DEPARTMENT OF AERONAUTICAL ENGINEERING

Structure & Curriculum

From

Academic Year 2023-24

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

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 ofprofessional ethics, 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 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

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Department Vision & Mission

Vision:

- To foster technically skilled Aeronautical Engineers of the utmost academic principles, toconvene the 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 skillsand 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, testingor maintenance of systems and subsystems to pursue career in aeronautical engineering.

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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)

Programme: Aeronautical Engineering

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

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	MAE1201	Flight Dynamics & Control	3	1	-	4	4	15	15	10	60	100
2	PCC	MAE1202	Aircraft Design	3	1	-	4	4	15	15	10	60	100
3	PCC	MAE1203	Research Methodology	3	-	-	3	3	15	15	10	60	100
4	PCC	MAE1204	Aircraft Design Lab	-	-	2	2	1	-	-	25	25	50
5	PCC	MAE1205	Computer Aided Engineering Lab	-	-	2	2	1	-	-	25	25	50
6	PCC	MAE1206-09	Program Elective-III	3	1	-	4	4	15	15	10	60	100
7	PEC	MAE1210-13	Program Elective-IV	3	-	-	3	3	15	15	10	60	100
8	MCC	MAU1202	**Audit Course-II**	2	-		2	Audit	-	-	-	-	-
			Total	**17**	**3**	**4**	**24**	**20**	**75**	**75**	**100**	**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).

TOTALCREDITS:20

Head Of Department
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Technology, Nagpur

Vice Principal
Tulsiramji Gaikwad-Patil
College Of Engineering &

Principal
Tulsiramji Gaikwad-Patil
College Of Engineering &
Technology, Nagpur

Programme: Aeronautical Engineering

Department Program Elective Courses

Program Elective- III	Program Elective- IV
Semester II	Semester II
MAE1206: High Speed Aerodynamics	MAE1210: Unmanned Arial Vehicle Systems
MAE1207: Combustion in Rocket Engine	MAE1211: Helicopter Aerodynamics
MAE1208: Experiment Stress Analysis	MAE1212: Vibration & Aero Elasticity
MAE1209: Aircraft Systems & Control	MAE1213: Aero engine Maintenance & Repairs

Head Of Department
Aeronautical Engineering
Tulsiram... College of Engineering and Technology, Nagpur

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

First Year M.Tech. (Semester-II)

MAE1201: Flight Dynamics and Control

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 4			Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1. Study the Forces and moments acting on a flight vehicle,
2. Characterize the Performance of airplane in level flight.
3. Study the Gliding flight and Turning performance
4. Explain the basic concepts equilibrium equation, Stability criterion.
5. Understand the Dihedral effect, Lateral control, Coupling between rolling and yawing moments

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 manoeuvres, 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 & Sons, 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.
3	J. D Anderson, A. W., Aircraft Dynamic Stability and Response, Pergamon Press, Oxford, 1st Ed., 1980.
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/

MAE1201	Course Outcomes
CO1	**Describes** the fundamentals of aircraft design and aerodynamic characteristics.
CO2	**Estimate** the drag and thrust of the flightvehicle under given operating condition.
CO3	**Enumerate** steady level flight performanceof an aircraft.
CO4	**Examine** accelerated flight performance ofan aircraft under given loading condition.
CO5	**Examine** the static and lateral stability of anaircraft.

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

First Year M.Tech (Semester-II)

MAE1202: Aircraft Design

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 4			Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1.	To make students aware about the aircraft design process and its purpose.
2.	To make the student understand the choice of the selection of design parameters, fixing the geometry.
3.	To investigate the performance and stability characteristics of airplanes.
4.	Explain the basic concepts and working principle of electric and Ion Propulsion.

Course Contents

Unit I	**Introduction:** State of art in airplane design, Purpose and scope of airplane design, Classification of airplanes based on purpose and configuration. Factors affecting configuration, Merits of different plane layouts. Stages in Airplane design. Designing for manufacturability, Maintenance, Operational costs, Interactive designs.
Unit II	**Preliminary Design Procedure** Data collection and 3-view drawings, their purpose, weight estimation, Weight equation method, Development and procedures for evaluation of component weights. Weight fractions for various segments of mission. Choice of wind loading and thrust. Loading .
Unit III	**Power Plant Selection** Choices available, comparative merits, Location of power plants, Functions dictating the locations.
Unit IV	**Design of Wing, Fuselage and Empennage** Selection of aerofoil. Selection of Wing parameters, selection of sweep, Effect of Aspect ratio, Wing Design and Airworthiness requirements, V-n diagram, loads, Structural features. Elements of fuselage design, Loads on fuselage, Fuselage Design. Fuselage and tail sizing. Determination of tail surface areas, Tail design, Structural features, Check for nose wheel lift off.
Unit V	**Design of Landing Gear and Control Surface:** Landing Gear Design, Loads on landing gear, Preliminary landing gear design. Elements of Computer Aided and Design, Special consideration in configuration lay-out, Performance estimation. Stability aspects on the design of control surface.

Text Books

1	Raymer, D.P. Aircraft conceptual Design, AIAA series, 5th edition, 2012.

2	Torenbeck, E. Synthesis of Subsonic Airplane Design, Delft University Press, U.K. 1986.
3	Kuechemann, D. The Aerodynamic Design of Aircraft, American Institute of Aeronautics publishers, 2012
Reference Books	
1	Jan Roskam, Airplane Design, Vol-I to VII, Dar Corporation, 1997.
2	John P. Fielding, Introduction to Aircraft Design, AIAA, 2nd Edition, 2012.
3	Thomas C. Corke, Design of Aircraft, Prentice Hall, 2003.
Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_ae04/preview
2	https://archive.nptel.ac.in/courses/101/101/101101083/
3	https://onlinecourses.nptel.ac.in/noc21_ae04/preview

MAE1202	Course Outcomes
CO1	**Investigate** the preliminary design of an aircraft starting from data collection to satisfy mission specifications
CO2	**Perform** the weight estimation and power plant selection for a specific aircraft
CO3	**Estimate** the geometric and design parameters of an airplane
CO4	**Design** a system, component or process to meet requirements for aircraft systems
CO5	**Demonstrate** complete design of an aircraft to a level of sufficient detail to satisfy given mission specifications

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

First Year M.Tech (Semester-II)

MAE1203- Research & Methodology

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 gain insights into how scientific research is conducted.
2.	To identify the influencing factor or determinants of research parameters.
3.	To test the significance, validity and reliability of the research results
4.	To learn and understand the basic statistics involved in data presentation.

Course Contents

Unit I	**Introduction** Introduction to research; Definitions and characteristics of research; Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical, Main components of any research work. **Ethics** Ethical issues - Copy right - Intellectual property rights and patent law - Reproduction of published material - Plagiarism - Citation and acknowledgement - Reproducibility and accountability
Unit II	**Research Formulation** Defining and formulating the research problem: Selecting the problem - Necessity of defining the problem, Literature review: Importance of literature review in defining a problem, Primary and secondary sources –reviews, treatise, monographs-patents – web as a source – searching in the web - Critical literature review – Identifying gap areas from literature review.
Unit III	**Research Design** Observation and Collection of data, Methods of data collection, Different types of variables, Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages, Hypothesis-testing, Generalization and Interpretation. Essentials of Research Design, Need for Research Design, Classifications of Research Design: causations and Experimental Design, Errors in Research Design, Types of Research Errors.
Unit IV	**Quantitative Methods** Probability Distributions, Fundamentals of Statistical Analysis and Inference, Multivariate methods, Concepts of Correlation and Regression, Fundamentals of Time Series Analysis and Spectral Analysis.
Unit V	**Optimization** Introduction to evolutionary algorithms - Fundamentals of Genetic algorithms, Particle Swarm Optimization, Simulated Annealing, Introduction to Neural Networks, Neural Network based optimization, Introduction to Fuzzy sets and Fuzzy Logic, Optimization of fuzzy logic

Text Books

1	Ranjit Kumar,"Research Methodology: A Step-by-Step Guide for Beginners",SAGE Publications

	Ltd; Fourth edition, 2014
2	C.R. Kothari,"Research Methodology: Methods and Techniques",NEW AGE; Second Edition, 2014.
3	Dinesh Kumar, Research Methods for Successful PhD, River Publishers Series in Innovation and Change in Education- Cross Cultural Perspective, 2017
Reference Books	
1	Marc van Dongen, LaTeX and Friends,Springer,Feb. 29, 2012 (ISBN 978-3-642-23815-4).
2	Bernard C. Beins and Maureen A. McCarthy "Research Methods and Statistics" Pearson, 201
3	Marc van Dongen, LaTeX and Friends,Springer,Feb. 29, 2012
Useful Links	
1	https://nptel.ac.in/courses/101109036
2	https://nptel.ac.in/courses/101102017
3	https://nptel.ac.in/courses/101104011

MAE1203	Course Outcomes
CO1	**Understand** Definitions and characteristics of research; Types of research – Descriptive vs. Analytical,
CO2	**Utilize** Ability to critically evaluate current research and propose possible alternate directions for further work
CO3	**The Ability** to develop hypothesis and methodology for research
CO4	**Analyze** their scientific results clearly for peer review.
CO5	**Understand** comprehend and deal with complex research issues in order to communicate.

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

First Year M.Tech (Semester-II)

MAE1204: Aircraft Design 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

Sr. No.	List of Experiment	
1	Comparative configuration study of different types of airplanes	1, 4
2	Comparative study on specification and performance details of different types of airplanes	2, 5
3	Preparation of comparative data sheets	2, 5
4	Worksheet layout procedures	2, 5
5	Comparative graphs preparation and selection of main parameters for the aircraft design	1, 4
6	Preliminary weight estimations and selection of main parameters	1, 4
7	Power plant selection, Airfoil selection, Wing tail and control surfaces selection	1, 4
8	Preparation of layouts of balance diagram and three view drawings	1, 4
9	Estimation of various drags	1
10	Detailed performance calculations and stability estimates.	3, 5
Text Books		
1	Raymer, D.P. Aircraft conceptual Design, AIAA series, 5th edition, 2012.	
2	Torenbeck, E. Synthesis of Subsonic Airplane Design, Delft University Press, U.K. 1986.	
3.	Kuechemann, D, The Aerodynamic Design of Aircraft, American Institute of Aeronautics publishers, 2012	
Reference Books		
1	Jan Roskam, Airplane Design, Vol-I to VII, Dar Corporation, 1997.	
2	John P. Fielding, Introduction to Aircraft Design, AIAA, 2nd Edition, 2012.	
3	Thomas C. Corke, Design of Aircraft, Prentice Hall, 2003	

Useful Links	
1	https://onlinecourses.nptel.ac.in/noc21_ae04/preview
2	https://archive.nptel.ac.in/courses/101/101/101101083/

MAE1204	Course Outcomes
CO1	**Investigate** the preliminary design of an aircraft starting from data collection to satisfy mission specifications
CO2	**Perform** the weight estimation and power plant selection for a specific aircraft
CO3	**Estimate** the geometric and design parameters of an airplane
CO4	**Design** a system, component or process to meet requirements for aircraft systems
CO5	**Demonstrate** complete design of an aircraft to a level of sufficient detail to satisfy given mission specifications

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

First Year M.Tech (Semester-II)

MAE1205: Computer Aided Engineering Lab

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

Sr. No.	List of Experiment	
1	Introduction to ANSYS	1
2	Cantilever beam with point load at free end	1
3	Distributed loading of a 1d cantilever beam	2
4	Application of distributed loads	2
5	Buckling failure	3
6	Stress analysis of axi-symmetry structure	3
7	Analysis of 2d truss	4
8	Thermal analysis	3
9	Modal analysis of a cantilever beam	3
10	Modal analysis of stepped shaft	3
	Harmonic analysis of guitar	4
	Radiation exchange between surfaces	5

Text Books

1	Practical Finite Element Analysis, Nitin S. Gokhale, Finite To Infinite, 2020.
2	Finite Element Analysis Theory And Application With ANSYS, Moaveni, Pearson Education, 2011.

Reference Books

1	John P. Fielding, Introduction to Aircraft Design, AIAA, 2nd Edition, 2012.
2.	Thomas C. Corke, Design of Aircraft, Prentice Hall, 2003

MAE1205	Course Outcomes
CO1	**Understand** the functions of ANSYS and working on ANSYS
CO2	**Formulate** and solve one dimensional structural Load on beams
CO3	**Solve** axi-symmetry structure structural 1D and 2D problems.
CO4	**Evaluate** steady state thermal & transient thermal analysis problems
CO5	**Solve** analysis Radiation exchange between surfaces problems

Department Elective-III

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

First Year M. Tech. (Semester-II)

MAE1206- High Speed 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 : 4		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, Numericals.
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, Numericals.
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 aerofoil

	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/

MAE1206	Course Outcomes
CO1	**Evaluate** basics flow parameter in hypersonic flow
CO2	**Understand** Surface inclination method
CO3	**Understand** approximation method for inviscid flow
CO4	**Study** viscous hypersonic flow
CO5	**Evaluate** effect of surface and boundary interaction in hypersonic flow

Department Elective-III

First Year (Semester II) M. Tech. Aeronautical Engineering

First Year M.Tech (Semester-II)

MAE1207 - Combustion in Rocket Engines

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 4			Duration of Exam : 3 Hours	

Course Objectives

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

Course Contents

Unit I	**INTRODUCTION TO COMBUSTION INSTABILITY:** Steady and unsteady combustion; origins of combustion instability; types of combustion instability; effects of combustion instability; factors affecting combustion instability.
Unit II	**INSTABILITIES IN SOLID ROCKET PROPULSION:** Introduction; general features; bulk, transverse, and axial mode instabilities; aerodynamic instabilities; processes contributing to stability; measurement methods for stability testing; particulate damping; effect of propellant characteristics; control of combustion instability.
Unit III	**INSTABILITIES IN LIQUID ROCKET PROPULSION:** Overview; classification of instabilities; initiation of instabilities; dynamic stability; dynamics of processes in liquid rocket engines; wave propagation; effects of design factors on excitation and damping; effects of atomization and droplet combustion; experimental evaluation of instability; control of combustion instability.
Unit IV	**ANALYSIS OF COMBUSTION INSTABILITY:** Introduction; thermal lags in solid phase; linear analysis of instability in solid rocket motors; analysis of low, intermediate, and high-frequency instability in liquid rocket engines using time lag models.
Unit V	**INSTABILITIES IN HYBRID ROCKET PROPULSION:** Introduction; subsystems of hybrid rocket motors; transient events in hybrid rocket propulsion; hybrid rocket instabilities; feed system coupled instabilities; chuffing; low-frequency instabilities; comparison among solid, liquid, and hybrid low-frequency instabilities; experimental evaluation of instability; driving mechanisms for instabilities; control of combustion instability; analysis of instability in hybrid rocket motors.

Text Books

1	M. Barrere, A. Jaumotte, B.F. De Veubeke and J. Vandenkerchove, Rocket Propulsion, Elsevier
2	M.S. Natanzon and F.E.C. Culick, Combustion Instability, Progress in Astronautics and Aeronautics 2008.

3	Introduction to Aerospace Materials by Adrian P Mouritz, Elsevier Science, 1st Edition, 2012.
Reference Books	
1	V. Yang and W. Anderson (Eds.). Liquid Rocket Engine Combustion Instability. Progress in Astronautics and Aeronautics Vol. 169, AIAA, Washington DC, 1995.
2	M.J. Chiaverini and K.K. Kuo (Eds.) Fundamentals of Hybrid Rocket Combustion and Propulsion. Progress in Astronautics and Aeronautics Vol. 218, AIAA, Reston, Virginia, 2007.
3	
Useful Links	
1	https://nptel.ac.in/courses/101204089
2	https://archive.nptel.ac.in/courses/112/106/112106073/

MAE1207	Course Outcomes
CO1	**Identify** the type of combustion instability in different types of rocket motors.
CO2	**Analyze** experimental data on combustioninstability.
CO3	**Identify** measures to be taken for stabilizingunstable combustion.
CO4	**Carry** out linear instability analysis.
CO5	**Design** rocket motors with consideration tothe effects of instabilities.

Department Elective-III

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

First Year M.Tech (Semester-I)

MAE1208- Experimental Stress Analysis

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		**ESE**	60 Marks
Tutorial	1 Hr / Week		**CIE**	40 Marks
Practical	-		**Total**	100 Marks
Theory Credits : 4			**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	**EXTENSOMETERS:** Principles of measurements, Accuracy, Sensitivity and range of measurements, Mechanical, Optical, Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.
Unit II	**ELECTRICAL RESISTANCE STRAIN GAUGES:** Principle of operation and requirements, Types and their uses, Materials for strain gauge, Calibration and temperature compensation, cross sensitivity, Rosette analysis, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.
Unit III	**PHOTOELASTICITY:** Two dimensional photo elasticity, Photo elastic materials, Concept of light photoelastic effects, stress optic law, Transmission and Reflection polariscopes, Interpretation of fringe pattern, Compensation and separation techniques, Introduction to three dimensional photo elasticity.
Unit IV	**BRITTLE COATING AND MOIRE METHODS:** Introduction to Moiré techniques, Brittle coating methods and Holography.
Unit V	**NON – DESTRUCTIVE TESTING:** Fundamentals of NDT, Radiography, Ultrasonics, Eddy Current testing, Fluorescent Penetrant Testing, Acoustic Emission Technique.

Text Books

1	Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill Inc., New York 1998.
2	Srinath, L.S., Raghava, M.R., Lingaiah, Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984.
3	Ramachandra, K.,Pant B., and Ramachandra, K., Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984.

Reference Books

1	Mein Schwartz, Composite Materials Handbook, Vol.3, Department of Defense, USA, 2002.

2	Pollock A.A., Acoustic Emission in Acoustics and Vibration Progress, Ed. Stephens R. W.B., Chapman and Hall, 1993.
3	Max Mark Frocht, Photo Elasticity, John Wiley and Sons Inc., New York, 1968.
Useful Links	
1	https://nptel.ac.in/courses/112106068
2	https://onlinecourses.nptel.ac.in/noc21_me02/preview

MAE1208	Course Outcomes
CO1	**Comprehend** the measurement techniques in understanding extensometers.
CO2	**Evaluate** the operating principles of straingauges through problem solving.
CO3	**Apply** the knowledge of photo elasticity working principles in evaluating the problemstatements.
CO4	**Understand** the basics of moirés method.
CO5	**Enumerate** different non destructivemethods and its applications.

Department Elective-III

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

First Year M.Tech (Semester-I)

MAE1209- Aircraft Systems & Control

Teaching Scheme			Examination Scheme	
Lectures	3 Hr / Week		ESE	60 Marks
Tutorial	1 Hr / Week		CIE	40 Marks
Practical	-		Total	100 Marks
Theory Credits : 4			Duration of Exam : 3 Hours	

Course Objectives

The Objectives of this course is:

1.	Study the differential control system..
2.	The known basic Concept of hydraulic & pneumatic system.
3.	Study different type of plane strain and axis symmetric problems.
4.	Explain the basic concepts fire protection systems, deicing system and anti-icing systems.

Course Contents

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

	instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.

Text Books	
1	McKinley, J.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw-Hill, 1993.
2	"General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, The English Book Store, New Delhi1995.
3	McKinley, J.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw-Hill, 1993.
Reference Books	
1	Allan G. Seabridge and Ian Moir, "Design and Development of Aircraft Systems: An Introduction (AIAA Education Series), 2004.
2	Introduction to aircraft Instruments- Reddy J.N. - McGraw Hill.
3	Aircarft Control & systems - Larry J. Segelind - John Wiley.
Useful Links	
1	https://nptel.ac.in/courses/101/104/101109046/
2	https://nptel.ac.in/courses/101/104/101104071/
3	https://nptel.ac.in/courses/105/106/105106051/

MAE1209	Course Outcomes
CO1	**Describe** the working principles of control systems in an aircraft.
CO2	**Summarize** the operations of Hydraulic, Pneumatic and Landing gear systems.
CO3	**Illustrate** the concepts of starting, ignition, fuel and lubricating systems of typical aircraft power plants.
CO4	**Discuss** the ideas of air cycle systems along with fire protection, deicing and anti-icing systems.
CO5	**Explain** the technical aspects of aircraft instruments and their working principle.

Department Elective-IV

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

First Year M.Tech (Semester-I)

MAE1210- Unmanned Arial Vehicle Systems

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 the basic concepts of unmanned aerial vehicles.
2.	To make students familiarize with the design aspects of UAV.
3.	To impart knowledge on the hardware components and their application in the UAV systems.
4.	To infer about the communication and control detail of UAV.
5.	To introduce the basic operational futures of UAV 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	Armand J. Chaput, "Design of Unmanned Air Vehicle Systems", Lockheed Martin Aeronautics Company, 1st Ed., 2001.
2	Introduction to UA
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/101/104/101104071/
3	https://onlinecourses.nptel.ac.in/noc20_ae03/preview

MAE1210	Course Outcomes
CO1	**Acquire** knowledge on the importance of UAVs with respect to their applications.
CO2	**Distinguish** between various subsystems and configurations of UAV.
CO3	**Perform** ground test and troubleshooting with respect to UAV operation.
CO4	**Distinguish** between needs of mini and micro UAVs.
CO5	**Gain** insights with design standards and regulatory aspects of UAVs.

Department Elective-IV

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

First Year M.Tech (Semester-II)

MAE1211- Helicopter 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.	To introduce basic concepts of hypersonic aerodynamics.
2.	To give exposure on various solution methods available for hypersonic inviscid flows.
3.	To make the students familiar with viscous hypersonic flow theory.
4.	To impart basic knowledge on hypersonic viscous interaction similarity parameter and to learn the basic aspects of shock wave boundary layer interactions.
5.	To make the students familiar with the basic concepts of high temperature effects in hypersonic flows.

Course Contents

Unit I	**Introduction** Historical Development of Helicopters. Helicopter Configuration. Control Requirements. Types of Rotor Systems. Basic Power Requirements.
Unit II	**Introduction to Hovering Theory** Momentum Theory. Blade Element Theory. Combined Blade Element and Momentum theories for non uniform inflow calculation. Ideal Rotor vs Optimum Rotor.
Unit III	**Vertical Flight** Various flow states of Rotor. Autorotation in Vertical Descent. Ground Flight.
Unit IV	**Forward Flight** Momentum Theory. Variable inflow Models. Blade Element Theory. Rotor Reference Planes. Hub Loads. Power variation with forward speed. Rotor Blade flapping Motion: Simple Mode.
Unit V	**Helicopter Trim and Stability** Equilibrium condition of helicopter, Trim analysis, Basics of helicopter stability.

Text Books

1	Bramwell, Done and Balmford: Helicopter Dynamics, Elsevier, 2nd Edition, 2001.
2	Gordon Leishman: Principles of Helicopter Aerodynamics, Cambridge Aerospace Series.
3	Stepniewski & Keys: Rotarywing Aerodynamics, Dover Publications, 3rd Edition, 2004

Reference Books

1	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Inc., Washington D, 4th edition, 1994.
2	Wayne Johnson: Helicopter Theory, Dover Publications.

Useful Links

1	https://nptel.ac.in/courses/101/104/101104017/

2	https://nptel.ac.in/courses/101/104/101104015/
3	https://nptel.ac.in/courses/101/104/10110401654/

MAE1211	Course Outcomes
CO1	**Explain** the different configurations of helicopter.
CO2	**Solve** the problems on the concepts of rotor dynamics and related theories.
CO3	**Compute** the power required for vertical flight.
CO4	**Examine** the stability and control of forward moving helicopter.
CO5	**Understand** the ground effect machines and trim stability and stability analysis.

Department Elective-IV
First Year (Semester-I) M.Tech. Aeronautical Engineering
First Year M.Tech (Semester-I)
MAE1212- Vibration & Aero-elasticity

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 unforced and force response system vibration.
2.	To make the student understand the concept of dynamics of multi Degree of freedom system..
3.	To get the knowledge of principles of aero-elasticity..
4.	To make students aware about the unforced and force response system vibration.

Course Contents

Unit I	**Introduction** Overview of the course, practical applications and research trends, harmonic and periodic motions, vibration terminology, introduction to spring and mass system, representation of practical problems in spring and mass system, vibration model, equation of motion.
Unit II	**Single-DOF Free Vibrations** Natural frequency energy method, Rayleigh method, Principle of virtual work, Damping models, Viscously damped free vibration, Special cases: oscillatory, non-oscillatory and critically damped motions. Logarithmic decrement, Experimental determination of damping coefficient, Forced harmonic vibration, Magnification factor. Rotor unbalance, Transmissibility, Vibration Isolation Equivalent viscous damping, Sharpness of resonance.
Unit III	**Two-DOF Free Vibrations** Generalized and Principal coordinates, derivation of equations of motion Lagrange's equation, Coordinate coupling, Forced Harmonic vibration, Tuned absorber, determination of mass ratio. Tuned and damped absorber, unturned viscous damped Forced Harmonic vibration.
Unit IV	**Vibration Absorber** Tuned absorber, determination of mass ratio. Tuned and damped absorber, unturned viscous damper. **Multi-DOF Vibration** Derivation of equations of motion, influence coefficient method, Properties of vibrating systems: flexibility and stiffness matrices, reciprocity theorem, Modal analysis: undammed, Modal analysis: damped.
Unit V	**Introduction Aero elastic Problems** Deformation of Structures and Influence Coefficients. Energy Method. Classification and Solution of Aero elastic Problems, Static Aero elasticity. Divergence of 2-D airfoil and Straight Wing. Aileron Reversal. Control Effectiveness. Wing loading and deformations. Swept Wing. Dynamic Aero elasticity. Dynamic/Flutter model of 2-D Airfoil. Finite State Model. Flutter Calculation. U-g Method. P-k Method. Exact Treatment of Bending - Torsion Flutter of Uniform Wing.

Text Books	
1	P. Srinivasan, Mechanical Vibration Analysis, Tata Mc Graw Hill, New Delhi, 4th edition, 1985.
2	J. P. Den Hartog, Mechanical Vibration, Mc Graw Hill, New York, 4th edition, 2005.
3	E.H. Dowell, A Modern Course in Aero elasticity, Springer-Verlag, 5th edition, 2012.
Reference Books	
1	N. L. Meirovitch, Elements of vibration Analysis, Mc Graw Hill, New York, 1st edition, 1986.
2	R. L. Bisplingh off, H. Ashley and R. L. Halfman, Aero elasticity, Addison- Wesley, 1st edition, 1955.
3	Applied Finite Element Analysis - Larry J. Segelind - John Wiley.
Useful Links	
1	https://nptel.ac.in/content/syllabus_pdf/101104005.pdf
2	https://nptel.ac.in/courses/112/103/112103111/
3	https://nptel.ac.in/courses/112/103/112103112/

MAE1212	Course Outcomes
CO1	**Estimate** unforced and force response for damped and undammed system.
CO2	**Differentiate** Dynamic, static and impulse loading and **estimate** damping ratio.
CO3	**Analyze** dynamics of multi Degree of freedom and rotating system.
CO4	**Synthesis** the dynamics of aircraft structures.
CO5	**Explicate** principles of aero-elasticity with Classification and Solution of Aero elastic Problems.

Department Elective-IV

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

First Year M.Tech (Semester-I)

MAE1213- Aero Engine Maintenance & Repairs

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 types of piston engines
2.	The known basic Concept of Maintenance and repairs of Piston engines
3.	Study different type of Propellers.
4.	Understand different type overhaul and maintenance of Propellers
5.	Study of various types of gas turbine engine maintenances.

Course Contents

Unit I	Principles of operations, functions of components carburetion and Fuel injection systems for small and large engines - **Ignition system components - spark plug detail** - Engine operating conditions at various altitudes – Engine power measurements – Classification of engine lubricants and fuels – Induction, Exhaust and cooling system - Maintenance and inspection check to be carried out. **Inspection and maintenance and troubleshooting** - Inspection of all engine components - Daily and routine checks - Overhaul procedures - Compression testing of cylinders - Special inspection schedules - Engine fuel, control and exhaust systems - Engine mount and **super charger** - Checks and inspection procedures.
Unit II	**Propeller theory** - operation, construction assembly and installation - **Pitch change mechanism-** Propeller axially system- Damage and repair criteria - General Inspection procedures - Checks on constant speed propellers - Pitch setting, **Propeller Balancing**, Blade cuffs, **Governor/Propeller operating conditions** – Damage and repair criteria.
Unit III	**Types of jet engines** – Fundamental principles – Bearings and seals - Inlets - **compressors**- turbines- exhaust section – classification and types of lubrication and fuels- Materials used - Details of control, starting around running and operating procedures – Inspection and Maintenance- permissible limits of damage and repair criteria of engine components- internal inspection of engines- compressor washing- **field balancing of compressor fans**- Component maintenance procedures - Systems maintenance procedures - use of instruments for online maintenance - Special inspection procedures- Foreign Object Damage - Blade damage
Unit IV	**Symptoms of failure** - Fault diagnostics - Case studies of different engine systems - Rectification during testing equipments for overhaul: Tools and equipments requirements for

	various checks and alignment during overhauling - **Tools for inspection** - **Tools for safety and for visual inspection** - Methods and instruments for **non destructive testing techniques** - Equipment for replacement of parts and their repair. Engine testing: Engine testing procedures and schedule preparation - Online maintenance.
Unit V	**Engine Overhaul - Overhaul procedures** - Inspections and cleaning of components - Repairs schedules for overhaul - Balancing of Gas turbine components. Trouble Shooting: Procedures for trouble shooting - **Condition monitoring of the engine on ground and at altitude** - engine health monitoring and corrective methods.

Text Books	
1	Turbomeca, "Gas Turbine Engines", The English Book Store, New Delhi, 1993
2	Kroes & Wild, "Aircraft Power Plants ", 7th Edition - Mcgraw Hill, New York, 1994.
3	This Item: Internal Combustion Engine. By Mathur.
Reference Books	
1	United Technologies' Pratt & Whitney, "The Aircraft Gas turbine Engine and its
2	Internal Combustion Engine Fundamentals. By John Heywood
Useful Links	
1	https://nptel.ac.in/courses/112/104/112104193/
2	https://nptel.ac.in/courses/105/105/105105041/

MAE1213	Course Outcomes
CO1	**Understand** the differential types equation of SI engine and CI engine and their maintenance.
CO2	**Analyze** the aircraft jet engines and their maintenance & inspections.
CO3	**Analyze** the functioning of various types of propellers.
CO4	**Solve** complicated 2D & 3D Isoperimetric structural problems for stress analysis.
CO5	**Perform** components - Repairs schedules for overhaul - Balancing of Gas turbine components