atmosphere. |
| **Unit II** | **The General N-Body Problem**<br>The Many body problems, Lagrange - Jacobi identity, The circular restricted three body problem, Libration points, Relative Motion in the N-body problem, The two - body problem, Satellite orbits, Relations between position and time, Orbital elements. |
| **Unit III** | **Satellite Injection and Satellite Orbit Perturbations**<br>General aspects of satellite injections, Satellite orbit transfer, Various cases, Orbit deviationsdue to injection errors, Special and general perturbations, Cowell's Method, Encke's method, Method of variations of orbital elements, General perturbations approach. |
| **Unit IV** | **Interplanetary Trajectories**<br>Two dimensional interplanetary trajectories, Fast interplanetary trajectories, Three dimensional interplanetary trajectories, Launch of interplanetary spacecraft, Trajectory about the target plant. |
| **Unit V** | **Ballistic Missile Trajectories**<br>The boost phase, The ballistic phase, Trajectory geometry, Optimal flights, Time of flight,Re-entry phase, The position of the impact point, Influence coefficients.<br>**Materials For Spacecraft**<br>Space environment, Peculiarities, Effect of space environment on the selection of materials of spacecraft. |

**Text Books**


| | |
|---|---|
| **1** | Sutton, G.P & Oscar Bilbraz, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 7thEdition, 2004. |
| **2** | Van de Kamp, P., "Elements of Astro-mechanic", Pitman, 2nd Ed., 1979. |

| | |
|---|---|
| **3** | Cornelisse, J.W., "Rocket propulsion and space dynamics", W.H. Freeman & Co., 4th Ed., 1984. |
| **Reference Books** | |
| **1** | Parker, E.R., "Materials for Missiles and Spacecraft", McGraw Hill Book Co., Inc., 3rd Ed., 1982. |
| **2** | Thompson, W.T., “Introduction to Space Dynamics”, Dover, New York, 1st Ed., 1986. |
| **3** | |
| **Useful Links** | |
| **1** | https://nptel.ac.in/courses/101/105/101105030/ |
| **2** | https://nptel.ac.in/courses/101/105/101105083/ |
| **3** | https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ae06/ |

| BAE33506 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Explain** the structure of the solar system, coordinate systems, celestial mechanics, and time measurement systems. | **3** | **9** |
| **CO2** | **Analyze** the two-body and restricted three-body problems and apply orbital mechanics to determine satellite motion and orbital elements. | **3** | **9** |
| **CO3** | **Evaluate** satellite injection strategies, effects of orbit transfer and injection errors. | **4** | **9** |
| **CO4** | **Analyze** interplanetary and ballistic missile trajectories considering phases of flight, geometry, and optimality conditions. | **3** | **9** |
| **CO5** | **Apply principles of trajectory geometry** and optimal flight theory to model and optimize missile flight paths | **3** | **9** |

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# PROGRAM ELECTIVE-I

## B.Tech. Vth Sem Aeronautical Engineering

## BAE33507:Industrial Aerodynamics

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 4 Hr / Week | | **ESE** | 60 Marks |
| **Tutorial** | - | | **CIE** | 40 Marks |
| **Practical** | - | | **Total** | 100 Marks |
| **Theory Credits: 4** | | | **Duration of Exam:** 3 Hours | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1.** | To introduce the basic concepts of Introduction to Atmospheric Circulations. |
| **2.** | To make students familiarize with Horizontal axis and vertical axis machines. |
| **3.** | To impart knowledge on the Boundary layers and separation.. |
| **4.** | To infer about the performance of different Pressure distribution on low rise buildings. |
| **5.** | To introduce the basic the Vortex shedding & Effects of Reynolds number. |

### Course Contents

| | |
|---|---|
| **Unit I** | **Atmosphere:** Introduction to Atmospheric Circulations, Mean velocity Profiles, Local winds & Terrain types, Power law logarithm law, Roughness Parameters, Simulation techniques in wind Tunnels |
| **Unit II** | **Wind Energy Collectors:** Horizontal axis and vertical axis machines, Energy density of different rotors, Air crew Coefficient Power coefficient, Betz coefficient by Fraud momentum theory and blade elementary theory. |
| **Unit III** | **Vehicle Aerodynamics:** Boundary layers and separation, Two dimensional wake and vertex formation, Strouhal and Reynolds numbers, Separation and reattachments, Power requirements and drag coefficients of automobiles, Effect of cut back angle, Aerodynamics of Trains. |
| **Unit IV** | **Building Aerodynamics:** Pressure distribution on low rise buildings, wind forces on buildings, Environmental winds in city blocks, Special problems of tall buildings, Building codes, ventilation and architectural aerodynamics |
| **Unit V** | **Flow Induced Vibrations:** Vortex shedding & Effects of Reynolds number on wake formation of bluff shapes, Wake Galloping, Oscillation of tall structure and launch vehicles under wind loads, stall flutter. |

### Text Books


| | |
|---|---|
| **1** | M. Sovran (Ed), “Aerodynamics and drag mechanisms of bluff bodies and road vehicles”, Plenum press, New York, 1978. |
| **2** | P. Sachs, “Winds forces in engineering”, Pergamon Press, 1978. |
| **3** | John. D. Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series, McGraw Hill Education, 3rd edition, 2012 |

| Reference Books | |
|---|---|
| 1 | Scorer R.S "Environmental Aerodynamics", Ellis Harwood Ltd, England, 1978 |
| 2 | R.D. Blevins, "Flow induced vibrations", Van Nostrand, 2nd edition 2014. |
| 3 | |
| **Useful Links** | |
| 1 | https://nptel.ac.in/content/syllabus_pdf/101104005.pdf |
| 2 | https://nptel.ac.in/courses/101/108/101108056/ |
| 3 | https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ae06/ |

| BAE33507 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Explain** the characteristics of atmospheric circulation and boundary layer profiles | **3** | **9** |
| **CO2** | **Compare** the performance of horizontal and vertical axis wind turbines based on energy extraction | **2** | **9** |
| **CO3** | **Analyze** boundary layer behavior, vortex shedding, and aerodynamic forces on vehicles. | **3** | **9** |
| **CO4** | **Evaluate** wind-induced pressures and forces on buildings to improve ventilation and stability. | **4** | **9** |
| **CO5** | **Analyze** flow-induced vibrations such as vortex shedding, galloping, and stall flutter. | **3** | **9** |

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## B. Tech. Vth Sem Aeronautical Engineering

## BAE33508: Mechanics of Machines Lab

| Teaching Scheme | | Examination Scheme | |
|---|---|---|---|
| **Practical** | **2 Hrs/week** | **CA** | **25 Marks** |
| **Total Credit** | **1** | **ESE** | **25 Marks** |
| | | **Total** | **50 Marks** |
| | | **Duration of ESE: 02 Hours** | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1** | Demonstrate the gyroscopic effect on airplane, ship, four wheeler, two wheeler and Exhibit skills towards application of dynamic force |
| **2** | To identify the motion of cam and follower for velocities and acceleration calculation |
| **3** | To Examine the balancing of the rotating elements to avoid the failure |
| **4** | To learn different types of governors and vibration concept in various machines |

| Sr. No. | List of Experiment | CO |
|---|---|---|
| **1** | Evaluate and compare the magnitude of active couple and Gyroscopic couple with respect to Gyroscope | **1** |
| **2** | Interpret displacement curve of Cam follower movement with respect to cam rotation | **2** |
| **3** | Determine the balancing of rotating masses using numerical. | **3** |
| **4** | Determine Performance Characteristic of Simple watt Governor | **5** |
| **5** | Calculate the frequency of Longitudinal vibration in spring mass system | **4** |
| **6** | Determine and compare the torsional frequency through free and damped vibration in logarithmic decay. | **3** |
| **7** | Determine natural frequency of torsional vibration in single and Double rotor system. | **3** |
| **8** | Calculate radius of gyration of a given body using bifiller suspension | **5** |
| **9** | Determine critical speed of Shaft in Transverse Vibration | **4** |
| **10** | Determine Natural frequency in Cantilever Beam | **4** |

**Text Books**

| | |
|---|---|
| **1** | Theory of Machine, S. S.Rattan,Tata McGrawHill. |
| **2** | Mechanism and Machine Theory,J.S.Rao & Dukki Patti, New Age International (P)Ltd,Publishers. |

**Reference Books**

| | |
|---|---|
| **1.** | Theory of Machines, Sadhu S ingh, Pearson publications. |
| **2.** | Theory of Machines and Mechanisms, J.E .Shigley and J.J. Uicker,Oxford University Press. |

**Useful Links**

| | |
|---|---|
| **1** | https://nptel.ac.in/courses/112104114/ |
| **2** | https://nptel.ac.in/courses/112/104/112104121/ |

| BAE33508 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Evaluate** the active couple and gyroscopic couple for a gyroscope and their effects on stability and motion. | **4** | **9** |
| **CO2** | **Analyze** cam rotation to follower motion to understand timing and dynamic behavior. | **3** | **9** |
| **CO3** | **Determine** unbalanced forces in rotating systems using numerical methods to achieve dynamic equilibrium. | **3** | **9** |
| **CO4** | **Analyze** natural frequencies of torsional, longitudinal, and transverse vibration systems including shafts, beams, and spring-mass systems. | **3** | **9** |
| **CO5** | **Determine** performance characteristics of governors and vibration systems (free and damped), such as critical speed and radius of gyration. | **3** | **9** |

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## B.Tech. V$^{th}$ Sem Aeronautical Engineering

## BAE33509: Aircraft Propulsion Lab

| Teaching Scheme | | | Examination Scheme | |
|---|---|---|---|---|
| **Practical** | **2 Hrs/week** | | **CA** | **25 Marks** |
| **Total Credit** | **1** | | **ESE** | **25 Marks** |
| | | | **Total** | **50 Marks** |
| | | | **Duration of ESE: 02 Hours** | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1** | Analyze the velocity distribution in free and wall jets from orifice outlets |
| **2** | Evaluate heat transfer characteristics under natural and forced convection |
| **3** | Analyze propeller performance under laboratory conditions |
| **4** | Conduct performance testing of internal combustion engines under various conditions |
| **5** | Examine fuel properties relevant to aviation safety and performance |

| Sr. No. | List of Experiment | CO |
|---|---|---|
| **1** | Determine the velocity profile of free jet from out let of orifice | **1** |
| **2** | Determine the velocity profile of wall jet from out let of orifice | **1** |
| **3** | Perform free convective heat transfer over a flat plate | **2** |
| **4** | Perform forced convective heat transfer over a flat plate | **2** |
| **5** | Determine the calorific value of aviation fuel | **3** |
| **6** | To determine the calorific value of Solid Rocket Propellant | **3** |
| **7** | Determine the performance of a propeller | **4** |
| **8** | Conduct Performance Test on Single Cylinder, Two stroke Petrol engine at different loads. | **5** |
| **9** | Conduct Performance Test on Single Cylinder, Four stroke Petrol engine at different compression ratio and different loads | **5** |
| **10** | Determine Flash & Fire Point of liquid aviation fuel (ATF) | **3** |

**Text Books**

| | |
|---|---|
| **1** | Hill Philip, Peterson Carl, Mechanics and Thermodynamics of Propulsion, 2$^{nd}$ edition, 1992, Addison Wesley |
| **2** | El Sayed Ahmed, Aircraft Propulsion & Gas Turbine Engines, Taylor & Francis, CRC Press, 3$^{rd}$ Edition, 2008. |

**Reference Books**

| | |
|---|---|
| **1.** | Mattingly J D, Elements of Propulsion: Gas Turbines and Rockets, AIAA Education Series, 2006. |
| **2.** | Fundamentals of engineering Thermodynamics by R. K. Rajput, Laxmi Publications, 4th Edition 2016. |

**Useful Links**

| | |
|---|---|
| **1** | https://nptel.ac.in/courses/l12/105/112105123/ |
| **2** | https://nptel.ac.in/courses/l12/104/112104113/ |

| BAE33509 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Analyze** the velocity profiles of free and wall jets from an orifice to understand jet flow characteristics and boundary layer development. | **3** | **9** |
| **CO2** | **Evaluate** free and forced convective heat transfer experiments over a flat plate and the heat transfer coefficients. | **4** | **9** |
| **CO3** | **Determine** the calorific values of aviation fuel and solid rocket propellant using bomb calorimetry | **3** | **9** |
| **CO4** | **Evaluate** the performance characteristics of a propeller under test conditions such as thrust, torque, and efficiency data. | **4** | **9** |
| **CO5** | **Analyze** two-stroke and four-stroke petrol engines compression ratios, engine efficiency, fuel consumption, and output. | **4** | **9** |

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## B. Tech. Vth Sem Aeronautical Engineering

## BAE33510: Aerodynamics Lab

| Teaching Scheme | | | Examination Scheme | |
|---|---|---|---|---|
| **Practical** | **2 Hrs/week** | | **CA** | **25 Marks** |
| **Total Credit** | **1** | | **ESE** | **25 Marks** |
| | | | **Total** | **50 Marks** |
| | | | **Duration of ESE: 02 Hours** | |

**Course Objectives**

The Objectives of this course are:

| | |
|---|---|
| **1** | To provide hands-on experience with fundamental aerodynamic testing techniques |
| **2** | To develop proficiency in using instrumentation and data acquisition systems |
| **3** | To enhance understanding of aerodynamic forces and flow behavior. |
| **4** | To build skills in interpreting and presenting experimental data |
| **5** | To enable experimental analysis of boundary layers and flow separation |

| Sr. No. | List of Experiment | CO |
|---|---|---|
| **1** | Calibration of the wind tunnel test section velocity verses the fan RPM | **1** |
| **2** | Estimating the pressure distribution (coefficient of pressure) over a circular cylinder | **1** |
| **3** | Estimating the pressure distribution (coefficient of pressure) over a symmetrical aerofoil | **1** |
| **4** | Estimating the pressure distribution (coefficient of pressure) over a cambered aerofoil | **2** |
| **5** | Estimating the pressure distribution (coefficient of pressure) over a flat plate model | **2** |
| **6** | Evaluating the three components of forces over a cambered aerofoil using 3- component wind tunnel balance | **3** |
| **7** | Evaluating the three components of forces over an aircraft model using 3-component wind tunnel balance | **3** |
| **8** | Estimating the functional area of test section by considering the boundary layer effect | **4** |
| **9** | Smoke flow visualization over different models (Aircraft model, car model, high rise building, circular cylinder, symmetrical aerofoil and cambered aerofoil) | **4** |
| **10** | Tuft flow visualization over different models (Aircraft model, car model, high rise building, circular cylinder, symmetrical aerofoil and cambered aerofoil) | **5** |

**Text Books**

| | |
|---|---|
| **1** | Hill Philip, Peterson Carl, Mechanics and Thermodynamics of Propulsion, 2nd edition, 1992,Addison Wesley |
| **2** | El Sayed Ahmed, Aircraft Propulsion & Gas Turbine Engines, Taylor & Francis, CRC Press, 3rdEdition, 2008. |

**Reference Books**

| | |
|---|---|
| **1.** | Mattingly J D, Elements of Propulsion: Gas Turbines and Rockets, AIAA Education Series, 2006. |
| **2.** | Fundamentals of engineering Thermodynamics by R. K. Rajput, Laxmi Publications, 4th Edition 2016. |

**Useful Links**

| | |
|---|---|
| **1** | https://nptel.ac.in/courses/l12/105/112105123/ |
| **2** | https://nptel.ac.in/courses/l12/104/112104113/ |

| BAE33510 | Course Outcomes | CL | Class Sessions |
|---|---|---|---|
| **CO1** | **Calibrate** a wind tunnel test section by establishing the relationship between fan RPM and flow velocity, and verify flow uniformity. | **3** | **9** |
| **CO2** | **Analyze** pressure distributions and coefficients of pressure over aerodynamic shapes (circular cylinder, flat plate, symmetrical and cambered aerofoils). | **3** | **9** |
| **CO3** | **Evaluate** the aerodynamic force components on aerofoil and aircraft models using a 3-component wind tunnel balance. | **4** | **9** |
| **CO4** | **Determine** the effectiveness of test section area of a wind tunnel considering boundary layer effects. | **3** | **9** |
| **CO5** | **Visualize** flow patterns using smoke and tuft flow methods over models to identify flow separation, attachment, and wake structures. | **2** | **9** |

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## B.Tech. Vth Sem Aeronautical Engineering

## BAE33511: Unmanned Aerial Systems (Open Elective-III)

| **Teaching Scheme** | | | **Examination Scheme** | |
|---|---|---|---|---|
| **Lectures** | 2 Hr / Week | | CT-I | 7 Marks |
| | | | CT-II | 7 Marks |
| | | | CA | 6 Marks |
| **Tutorial** | - | | ESE | 30 Marks |
| **Practical** | - | | Total | 50 Marks |
| **Theory Credits: 2** | | | **Duration of Exam :** 2 Hours | |

**Course Objectives**

The Objective of this course is:

| | |
|---|---|
| **1.** | To introduce the basic concepts of unmanned aerial vehicles. |
| **2.** | To make students familiarize themselves with the design aspects of UASs |
| **3.** | To impart knowledge on the hardware components and their application in the UASs. |

**Course Contents**

| | |
|---|---|
| **Unit-I** | **Introduction to UAS:** History of UAS, classification, Introduction to Unmanned Aircraft Systems, models and prototypes, System Composition, applications, Payloads. |
| **Unit-II** | **The Design of UAS:** Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards and Regulatory Aspects, India, UK, USA and Europe, control surfaces, specifications. |
| **Unit-III** | **Avionics Hardware:** Autopilot, AGL, pressure sensors, servos, accelerometer, gyros, actuators, power supply, processor, integration, installation, configuration, and testing. Working Principles of various types of battery and its applications. |

**Text Books**


| | |
|---|---|
| **1** | Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2nd Ed., 2007.. |
| **2** | Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAS Systems", UAS Systems, Inc, 4th Ed., 1998.. |
| **3** | Reg Austin "Unmanned aircraft systems: UAS design, development and deployment", Wiley, 5th Ed., 2010.. |


**Reference Books**


| | |
|---|---|
| **1** | G. Lalit Gupta and OP. Sharma, 'Aircraft Systems (Fundamentals of Flight Vol. IV)', HimalayanBooks;2006. |
| **2** | Treager. S, "Gas Turbine Technology", McGraw-Hill, 3rd edition,2013, ISBN-13: 978- 1259064876. |
| **3** | R.W. Sloley and W.H. Coulthard, 'The aircraft Engineers Handbook, No 4, Instruments', 6th Edition, 2005, ISBN13: 978-8175980518. |

| Useful Links | |
|---|---|
| **1** | https://nptel.ac.in/courses/101104071 |
| **2** | https://nptel.ac.in/courses/101/105/101105059/ |
| **3.** | https://nptel.ac.in/courses/101/105/101105031/ |

| **BAE33511** | **Course Outcomes** | **CL** | **Class Sessions** |
|---|---|---|---|
| **CO1** | **Acquire** knowledge on the importance of UAS with respect to their applications. | **3** | **9** |
| **CO2** | **Distinguish** between various subsystems and configurations of UAS. | **3** | **9** |
| **CO3** | **Perform** ground test and troubleshooting with respect to UAS operation. | **4** | **9** |

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| Third Year (Semester-V) B.Tech | | | | |
|---|---|---|---|---|
| **BME33501:** Heat Transfer | | | | |
| **Teaching Scheme** | | | **Examination Scheme** | |
| **Lectures** | 3 Hr/Week | | **CT** | 30 |
| **Tutorials** | - | | **CA** | 10 |
| **Total Credits** | 4 | | **ESE** | 60 |
| | | | **Total** | 100 Marks |
| | | | Duration of ESE:03Hrs | |

| **Course Objectives:** | |
|---|---|
| 1 | Students will learn the different modes of heat transfer like conduction, convection & Radiation, |
| 2 | To acquaint Heat transfer through extended surfaces. |
| 3 | Students understand the concept of convection, free and forced convection |
| 4 | To Solve lumped parameter transient heat transfer problems. |
| 5 | To Predict heat exchanger performance |

| | **Course Contents** | **Hours** |
|---|---|---|
| **Unit I** | **Introduction to heat transfer:** Modes and laws of heat transfer, conduction, convection & radiation. Fourier's law, Newton's law of cooling, Stefan Boltzmann law; thermal resistance and conductance, thermal diffusivity, analogy between flow of heat and electricity, One dimensional steady state conduction equation for the plane wall, Cylinder and its Numerical, overall heat transfer coefficient. | **(9)** |
| **Unit II** | **Conduction with internal heat generation:** Plane wall, cylinder and its Numerical. **Extended Surfaces:** Types and Applications of Fins, Heat transfer through extended surfaces, derivation of temperature distribution equations and heat transfer through fins, Effectiveness and efficiency of a fin. | **(9)** |
| **Unit III** | **Convection:** Types of convection, Hydrodynamic and thermal boundary layer, Laminar and turbulent flow over a flat plate and through a duct. **Free and Forced Convection:** Physical significance of the dimensionless numbers related to free and forced convection, empirical correlations for free and forced convection for heat transfer in laminar and turbulent flow over a flat plate and through a duct. **Introduction to Condensation and Boiling**: Condensation and its type, Film and drop wise condensation, Modes of boiling, Different boiling regimes, pool boiling. | **(9)** |
| **Unit IV** | **Radiation:** Stefan- Boltzmann law, Emissive power, Surface emission properties, Absorptivity, Reflectivity, Transmissivity, Concept of Black body radiation, Planck's distribution law, Wien's displacement law, The grey, black and real surface. Radiation shape factor, Kirchoff's law, Radiation shields. | **(9)** |
| **Unit V** | **Heat Exchangers:** Heat exchangers classification, overall heat transfer coefficient, heat exchanger analysis, use of log mean temperature difference (LMTD) for parallel, counter and cross flow heat exchangers, fouling factor, The effectiveness-NTU method for parallel and counter flow heat exchangers. | **(9)** |

| Text Books | |
|---|---|
| T.1 | S. P Sukhatme, A Text Book of Heat Transfer, University Press, 4th Edition, 2005 |
| T.2 | Fundamentals of Heat and Mass Transfer, K. N. Seetharam & T.R. Seetharam, Willey. |
| T.3 | R.C. Sachdeva: Fundamentals of Engineering Heat and Mass Transfer, Wiley Eastern Ltd. (I), 2010 |
| **Reference Books** | |
| R.1 | J.P. Holman: Heat Transfer; McGraw-Hill, 1996 |
| R.2 | Yunus A. Cengel, Heat Transfer: A Practical Approach, McGraw-Hill Higher Education, 2002 |

| | Useful Links |
|---|---|
| 1 | https://nptel.ac.in/courses/112/107/112107256/ |
| 2 | https://nptel.ac.in/courses/112/106/112106155/ |
| 3 | hhttps://nptel.ac.in/courses/103/103/103103035/ |

| | Course Outcomes | CL |
|---|---|---|
| **BME33501.1** | **Compare** the different modes of heat transfer and calculation of thermal resistance and Thermal Conductivity | 3 |
| **BME33501.2** | **Apply** internal heat generation concepts to calculate heat transfer rates and understand the significance of different types of fins | 3 |
| **BME33501.3** | **Apply** empirical correlations to estimate forced and free convection heat transfer in internal and external flows." | 3 |
| **BME33501.4** | **Evaluate** heat transfer rate by radiation from ideal and actual surfaces and enclosures of different geometries. | 5 |
| **BME33501.5** | **Evaluate** heat exchanger performance for the parallel and counter flow. | 5 |

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