TULSIRAMJI GAIKWAD-PATIL
College of Engineering & Technology
Mohgaon, Wardha Road, Nagpur - 441 108

DEPARTMENT OF AERONAUTICAL ENGINEERING

Structure & Curriculum
Semester: 7th

From

Academic Year 2023-24

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 ofprofessional 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 knowledgeand 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. Under graduate students will acquire knowledge to investigate and solve AeronauticalEngineering problems using basics of applied science and engineering.
2. Under graduate 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. Under graduate 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. Under graduate students will contribute in the domain specific and inter disciplinary research through the project based learning.

Program Specific Outcomes (PSO)

- Develop profound working knowledge to solve combination of complex problems inaerodynamics, 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.
- Under graduates will be able to utilize the extensive knowledge of design, manufacturing, testingor maintenance of systems and subsystems to pursue career in aeronautical engineering.

Scheme of Instructions: Semester–VII (Fourth Year B.Tech. in Aeronautical Engineering) Batch A

Sr. No.	Course Category	Course Code	Course Title	L	T	P	Contact Hrs./Wk	Credits	EXAM SCHEME				
									CT1	CT2	TA/CA	ESE	TOTAL
1	PCC	BAE4701	Unmanned Aerial Systems	3	-	-	3	3	15	15	10	60	100
2	PCC	BAE4702	Flight Mechanics	3	-	-	3	3	15	15	10	60	100
3	PCC	BAE4703	Unmanned Aerial Vehicles Lab	-	-	2	2	1	-	-	25	25	50
4	PROJ	BAE4704	Seminar based on emerging courses@	-	-	4	4	2	-	-	25	25	50
5	PEC	BAE4705-08	Program Elective-V	3	-	-	3	3	15	15	10	60	100
6	PEC	BAE4709-12	Program Elective-VI	3	-	-	3	3	15	15	10	60	100
7	OEC	B$$XX01-18	Open Elective-III	4	-	-	4	4	15	15	10	60	100
8	OEC	B$$XX01-18	Open Elective -IV	4	-	-	4	4	15	15	10	60	100
9	MCC	BAU47XX	Behavioral and Interpersonal Skills	2	-	-	2	Audit	-	-	-	--	--
			Total	22	-	6	28	23	90	90	110	410	700

@There will be two presentations, based on seminar topic to be selected in consultation with guide preferably based on emerging trends.
* Indicates out of the four course codes each student has to select any one PEC from the list provided at the end of structure.

Note – Batch A will go for regular courses in 7th semester and will carry out industry-based project or internship in the 8th semester.

L- Lecture **T-Tutorial** **P-Practical**
CT1- Class Test 1 **TA/CA- Teacher Assessment/Continuous Assessment**
CT2- Class Test 2 **ESE- End Semester Examination (For Laboratory End Semester performance)**

Course Category	HSMC (Hum. Sc., Soc. Sc. & Mgmt.) Courses	BSC (Basic Sc.) Courses	ESC (Engg. Sc. Courses	PCC (Programme Core Courses)	PEC Programme Elective Courses	OEC (Open Elective Courses other discipline)	Project/Seminar Industrial Training	MCC (Mandatory Courses)
Credits	--	--	--	7	06	08	2	Yes
Cumu. Sum	08	26	21	55	18	14	5	--

PROGRESSIVE TOTAL CREDITS :124+23 =147

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Vice Principal
Tulsiramji Gaikwad-Patil
College Of Engineering &
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Principal
Tulsiramji Gaikwad - Patil
College Of Engineering &

List of Program Electives offered

By

Aeronautical Engineering Department

Program Elective-V	Program Elective- VI
Semester VII	**Semester VII**
BAE4705: Theory of Combustion	**BAE4709: Control Theory & Systems**
BAE4706: Industrial Aerodynamics	**BAE4710: Aircraft Materials & NDT**
BAE4707: Aviation Managements	**BAE4711: High Speed Aerodynamics**
BAE4708: Finite Element Methods	**BAE4712: Computational Fluid Dynamics**

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Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year B. Tech (Semester-VII)

BAE4701: Unmanned Aerial Systems

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the basic concepts of unmanned aerial vehicles.
2.	To make students familiarize with the design aspects of UASs.
3.	To impart knowledge on the hardware components and their application in the UASs.
4.	To infer about the communication and control detail of UASs.
5.	To introduce the basic operational futures of UASs.

Course Contents

Unit I	**Introduction to UAS** History of UAS, classification, Introduction to Unmanned Aircraft Systems, models and prototypes, System Composition, applications.
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.
Unit IV	**Communication Payloads and Controls** Payloads, Telemetry, tracking, Aerial photography, controls, PI, PD and PID feedback, Radio control frequency range, modems, memory system, simulation, ground test, analysis, trouble shooting.
Unit V	**Development of UAS** Waypoints navigation, ground control software, System Ground Testing, System In-flight Testing, Future Prospects and Challenges, Case Studies – Mini and Micro UAS. different types of vehicles launchers.

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	Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 1st Ed., 2001.
2	"Design of Unmanned Air Vehicle Systems", by Stoecker & Jones. McGraw-Hill
Useful Links	
1	https://nptel.ac.in/courses/101/104/101104071/
2	https://onlinecourses.nptel.ac.in/noc20_ae03/preview

BAE4701	Course Outcomes	CL	Class Sessions
CO1	**Acquire** knowledge on the importance of UAS with respect to their applications.	2	9
CO2	**Distinguish** between various subsystems and configurations of UAS.	3	9
CO3	**Perform** ground test and troubleshooting with respect to UAS operation.	3	9
CO4	**Distinguish** between needs of mini and micro UAS.	4	9
CO5	**Gain** insights with design standards and regulatory aspects of UAS.	2	9

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Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4702: Flight Mechanics

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To provide the basic equations governing the steady performance of airplanes.
2.	To describe the gliding and climbing flights and the parameters that decides those performances.
3.	To provide the methods to calculate the approximate total takeoff and landing distance.
4.	To introduce the concept of load factor and provides necessary equations to assess the turn performance of an airplane.
5.	To learn the details of longitudinal and lateral stability to estimate the stability criteria for an aircraft.

Course Contents

Unit I	**Forces and Moment on the Airplane** Forces and moments acting on a flight vehicle, Equation of motion of a rigid flight vehicle, Different types of drag, Drag polars of vehicles from low speed to high speeds, Variation of thrust, power and SFC with velocity and altitudes for air breathing engines and rockets, Power available and power required curves.
Unit II	**Aircraft Performance** Performance of airplane in level flight, Maximum speed in level flight, Conditions for minimum drag and power required Range and endurance, Climbing flight (Maximum rate of climb) and steepest angle of climb, Service and absolute ceiling.
Unit III	**Gliding and Turning performance** Gliding flight (minimum rate of sink and shallowest angle of glide), Turning performance (Turning rate turn radius). Bank angle and load factor, take-off and landing performance, Limitations of pulls up and pushes over.
Unit IV	**Static Longitudinal Stability and Control (Stick Fixed and Stick Free)** Degree of freedom of rigid bodies in space, Static and dynamic stability, Purpose of controls in airplanes, inherently stable and marginal stable airplanes, Static, Longitudinal stability, Stick fixed stability, Basic equilibrium equation, Stability criterion, Effects of fuselage and nacelle, Influence of CG location, Power effects, Stick fixed neutral point. Stick free stability, Hinge moment coefficient, stick free neutral points, Symmetric maneuvers, Stick force gradients, Stick force per 'g', Aerodynamic balancing. Determination of neutral points and maneuver points from flight test.
Unit V	**Lateral and Directional Stability** Dihedral effect, Lateral control, Coupling between rolling and yawing moments, Adverse yaw effects, Aileron reversal, Static directional stability, Weather cocking effect, Rudder requirements, One engine inoperative condition, Rudder lock.

Text Books

1	Perkins, C. D. and Hage, R. E., Airplane Performance stability and Control, John Wiley & Son:, Inc, New York, 3rd Edn. 2008.
2	Nelson, R. C., Flight Stability and Automatic Control, McGraw-Hill Book Co., 1st Ed., 1998.

3	Etkin, B., Dynamics of Flight Stability and Control, John Wiley, New York, 2nd Ed., 1982.
Reference Books	
1	Babister, A. W., Aircraft Dynamic Stability and Response, Pergamon Press, Oxford, 1st Ed., 1980.
2	Dommasch, D. O., Shelby, S. S., and Connolly, T. F., Aeroplane Aero dynamics, Issac Pitman, London, 3rd Ed., 1981.
Useful Links	
1	https://nptel.ac.in/courses/101/104/101104061/
2	https://nptel.ac.in/courses/101/106/101106041/
3	https://nptel.ac.in/courses/101/104/101104007/

BAE4702	Course Outcomes	CL	Class Sessions
CO1	**Describes** the fundamentals of aircraft design and aerodynamic characteristics.	3	9
CO2	**Estimate** the drag and thrust of the flight vehicle under given operating condition.	4	9
CO3	**Enumerate** steady level flight performance of an aircraft.	3	9
CO4	**Examine** accelerated flight performance of an aircraft under given loading condition.	4	9
CO5	**Examine** the static and lateral stability of an aircraft.	5	9

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Fourth Year (Semester-VII) B.E. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4703: Unmanned Aerial System Lab

Teaching Scheme			Examination Scheme	
Practical	2 Hrs/week		**CA**	25 Marks
Total Credit	1		**ESE**	25 Marks
Duration of ESE: 02 Hrs 00 Min.			**Total**	50 Marks

Course Outcomes (CO)

BAE4705	Students will be able to
1	Select components for UAS systems design and manufacturing.
2	Prepare the draft of application for UAS registration with NPNT compliance.
3	Test and use the avionics hardware, PID controller for UAS systems.
4	Carryout the testing and simulation of navigational equipment's.
5	Conduct the mission planning of UAS system and simulate of projectile in SIMULINK.

Sr. No.	List of Experiment	CO
1	Introduction to Unmanned Aircraft systems, Scope of the Lab, History, models and prototypes--Application	1
2	The Design of UAS Systems: Introduction to Design and Selection of the system--Aerodynamics and Airframe Configurations-Characteristics of Aircraft Types	1
3	The Design of UAS Systems: Design standards and Regulatory aspects -UK, USA and Europe--Design for stealth --Control surfaces --Specifications	2
4	Avionics Hardware: Autopilot--AGL pressure sensor-servos-Accelerometer-Gyro actuators--Sensor Fusion -Power supply	2
5	Avionics Hardware: Installation, Configuration and testing	3
6	Communication Payloads and controls: Payloads--Telemetry tracking --Aerial Photography--PID control feedback- Radio control frequency range	3
7	Communication Payload and controls: Simulation-ground test-analysis-trouble shooting	3
8	Waypoint navigation--Ground control software--system ground testing--System In-flight testing	4
9	Familiarization with Flight control software--Component calibrations, PID tuning strategy used	3
10	Introduction to Basics of SIMULINK modeling and Implementation of Projectile motion in SIMULINK	4
11	Modeling of Linear and Rotational Dynamics blocks in SIMULINK	5
12	Modeling of PID control in SIMULINK	5
13	Case Study: Implementation of Altitude hold controller of a Quad copter using PID control	5

Text Books

1	Unmanned Air Systems_ UAS Design, Development and Deployment-Reg Austin, John Wiley-2010.2
2.	Paul G Fahlstrom, Thomas J Gleason, "Introduction to UAS Systems", UAS Systems, Inc, 4th Ed., 1998.

	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	Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 1st Ed., 2001.
2	"Design of Unmanned Air Vehicle Systems", by Stoecker & Jones. McGraw-Hill
Useful Links	
1	https://nptel.ac.in/courses/101/104/101104071/
2	https://onlinecourses.nptel.ac.in/noc20_ae03/preview

MAE4703	Course Outcomes	CL	Class Sessions
CO1	**Acquire** knowledge on the importance of UAS with respect to their applications.	**2**	**9**
CO2	**Distinguish** between various subsystems and configurations of UAS.	**3**	**9**
CO3	**Perform** ground test and troubleshooting with respect to UAS Operation.	**3**	**9**
CO4	**Apply** the mini UAS and micro UAS for the social and industrial needs	**4**	**9**
CO5	**Understand** the insights with design standards and regulatory aspects of UAS.	**2**	**9**

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Program Elective-V

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4705: Theory of Combustion

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the basic concepts of adiabatic flame temperature.
2.	To make students familiarize with the chemical kinetics and species conservation equations
3.	To impart knowledge on the different flame structures and stability characteristics
4.	To infer about the performance of different combustors and design of flame holders.
5.	To introduce the basic the combustion mechanisms of different propellants.

Course Contents

Unit I	**Introduction:** History of solid liquid and gaseous fuels, production, present scenario and consumption pattern of fuels. the Coal origin, its classification, composition, and properties. Coal mining, preparation, and washing. Combustion of coal and coke making, different types of coal combustion techniques, and consumption pattern of fuels, fundamental definitions, properties and various measurements, properties of solid liquid fuels and their measurement techniques.
Unit II	**Solid, Liquid and Gaseous Fuels:** Types of fuels, solid, liquid and gaseous fuels, combustion techniques, and consumption pattern of fuels, direct and Indirect liquefaction, coal gasification, oxidation and hydrogenation. Efficient use of solid fuels. Origin and classification of petroleum, refining, properties. Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, hydrogen, acetylene, other fuel gases. Cleaning, purification and quality enhancement of gaseous fuels.
Unit III	**Stoichiometry of Combustion:** Estimation of minimum amount of air required for a fuel of known composition, theoretical and actual combustion processes - Air fuel ratio, estimation of dry flue gases for known fuel composition, calculation of the composition of fuel and excess air supplied from exhaust gas analysis, dew point of products. calorific value of fuels, adiabatic flame temperature, mechanism and kinetics of combustion.
Unit IV	**Combustion Technology:** Stoichiometry and thermodynamics of combustion, calculation of heat of formation and heat of combustion, first law analysis of reacting system, combustion of oil, combustion of coal, combustion of gas, flue gas analysis, flame properties, draft system, combustion appliances, gas burners, functional requirement of burners, gas burner classification, stoker firing, pulverized system of firing, fluidized bed combustion process, combustion controls. Introduction to different

	types of furnaces: heat treatment furnaces, industrial furnaces, process furnaces & kilns. Applications of batch & continuous furnaces, oxy-rich combustion.
Unit V	**Combustion in Jet Engines:** Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlled by diffusion mixing and heat convection, peculiarities of supersonic combustion. **Combustion in Chemical Rockets:** Combustion in liquid propellant rockets, Combustion of solid propellants, application of laminar flame theory to the burning of homogeneous propellants, Combustion in hybrid rockets, combustion instability in rockets.

Text Books	
1	Kuo K.K. "Principles of Combustion" John Wiley and Sons, 2nd Ed., 2005
2	John Griswold, "Fuels Combustion and Furnaces" Mc-Graw Hill Book Company Inc.
3	Mishra D. P., "Fundamentals of Combustion", Prentice Hall of India, New Delhi, 3rd Ed., 2008
Reference Books	
1	Mukunda H. S., "Understanding Combustion", Second edition, Orient Blackswan, 2nd Ed., 2009.
2	Warren C. Strahle, "An Introduction to Combustion", Taylor & Francis, 3rd Ed., 1993.
Useful Links	
1	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
2	https://nptel.ac.in/courses/112/103/112103111/

BAE4705	**Course Outcomes**	**CL**	**Class Sessions**
CO1	**Calculate** adiabatic flame temperature and estimate equilibrium products of combustion.	**2**	**9**
CO2	**Solve** chemical kinetics and species conservation equations	**3**	**9**
CO3	**Acquire** knowledge in different flame structures and stability characteristics	**3**	**9**
CO4	**Compare** the performance of different combustors and design of flame holders.	**4**	**9**
CO5	**Analyze** the combustion mechanisms of different propellants.	**2**	**9**

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Program Elective-V

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4706: Industrial Aerodynamics

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

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.
Useful Links	
1	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
2	https://nptel.ac.in/courses/101/108/101108056/

BAE4706	**Course Outcomes**	**CL**	**Class Sessions**
CO1	**Understand** the concept of atmosphere and related numerical.	**1**	**9**
CO2	**Identify** the wind energy collectors and other energy resource.	**2**	**9**
CO3	**Apply** knowledge of aerodynamic to road vehicles.	**3**	**9**
CO4	**Apply** knowledge of aerodynamic to buildings.	**3**	**9**
CO5	**Understand** the flow induced vibrations	**3**	**9**

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Program Elective-V

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year B. Tech (Semester-VII)

BAE4707: Aviation Managements

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the basic concepts of the air traffic managements.
2.	To make students familiarize with air traffic controller.
3.	To impart knowledge about the flight phases.
4.	To infer about the basic concepts air space managements.
5.	To introduce the aircraft emergency.

Course Contents

Unit I	**Introduction to ATM:** Comparison with other modes of transport, Role of IATA, ICAO, The general aviation industry airline, Factors affecting general aviation, use of aircraft, airport: airline management and organization, levels of management, functions of management, Principles of organization planning the organization, chart, staff departments and line departments.
Unit II	**Air Traffic Controller (ATC):** Vocabulary and units, Missions and actors of the air traffic management system, Visual flight rules and instrumental flight rules, Airspace classes, Airspace organization and management, Flight information regions and functional airspace blocks, Lower and upper airspace, Controlled airspace: en route, approach or airport control, Air route network and airspace sectoring.
Unit III	**The Flight Phases:** The Context of Air Traffic Management, Traffic separation, Separation standard, loss of separation Conflict detection and resolution, The distribution of tasks among controllers, The controller tools, Traffic regulation, Capacity and demand, Workload and air traffic control complexity, Airspace management in en route air traffic control centers, Operating air traffic control sectors in real time, Anticipating sector openings (France and Europe), Air traffic flow management.
Unit IV	**Airspace Management:** Airspace sector design, Functional airspace block definition, Simulated annealing algorithm, Ant colony algorithm, A fusion–fission method, Comparison of fusion–fission and classical graph partitioning methods, Prediction of air traffic control sector openings, Problem difficulty and possible approaches, Using a genetic algorithm, Tree-search methods, constraint programming, A neural network for workload prediction, Conclusion on the prediction of sector openings.
Unit V	**Aircraft Emergency:** Introduction, Airports' main challenges, Known difficulties, Optimization problems in airport traffic management, Gate assignment, Problem description, Resolution methods, Runway scheduling,

	Problem description, An example of problem formulation, Resolution methods, Surface routing, Problem description, Related work, Global airport traffic optimization, Problem description , Coordination scheme between the different predictive systems.

Text Books

Fedric J.H., "Airport Management", English Book House, New Delhi-I.
Gene Krope, "Airline Procedures", English Book House, New Delhi-I.
Wilson & Bryon, "Air Transportation", English Book House, New Delhi-I.

Reference Books

Philip Lockin D, "Economics of Transportation", English Book House, New Delhi-I.
Indian Aircraft manual", Published by DGGA, English Book House, New Delhi-I.
Alexander T Wells, "Air Transportation", Wadsworth Publishing Company, California, 1993.

Useful Links

https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
https://nptel.ac.in/courses/101/104/101104071/
https://www.nptelvideos.com/lecture.php?id=5030

BAE4707	Course Outcomes	CL	Class Sessions
CO1	**Understand** the history of air traffic managements and its roles in airlines.	**4**	**9**
CO2	**Study** about concept of airspace structures and air traffic controller.	**2**	**9**
CO3	**Apply the** concept of phases of flight in ATM.	**2**	**9**
CO4	**Understand** flight scheduling methods and related practices	**3**	**9**
CO5	**Identify** the problems solving between ATC and ATM.	**4**	**9**

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Program Elective-V

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4708: Finite Elements Method

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the concepts of the plane stress & plane strain differential equation of equilibrium.
2.	To make students familiarize with equations of compatibility equation, with boundary conditions.
3.	To Know the Concept of discretization of body into elements and basic types of 2-D.
4.	To the analysis the types of 2D elements applied to plane stress, plane strain and axis symmetric problems.
5.	To the concept of the formulation of mass matrix for 1-D bar element, free vibration analysis using 1-D bar element.

Course Contents

Unit I	**Basics of Stress Analysis** Fundamentals of stress and strain, stress and strain components, stress strain relationship, Elastic constants, plane stress, plane strain, differential equation of equilibrium, compatibility equation, Boundary conditions, Saint Venant's principle, Airy's stress function.
Unit II	**Fundamental concepts of FEM** Historical background, Scope of FEM in Engg. Applications, Principle of minimum potential energy, Concept of Virtual work, Raleigh–Ritz method, FEM analysis procedure. Concept of discretization of body into elements, degrees of freedom, bandwidth, Basic types of 2-D & 3-D elements, displacement models, convergence requirements, shape function.
Unit III	**FEM Modeling** Finite element modeling and analysis using Bar and Beam elements, stiffness matrix, assembly, boundary conditions, load vector, temperature effects. Two dimensional plane trusses, Local & Global coordinate system, element stiffness matrix, assembly, boundary conditions, and load vector, force and stress calculations
Unit IV	**2D FEM Problems** Two dimensional problem using CST & LST, formulation of CST & LST elements, elemental stiffness matrix, assembly, boundary conditions, load vector, stress calculation, Temperature effect.
Unit V	**Dynamic Analysis** Introduction to Isoperimetric and Higher order elements. Introduction to dynamic analysis, formulation of mass matrix for one-dimensional bar element, free vibration analysis using one dimensional bar element. Torsion of prismatic bars using triangular elements. **Introduction to FEM Software:** Extention of the method to other engineering problems.

Text Books	
1	Introduction to Finite Elements in Engineering– T. R. Chandrupatla & A. D. Belegundu.
2	Theory of Elasticity – S.P. Timoshenko.
3	Concept and applications of Finite element Analysis – P.D. Cook.
Reference Books	
1	The Finite Element Method–A Basic introduction for engineers–D. W. Griffths, D. A. Nethercot.
2	Introduction to Finite Element- Reddy J.N. - McGraw Hill.
3.	Applied Finite Element Analysis - Larry J. Segelind - John Wiley.
Useful Links	
1	https://nptel.ac.in/courses/112/104/112104193/
2	https://nptel.ac.in/courses/105/105/105105041/
3.	https://nptel.ac.in/courses/105/106/105106051/

BAE4708	Course Outcomes	CL	Class Sessions
CO1	**Understand** the plane stress & plane strain differential equation of equilibrium & compatibility equation, with boundary conditions	**3**	**9**
CO2	**Analyze** the Concept of discretization of body into elements and basic types of 2-D & 3-D elements, displacement models,	**3**	**9**
CO3	**Analyze** the various types of 2D elements applied to plane stress, plane strain and axis symmetric problems.	**3**	**9**
CO4	**Solve** complicated 2D & 3D Isoperimetric structural problems for stress analysis.	**4**	**9**
CO5	**Determine** formulation of mass matrix for one-dimensional bar element, free vibration analysis using one dimensional bar element.	**2**	**9**

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Program Elective-VI

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4709: Control Theory & Systems

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To known the Automatic control of industrial processes is essential for increasing the output and in turn the profit of an industry
2.	To make students familiarize with Necessity of Control System.
3.	To impart knowledge on the Introduction to Controller Design & Stability.
4.	To infer about the analysis the Various State variable Analysis.
5.	To introduce the Stability of linear discrete-time systems.

Course Contents

Unit I	**Introduction to control problem:** Necessity of Control System with examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time
Unit II	**Introduction to control problem:** Necessity of Control System with examples. Mathematical models of physical systems. Control hardware and their models. Transfer function models of linear time
Unit III	Frequency-response analysis 8 20 Relationship between time and frequency response, Polar plots, Bode plots. Nyquist Plot & Nyquist stability criterion. Relative stability using Nyquist criterion – gain and phase margin. Closed-loop frequency response.
Unit IV	**Introduction to Controller Design:** Stability, steady-state accuracy, transient accuracy, disturbance rejection, insensitivity and robustness of control systems. Root-loci method of feedback controller design. Design specifications in frequency-domain. Frequency-domain methods of design. Application of Proportional, Integral and Derivative Controllers, Lead and Lag compensation in designs. Design of Controller for any physical system.
Unit V	**State variable Analysis:** Concepts of state variables: State space model. Diagonalization of State Matrix. Solution of state equations. Eigen values and Stability Analysis. Concept of controllability and observability. State Space to transfer Function & Transfer Function to State Space Representation, State Transition Matrix, Pole-placement by state feedback. Discrete-time systems. Difference Equations. State-space models of linear discrete-time systems. Stability of linear discrete-time systems.

Text Books

1	M. Gopal, "Control Systems: Principles and Design", McGraw Hill Education, 1997.
2	K. Ogata, "Modern Control Engineering", Prentice Hall, 1991.
3	B. C. Kuo, "Automatic Control System", Prentice Hall, 1995.
Reference Books	
1	J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International, 2009.
2	"Automatic Control System" Principles and Applications – Blazek, J.
Useful Links	
1	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
2	https://nptel.ac.in/courses/101/104/101104071/
3.	https://nptel.ac.in/courses/108/104/108104091/

BAE4709	Course Outcomes	CL	Class Sessions
CO1	**Understand** the fundamentals of the Control system	**2**	**9**
CO2	**Understand** about Type & Order of the system with Time Response Specification.	**3**	**9**
CO3	**Analysis** of the examiner different techniques for Time & Frequency Response	**3**	**9**
CO4	**Design** controller as per given specifications using different techniques	**4**	**9**
CO5	**Express and solve** the system equations in state-variable form.	**2**	**9**

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Program Elective-VI

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4710: Aircraft Materials & NDT

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the Ferrous materials, nonferrous materials and alloys.
2.	To make students familiarize Mechanical testing, factors affecting Strength and deformation.
3.	To impart knowledge on the Indian Standard, British and American.
4.	To infer about the analysis the Different types of non-destructive techniques.
5.	To the application of NDT technique during the process of manufacturing and maintenance.

Course Contents

Unit I	**Aircraft materials** Ferrous materials, nonferrous materials and alloys, ceramic materials and fiber reinforced composite materials, polymers, metal matrix particulate, Engineering Materials, Structural properties of materials, Atomic and lattice structure, bonding in Solids, Imperfections in crystals, Solid phase and phase diagrams, Furnishing Materials: Plastic, wood, plywood, glue, dopes and rubber used in aircraft manufacture. Paints, surface finishes and materials.
Unit II	**Properties and testing** Isotropy, Orthotropic, True stress and strain, Strength and elasticity, Stiffness, Resistance, Plasticity, Ductility, Toughness and Hardness of materials, Concept of Fatigue and Creep, Mechanical Testing, Factors Affecting Strength, Deformation, Plasticity and Viscous elasticity, Fracture, Heat treatment, Chemical, thermal and technological Properties of testing and storage.
Unit III	**Specifications** Indian Standard, British, American, French, German, and International specifications, Corrosion of material, its detection and prevention. Protective finishes, Testing Destructive and nondestructive testing techniques. Crack detection, inspection of parts by hot oil and chalk, dye penetrate, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods.
Unit IV	**Non-destructive testing** Importance of NDT in quality assurance. Different types of non-destructive techniques to obtain information regarding size, location and orientation of damage or cracks. Visual inspection techniques coin tapping technique for composite structures and adhesive bonds. Ultrasonic testing: Pulse echo technique, pitch-catch technique, through transmission technique, A-scan B Scan the methods of NDT and highlight its role in quality assurance.

Unit V	**X-ray radiography** Absorption spectra, short wave length, X-ray for detection of voids. Die penetration technique, Magnetic particle testing. The emphasis should also be on its application during the process of design, manufacturing and maintenance.
Text Books	
1	K Hajra Chowdhary S, Materials, Science and Engineering Processes, Media Promoters
2	George E. F. Titterton, Aircraft Materials, English Book Stores, Delhi
3	M L Begman, Manufacturing Processes, Asia Publishing House, Bombay.
Reference Books	
1	Nondestructive Testing, Edword Arnold, U.K
2	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Inc., Washington D, 4th edition, 1994.
3.	Nondestructive Testing, Edword Arnold, U.K
Useful Links	
1	https://nptel.ac.in/courses/101/103/101103003/
2	https://nptel.ac.in/courses/101/105/101105024/
3.	https://nptel.ac.in/courses/108/104/108104031/

BAE4710	Course Outcomes	CL	Class Sessions
CO1	**Understand** the fabrication of aircraft parts of composites materials and should analyze sandwich , honeycomb and laminated plates	**2**	**9**
CO2	**Understand** the various maintenance practices in plastic and composite parts of aircraft and Should be aware of crack detection, inspection of parts.	**3**	**9**
CO3	**Examine** the concept of the hot oil and chalk, dye-penetrate, magnetic particles, X-ray, ultrasonic testing technique.	**3**	**9**
CO4	**Apply** knowledge of the working methodology, advantages and disadvantages of Nondestructive testing.	**4**	**9**
CO5	**Apply** the concept of the steps involved in the NDT process and the safety practices in aircraft maintenance and NDT Process.	**2**	**9**

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Program Elective-VI

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4711: High Speed Aerodynamics

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks

Course Objectives

The Objectives of this course is:

1.	To introduce the concept of shock waves and shock layer.
2.	To known the students Newtonian theory – tangent wedge or tangent cone and shock expansion methods.
3.	To impart knowledge on the Approximate methods hypersonic small disturbance equation.
4.	To the analysis the Navier–Stokes equations, boundary layer equations for hypersonic flow,.
5.	To the understand of the Strong and weak viscous interactions and boundary layer interactions.

Course Contents

Unit I	**Basics of Hypersonic Flows** Thin shock layers, entropy layers, low density and high density flows, hypersonic flight paths hypersonic flight similarity parameters, shock wave and expansion wave relations of inviscid hypersonic flows.
Unit II	**Surface Inclination Methods for Hypersonic Inviscid Flows** Local surface inclination methods, modified Newtonian Law, Newtonian theory – tangent wedge or tangent cone and shock expansion methods, Calculation of surface flow properties
Unit III	**Approximate Methods for Inviscid Hypersonic Flows** Approximate methods hypersonic small disturbance equation and theory, thin shock layer theory, blast wave theory, entropy effects, rotational method of characteristics, hypersonic shock wave shapes and correlations
Unit IV	**Viscous Hypersonic Flow Theory** Navier–Stokes equations, boundary layer equations for hypersonic flow, hypersonic boundary layer, hypersonic boundary layer theory and non-similar hypersonic boundary layers, hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating, heat flux estimation
Unit V	**Viscous Interactions in Hypersonic Flows** Strong and weak viscous interactions, hypersonic shockwaves and boundary layer interactions, Estimation of hypersonic boundary layer transition, Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

Text Books

1	Introduction to Fluid Mechanics by E. J. Shaughnessy, Oxford University Press, 2nd Ed., 2005
2	John. D. Anderson, Jr., Hypersonic of Aerodynamics, McGraw Hill Education, 3rd edition, 2012.

3	John. D. Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series, McGraw Hill Education, 3rd edition, 2012.
Reference Books	
1	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Inc., Washington D, 4th edition, 1994.
2	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Inc., Washington D, 4th edition, 1994.
3.	William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series, 3rd edition, 1994.
Useful Links	
1	https://nptel.ac.in/courses/101/103/101103053/
2	https://nptel.ac.in/courses/101/105/101105068/
3.	https://nptel.ac.in/courses/108/104/108104013/

BAE4711	Course Outcomes	CL	Class Sessions
CO1	**Evaluate** basics flow parameter in hypersonic flow	**3**	**9**
CO2	**Understand** Surface inclination method	**3**	**9**
CO3	**Understand** approximation method for inviscid flow	**4**	**9**
CO4	**Study** viscous hypersonic flow	**4**	**9**
CO5	**Evaluate** effect of surface and boundary interaction in hypersonic flow	**5**	**9**

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Program Elective-VI

Fourth Year (Semester-VII) B. Tech. Aeronautical Engineering

Fourth Year (Semester-VII)

BAE4712: Computational Fluid Dynamics

Teaching Scheme		Examination Scheme	
Lectures	03 Hrs/Week	CT-1	15 Marks
Tutorials	00 Hrs/Week	CT-2	15 Marks
Total Credits	03	CA	10 Marks
Duration of ESE: 03 Hrs		ESE	60 Marks
		Total	100 Marks
Theory Credits : 3		Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1.	To gain basic ideas on numerical fluid dynamics.
2.	To acquire knowledge on the basic concepts involved in grid generation in computational fluid dynamics.
3.	To impart knowledge on various aspects of time dependent methods.
4.	To get insight into finite volume method.
5.	To arrive at the solution of fluid flow equations and to apply those concepts for industrial needs.

Course Contents

Unit I	**Importance of CFD** Importance of CFD to various engineering streams. Basic fluid dynamics equations – continuity, momentum and energy, Conservation law form and non-conservation law forms of the Governing Differential Equations, Lagrangian and Eulerian formulations.
Unit II	**Description and procedure used in Finite Difference** Finite Element and Finite Volume schemes for simple one dimensional conduction problems, Application to unsteady one-dimensional conduction problems.
Unit III	**Application of Finite Difference method** Application of Finite Difference method to 1D & 2D steady and unsteady conduction problems. Central and backward difference schemes. Explicit and Implicit schemes, Crank-Nicholson scheme.
Unit IV	**Solution of linear algebraic equations** Direct solution methods and Iterative schemes. Boundary value and initial value problems and their solution procedure. Runge Kutta methods. Shooting methods.
Unit V	**Conduction and convection problems** Navier Stokes equations. Application to incompressible flow. Pressure correction scheme, staggered grid, SIMPLE and SIMPLER schemes. Finite Volume method for compressible flow. Schemes like Jameson, Mac Cormack. Acceleration devices, Grid independent studies, Grid Generation.

Text Books

1	Bose, T.K., "Computation Fluid Dynamics", Wiley Eastern Ltd., 1988.
2	Chow, C.Y., "Introduction to Computational Fluid Dynamic", John Wiley, 1979.

3	Hirsch, A.A., "Introduction to Computational Fluid Dynamics", McGraw Hill, 1989.
Reference Books	
1	Fletcher, "Computational Fluid Dynamics ", Vol. I & II, Springer Verlag, 1993.
2	Patankar, S.V., Numerical heat transfer and fluid flow, Hemispher Publishing Corporation, 1992
3	Anderson J.D., "Computational fluid dynamics", 1995.
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/101/106/101106082/

BAE4712	Course Outcomes	CL	Class Sessions
CO1	**Familiarize** with different governing equations and boundary conditions.	**3**	**9**
CO2	**Understand** the partial differential equations and its physical behaviors in fluid flow problems.	**2**	**9**
CO3	**Discredited** governing equations using Finite difference methods and carry out numerical error analyses.	**5**	**9**
CO4	**Follow** the basic procedures to generate grid for fluid flow.	**4**	**9**
CO5	**Apply** the difference formulations to fluid flow problems.	**4**	**9**

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