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

Structure & Curriculum
M. Tech 1st Semester

From

Academic Year 2024-25

As Per NEP-2020

Institute Vision & Mission

Vision:

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

Mission:

1. To strive for rearing standard and stature of the students by practicing high standards of profession alethics, transparency and accountability.
2. To provide facilities and services to meet the challenges of Industry and Society.
3. To facilitate socially responsive research, innovation and entrepreneurship.
4. 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 convenethe needs of academia, industry and society.

Mission:

1. Impart quality technical education and unique interdisciplinary experiences.
2. Develop the analytical, computational and design capabilities to provide sustainable solutions.
3. Expose the students to the current trends and opportunities in the Aerospace industry.
4. 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 Aeronautical Engineering 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)

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

Programme: Aeronautical Engineering

Scheme of Instructions: 1st Year M. Tech. in Aeronautical Engineering Semester–I

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	MAE21101	Aerodynamics	4	-	-	4	4	20	20	-	60	100
2	PCC	MAE21102	Aircraft Propulsion	4	-	-	4	4	20	20	-	60	100
3	PCC	MAE21103	Aircraft Structure & Materials	4	-	-	4	4	20	20	-	60	100
4	PCC	MAE21104	Aeronautical Engineering Lab-1	-	-	4	4	2	-	-	50	50	100
5	PEC	MAE21105-08	Program Elective-I	3	-	-	3	3	20	20	-	60	100
6	PEC	MAE21109-12	Program Elective-II	3	-	-	3	3	20	20	-	60	100
			Total	18	-	4	22	20	100	100	50	350	600

L- Lecture T- Tutorial P- Practical CT-1- Class Test-I CT-2 - Class Test-2

TA/CA - Teacher Assessment/ Continuous Assessment ESE- End Semester Examination (For Lab & Theory End Semester Exam

Professional Elective/Audit Course/ Open Elective (List is provided at the end of structure).

TOTAL CREDITS: 20

Head Of Department
Aeronautical Engineering
Tulsiramji Gaikwad-Patil
College Of Engineering And
Technology Nagpur

Dean Academics (PG and Ph. D)
Tulsiramji Gaikwad-Patil College
of Engineering and Technology
Nagpur (M.S.)

List of Program Elective Courses

Semester-I	
Program Elective-I	**Program Elective-II**
MAE21105: Boundary Layer theory	**MAE21109:** Experimental Aerodynamics
MAE21106: Theory of Fuel and Combustion	**MAE21110:** Air Transportation
MAE21107: Aircraft Materials & NDT	**MAE21111:** Unmanned Aerial Vehicle Systems
MAE21108: Finite Element Methods	**MAE21112:** Computational Fluid Dynamics

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Nagpur (M.S.)

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech. (Semester-I)

MAE21101- Aerodynamics

Teaching Scheme		Examination Scheme	
Lectures	3 Hr / Week	ESE	60 Marks
Tutorial	1 Hr / Week	CIE	40 Marks
Practical	-	Total	100 Marks
Theory Credits : 3		Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1. Study the types of inviscid, incompressible fluid flow
2. Characterize the incompressible fluid flow to solve complex engineering problems on finite.
3. Study different type of feed systems used in modern chemical rockets.
4. Explain the basic concepts and working principle airfoil theory & Finite wing theory
5. Understand the application of numerical methods in aerodynamics.

Course Contents

Unit I	**Fundamentals of Inviscid, Incompressible Flow:** Path lines, Streak Lines, and Streamlines, Angular Velocity, Vorticity, and Circulation, Kelvin's Theorem, Irrotational Flow and the Velocity Potential, Boundary and Infinity Conditions, Bernoulli's Equation, Vortex Quantities, Two-Dimensional Vortex, The Biot–Savart Law, Velocity Induced by a Straight Vortex Segment, Stream Function.
Unit II	**Incompressible Flow about Wings of Finite Span:** Introduction, The Joukowski Airfoil, The NACA Series of Airfoils, Thin-Airfoil Theory, Thin Airfoil with a Flap, Distributed Singularity (Panel) Numerical Methods, Inverse Methods of Solution, Prandtl Lifting-Line Theory, Wing-Panel Methods, Wing-Analysis Methods, Aerodynamic Strip Theory, Winglets, Strakes and Canards, Vortex Lift.
Unit III	**Viscous Incompressible Flow:** Introduction, Navier–Stokes Equations, Exact Solutions of the Navier– Stokes Equations, Role of the Reynolds Number, The Prandtl Boundary-Layer Equations, Incompressible Boundary-Layer Theory, Results from the Solution of the Blasius Equation, Boundary Layer with a Stream wise Pressure Gradient, Free-Shear Layers, Wakes and Jets, Transition to Turbulence, Turbulent Flow.
Unit IV	**Numerical (Panel) Methods:** Basic Formulation, The Boundary Conditions, Physical Considerations, Reduction of the Problem to a Set of Linear Algebraic Equations, Aerodynamic Loads, Preliminary Considerations, Prior to Establishing Numerical Solutions, Steps toward Constructing a Numerical Solution, Solution of Thin Airfoil with the Lumped-Vortex Element, Effects of Compressibility and Viscosity.
Unit V	**Experimental Aerodynamics:** Relevant testing parameters, Wind tunnel classifications, Low-speed subsonic wind tunnels, components, Turbulence reduction devices, Evaluation of power losses, Wind tunnel boundary corrections, High-speed subsonic and transonic wind tunnels, Wall effects in

	transonic wind tunnels, Supersonic wind tunnels, Hypersonic wind tunnels, Special wind tunnels, Physical basis of flow visualization, Velocity profiles, Smoke flow, Tuft flow and Oil flow visualization, optical flow visualization techniques.
Text Books	
1	Low-Speed Aerodynamics by Joseph Katz and Allen Plotkin, Cambridge University Press, 2nd Edition, 2010.
2	Basic Aerodynamics by Gary A. Flandro, Howard M. McMahon and Robert L. Roach, Cambridge University Press, 1st Edition, 2012.
3	Experimental Aerodynamics by Stefano Discetti and Andrea Ianiro, CRC Press, 1st Edition, 2016.
Reference Books	
1	Low Speed Aerodynamics, by Kunal Ghosh, PHI Learning Pvt. Ltd., 1st Edition, 2018.
2	Low-Speed Wind Tunnel Testing, by Jewel B. Barlow, William H. Rae, Alan Pope, John Wiley & Sons, 2nd Edition, 1999.
3	Aerodynamics for Engineering Students by E. L. Houghton, Steven H. Collicott, P. W. Carpenter, Daniel T. Valentine, Elsevier Science, 7th Edition, 2016.
Useful Links	
1	https://archive.nptel.ac.in/courses/101/105/101105088/
2	https://archive.nptel.ac.in/courses/101/105/101105059/
3	https://nptel.ac.in/courses/101/106/101106082/

MAE21101	Course Outcomes
CO1	**Apply** the knowledge of inviscid, incompressible fluid flow for solving realtimefluid flow problems.
CO2	**Apply** the knowledge of incompressible fluid flow to solve complex engineering problems on finite wings.
CO3	**Evaluate** the importance of viscous fluid flows and arrive at the solution of relatedproblems.
CO	**Analyze** the application of numerical methods in aerodynamics and use panel methods to generate solutions.
CO5	**Understand** the basics of experimental aerodynamics and apply the knowledge for project work.

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21102- Aircraft Propulsion

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 3			Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1.	Study the types of aircraft propulsion and their working principles.
2.	Characterize the advancement, performance and Gas turbine engines.
3.	Study different type of feed systems used in modern chemical rockets.
4.	Explain the basic concepts and working principle of electric and Ion Propulsion.
5.	Understand the configurations of rocket nozzles, associated problems its application.

Course Contents

Unit I	**Elements of Aircraft Propulsion:** Introduction to Aircraft Propulsion, Basic need of power plants for aircraft applications, Classification of power plants based on methods of aircraft propulsion, jet and rocket propulsion, Differences between jet propulsion engines and rocket propulsion engines, Types and areas of applications, fundamental of aircraft piston engines.
Unit II	**Introduction to Gas Turbine Engines:** Classification of air breathing engines, Principle of turbojet, turboprop, turbojet with reheat, by-pass and turbo fan concepts, Thrust augmentation in jetengines and its application to aircraft.
Unit III	**Thermodynamics of Jet Engines:** Thermodynamic analysis of jet engine, components of a jet engine, Compressor, combustion chamber, turbine and jet nozzle, their efficiencies, Introduction to ramjet, pulse jet and their application, Introduction to combustion and chemical kinetics.
Unit IV	**Ramjet and Scramjet Propulsion:** Ramjet, Operating principle, Sub critical, critical and supercritical operation, Combustion in ramjet engine, Ramjet performance, Fundamentals of hypersonic air breathing vehicles, Preliminary concepts in engine airframe integration, Various types of supersonic combustors, Requirements for supersonic combustors, Performance estimation of supersonic Combustors.
Unit V	**Rocket and Electric Propulsion:** Introduction to rocket propulsion, Reaction principle, thrust equation, Classification of rockets based on propellants used, solid, liquid and hybrid, Comparison of these engines with special reference to rocket performance. Electric propulsion, classification, electro thermal, electro static, electromagnetic thrusters, geometries of Ion thrusters, beam/plume Characteristics, hall thruster.

Text Books	
1	George P. Sutton, Elements of rocket propulsion, Wiley and Sons, Inc, 7th Edition, 2001.
2	Martin J.L Turner, Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, Springer: Praxis Publishing, 3rd Edition, 2009.
3	K. Ramamurthi, Rocket Propulsion, Trinity Press, 3rd Edition, Reprint, 2016.
Reference Books	
1	Mukunda H. S., Understanding Aerospace chemical propulsion, Interline publications, 2nd Ed. 2004.
2	Philip G. Hill, Carl R. Peterson, Mechanics and Thermodynamics of Propulsion, Pearson, 12th Edition, 2014.
3	Gorden, C.V., Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA Education Series, New York, 3rd Edition, 1986.
Useful Links	
1	https://nptel.ac.in/courses/101/106/101106033/
2	https://nptel.ac.in/courses/101104019
3	https://nptel.ac.in/courses/101/106/101106082/

MAE21102	Course Outcomes
CO1	**Apply** the knowledge of aircraft propulsion methods and solve problems on basicsof propulsion.
CO2	**Utilize** the knowledge of turbine based engine for solving problems on aircraftpropulsion.
CO3	**Implement** the understanding of thermodynamic analysis of jet engines for solving the complex problems.
CO	**Analyze** the operating principle of ramjet and scramjet engines and solve relatedproblems.
CO5	**Solve** the basic problems on rocket and electric propulsion.

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First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21103- Aircraft Structures & Materials

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 3			Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1.	Study the types of aircraft propulsion and their working principles.
2.	Characterize the advancement, performance and Gas turbine engines.
3.	Study different type of feed systems used in modern chemical rockets.
4.	Explain the basic concepts and working principle of electric and Ion Propulsion.
5.	Understand the configurations of rocket nozzles, associated problems its application.

Course Outcomes

At the end of the unit, students will be able to :

CO1	**Understand** the properties of materials used in aeronautical applications
CO2	**Utilize** the knowledge of material types and manufacturing process involved in aircraft for solving related problems.
CO3	**Implement** the understanding of aircraft structure and solve complex problems.
CO4	**Analyze** the loads applied on aircraft and evaluate its effect on the structure.
CO5	**Understand** the basic certification requirements for aircraft structures.

Course Contents

Unit I	**Material physics & properties:** Stress-strain, Loading modes, Engineering terminology, Normal stress, Shear stress, Bi-axial loading, Stiffness and apparent stiffness, Isotropic and Anisotropic sheet deformation, Toughness, Environment & durability, effect of ambient temperature, effect of humidity, Environmental aspects. **Material Types and Manufacturing:** Introduction, Metal alloys, Polymers, Ceramic Materials, Composite materials, Rule of mixtures, Requirements for structural materials.
Unit II	**Design & certification:** Introduction, Safety, regulations and specifications, Requirements for aeronautical structures, Structural design philosophies, Design approach. V-n Diagram,Guest Load weight to load ratio, weight power ratio, wing loading, fuselage loading, aircraft
Unit III	**Combined Open and Closed Section Beam:** Bending, Shear, Torsion for combined sections, Structural Idealization, Idealization of a panel, Effect of idealization on the analysis of open and closed section beams, Bending of open and closed section beams, Shear of open section beams, Shear loading of closed section beams, Alternative method for the calculation of shear flow distribution, Torsion of open and closed section beams, Deflection of open and closed section beams, Numerical problems.
Unit IV	**Aircraft & spacecraft loads:** Introduction, Externally loaded airframe, Load path, Loads and load paths in an airframe, Complex load cases, Load and load cases for spacecraft structures.

	Pressurization of a fuselage structure, Torsional loading of a fuselage structure, Bending of a wing structure, Case study: bending of wing spar.
Unit V	**Aircraft & spacecraft structures:** Introduction, Airframe, Structural concepts, Fuselage Structures, Wing structures, Torsion box, Structural details, Typical spacecraft structures, Typical launch vehicle structures.
Text Books	
1	Aerospace Structures and Materials by Yucheng Liu, Bentham Science Publishers, 2nd Edition, 2016.
2	Aircraft Structures for Engineering Students by T. H. G. Megson, Elsevier Science, 6th Edition, 2017.
3	Introduction to Aerospace Materials by Adrian P Mouritz, Elsevier Science, 1st Edition, 2012.
Reference Books	
1	Analysis and Design of Flight Vehicle Structures by E.F. Bruhn, Tristate Offset Co., 2012.
2	Aircraft Structures by David J. Peery, Dover Publications, 3rd Edition, 2013.
3	Aircraft Materials and Analysis by Tariq Siddiqui, McGraw Hill LLC, 2nd Edition, 2014.
Useful Links	
1	https://nptel.ac.in/courses/101105084
2	https://nptel.ac.in/courses/101105022
3	https://nptel.ac.in/courses/101104010

MAE21103	Course Outcomes
CO1	**Understand** the properties of materials used in aeronautical applications
CO2	**Utilize** the knowledge of material types and manufacturing process involved in aircraft for solving related problems.
CO3	**Implement** the understanding of aircraft structure and solve complex problems.
CO4	**Analyze** the loads applied on aircraft and evaluate its effect on the structure.
CO5	**Understand** the basic certification requirements for aircraft structures.

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21104: Aeronautical Engineering Lab-1

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

The Objectives of this course is:

1.	To understand the pressure and velocity measurement methods in wind tunnel
2.	To get knowledge about the three force components method for lift and drag analysis over an aircraft.
3.	To make known concept of jet fuels and its applications.
4.	To study about the Unsymmetrical Bending of C Section and Z section Beam.
5.	To study about deflection in the beam at various loads.

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 airfoil and cambered airfoil.	2
4	Evaluating the three components of forces over an aircraft model using 3-component wind tunnel balance.	2
5	Determine Flash & Fire Point of liquid aviation fuel (ATF)	3
6	Conduct Performance Test on Single Cylinder, Four stroke Petrol engine at differentcompression ratio and different loads	3
7	Conduct Performance Test on Single Cylinder, Two stroke Petrol engine at different loads	4
8	Unsymmetrical Bending of C Section and Z section Beam	4
9	Deflection of Simply supported Beam test setup and beam under combined loading	5
10	Shear Center location for open channel sections and Shear Center location for closed D sections.	5

Text Books

1	Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 2nd Ed., 2010.
2	Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 5th Ed., 1989.
3.	White, F. M., Fluid Mechanics, McGraw Hill, 7th Ed., Special Indian Edition, 2011.

Reference Books

1	Panton, R. L., Incompressible Flow, 3rd Ed., Wiley India Edition, 2006.
2	Cengel, Y. A., Cimbala, J. M., Fluid Mechanics: Fundamentals and Applications, McGraw-Hill Higher Education, 6th Ed., 2006.

MAE21104	Course Outcomes
CO1	**Perform** various type flow visualization and evaluate aerodynamic properties of the structures.
CO2	**Evaluate** the aerodynamic forces and aerodynamic properties and shown the pressure distribution over different aerodynamic bodies.
CO3	**Estimate** Performance Test on Single Cylinder, Two stroke Petrol engine at different loads
CO4	**Apply** the unsymmetrical bending and deflection test on different cross-sections and loading conditions of beams.
CO5	**Evaluate** location of shear center for open and closed sections.
CO6	**Estimate** the constant strength and flexibility matrix of the beam.

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Programme Elective -I

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M. Tech. (Semester-I)

MAE21105- Boundary Layer theory

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 is:

1.	To learn the basics of viscous flow, its characteristics and solution strategies.
2.	To introduce basics of laminar and turbulent flow, its properties and application.
3.	To get acquaintance with methods of delaying flow separation with boundary layer control.
4.	To make students aware about thermal boundary layer formation, effects and solution strategies.
5.	To learn the basics of viscous flow, its characteristics and solution strategies.

Course Contents

Unit I	**Basics of Viscous Flow** 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, 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.
Unit II	**Thermal Boundary Layer** Heat transfer from heated surface. Heat transfer from cold surface, thermal boundary layer growth over the hot and cold surface, flow over the flat plate with different flow conditions with heat transfer, exact and approximate solutions to thermal boundary layer flows, relation between thermal and hydrodynamic boundary layer theories, Reynolds analogy and Colburn analogy, non-dimensional numbers governing boundary layer flows, 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 aerofoils.
Unit IV	**Turbulent Boundary Layer** Fundamentals of turbulent flow, Mean motion fluctuations, Reynolds Equations, Reynolds stresses, wind tunnel turbulence, Prandtls mixing length theory, velocity distribution laws, Numericals. 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, Numericals.

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	Fluid mechanics by R. K. Bansal, Laxmi Publications, 9th Ed., 2007.
2	Heat transfer by R. K. Rajput, S Chand & Co Ltd, 5th Ed., 2004.
3	Introduction to Fluid Mechanics by E. J. Shaughnessy, Oxford University Press, 2nd Ed., 2005
Reference Books	
1	Boundary layer theory by H. Schlichting, Springer, India, Revised, Enlarged Ed., 2003.
2	Further aerodynamics for Engg. Students by Houghton and Boswell, Edward Arnold, 1st Ed., 1969.
3	Aerodynamics for Engineering Students by E. L. Houghton, Steven H. Collicott, P. W. Carpenter, Daniel T., 7th Edition, 2016.
Useful Links	
1	https://archive.nptel.ac.in/courses/101/105/101105088/
2	https://nptel.ac.in/content/storage2/courses/112104118/ui/Course_home-9.htm
3	https://nptel.ac.in/courses/112/106/112106190/

MAE21106	Course Outcomes
CO1	**Apply** the concept of viscous flow to solve problems on boundary layer.
CO2	**Solve** the problems on thermal boundary layer using Reynolds analogy and Colburn analogy
CO3	**Analyze** flow transition from laminar to turbulent using Summerfield equation
CO4	**Estimate** turbulent boundary layer characteristics by various methods
CO5	**Investigate** the causes of boundary layer separation and control strategies

Department Elective-I

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21106- Fundamental Fuel & Combustions

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 is:

1.	Study the types of fuels and their properties.
2.	Characterize the advancement, performance of fuels and refining process of fuel
3.	Study different type of manufacturing of fuels in modern.
4.	Explain the basic concepts and working combustion technology.

Course Contents

Unit I	**Introduction:** Types of fuels, solid, liquid and gaseous fuels, History of solid liquid and gaseous fuels, production, present scenario 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:** Coal origin, its classification, composition, and properties. Coal mining, preparation, and washing. Combustion of coal and coke making, different types of coal combustion techniques, coal tar distillation, coal liquefaction: direct and Indirect liquefaction, coal gasification, oxidation and hydrogenation. Efficient use of solid fuels. Origin and. 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	**Manufactured Fuels:** Agro fuels, solid fuel handling, properties related to combustion, handling, and storage. Bio- Fuels: types of bio-fuels, production processes and technologies, Bio-fuel applications. classification of petroleum, refining, properties & testing of petroleum products, various petroleum products, petroleumrefining in India, liquid fuels from other sources, storage and handling of liquid fuels
Unit IV	**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 V	**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.
Text Books	
1	Aerospace Structures and Materials by Yucheng Liu, Bentham Science Publishers, 2nd Edition, 2016.
2	Aircraft Structures for Engineering Students by T. H. G. Megson, Elsevier Science, 6th Edition, 2017.
3	Introduction to Aerospace Materials by Adrian P Mouritz, Elsevier Science, 1st Edition, 2012.
Reference Books	
1	Analysis and Design of Flight Vehicle Structures by E.F. Bruhn, Tristate Offset Co., 2012.
2	Aircraft Structures by David J. Peery, Dover Publications, 3rd Edition, 2013.
3	Aircraft Materials and Analysis by Tariq Siddiqui, McGraw Hill LLC, 2nd Edition, 2014.
Useful Links	
1	https://nptel.ac.in/courses/101105084
2	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
3	https://nptel.ac.in/courses/112/103/112103111/

MAE21107	Course Outcomes
CO1	**Calculate** adiabatic flame temperature and estimate equilibrium products of combustion.
CO2	**Solve** chemical kinetics and species conservation equations
CO3	**Acquire** knowledge in different flame structures and stability characteristics
CO	**Compare** the performance of different combustors and design of flame holders.
CO5	**Analyze** the combustion mechanisms of different propellants.

Department Elective-I

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21107- Aircraft Materials and NDT

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 is:

1.	Study the various types of composite materials and their properties.
2.	Characterize the advancement Polymer Matrix Composites.
3.	Study different type of manufacturing of Micro-Mechanical Behavior of a Lamina.
4.	Explain the basic concepts and composite for aircraft structure.

Course Contents

Unit I	**Introduction to Composite Materials:** Definition, classification of composite materials, classification of reinforcement, particulate, short fiber, whiskers, long fibers composites. Matrix materials, metals, ceramics, polymers (including thermoplastics and thermosets), Carbon-Carbon Composites, Metal Matrix Composites, MMC with particulate and short fiber reinforcement, liquid and solid-state processing of MMC, stir casting, squeeze casting. Properties of MMCs, Applications of Al, Mg, Ti based MMC.
Unit II	**Processing of Polymer Matrix Composites:** Thermoset Polymers Hand layup Process, Vacuum Bagging Process, Post Curing Process, Filament winding, Pultrusion, Performing, Autoclave Process Processing of Polymer Matrix Composites: Thermoplastic Polymers Extrusion process, Injection Molding Process, Thermo-forming process. Post Processing of Composites, Adhesive bonding, drilling, cutting process.
Unit III	**Micro-Mechanical Behavior of a Lamina:** Determination of elastic constants-Rule of mixtures, transformation of coordinates, micromechanics based analysis and experimental determination of material constants. **Macro-Mechanical Behavior of a Lamina:** Global and local axis for angle lamina, determination of global and local stresses and moduli, for 2D-UD lamina with different fiber orientation and different fiber materials glass, carbon and aramid fiber reinforcement.
Unit IV	**Failure Analysis:** Failure Theory: Tsai-Hill, Tsai-Wu, Max Stress and Max Strain Classical plate theory. Stress and strain variation in a laminate, Resultant forces and moments, A B and D matrices, Strength analysis of a laminate. **Applications of Composites Materials:** Automobile, Aircrafts, missiles, Space hardware, Aeronautical and electronics, marine, recreational and Sports equipment, future potential of composites.
Unit V	**Non Destructive testing (NDT):** Fundamentals of NDT, Radiography, Ultrasonic, Eddy Current testing, magnetic and Fluorescent

	Penetrate Testing, Acoustic Emission Technique.
Text Books	
1	K.K Chawla, Composite Materials- Science and Engineering, Springer Verlag, 2nd edition, 1998.
2	Autar Kaw, Mechanics of Composites, CRC Press, 2nd edition, 2006.
3	Introduction to Aerospace Materials by Adrian P Mouritz, Elsevier Science, 1st Edition, 2012.
Reference Books	
1	Mein Schwartz, Composite Materials Handbook, Vol.3, Department of Defense, USA, 2002.
2	Ajay Kapadia, Non-Destructive Testing of Composite Materials, National Composites Network, Best Practices Guide, TWI Publications, 2006.
3	R M Jones, Mechanics of Composite Materials, 2nd Edn, Taylor & Francis, 2015.
Useful Links	
1	https://nptel.ac.in/courses/101105084
2	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf

MAE21108	Course Outcomes
CO1	**Describe** the fundamental concepts of composite materials.
CO2	**Analyze** the composite materials by micro and macro mechanics analysis.
CO3	**Understand** the Micro-Mechanical Behavior of a Lamina of composites.
CO	**Examine** the failure of composite by different methods and applications of compositematerials.
CO5	**Analyze** the nondestructive testing of an aircraft structure components and its utilization.

Department Elective-I

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21108- Finite Elements Method

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 is:

1.	Study the differential equation of equilibrium & compatibility equation.
2.	The known basic Concept of discretization of body into elements.
3.	Study different type of plane strain and axis symmetric problems.
4.	Explain the basic concepts 1-D & 2-D free vibration analysis using one dimensional 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-Delements, 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 Iso-parametric 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:** Extension 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/

MAE21109	Course Outcomes
CO1	**Understand** the plane stress & plane strain differential equation of equilibrium & compatibility equation, with boundary conditions
CO2	**Analyze** the Concept of discretization of body into elements and basic types of 2-D & 3-D elements, displacement models,
CO3	**Analyze** the various types of 2D elements applied to plane stress, plane strain and axis symmetric problems.
CO	**Solve** complicated 2D & 3D Isoperimetric structural problems for stress analysis.
CO5	**Determine** formulation of mass matrix for one-dimensional bar element, free vibration analysis using one dimensional bar element.

Programme Elective-II

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21109- Experimental Aerodynamics

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 is:

1.	Study the differential wind tunnel.
2.	The known basic Concept of shock wave.
3.	Study different type of nozzles in aircraft.
4.	Explain the basic concepts measurement technique in wind tunnel.

Course Contents

Unit I	**Introductory concepts** Compressibility Thermodynamic concepts Conservation equations Communication in gases Stagnation state One Dimensional Flow, Pressure waves in gases Communication in gases Stagnation state Differential equations for 1D flow Isentropic Flow with area variations Numerical example.
Unit II	**Shock Waves** Normal Shock Concept Normal Shock relations Moving normal shocks Numerical Examples (stationary and moving) Concept and theory Oblique Shock relations Property variations Detached Shocks Shock Reflections Numerical Examples Shock-Shock Interactions,1-D Expansion wave Expansion Fan Prandtl Meyer Function Smooth expansions/compressions Numerical Examples, Shock expansion theory and its applications.
Unit III	**Nozzle flow** Quasi-1D flow with area variations, Geometric Choking Numerical Examples Divergent Nozzles Convergent-Divergent Nozzles Numerical Examples Multiple Choking points, Supersonic Jet, Jet structure Numerical Examples and Supersonic Shear layers. **Non-isentropic flows** Crocco's Theorem Fanno Flow Numerical Examples Rayleigh Flow Numerical Examples Various Choking mechanisms, Ramjets and scramjets.
Unit IV	**Experimental setups and Flow Visualization** Shock Tubes Compressible flow facilities Measurement Techniques Experiment Design, schlieren Shadowgraph, Interferometer.

Unit V	**2D Method of Characteristics** Characteristics concept Characteristic directions; and constitutive relations, Subroutines, Marching techniques, Example simulations, Fanno flow, Reyleigh Flow.
Text Books	
1	Liepmann, H.W. and Roshko, A., Elements of Gas Dynamics Dover Publications, Inc., Mineola, NY, USA. 1st Edition, 2001.
2	Oosthuizen, P.H. and Carscallen, W.E., Compressible Fluid Flow McGraw-Hill international editions, McGraw-Hill Companies, Inc., Singapore.
3	Babu V., Fundamentals of Gas Dynamics, Ane Books India, Chennai.
Reference Books	
1	Chapman A.J. and Walker W.F. Introductory Gas Dynamics Holt, Reinhart and Winston, Inc.NY, USA.
2	Introduction to wind tunneltechnique J.N. - McGraw Hill.
Useful Links	
1	https://nptel.ac.in/courses/101/106/101106044/
2	https://nptel.ac.in/courses/112/106/112106166/
3	https://nptel.ac.in/courses/112/103/112103021/

MAE21110	Course Outcomes
CO1	**Classify** the wind tunnel and boundary corrections and image processing.
CO2	**Study** the shock waves in supersonic flow.
CO3	**Portray** flow measurement technique using advance visualization methods
CO	**Conduct** quantitative analysis of forces on aircraft.
CO5	**Understand** the various types measurement technique in wind tunnel

Department Elective-II

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21110- Air Transportation

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 is:

1.	To introduce basic concepts of air transportation management and organizational management.
2.	To give exposure on various methods available for fleet planning and aircraft selection procedure.
3.	To make the students familiar with aircraft and related equipment maintenance procedures and types.
4.	Explain the basic concepts maintenance practices and related procedures.

Course Contents

Unit I	**Development of air transportation:** 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	**Forecasting:** Fleet size, Fleet planning, the aircraft selection process, operating cost, passenger capacity, load factor etc., Passenger fare and tariffs, Influence of geographical, economic and political factors on routes and route selection.
Unit III	**The aircraft selection process:** Fleet commonality, factors affecting choice of fleet, route selection and Capitol acquisition, Valuation and Depreciation, Budgeting, Cost planning, Aircrew evaluation, Route analysis, Aircraft evaluation.
Unit IV	**Equipment maintenance:** Flight operations and crew scheduling, Ground operations and facility limitations equipment and typesof schedules, hub & spoke scheduling, advantages/ disadvantages and preparing flight plans, Aircraft scheduling in line with aircraft maintenance practices.
Unit V	**Aircraft reliability:** The maintenance schedule and its determinations, Condition monitoring maintenance, Extended range operations (EROPS) and ETOPS, Ageing aircraft maintenance production.

Text Books

1	Fedric J.H., "Airport Management", Himalaya publishing House, 6th Edition McGraw Hill india.
2	Gene Krope, "Airline Procedures", English Book House, 5th Edition New Delhi-I.
3	Wilson & Bryon, "Air Transportation", Prentice-Hall, the University of California, 1st Edition 1949

Reference Books

1	Philip Lockin D, "Economics of Transportation", Irwin (Richard D.) Inc.,U.S.; 7th Revised edition
2	Indian Aircraft manual", Published by DGGA, English Book House, New Delhi-I.
3	Alexander T Wells, "Air Transportation", Wadsworth Publishing Company, California, 4th edition 1993.
Useful Links	
1	https://nptel.ac.in/courses/101/104/101104071/
2	http://www.nptelvideos.com/lecture.php?id=5030
3	https://nptel.ac.in/courses/101/104/103504091/

MAE21110	Course Outcomes
CO1	**Understand** the history of air transportation and roles of IATA and concerned authorities
CO2	**Study** weather forecasting method for safe flight
CO3	**Study** cost estimation and management in air transportation
CO	**Understand** flight scheduling methods and related practices
CO5	**Study** reliability centered maintenance practices and related procedures

Department Elective-II

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21111- Unnamed Arial Vehicles

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 is:

1.	To make students aware about the importance of UAVs with respect to their applications.
2.	To make the student understand the subsystems and configurations of UAV.
3.	To gate the performance with design standards and regulatory aspects of UAVs.
4.	To get the basic concepts of navigation and flight control systems.

Course Contents

Unit I	**Introduction to UAV** History of UAV, classification, Introduction to Unmanned Aircraft Systems, models and prototypes, System Composition, applications.
Unit II	**The Design of UAV System** Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards and Regulatory Aspects, UK, USA and Europe, Design for Stealth, control surfaces, specifications.
Unit III	**Avionics Hardware** Autopilot, AGL, pressure sensors, servos, accelerometer, gyros, actuators, power supply, processor, integration, installation, configuration, and testing.
Unit IV	**Communication Payloads and Controls** Payloads, Telemetry, tracking, Aerial photography, controls, PID feedback, Radio control frequency range, modems, memory system, simulation, ground test, analysis, trouble shooting.
Unit V	**Development of UAV Systems** Waypoints navigation, ground control software, System Ground Testing, System In-flight Testing, Future Prospects and Challenges, Case Studies – Mini and Micro UAVs.

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 UAV Systems", UAV Systems, Inc, 4th Ed., 1998.
3	Reg Austin "Unmanned aircraft systems: UAV design, development and deployment", Wiley, 5th Ed., 2010.

Reference Books

1	Parker, E.R., "Materials for Missiles and Spacecraft", McGraw Hill Book Co., Inc., 3rd Ed., 1982.

2	Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 1st Ed., 2001.
Useful Links	
1	https://nptel.ac.in/courses/101/104/101104071/
2	https://onlinecourses.nptel.ac.in/noc20_ae03/preview
3	https://nptel.ac.in/noc/courses/noc20/SEM2/noc20-ae06/

MAE21112	Course Outcomes
CO1	**Demonstrate** various types of unmanned aerial vehicles
CO2	**Design** the Unmanned aerial vehicle and know the regulations
CO3	**Demonstrate** various types of sensors in UAV systems
CO4	**Apply** the concepts controlling of unmanned aerial vehicle
CO5	**Develop** the Unmanned aerial vehicle and test it practically

Department Elective-II

First Year (Semester-I) M.Tech. Aeronautical Engineering

First Year M.Tech (Semester-I)

MAE21112- Computational Fluid Dynamics

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 is:

1.	Study the differential equation of equilibrium and boundary conditions.
2.	The known basic Concept of discretization of body into elements.
3.	Study different type of plane strain and axis symmetric problems.
4.	Explain the basic concepts procedures to generate grid for fluid flow.

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 problemsand 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", 2 nd edition Wiley Eastern Ltd., 1988.
2	Chow, C.Y., "Introduction to Computational Fluid Dynamic", 4th Edition John Wiley, 1979.
3	Hirsch, A.A., "Introduction to Computational Fluid Dynamics", 6th edition 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, 3rd edition 1992
3	Anderson J.D., "Computational fluid dynamics", 5th edition McGraw hill education 1995.

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/101/106/101106045/

MAE21112	Course Outcomes
CO1	**Familiarize** with different governing equations and boundary conditions.
CO2	**Understand** the partial differential equations and their physical behaviors in fluid flow problems.
CO3	**Discrete** governing equations using Finite difference methods and carry outnumerical error analyses.
CO	**Follow** the basic procedures to generate grid for fluid flow.
CO5	**Apply** the difference formulations to fluid flow problems.

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