ANNA UNIVERSITY, CHENNAI

NON- AUTONOMOUS COLLEGES

AFFILIATED TO ANNA UNIVERSITY

M.E. AERONAUTICAL ENGINEERING

REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Apply advanced concepts in aerodynamics, propulsion, flight mechanics, and structural analysis to design, analyze, and optimize aircraft systems and components.
PSO2	Utilize modern computational tools, experimental methods, and regulatory standards to solve real-world aerospace engineering problems and support safe, efficient, and innovative aviation technologies.

ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Aeronautical Engineering **Regulations:** 2025

Abbreviations:

BS –Basic Science (Mathematics, Physics, Chemistry)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**) & Emerging Technology (**ET**))

SD – Skill Development

SL – Self Learning

PW – Project Work

L – Laboratory Course

T – Theory

LIT – Laboratory Integrated Theory

TCP – Total Contact Period(s)

Semester I

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	MA25C06	Applied Mathematical and Statistical Modelling	T	3	1	0	4	4	BS
2.	AO25101	Aircraft Propulsion	T	3	1	0	4	4	ES (PC)
3.	AO25102	Aircraft Structures	T	3	1	0	4	4	ES (PC)
4.	AO25103	Airplane Aerodynamics	T	4	0	0	4	4	ES (PC)
5.	AO25104	Aerodynamics Laboratory	L	0	0	4	4	2	ES (PC)
6.	AO25105	Propulsion Laboratory	L	0	0	4	4	2	ES (PC)
7.	AO25106	Technical Seminar	-	0	0	2	2	1	SD
						Total	**26**	**21**	

Semester II

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	AO25201	Flight Mechanics and Control	T	3	1	0	4	4	ES (PC)
2.		Programme Elective I	T	3	0	0	3	3	ES (PE)
3.		Programme Elective II	T	3	0	0	3	3	ES (PE)
4.	AO25202	CFD Applications for Aeronautical Engineering	LIT	3	0	2	5	4	ES (PC)
5.	AO25203	Advanced Finite Element Methods	LIT	3	0	2	5	4	ES (PC)
6.	AO25204	Aircraft Structures Laboratory	L	0	0	4	4	2	ES (PC)
7.		Industry-Oriented Course I	-	1	0	0	1	1	SD
8.		Self-Learning Course	-	-	-	-	-	1	-
						Total	**27**	**23**	

Semester III

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.		Programme Elective III	T	3	0	0	3	3	ES (PE)
2.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
3.		Programme Elective V	T	3	0	0	3	3	ES (PE)
4.		Industry Oriented Course II	--	1	0	0	1	1	SD
5.	AO25301	Industrial Training	---	---	---	---	---	2	SD
6.	AO25302	Project Work I	---	0	0	12	12	6	SD
						Total	**22**	**18**	

Semester IV

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	AO25401	Project Work II	---	0	0	24	24	12	SD
						Total	**24**	**12**	

Total Credits for the Programme = 72

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	AO25001	Rocketry and Space Mechanics	3	0	0	3	3
2.	AO25002	Avionics	3	0	0	3	3
3.	AO25003	Aerospace Materials for Aeronautical Engineering	3	0	0	3	3
4.	AO25004	Aircraft Engine Repair and Maintenance	3	0	0	3	3
5.	AO25005	Experimental Aerodynamics	3	0	0	3	3
6.	AO25006	Computational Heat Transfer for Aeronautical Engineering	3	0	0	3	3
7.	AO25007	Mechanics of Composite Materials	3	0	0	3	3
8.	AO25008	Introduction to Aerospace Engineering	3	0	0	3	3
9.	AO25009	Industrial Aerodynamics	3	0	0	3	3
10.	AO25010	Theory of Elasticity and Plasticity	3	0	0	3	3
11.	AO25011	Helicopter Aerodynamics	3	0	0	3	3
12.	AO25012	Airworthiness Standards and Certification	3	0	0	3	3
13.	AO25013	Combustion in Jet and Rocket Engines	3	0	0	3	3
14.	AO25014	Advanced Propulsion Systems	3	0	0	3	3
15.	AO25015	Analysis of Composite Structures	3	0	0	3	3
16.	AO25016	Airframe Repair and Maintenance	3	0	0	3	3
17.	AO25017	Aircraft Systems Engineering	3	0	0	3	3
18.	AO25018	Flight Instrumentation	3	0	0	3	3
19.	AO25019	Experimental Stress Analysis	3	0	0	3	3
20.	AO25020	NDT Methods	3	0	0	3	3
21.	AO25021	Aircraft Structural Mechanics	3	0	0	3	3
22.	AO25022	Multifunctional Materials and their Applications	3	0	0	3	3
23.	AO25023	Aeroelasticity	3	0	0	3	3

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
24.	AO25024	Theory of Boundary Layers	3	0	0	3	3
25.	AO25025	Aircraft Control Engineering	3	0	0	3	3
26.	AO25026	High Speed Jet Flows	3	0	0	3	3
27.	AO25027	Hypersonic Aerodynamics	3	0	0	3	3
28.	AO25028	Navigation, guidance and Control for Space vehicles	3	0	0	3	3
29.	AO25029	Air Traffic Control	3	0	0	3	3
30.	AO25030	Hypersonic Propulsion	3	0	0	3	3
31.	AO25031	Aircraft Regulations and Certifications	3	0	0	3	3
32.	AO25032	Vibration and Structural Dynamics	3	0	0	3	3

Semester I

MA25C06	Applied Mathematical and Statistical Modelling	L	T	P	C
		3	1	0	4

Course Objectives:

- To equip students with advanced mathematical techniques, specifically Fourier Transforms, for formulating and solving partial differential equations that model fundamental mechanical engineering phenomena such as heat transfer, vibrations, and fluid flow.
- To provide a strong foundation in statistical inference, enabling students to estimate population parameters (like material properties and process capabilities) from experimental data and assess the quality and reliability of these estimators.
- To enable students to design efficient, structured experiments and apply appropriate statistical tests to make valid, data-driven decisions for comparing processes, optimizing designs, and solving complex engineering problems.

Fourier Transform: Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity, Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

Estimation Theory: Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.

Testing of Hypothesis: Sampling distributions, small and large samples, Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, independent of attributes.

Design of Experiments: Analysis of variance, One way and two-way classifications, completely randomized design, Randomized block design, Latin square design, 2^2 Factorial design.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%.

References:

1. Andrews, L. C., & Shivamoggi, B. K. (2003). Integral transforms for engineers. Prentice Hall of India.
2. Devore, J. L. (2014). Probability and statistics for engineering and the sciences, Cengage Learning.
3. Johnson, R. A., Miller, I., & Freund, J. (2015). Miller and Freund's probability and statistics for engineers, Pearson Education Asia.

E-resources:

1. https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data
2. https://www.itl.nist.gov/div898/handbook/
3. https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008

AO25101	Aircraft Propulsion	L	T	P	C
		3	1	0	4

Course Objectives:

This course aims to provide students with a foundational understanding of aircraft and rocket propulsion systems. It covers various propulsion types, propeller theories, and the working principles of components like inlets, nozzles, compressors, turbines, and combustion chambers. Students will also be introduced to modern electric propulsion technologies.

Elements of Aircraft Propulsion: Classification of power plants, Methods of aircraft propulsion, Propulsive efficiency, Specific fuel consumption, Thrust and power- Factors affecting thrust and power-Illustration of working of Gas turbine engine, Characteristics, advantages and disadvantages of turboprop, turbofan and turbojet, Ram jet, Scram jet –flight regimes diagram for different power-plants, Methods of Thrust augmentation.

Activity: Categorize different propulsion systems (turbojet, turbofan, etc.).

Propeller Theories: Momentum theory, Blade element theory, combined blade element and momentum theory, Propeller co-efficient, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight thrust and power, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts, UAV propellers and applications

Activity: Calculate SFC and propulsive efficiency for different engines, compare Propulsion Efficiency Calculation under various conditions.

Inlets, Nozzles and Combustion Chambers: Impact of Flight Mach Number on Inlet Duct Geometry, Subsonic and supersonic inlets, Supersonic Inlet Types, Relation between minimum area ratio and external deceleration ratio, starting problem in supersonic inlets, Modes of inlet operation, jet nozzle, Efficiencies, Over expanded, under and optimum expansion in nozzles, Thrust reversal. Classification of Combustion chambers, Combustion chamber performance, Flame tube cooling, Flame stabilization - Afterburner.

Activity: Design a supersonic inlet based on flight Mach number, optimize geometry for efficiency.

Axial And Centrifugal Flow Compressors and Fans: Introduction to Axial flow compressor, centrifugal compressors, geometry, twin spools, three spools, stage analysis- velocity polygons, degree of reaction, radial equilibrium theory, Compressor Design Parameters, Compressor instability, performance maps

Activity: Analyze multi-stage axial compressors using velocity triangles, design a centrifugal compressor and calculate key performance parameters.

Turbines: Introduction to Turbines, Radial & axial flow turbines, Practical application, Blade Geometry, Compressor Turbine Matching- velocity polygons, stage analysis, performance maps, thermal limit of blades and vanes, Turbine Cooling methods

Activity: Match turbine power with compressor power requirements, research and present different turbine cooling techniques.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Hill, P. G., & Peterson, C. R. (2009). Mechanics & thermodynamics of propulsion (2nd ed.). Pearson Education.
2. Oates, G. C. (1985). Aerothermodynamics of aircraft engine components. AIAA Education Series.
3. Cohen, H., Saravanamuttoo, H. I. H., Rogers, G. F. C., Straznicky, P., & Nix, A. (2017). Gas turbine theory (7th ed.). Pearson Education Canada.
4. Gill, W. P., Smith, H. J., & Ziurys, J. E. (1980). Fundamentals of internal combustion engines as applied to reciprocating, gas turbine & jet propulsion power plants. Oxford & IBH Publishing Co.
5. Farokhi, S. (2014). Aircraft propulsion (2nd ed.). John Wiley & Sons Ltd.

E-Resources:

https://nptel.ac.in/courses/101101002

https://nptel.ac.in/courses/112104117

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/

https://ocw.mit.edu/resources/res-16-001-ocw-scholar-introduction-to-aerospace-engineering-and-design-spring-2012/lecture-notes/

https://www.grc.nasa.gov/www/k-12/airplane/bgp.html

https://www.grc.nasa.gov/www/k-12/airplane/shortp.html

https://www.coursera.org/learn/aircraft-propulsion

https://www.edx.org/course/fundamentals-of-turbomachinery

	Description of CO	PO	PSO1	PSO2
CO1	Understand the basic principles of various aircraft propulsion systems, including turboprop, turbojet, turbofan, and ramjet engines.	PO1 (3), PO3 (2)	3	2
CO2	Analyze and calculate the performance of propellers using momentum and blade element theories and predict their thrust and power.	PO1 (3), PO2 (2)	3	2
CO3	Evaluate the working and design of inlets, nozzles, and combustion chambers in relation to engine performance and thrust augmentation.	PO1 (3), PO3 (2)	3	2
CO4	Understand and apply the principles of axial and centrifugal flow compressors, turbines, and their performance characteristics in engine design.	PO1 (3), PO3 (3)	3	3

AO25102	Aircraft Structures	L	T	P	C
		3	1	0	4

Course Objectives:

This course aims to equip students with the ability to determine structural loads acting on aircraft components, understand stressed skin construction, analyze beam bending and shear flow in structural elements, and evaluate the behaviour of thin plates under various loading conditions. It also introduces key design philosophies and airworthiness considerations in aircraft structural design.

Aircraft Structural Loads and Load Factor Analysis: Loads Acting on an Aircraft, Balancing Tail Loads, Determination of the Load Factor during Symmetric Maneuvers, Inertia Loads, Function of Aircraft Wing & Fuselage Components Airworthiness Requirements, Construction of the V-n Diagram, Effect of Gust

Activity: Calculate load factor during symmetric maneuvers and create a V-n diagram, Calculate additional loads on wings and fuselage during gust encounters.

Stressed Skin Design and Structural Materials: Materials Used for Aircraft Construction, Structural Components of an Aircraft & Their Functions, Safe Life vs Fail Safe Design, Certification Standards, Principles of Damage Tolerance, Prediction of Fatigue Strength, Basic Principles of Fatigue & Fracture Mechanics

Activity: Choose appropriate materials for aircraft components based on properties like strength and fatigue resistance, predict fatigue life of a wing spar based on loading cycles and damage tolerance principles.

Beam Theory, Bending: Bending Moment and Shear Force, Generalized Theory of Pure Bending, Stresses in Beams of Symmetrical and Unsymmetrical Sections, Neutral Axis Determination, Box Beam Analysis, Deflection of Beams, Stresses in Composite Beams, Sandwich Beams, Sizing of Wing Spar

Activity: Calculate bending stress and shear force in beams of different cross-sections. Calculate deflection of beams under various loading conditions.

Shear Flow: Shear Flow in Thin-Walled Beams, Determination of the Shear Centre Position in Symmetrical and Unsymmetrical Cross-Sections, Structural Idealization, Flexural Shear Flow in Box Beams, Shear flow due to Combined Bending & Torsion, Torsion of Thin-Walled Open Sections Stress Shear Flow Analysis of Aircraft Components, Thin-Webbed Tapered Beams

Activity: Calculate shear flow in thin-walled beams like wing spars. determine shear center location in unsymmetrical cross-sections.

Thin Plate Structures and Buckling Behaviour: Pure Bending of Thin Plates, Thin Plates Under Combined Loading, Stress Resultants, Buckling of Thin Plates in Compression, Plate Buckling Coefficient, Ultimate Strength of Stiffened Sheets, Effective Sheet Width, Needham Method, Gerard Method, Instability of Thin-Walled Columns, Local Buckling & Crippling, Analysis of Tension Field Beams.

Activity: Calculate critical buckling load for thin plates under compressive loads, Use Needham or Gerard methods to calculate effective sheet width in stiffened plates.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology and weightage: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)
References: 1. Curtis, H. D. (1997). Fundamentals of aircraft structural analysis. WCB-McGraw Hill. 2. Rivello, R. M. (2007). Theory and analysis of flight structures (4th ed.). McGraw Hill. 3. Donaldson, B. K. (2008). Analysis of aircraft structures: An introduction (2nd ed.). Cambridge University Press. 4. Bruhn, E. H. (1985). Analysis and design of flight vehicle structures. Tri-State Offset Company. 5. Peery, D. J., & Azar, J. J. (2012). Aircraft structures. McGraw-Hill.
E-Resources: https://nptel.ac.in/courses/101106042 https://nptel.ac.in/courses/101106153 https://ocw.mit.edu/courses/1-050-solid-mechanics-fall-2004/ https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-036-structural-mechanics-spring-2003/ https://www.nasa.gov/centers/glenn/about/fs21grc.html https://ntrs.nasa.gov/
Other Resources: Interactive simulation platforms: https://amesweb.info/SectionalProperties/Shear-Flow-Thin-Walled-Section.aspx

	Description of CO	PO	PSO1	PSO2
CO1	Determine the structural loads acting on aircraft components, analyze the load factors, and construct V-n diagrams.	-	-	-
CO2	Understand stressed skin construction, the use of materials in aircraft, and apply damage tolerance and fatigue strength predictions.	PO1 (3), PO2 (2)	3	2
CO3	Analyze beam bending, shear flow, and stress distribution in thin-walled beams, and evaluate structural components under combined loading conditions.	PO1 (3), PO2 (2)	3	2
CO4	Apply principles of plate theory to analyze the buckling and stability of thin plates, including the design of tension field beams and stiffened sheets.	PO1 (3), PO3 (3)	3	3

AO25103	Airplane Aerodynamics	L	T	P	C
		4	0	0	4

Course Objectives:

- To gain insights into the basics of fluid flow, its model and tool to solve the fluid flow problems.
- To be familiar with the conservation laws of fluid dynamics, and how to apply them to practical fluid flows.
- To gain knowledge on elementary flows to combine and form realistic flows with suitable assumptions.
- To analyse incompressible flow over three-dimensional bodies like wing and so on.
- To gain knowledge on the basic concepts of viscous flows, boundary layers to practical flows

Fundamentals of Aerodynamics and Fluid Flow: Aerodynamic force and moments, lift and Drag coefficients, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Application of conservation of mass, momentum, energy to fluid flows Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity distributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect.

Activity: Calculate lift and drag coefficients for different shapes, Study the effect of rotation on aerodynamic forces using a rotating cylinder or simulation.

Incompressible Flow Theory and Thin Airfoil Concepts: Conformal Transformation, Karman, Trefftz profiles, Kutta condition, Kelvin's Circulation Theorem and the Starting Vortex, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot, Savart law, lifting line theory, effect of aspect ratio.

Activity: Apply thin airfoil theory to calculate lift distribution on an airfoil, Use the Kutta condition to simulate flow around a thin airfoil and calculate induced lift.

Compressible Flow Fundamentals: Compressibility, Isentropic flow through nozzles, Normal shocks, Oblique and Expansion waves, moving shock waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Transonic flow Theory, Prandtl- Glauert Rule, Linearized supersonic flow, Method of characteristics.

Activity: Analyze normal and oblique shock waves, calculating pressure, temperature, and velocity, Apply isentropic theory to analyze flow properties in a nozzle.

High-Speed Aerodynamics: Airfoils, Wings, and Configurations: Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, transonic area rule, swept wings (ASW and FSW), Supersonic airfoils, Shock-Expansion Theory, Wave drag, Delta wings.

Activity: Use the transonic area rule to reduce wave drag in an aircraft design, Apply shock-expansion theory to calculate lift and drag for supersonic airfoils.

Viscous Flow and Boundary Layer Theory: Introduction to viscous flow, concept of boundary layer, Adverse effect of Boundary Layer, Laminar and turbulent Boundary Layers, Prediction of Skin friction drag, Blasius Theory, Boundary Layer Separation, Transition and Control.

Activity: Calculate boundary layer thickness over a flat plate using Blasius' solution, Simulate and compare laminar and turbulent boundary layer characteristics.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Anderson, J. D. (2010). Fundamentals of aerodynamics (5th ed.). McGraw-Hill Education.
2. Rathakrishnan, E. (2013). Gas dynamics (5th ed.). Prentice Hall of India.
3. Shapiro, A. H. (1982). Dynamics & thermodynamics of compressible fluid flow. Ronald Press.
4. Houghton, E. L., & Caruthers, N. B. (2003). Aerodynamics for engineering students (5th ed.). Butterworth-Heinemann.
5. Zucrow, M. J., & Anderson, J. D. (1989). Elements of gas dynamics. McGraw-Hill Book Co.
6. Rae, W. H., & Pope, A. (1999). Low speed wind tunnel testing (3rd ed.). John Wiley Publications.

E-Resources

https://nptel.ac.in/courses/101101025
https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-100-aerodynamics-fall-2010/
http://aero.stanford.edu/fundamentals.html
http://www.aero.iitb.ac.in/nptel/notes/Aero_Dynamics.pdf
https://ntrs.nasa.gov/
http://www.aero.und.edu/aero/library/

Other Resources:

Interactive simulation platforms:
https://www.grc.nasa.gov/www/k-12/airplane/foil4.html
http://www.mh-aerotools.de/airfoils/javafoil.html

	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply the fundamentals of aerodynamics and fluid flow, including aerodynamic forces, moments, and conservation laws in fluid dynamics.	PO1 (3), PO2 (2), PO3 (3)	3	3
CO2	Analyze incompressible flow over aerodynamic bodies and apply thin airfoil theory, Kutta condition, and vortex theories to calculate lift and drag.	PO1 (3), PO2 (2)	3	3
CO3	ı knowledge of compressible flow, including shock waves, oblique and expansion waves, and the transonic flow theory for high-speed aerodynamic applications.	PO1 (3), PO2 (2)	3	3
CO4	Understand viscous flow and boundary layer theory, predict drag, and explore laminar/turbulent boundary layers and their control methods for aerodynamic optimization.	PO1 (3), PO3 (2)	3	3

AO25104	Aerodynamics Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:
This course aims to provide students with practical knowledge of subsonic and supersonic wind tunnel operations and fundamental aerodynamic principles involving inviscid, incompressible fluids. It enables students to calculate key aerodynamic characteristics of different bodies, understand and distinguish between laminar and turbulent flow behaviour, and gain hands-on experience with flow visualization techniques in subsonic regimes.

List of Experiments:
1. Calibration of subsonic wind tunnel.
2. Pressure distribution over a smooth cylinder.
3. Pressure distribution over a rough cylinder.
4. Pressure distribution over a symmetric aerofoil section.
5. Pressure distribution over a cambered aerofoil section.
6. Pressure distribution over a wing of cambered aerofoil section.
7. Force and moment measurements using wind tunnel balance.
8. Wake measurements behind a bluff body.
9. Velocity boundary layer measurements over a flat plate.
10. Force measurements on aircraft model using wind tunnel balance.
11. Moment measurements on aircraft model using wind tunnel balance.
12. Calibration of supersonic wind tunnel.
13. Subsonic flow visualization studies

***Minimum 10 Experiments need to conduct from the above**

Laboratory Equipments Required
1. Subsonic wind tunnel
2. Rough and smooth cylinder
3. Symmetrical and Cambered aerofoil
4. Wind tunnel balance
5. Schlieren system
6. Pressure Transducers
7. Supersonic wind tunnel
8. Blower
9. Testing models like flat plate, bluff body

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

E-Resources:

https://www.grc.nasa.gov/www/k-12/airplane/windtun.html
https://nptel.ac.in/courses/101101025
https://www.youtube.com/watch?v=Ti4i-DlzfhY
https://ocw.mit.edu/courses/16-100-aerodynamics-fall-2010/
https://www.grc.nasa.gov/www/k-12/airplane/foil3.html
https://www.youtube.com/watch?v=2GxLzr1U1fU
https://www.nasa.gov/sites/default/files/atoms/files/windtunnelbasics.pdf
https://nptel.ac.in/courses/112106189
https://www.efunda.com/formulae/fluids/wake.cfm
https://www.youtube.com/watch?v=_iJcM13HVuA
https://www.me.umn.edu/courses/me4001/smoke.html
https://www.grc.nasa.gov/www/k-12/airplane/tunrst.html

	Description of CO	**PO**	**PSO1**	**PSO2**
CO1	Perform experiments to calibrate subsonic and supersonic wind tunnels, measure pressure distributions, and evaluate aerodynamic forces and moments in subsonic regimes.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO2	Analyze aerodynamic characteristics (pressure, force, moment) of bodies like cylinders, aerofoils, and aircraft models using wind tunnel testing methods.	PO1 (3), PO2 (2)	3	3
CO3	Conduct flow visualization techniques and measure velocity boundary layers to study laminar and turbulent flow characteristics in subsonic flows.	PO1 (3), PO3 (2)	3	3
CO4	Analyze and interpret aerodynamic data from experiments, including wake measurements, force and moment data, and boundary layer studies, to draw meaningful conclusions.	PO1 (3), PO2 (2), PO3 (3)	3	3

AO25105	Propulsion Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

This lab course provides hands-on experience with pressure distribution in inlets and nozzles, compressor blade testing, and flow visualization of supersonic jets. It also introduces cold flow studies and data interpretation using software tools.

List of Experiments:

1. Wall pressure measurements of a subsonic diffuser.
2. Cascade testing of compressor blades.
3. Pressure distribution on a cavity model.
4. Wall pressure measurements on non-circular combustor.
5. Wall pressure measurements on converging nozzle.
6. Wall pressure measurements on convergent-divergent nozzle.
7. Total pressure measurements along the jet axis of a circular subsonic jet.
8. Total pressure measurements along the jet axis of a circular supersonic jet.
9. Cold flow studies of a wake region behind flame holders.
10. Wall pressure measurements on supersonic inlets.
11. Flow visualization on supersonic jets.

***Minimum 10 Experiments need to conduct from the above**

Laboratory Equipments Required

1. Subsonic wind tunnel
2. High speed jet facility
3. Blower
4. Pressure scanner
5. Schlieren system
6. Nozzle and cavity models

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

E-Resources:

https://www.grc.nasa.gov/www/k-12/airplane/incompress.html
https://nptel.ac.in/courses/112104118
https://arc.aiaa.org/doi/10.2514/6.2001-2918
https://ntrs.nasa.gov/api/citations/19920008884/downloads/19920008884.pdf
https://www.grc.nasa.gov/www/k-12/airplane/nozzler.html
https://nptel.ac.in/courses/112106189

https://ocw.mit.edu/courses/16-100-aerodynamics-fall-2010/ https://ntrs.nasa.gov/citations/19930092576 https://ntrs.nasa.gov/citations/19940021516 https://ntrs.nasa.gov/citations/19720018946 https://www.youtube.com/watch?v=RrQ2p41XoJ0

	Course Outcome (CO)	PO	PSO1	PSO2
CO1	Measure and analyze pressure distribution in various subsonic and supersonic flow devices, including diffusers, nozzles, and combustors.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO2	Perform cascade testing of compressor blades and analyze the aerodynamic properties and performance of different blade configurations.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO3	Conduct cold flow studies, including wake region analysis and pressure measurements in supersonic jets, and interpret the data using computational tools.	PO1 (3), PO3 (2)	3	3
CO4	Use flow visualization techniques, such as Schlieren and pressure scanning systems, to study supersonic and subsonic flows and interpret the results.	PO1 (3), PO2 (2), PO3 (3)	3	3

Semester II

AO25201	Flight Mechanics and Control	L	T	P	C
		3	1	0	4

Course Objectives:

This course aims to equip students with a solid understanding of aircraft performance in steady and accelerated flight, including climb, glide, and manoeuvring conditions. It introduces the fundamentals of static and dynamic stability, both longitudinal and lateral-directional, and provides the tools to analyse trim, control requirements, and motion using linearized equations.

Aircraft Dynamics

Newton's second law for rigid aircraft dynamics - Axes system and transforms - Linearized equations of motion, Estimation of force and moment derivatives, Short period and Phugoid motion, Pure pitching motion - Natural frequency and damping ratio. Linearized Coupled equations for lateral-directional dynamics - Dutch roll, Roll and Spiral approximations - Pure rolling - Aerodynamic derivatives of lateral and directional dynamics.

Steady Flight Performance

Essentials of Aerodynamics and ISA - Straight and level flight: thrust and power required/available, differences of propeller-driven and jet-powered airplanes -Steady Climb and Descent performance: climb angle and rate of climb, descent angle and rate of descent - Fuel Consumption and Endurance - Fuel Consumption and Range - Airspeed, Wing Loading, and Stall.

Maneuver Performance

Steady Coordinated Turn - maximum producible load factor - Limitations on load factor - fastest and tightest turn - Vertical maneuver: pull-up and pull-down - effect of gust on V-n diagram - Takeoff and landing performance.

Static Longitudinal Stability and Control

Fundamentals of Static Equilibrium and Stability - Simplified Pitch Stability Analysis for a Wing-Tail Combination - Estimating the Downwash Angle on an aft Tail - Stick-Fixed Neutral Point and Static Margin. Simplified Pitch Stability Analysis for a Wing-Canard and flying wing configuration - Stick free stability - Hinge moment, Free elevator factor, Power effects - propeller and jet aircrafts, longitudinal control, elevator effectiveness, elevator control power, elevator angle to trim, most forward C.G, elevator angle per 'g', maneuver point, control force gradient and control force per 'g', Flight measurement of neutral and maneuver points - Aerodynamic balancing of control surfaces.

Static Lateral, Directional Stability and Trim

Yaw stability and trim - contribution by wing, fuselage, tail - Estimating the Sidewash Gradient on a Vertical Tail - Rudder fixed and rudder free aspects, pedal force - Rudder lock and Dorsal fin, Directional control, rudder requirements. Lateral stability - Dihedral effect, criteria for lateral stability, evaluation of lateral stability -contribution of fuselage, wing, wing fuselage, tail, total static lateral stability, roll control, strip theory estimation of aileron control power, roll control by spoilers, aileron reversal, aileron reversal speed.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology and weightage: Assessment Exams (50%), Assignments/Case Study (20%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%)

References:

1. Energy Manager Training Manual (4 Volumes) available at McCormic, B.W., "Aerodynamics, Aeronautics & Flight Mechanics", Second edition, , 1995, John Wiley & Sons.
2. Michael V. Cook. "Flight Dynamics Principles", Second edition, 2007, Elsevier.
3. Pamadi, B.N. "Performance, Stability, Dynamics, and Control of Airplanes", 2004, AIAA Education Series.
4. Anderson,JD, “Aircraft Performance & Design”, First edition, Mc Graw Hill India, 2010.
5. Perkins C.D., &Hage, R.E. "Airplane Performance, Stability and control", 2011, Wiley India.
6. Nelson, R.C. "Flight Stability & Automatic Control", Second edition, 2017, McGraw-Hill.

E-Resources:

https://nptel.ac.in/courses/101104062
https://nptel.ac.in/courses/101104064
https://ocw.mit.edu/courses/16-333-aircraft-stability-and-control-fall-2004/
https://www.grc.nasa.gov/www/k-12/airplane/bga.html
https://arc.aiaa.org/doi/book/10.2514/4.861750
https://www.grc.nasa.gov/www/k-12/airplane/foil3.html
https://open.umn.edu/opentextbooks/textbooks/introduction-to-flight-testing-and flight-mechanics
https://ntrs.nasa.gov/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Assess the performance of an aircraft in steady, level, climb, and glide conditions using analytical methods.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO2	Analyze accelerated flight maneuvers, including coordinated turns, and construct V–n diagrams accounting for gust loads.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Evaluate static longitudinal stability and perform preliminary stability and trim analysis for various aircraft configurations.	PO1 (3), PO2 (2), PO3 (3)	3	3
CO4	Analyze aircraft dynamic stability using linearized equations of motion and evaluate longitudinal and lateral-directional dynamic modes.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25202	CFD Applications for Aeronautical Engineering	L	T	P	C
		3	0	2	4

Course Objectives:

This course introduces students to the fundamental governing equations of fluid dynamics and their numerical solutions using Computational Fluid Dynamics (CFD). It covers grid generation techniques, time-dependent methods, and the finite volume method. Students will also gain hands-on experience in solving practical aeronautical problems and learn about CFD applications in industry, including high-performance computing and software development.

Governing Equations and Introduction to CFD

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, mathematical properties of fluid dynamic equations and classification of partial differential equations - Local similar solutions of boundary layer equations with numerical integration and shooting technique. Numerical solution inviscid internal flows such as supersonic nozzle isentropic flows for Mach number distribution -Numerical solutions using Panel methods for external flows.

Grid Generation and Quality Assessment

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries - Elliptic grid generation using Laplace's equations - Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries –Multi-blocking and Grid Interfaces – Adaptive Grids and Grid movement –Assessment of grid quality and parameters to assess the quality – Adverse effects of poor grid quality on numerical solution – Grid size distribution aspects on convergence of the solution.

Time-Dependent Methods and Applications

Explicit and Implicit time dependent methods – examples and illustrations - stability aspects - Time split and operator splitting methods - Approximate factorization scheme – Time dependent methods for solution of external flows such as over hypersonic blunt bodies - Unsteady transonic flow around airfoils. Illustration of applications for one dimensional and two-dimensional diffusion problems – time dependent method applications for convection and diffusion problems

Finite Volume Method and Flux Schemes

Introduction to Finite volume Method –Comparison of Finite Difference Method and Finite volume Method - Different Flux evaluation schemes such as central, upwind and hybrid schemes –Artificial diffusion - Conditions for convergence - Staggered grid approach - Pressure-Velocity coupling - SIMPLE, SIMPLER algorithms-pressure correction equation (both incompressible and compressible forms) - Applications of Finite Volume Method.

Industrial Applications of CFD

Turbulence modelling for viscous flows, verification and validation of CFD code, application of CFD tools to 2D and 3D configurations - CFD for aerodynamic heating analysis – Coupling of CFD code with heat conduction code, Unsteady flows – Oscillating geometries, Computational aeroelasticity – Coupling of CFD with structural model – CFD software development for aerospace applications- High performance computing for CFD applications – Parallelization of codes –Hardware requirements and parallel computer architecture - domain decomposition method.

List of Practical's for Lab Integrated Course

Practical:

- Numerical simulation of 1-D diffusion and conduction in fluid flows, Numerical simulation of 1-D convection-diffusion problems
- Structured grid generation over an airfoil section
- 3D numerical simulation of flow through CD nozzles
- Numerical simulation of 2-D unsteady heat conduction, Numerical simulation of 2-D diffusion and 1-D convection combined problems

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignments/Case Study (20%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%)

References:

1. Hirsch,A.A, "Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.
2. Sedat Biringen & Chuen-Yen Chow, "Introduction to Computational Fluid Dynamics by Example", Wiley publishers, 2nd edition, 2011.
3. Wirz, HJ & Smeldern, JJ, "Numerical Methods in Fluid Dynamics", Washington: Hemisphere Pub. Corp., 1978.
4. Bose. TK, "Numerical Fluid Dynamics", Narosa Publishing House, 2001.
5. Chung. TJ, "Computational Fluid Dynamics", Cambridge University Press, 2010.
6. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017.

E-Resources:

https://nptel.ac.in/courses/112105045
https://ocw.mit.edu/courses/16-920j-numerical-methods-for-partial-differential-equations-sma-5212-spring-2006/
https://www.grc.nasa.gov/www/cfd/
https://www.cfd-online.com/
https://www.ansys.com/academic/students
https://www.openfoam.com/documentation/
https://turbmodels.larc.nasa.gov/
https://www.comsol.com/computational-fluid-dynamics

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain governing equations of fluid dynamics and apply numerical methods to solve inviscid and viscous flow problems using CFD techniques.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO2	Generate structured and unstructured computational grids, assess grid quality, and analyze the impact of grid parameters on numerical accuracy and convergence.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Apply time-dependent methods and finite volume techniques to solve steady and unsteady aeronautical flow problems, including convection–diffusion and compressible flows.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Analyze industrial CFD applications including turbulence modeling, aero-thermal analysis, aeroelastic coupling, high-performance computing, and parallelization techniques.	PO1 (3), PO3 (3), PO5 (3)	3	3

AO25203	Advanced Finite Element Methods	L	T	P	C
		3	0	2	4

Course Objectives:

- To provide a strong foundation in energy methods, variational principles, and fundamentals of the Finite Element Method (FEM).
- To develop the ability to analyze 1-D structural elements such as bars, trusses, and vibration problems using FEM.
- To enable analysis of beams and 2-D plane stress/strain problems using appropriate finite elements.
- To impart hands-on experience in solving practical engineering problems using FEM and commercial software tools.

Fundamentals and Basic Procedures

Applied of Energy Methods – Rayleigh-Ritz Method – Method of Weighted Residuals – Galerkin Technique – Overview of the Finite Element Method – Modeling & Discretization – Element Choice – Degrees of Freedom – Interpolation Functions – Virtual Work Principle.

1-D Structural Analysis

Governing Differential Equation – 1-D Problems Involving Bar Elements – Variational Techniques – Equivalence of the Finite Element and Variational Methods – Formulation of Finite Element Equations & Characteristic Matrices – Static Analysis of a Bar under Axial and Thermal Loading – Nodal Load Vector – Axial Vibration of a Bar – Planar Truss Analysis

Flexure Elements

Beam Bending – Modeling of a Physical Beam – Virtual Work Principle – Formulation Techniques – Derivation of the Stiffness Matrix – Shape Functions – Convergence Requirements – Determination of the Nodal Load Vector – Linear Static Analysis – Transverse Vibration of Beams – Derivation of Mass Matrix – Determination of Natural Frequencies & Mode Shapes

Two-Dimensional Problems

Solution of Plane Stress & Plane Strain Problems Using the CST Element – Area Coordinates & Shape Functions – Nodal Load Vector – 4-node Quadrilateral Finite Element – Jacobian Matrix – Isoparametric Formulation – Strain Displacement Matrix– Numerical Integration – Features of the Linear Strain Triangle – Higher Order Element Capabilities – Meshing Techniques

Practical Problems

Finite Element Formulation for Axi-symmetric Problems – Derivation of Element Matrices for 1-D & 2-D Heat Transfer Analysis – Finite Difference Method – Torsion of a Solid Bar – Features and Procedure of Finite Element Software – Numerical Solution Methods – Finite Element Formulation and Solution of Simple Problems Involving Fluid Mechanics

List of Practical's for Lab Integrated Course

Practical:

- Static analysis of a uniform bar subject to different loads (1-D element), Thermal stresses in uniform and tapered members (1-D element)
- Static analysis of trusses/frames under different loads, Free vibration analysis of a bar
- Stress analysis and deformation of beams using 1-D and 2-D elements with various loads
- Stress concentration analysis in an infinite plate with a small hole.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignments/Case Study (20%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%)

References:

1. Bathe K.J. and Wilson, E.L, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 2016.
2. Krishnamurthy, C.S, "Finite Element Analysis", Tata McGraw Hill, 2nd edition, 2001.
3. Rao. S.S, "The Finite Element Methods in Engineering", Butterworth and Heinemann, 5th edition, 2010.
4. Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley and Sons, 2003
5. Segerlind L J, "Applied Finite Element Analysis", John Wiley and Sons Inc., New York, 2nd Edition,1984
6. Tirupathi.R. Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 4th Edition, 2012.

E-Resources:

https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-fall-2009/
https://nptel.ac.in/courses/112/107/112107161/
https://engineering.tamu.edu/~jreddy/Books/3rd_edition_2019.pdf
https://www.simscale.com/docs/tutorials/
https://www.ansys.com/learning/resources
https://www.comsol.com/learning-center
https://www.khanacademy.org/science/engineering/finite-element-method
https://caeai.com/resources/tutorials/

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Apply energy methods, variational principles, and weighted residual techniques to formulate finite element equations for engineering problems.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO2	Formulate and solve 1-D structural problems including axial loading, thermal effects, vibration of bars, and planar truss analysis using FEM.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Analyze flexural and two-dimensional problems using beam, CST, quadrilateral, and isoparametric elements including stress, deformation, and vibration analysis.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Apply finite element techniques to practical engineering problems including heat transfer, axisymmetric analysis, torsion, fluid mechanics, and interpret results using FEM software tools.	PO1 (3), PO3 (3), PO5 (3)	3	3

AO25204	Aircraft Structures Laboratory	L	T	P	C
		0	0	4	2

Course Objectives:

This lab course provides hands-on experience with electrical resistance strain gauges, photoelasticity, and stress analysis techniques. Students explore symmetrical and unsymmetrical bending of beams, composite laminate fabrication, and mechanical testing. It also covers non-destructive evaluation methods, offering practical insights into real-world structural behaviour and material performance.

List of Experiments:

1. Experiments in Symmetrical Bending of Beams
2. Unsymmetrical Bending of Beams
3. Installation and Performance of Electrical Resistance Strain Gauges
4. Strain Measurement Using Electrical Resistance Strain Gauges – Combined Loading
5. Shear Center Position of Thin-Walled Beams
6. Transmission and Reflection Polariscope Experimental Set-up & Working Principle
7. Calibration of a Photoelastic Specimen
8. Fabrication of a Composite Laminates Using Hand Lay-Up/Vacuum Bagging
9. Mechanical Testing and Experimental Characterization Studies
10. Non-Destructive Evaluation of Composites – Ultrasonics / Acoustic Emission
11. Fatigue Testing of 3-D Printed Specimens
12. Behaviour& Buckling Load of Practical Columns
13. Failure and Strength of Thin –Walled Columns
14. Experimental Modal Analysis
15. Forced Vibration and Resonance Testing of Aircraft & Aerospace Components

***Minimum 10 Experiments need to conduct from the above**

Weightage: Continuous Assessment: 60%, End Semester Examinations: 40%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Conduct experiments on symmetrical and unsymmetrical bending of beams and evaluate stress–strain behaviour using strain measurement techniques.	PO1 (3), PO4 (3)	3	3
CO2	Install and use electrical resistance strain gauges and photoelastic techniques for experimental stress analysis under various loading conditions.	PO4 (3), PO5 (3)	3	3

CO3	Fabricate composite laminates and perform mechanical, fatigue, and buckling tests to characterize structural performance.	PO1 (3), PO4 (3), PO5 (3)	3	3
CO4	Perform non-destructive evaluation, modal analysis, and vibration testing of aerospace structures and interpret experimental results.	PO4 (3), PO5 (3), PO12 (2)	3	3

Semester III

AO25301	Industrial Training	L	T	P	C
		0	0	0	2

Course Objectives:

To understand, learn and apply the principles and practices of Aircraft/Launch Vehicle/Satellite/Drones or Relevant areas in Industrial Utilities through hands on training.

Guidelines:

- Each student has to undergo Industrial training for a minimum period of four weeks during the upcoming summer vacation (i.e., between II and III Semester).
- The Internship has to be undergone continuously for the entire period.
- The Internship must be carried out in an Aero related industry.
- The End Semester Examination must be conducted at the start of III Semester.
- The mark will be based on the project report (Introduction; Project or Training details; Techno Economics; Discussion; and Conclusion) and their presentation followed by oral examination on the same by internal examiner.

Weightage:

Assessment: 100%

AO25302	Project Work I	L	T	P	C
		0	0	12	6

Course Objectives:

The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

Guidelines:

- Each PG student shall work individually on a selected specific topic which shall be approved by the Head of the Division under the supervision of a Faculty Member (Guide / Supervisor) who is familiar in the selected specific topic. The selected specific topic maybe theoretical and or experimental and or simulation and or case study. The students' Project Work – Phase I shall be evaluated through Internal Examination and End Semester Examination.
- The Internal Examination must be conducted periodically (Zeroth, First, Second and third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.
- At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Project Work – Phase I Report must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary hypothesis and or experimental setup and or simulation and or case study for carrying out the research project work along with preliminary results; discussions, relevant conclusions and future direction along with specified references.
- The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner

Weightage: Assessment: 100%

Semester IV

AO25401	Project Work II	L	T	P	C
		0	0	24	12

Course Objectives:

The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

Guidelines:

- The student may continue to work on the Project Work – I's selected topic as per the formulated efficient methodology under the same Faculty Member (Guide/Supervisor).
- The students' Project Work – II shall be evaluated through Internal Examination and End Semester Examination.
- The Internal Examination must be conducted periodically (First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.
- At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Thesis (Project Work – II Report) must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary theoretical hypothesis and or experimentation and or simulation and or case study for carrying out the research project work along with complete results with critical analysis and detail discussions, followed by relevant conclusions, along with specified references.
- The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner

Weightage:

Assessment: 100%

PROGRAMME ELECTIVE COURSES

AO25001	Rocketry and Space Mechanics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

- To impart knowledge on the different concepts and Laws related to planetary motion and space mechanics.
- To impart knowledge on satellite orbit transfer and factors affecting satellite life time
- To impart knowledge on rocket motion and analytical methods related to rocket motion for different conditions.
- To impart knowledge on rocket aerodynamics and how it varies with Mach number.
- To impart knowledge on different methods of rocket control and methods of staging and stage separation in rockets.

Orbital Mechanics: Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Librations points – Estimation of orbital and escape velocities.

Satellite Dynamics: Types of Satellite Orbits – Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – orbit transfer and examples – Hohmann orbits – calculation of orbit parameters – Determination of satellite rectangular coordinates from orbital elements.

Rocket Motion: Principle of operation of rocket motor – thrust equation – one dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories – determinations of range and altitude – simple approximations to burnout velocity.

Rocket Aerodynamics: Description of various loads experienced by a rocket passing through atmosphere – Airframe components - Drag estimation – Wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – Rocket stability – Rocket dispersion – Launching problems.

Staging and Control of Rocket Vehicles: Need for multi staging of rocket vehicles – Types of Multi staging – multistage vehicle optimization – stage separation dynamics and separation techniques- Aerodynamic and jet control methods of rocket vehicles – SITVC.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

References:

1. Parker, ER, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.
2. Suresh. B N & Sivan. K, "Integrated Design for Space Transportation System", Springer India, 2015.
3. Sutton, GP, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th Edition, 2010.
4. Van de Kamp, "Elements of Astromechanics", Pitman Publishing Co., Ltd., London, 1980.

5. Cornelisse, JW, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982.
6. Howard D. Curtis, “Orbital Mechanics for Engineering Students (with MATLAB examples)”, Butterworth-Heinemann Publishing, 4th edition, 2019.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the fundamental laws of orbital mechanics and analyze two-body and three-body problems.	PO1 (3), PO2 (3)	3	3
CO2	Calculate orbital parameters and perform conceptual trajectory designs for geocentric and interplanetary missions.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Evaluate planar motion of rockets and aerodynamic forces and moments acting on missile airframes under different flight conditions.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Conceptually design optimal multistage rockets and compare different stage separation methods.	PO1 (3), PO3 (3), PO5 (2)	3	3

AO25002	Avionics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the basic of avionics systems and its need for civil and military aircrafts.
- To impart knowledge on different avionic architecture and various avionics data buses.
- To impart knowledge on different cockpit displays and display technologies.
- To impart knowledge on different navigation systems and their operating principles.
- To impart knowledge on the functions of FMS and Ilities of avionics.

Introduction to Avionics: Need for avionics in civil and military aircraft and space systems – System Integration - Integrated avionics and weapon systems – Typical avionics subsystems, Air data quantities – Altitude, Air speed, Vertical speed, Mach number - design, technologies – Introduction to Digital Computer and memories.

Digital Avionics Architecture: Evolution of Avionics system architecture – Hardware and Software Redundancy- Data buses – MIL-STD-1553B – ARINC – 429 – ARINC – 629– AFDX.

Flight Decks And Cockpits: Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen –Direct voice input (DVI) – Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS.

Introduction To Navigation Systems: Dead Reckoning systems– Inertial sensors– Inertial Navigation Systems (INS) – INS block diagram – Radio navigation – Hyperbolic Navigation - ILS, MLS –– Satellite Navigation Systems – GPS– Waypoint Navigation – INS GPS Hybrid Navigation – RNAV.

Auto Pilot And FMS: Functions of FMS – Auto pilot – FADEC - Basic principles, Longitudinal and lateral auto pilot - Ilities of Avionics, Reliability, Availability, and Maintainability – BITE.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Middleton, D.H., Ed., Avionics systems, Longman Scientific and Technical, LongmanGroup UK Ltd., England, 1989.
2. Pallet.E.H.J., Aircraft Instruments and Integrated Systems, Longman Scientific, 1992.
3. Spitzer, C.R. Digital Avionics Systems, Prentice-Hall, Englewood Cliffs, N.J.,U.S.A.1993.
4. Spitzer. C.R. The Avionics Hand Book, CRC Press, 2000.

5. Mike Tooley, David Wyatt, “Aircraft Communications and Navigation Systems”, Second Edition, Eoutledge (Taylor & Francis group), 2017.
6. Albert Helfrick.D., Principles of Avionics, Avionics Communications Inc., 7th Edition, 2012.
7. Collinson.R.P.G. Introduction to Avionics, Chapman and Hall, 2003.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the need for avionics in aircraft and describe the functions of basic aircraft systems.	PO1 (3), PO2 (2)	3	2
CO2	Select suitable avionics architectures, explain the functions of a data bus, and describe cockpit display technologies.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Explain the importance and operating principles of navigation systems.	PO1 (3), PO2 (2), PO3 (2)	3	3
CO4	Explain the functions of autopilot and compare different types of airspeeds.	PO1 (3), PO3 (2)	3	2

AO25003	Aerospace Materials for Aeronautical Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To get insights into the basic aspects of material science and mechanical behavior of materials.
- To provide basic idea on ferrous and non-ferrous materials
- To gain knowledge on the analysis and manufacturing methods of composite materials
- To gain knowledge on smart materials.
- To provide basic idea on high temperature characterization.

Material Science And Mechanical Behavior Of Engineering Materials: Crystallography of metals & metallic alloys – Imperfections – Dislocations in Different Crystal Systems – Effect on plasticity – Strengthening Mechanisms Due to Interaction of Dislocations with Interfaces – Other Strengthening Methods – Dislocation Generation Mechanisms - Stress-strain curve and mechanical behavior of materials – linear elasticity and plasticity – failure of ductile and brittle materials – use of failure theories – maximum normal stress and maximum shear stress failure theories – importance of the octahedral stress failure theory – failure theories based on strain energy – cyclic loading and fatigue of materials – the S-N curve

Ferrous And Non-Ferrous Materials: Metals and alloys used for different aerospace applications – Properties of conventional and advanced aerospace alloys – Effect of alloying elements – Summary of conventional and state-of-the-art manufacturing processes – Types of heat treatment and their effect – other processing parameters – Materials for aerospace application – Design requirements & standards

Ceramics And Composites: Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites.

Smart Materials: Introduction to Smart Materials, Principles of Piezoelectricity, Perovskite Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magneto strictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids

High Temperature Materials: Classification, production and characteristics, Methods and testing, Determination of mechanical and thermal properties of materials at elevated temperatures, Application of these materials in Thermal protection systems of Aerospace vehicles, High temperature material characterization.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)
REFERENCES: 1. Gupta S Chand Balram & Co, Aerospace material ,2009 2. Parker ER, Materials for Missiles and Space, Mc Graw-Hill 1963 3. Titterton G F Lienhard V, Aircraft Material and Processes, English Book Store, New Delhi 5th Ed.,1998 4. H Buhl, Advanced Aerospace Materials, Springer, Berlin 1992 5. Brian Culshaw, Smart Structures and Materials, Artech House, 2000

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Apply knowledge of mechanical behavior and selection criteria of materials for aerospace and engineering applications.	PO1 (3), PO2 (2)	3	3
CO2	Understand and evaluate the properties of ferrous, non-ferrous, and high-temperature materials used in the aerospace industry.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Explain the applications of aluminum alloys, ceramics, composites, and smart materials in aerospace engineering.	PO1 (3), PO3 (2)	3	3
CO4	Characterize and assess the performance of advanced materials under various aerospace operating conditions.	PO1 (3), PO3 (3)	3	3

AO25004	Aircraft Engine Repair and Maintenance	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will make students

- Understand the principles and components of piston engines.
- Analyze propeller systems and perform inspections and repairs.
- Develop skills for engine inspection, testing, and repair procedures.
- Gain knowledge of jet engine types, maintenance, and troubleshooting.
- Acquire skills for jet engine overhaul and component balancing.

Basic Of Piston Engine Inspection And Maintenance: Classification of piston engines - Principles of operation - Function of components – Materials used- Details of starting the engines- 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. Routine maintenance and inspection procedures for piston engines Pre-flight inspections, oil changes, filter replacements, etc. Troubleshooting - Inspection of all engine components – Daily and routine checks-Overhaul procedures Overview of engine overhaul process- Major maintenance tasks, component replacements, and inspection during overhaul

Propeller Inspection And Repair: Basic principles and concepts of propeller operation- Propeller terminology and characteristics - 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- Guidelines for determining the permissible limits of propeller damage- Repair procedures for various types of propeller damage

Engine Inspection, Testing And Repair: Symptoms of failure-Fault diagnostics-Case studies of different engine systems-Rectification during testing- equipments for overhaul: Step-by-step procedures for engine overhaul Disassembly, cleaning, inspection, repair, and reassembly processes 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. Compression testing of cylinders-Special inspection schedules - Engine fuel, control and exhaust systems - Engine mount and supercharger-Checks and inspection procedures.

Jet Engine Inspection and Maintenance: 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-Techniques and procedures for conducting maintenance tasks while the engine is operational-Special inspection procedures-Foreign Object Damage-Blade damage.

Jet Engine Overhaul and Troubleshooting: 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- Incorporating updates and modifications during engine overhaul- Safety Considerations in Overhaul- Maintenance record management and traceability

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Turbomeca, "Gas Turbine Engines ", The English Book Store ", New Delhi,1993.
2. UnitedTechnologies'Pratt&Whitney,"TheAircraftGasturbineEngineanditsOperation", The English Book Store, New Delhi.
3. Kroes&Wild,"AircraftPowerplants",7thEdition- McGrawHill, New York, 1994.
4. Jeppesen Sanderson "A & P Technician Powerplant Textbook" 2nd edition, Jeppesen Sanderson, 2004

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Understand piston engine principles and identify engine components.	PO1 (3), PO2 (2)	3	3
CO2	Perform propeller inspections, repairs, and checks according to criteria.	PO3 (3), PO5 (2)	3	3
CO3	Apply engine testing and diagnostic techniques for maintenance and troubleshooting.	PO2 (3), PO4 (3)	3	3
CO4	Demonstrate proficiency in jet engine inspection, maintenance, and overhauling.	PO3 (3), PO5 (3)	3	3

AO25005	Experimental Aerodynamics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: of this course are

- This course will enable the students to learn basics of wind tunnel operation and its associated measurements.
- To present the concepts of different flow visualization methods.
- This course also imparts knowledge on flow measurement variables
- This course enables students to be familiar with data acquisition methods pertaining to experiments in aerodynamics.
- This course will help students to do uncertainty analysis for their experiments.

Low Speed Tunnel: Objective of experimental studies, Types of wind tunnels, Low speed tunnel, Energy ratio, Power losses in a wind tunnel – Calibration of subsonic wind tunnels – Speed Setting – Flow Direction – Three-Hole and Five-Hole Yaw Probes – Turbulence – Wind tunnel balance – Water tunnel.

High Speed Tunnel: Transonic wind tunnel – Transonic Test Section – Supersonic wind tunnels – Losses in Supersonic Tunnels – Supersonic Wind Tunnel Diffusers – Effects of Second Throat – Runtime calculation – Calculating Air Flow Rates – Calibration of Supersonic Wind Tunnels – Hypersonic wind tunnel and Calibration – Ludwieg Tube – Shock tube and shock tunnels – Gun tunnel – Plasma arc tunnels – Measurement of shock speed.

Flow Visualization Techniques: Visualization techniques – Smoke tunnel –- Dye Injection – Bubble Techniques – Surface Flow Visualization techniques – oil – Tufts – China Clay – Ultraviolet Fluorescence Photography – Interferometer – Fringe-Displacement method – Shadowgraph – Schlieren system – Background Oriented Schlieren (BOS) system – Laser sheet flow visualization.

Measurements Of Properties: Pressure measurement techniques-Pitot, Static, and Pitot-Static Tubes-Pitot-Static tube characteristics – Pressure Sensitive Paints - Pressure transducers – Velocity measurements – Hot-wire anemometry-Constant current and Constant temperature Hot-Wire anemometer – Hot-film anemometry - Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV)- Temperature measurements – Measurement of heat flux – Foil type heat flux gauge – Transient analysis of foil gauge – Thin film sensors – Slug type heat flux sensor.

Data Acquisition Systems and Uncertainty Analysis: Data acquisition and processing – Signal conditioning – Statistical analysis of experimental data – Regression analysis – Estimation of measurement errors – Uncertainty calculation – Uses of uncertainty analysis.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Rathakrishnan, E, “Instrumentation, Measurements, and Experiments in Fluids”, CRC Press – Taylor & Francis, 2007.
2. Robert B Northrop, “Introduction to Instrumentation and Measurements”, Second Edition, CRC Press, Taylor & Francis, 2006.
3. Allan Pope and Kenneth L Goin, “High Speed Wind Tunnel Testing”, Krieger Publishing Company, 1978.
2. Jewel B. Barlow, Willian. H.Rae and Allan Pope, “Low-Speed Wind Tunnel Testing”, Wiley-Interscience, 3rd edition, 1999.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Have knowledge on measurement of flow properties in wind tunnels and their associated instrumentation.	PO1 (3), PO2 (2)	3	3
CO2	Demonstrate and conduct experiments related to subsonic and supersonic flows.	PO3 (3), PO5 (3)	3	3
CO3	Explain flow visualization techniques for subsonic and supersonic flows.	PO2 (3), PO4 (2)	3	3
CO4	Calibrate transducers and other flow measurement devices, and perform error estimation and uncertainty analysis of experimental data.	PO4 (3), PO5 (3)	3	3

AO25006	Computational Heat Transfer for Aeronautical Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

- To get insights into the basic aspects of various discretization methods.
- To provide basic ideas on the types of PDE's and its boundary conditions to arrive at its solution.
- To impart knowledge on solving conductive, transient conductive and convective problems using computational methods.
- To solve radiative heat transfer problems using computational methods.
- To provide a platform for students in developing numerical codes for solving heat transfer problems.

Introduction: Introduction-Taylor's series expansion-Discretization Methods Forward, backward and central differencing scheme for first order and second order Derivatives. Types of partial differential equations-Types of errors-Solution to algebraic equation-Direct Method and Indirect Method-Types of boundary condition-FDM - FEM - FVM.

Governing Equations for Fluid Flow and Heat Transfer: Governing Equations in fluid flows-Continuity, momentum and energy equation-turbulence model, governing equations in conductive heat transfer-Cartesian, cylindrical and spherical coordinate, Governing equations convective- Force and free convection and radiative heat transfer.

Finite Difference Formulation for Conductive Heat Transfer: General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with Heat generation-without Heat generation- 2D-heat conduction problem with different boundary conditions- Numerical treatment for extended surfaces- Numerical treatment for 3D-Heat conduction- Numerical treatment to 1D-steady heat conduction using FEM. Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes formulation (FDM) of One– dimensional un-steady heat conduction –with heat Generation-without Heat generation - 2D-transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes-Importance of Courant number- Analysis for I-D,2-D transient heat Conduction problems.

Finite Difference Formulation for Convective and Radiative Heat Transfer: Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection- diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme-Stream function-vorticity approach-Creeping flow. Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method - Montecarlo Method- Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems. Error analysis in comparison with FDM

Numerical Approach for Heat Transfer Problems: Introduction, Addition and Subtraction of Two Matrices, Program for Solving M × N Matrix, 5 Jacobi's Iterative Method for Solving Matrix, Coding for One-Dimensional Heat Conduction in a Slab with Temperature Specified Boundary Condition, Coding for Transient Heat Conduction in a Slab with Temperature Specified Boundary Condition, Convection and Radiation problems using any one of the programming languages namely C, c++, MATLAB and Python.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Chung,TJ, "Computational Fluid Dynamics", Cambridge University Press, 2002.
2. Holman,JP, "Heat Transfer", McGraw-Hill Book Co, Inc.,McGraw-Hill College; 8th / Disk edition, 1997.
3. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017.
4. John H. Lienhard, "A Heat Transfer", Text Book, Dover Publications, 4th edition, 2013.
5. Sachdeva,SC, "Fundamentals of Engineering Heat & Mass Transfer", New age publisher, 4th edition Internationals, 2017
6. Richard H. Pletcher, John C. Tannehill & Dale Anderson, "Computational Fluid Mechanics and Heat Transfer", 3rd edition, CRC Press, 2012
7. Thanigaiarasu S, "Computational Fluid Dynamics and Heat transfer", IK International Publishing House, 2021.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Understand discretization methodologies for solving heat transfer problems.	PO1 (3), PO2 (2)	3	3
CO2	Solve two-dimensional conduction and convection heat transfer problems.	PO1 (3), PO3 (3)	3	3
CO3	Develop solutions for transient heat conduction in simple geometries.	PO2 (3), PO3 (2)	3	3
CO4	Formulate numerical solutions for conduction and radiation heat transfer problems and develop basic numerical codes for practical engineering applications.	PO2 (3), PO5 (3)	3	3

AO25007	Mechanics of Composite Materials	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To provide the basic knowledge on the properties of fiber and matrix materials used in commercial composites as well as some common manufacturing techniques.
- To determine stresses and strains in composites and also imparts an idea about the manufacturing methods of composite materials
- To impart knowledge on the macro mechanics of composite materials.
- To get the knowledge in failure moddes of composites
- To get an idea on failure theories of composites

Introduction To Composite Materials: Definition and classification of composite materials - Polymer Matrix Composites - Metal Matrix Composites - Ceramic Matrix Composites - Carbon-Carbon Composites. Reinforcements and Matrix Materials - Layup and curing, fabricating process - open and closed mould process, Hand layup techniques- structural laminate bag molding - production procedures for bag molding - filament winding, pultrusion - pulforming, thermo-forming - injection molding- blow molding.

Micromechanics Of Composites: Density- Mechanical Properties- Prediction of Elastic Constants- Micromechanical Approach - Halpin-Tsai Equations - Transverse Stresses- Thermal Properties - Expression for Thermal Expansion Coefficients of Composites - Expression for Thermal Conductivity of Composites - Mechanics of Load Transfer from Matrix to Fiber - Load transfer in Particulate Composites.

Macromechanics of Composites: Elastic Constants of an Isotropic Material - Elastic Constants of a Lamina - Relationship between Engineering Constants and Reduced Stiffnesses and Compliances - Variation of Lamina Properties with Orientation - Analysis of Laminated Composites - Stresses and Strains in Laminate Composites - Inter-laminar Stresses and Edge Effects - Numerical Problems.

Monotonic Strength and Fracture: Tensile and Compressive strength of Unidirectional Fiber Composites - Fracture Modes in Composites - Single and Multiple Fracture – Debonding - Fiber Pullout and Delamination Fracture - Strength of an Orthotropic Lamina - Maximum Stress Theory - Maximum Strain Criterion - Tsai-Hill Criterion -Tsi -Wu tensor theory- Comparison of Failure Theories.

Failure Analysis and Design of Laminates: Special cases of Laminates - Symmetric Laminates - Cross-ply laminates - Angle ply Laminates - antisymmetric Laminates - Balanced Laminate - Failure Criterion for a Laminate - Design of a Laminated Composite - Numerical Problems.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004
2. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
3. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993
4. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993
5. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
6. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012
7. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Identify the properties of fiber and matrix materials used in commercial composites.	PO1 (3), PO2 (2)	3	3
CO2	Select appropriate manufacturing processes for fabricating composite components.	PO3 (3), PO5 (3)	3	3
CO3	Predict the failure strength of laminated composite plates.	PO2 (3), PO3 (2)	3	3
CO4	Analyze linear elasticity with emphasis on isotropic and anisotropic material behavior, and apply principles for analysis, design, optimization, and testing of advanced composite structures.	PO1 (3), PO4 (3)	3	3

AO25008	Introduction to Aerospace Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: of this course are

- To introduce the basic concepts of aerodynamics.
- To impart knowledge about steady flight performance of conventional aircraft.
- To provide basic knowledge on static stability and trim requirements of aircraft.
- To impart knowledge on different types of engines used on aircraft and modern materials.
- To provide basic knowledge on rocket types and trajectories.

Essentials Of Aerodynamics: Classification of flight vehicles - Anatomy of flight vehicles - Airfoil and wing nomenclature - Aerodynamic forces - lift and drag - high lift devices - Mach number and different speed regimes - International Standard Atmosphere (ISA) - Pitot static tube – IAS, EAS and TAS - Types of drag and methods of drag reduction in airplanes.

Flight performance: Steady and level flight - Thrust and Power required curves - Cruise velocity expression - Stall velocity -Steady climb - ROC and Climb angle - Powerless glide - ROD and Glide angle - Range and Endurance of jet and propeller-driven aircraft.

Introduction To Stability and Control: Principles of stability and control - Longitudinal stability - Criteria and contribution - Trim requirements - Elevator control power - Weathercock stability - Contribution from components - Rudder requirements - Dihedral effect - contribution of various components - aileron control.

Aircraft Propulsion and Materials: Thrust equation - Working of Gas Turbine Engines - relative advantages and disadvantages. Introduction to Aircraft structures - load carrying members on Wing and Fuselage - Different types of construction - Materials used on modern airplane and their requirements.

Fundamentals Of Rocket Motion: Elements of rocket propulsion - types of rocket and their applications - Rocket parameters – two-dimensional rocket motion in free space - rocket trajectories – need for multi-staging – rocket performance.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Shevell, R. A., Fundamentals of Flight, 2nd edition, 2004, Pearson Education.
2. Pilot's Handbook of Aeronautical Knowledge, 2016, FAA-H-8083-25B.
3. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd edition, 2009, McGraw-Hill.
4. Anderson, J.D., Introduction to Flight, 9th edition, 2022, McGraw-Hill.

5. Kermode, A.C., Flight without Formulae, , 11th edition, 2011, Pearson Education.

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Determine atmospheric properties at a given altitude using ISA and categorize flight vehicle configurations.	PO1 (3), PO2 (2)	2	3
CO2	Evaluate cruise, climbing, and gliding performance of a given aircraft.	PO2 (3), PO3 (3)	3	1
CO3	Analyze longitudinal, directional, and lateral stability and ensure trim of a flight vehicle design.	PO1 (3), PO3 (3)	3	3
CO4	Select appropriate propulsion systems based on design requirements, identify structural components of an airplane, and calculate velocity increment of single and multi-stage rockets.	PO2 (3), PO4 (3), PO5 (2)	3	3

AO25009	Industrial Aerodynamics	L	T	P	C
		3	0	0	3

Atmosphere: Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows.

Wind Energy Collectors: Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

Vehicle Aerodynamics: Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics of trains and Hovercraft.

Building Aerodynamics: Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Special problems of tall buildings, Building codes, Building ventilation and architectural aerodynamics.

Flow Induced Vibrations: Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. M.Sovran (Ed), "Aerodynamics and drag mechanisms of bluff bodies and road vehicles", Plenum press, New York, 1978.
2. N.G. Calvent, "Wind Power Principles", Charles Griffin & Co., London, 1979.
3. P. Sachs, "Winds forces in engineering", Pergamon Press, 1978.
4. R.D. Blevins, "Flow induced vibrations", Van Nostrand, 1990.

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain atmospheric wind characteristics, boundary layer development, terrain effects, and turbulent flow behavior in industrial environments.	PO1 (3), PO2 (3)	2	2
CO2	Apply aerodynamic principles to analyze and estimate performance of wind energy systems using momentum theory and power coefficient concepts.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO3	Analyze aerodynamic forces and drag characteristics of automobiles, trains, hovercraft, and low-rise/high-rise buildings under wind loading conditions.	PO1 (3), PO2 (3), PO3 (2)	3	2
CO4	Evaluate flow-induced vibration phenomena in bluff bodies and structures, including vortex shedding, galloping, and stall flutter.	PO1 (3), PO2 (3), PO4 (3)	2	3

AO25010	Theory of Elasticity and Plasticity	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To learn the basic concepts and equations of elasticity.
- To provide with the concepts of plain stress and strain related problems.
- To gain knowledge on equilibrium and stress-strain equations of polar coordinates
- Will be exposed to axisymmetric problems.
- To get insight into the basic concepts of plates and shells.

Introduction: Elasticity – Stresses - notation for force, stress and strain – Hooke's law – Relation between elastic constants – Equilibrium and compatibility equations – Analysis of stress, strain and deformation – Stress and strain transformations equations – Cauchy's formula – Principal stress and principal strains in 2D & 3D – Octahedral stresses– Boundary conditions- Stress Function.

Concept Of Stresses and Strains: Plane stress and plane strain problems – Airy stress function – Biharmonic equation –Compatibility equation in terms of stress – Solution of bar and beam problems using the elasticity approach – torsion and bending of non – circular prismatic bars – Determination of stresses, strain and displacements – Warping of cross-sections – Prandtl's stress function approach – polynomial solution - St. Venant's method.

Polar Coordinates: Strain components in polar coordinates – Equilibrium and stress-strain equations in polar coordinates – Effect of circular holes in plates – Stress concentration – Bending of a curved beam (Winkler-Bach theory) – Deflection of a thick curved bar –. rotating discs, walled cylinders, infinite plate with point load

Axisymmetric Problems: Equilibrium and stress-strain equations in cylindrical coordinates – Lame's problem – Thick-walled cylinders subject to internal and external pressure – Application of failure theories – Stresses in composite tubes – Shrink fitting – Stresses in rotating discs Stresses due to gravitation –– Rotating shafts and cylinders – Application of Thick cylinders

Introduction To Plasticity & Yield Criteria: Overview of plasticity and its importance in engineering-Brief history and development of plasticity theory-Basic concepts: stress, strain, deformation, and yield criteria-Review of stress and strain tensors-Equilibrium equations and compatibility conditions-Constitutive equations: linear elasticity and plasticity-Overview of yield criteria and their significance Tresca yield criterion-Von Mises yield criterion-Other yield criteria: Mohr-Coulomb, Drucker-Prager, etc.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Harry Kraus, “Thin Elastic Shells”, John Wiley and Sons, 1987.
2. Flugge, W, “Stresses in Shells”, Springer – Verlag, 1985.
3. Timoshenko, S.P. Winowsky. S., and Kreger, “Theory of Plates and Shells”, McGraw Hill Book Co., 1990.
4. Varadan, TK and Bhaskar,K, “Analysis of plates-Theory and problems”, Narosha Publishing Co., 2001
5. Grewal B.S., “Higher Engineering Mathematics”, 44th Edition, New Delhi, 2017. Khanna Publishers.
6. Timoshenko S. P. and Goodier J. N. – ‘Theory of Elasticity’- McGraw Hill International Editions, 1970 – 3rd Edition
7. Sadd, M. H., Elasticity: Theory, Applications, and Numerics , 3rd ed., Academic Press (2014)

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand basic elasticity relationships, stress–strain relations, and fundamental governing equations.	PO1 (3), PO2 (2)	2	2
CO2	Perform stress analysis in two-dimensional and three-dimensional problems.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Formulate constitutive and governing equations and solve elasticity problems in Cartesian and cylindrical coordinate systems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Determine stress, strain, and displacement fields for common axisymmetric members and practical engineering components.	PO1 (3), PO2 (3), PO4 (2)	3	2

AO25011	Helicopter Aerodynamics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will make students

- This course will make students to provide with introductory concepts of types of rotorcrafts.
- This course imparts knowledge on the fundamental aspects of helicopter aerodynamics and performance of helicopters.
- This course will provide basic knowledge on the performance of helicopters.
- This course presents stability and control aspects of helicopters.
- This course will explore the basic aerodynamic design aspects of helicopters.

Helicopter Aerodynamics: Types of rotorcrafts – auto gyro, gyrodyne, helicopter, Configuration Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti-torque pedals.

Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, induced velocity, local solidity, performance of ideally twisted constant chord blade, rapid performance in hover.

Performance In Hover and Climb: Optimum hover rotor, induced torque, profile drag torque, performance equation, optimum rotor design, ground effect, Flow stated of rotor-Normal working state, vortex-ring state, windmill state, vertical descent performance, autorotation diagram.

Performance In Horizontal Flight: Flapping and lag hinge, steady hover, equilibrium in horizontal blade, blade hinge motion, induced velocity, blade element angle of attack, flapping coefficient, Forward flight-performance equation, drag-lift ratio, parasite drag coefficient, climb drag lift ratio, blade stall.

Stability And Control: Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

Aerodynamic Design: Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep, vibration problem of Helicopter blades.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Gessow.A and Meyers,GC, “Aerodynamics of the Helicopter”, Macmillan and Co., New York,1982.
2. John Fay, “The Helicopter”, Himalayan Books, New Delhi, 1995.
3. Lalit Gupta, “Helicopter Engineering”, Himalayan Books, New Delhi, 1996.

4. Lecture Notes on Helicopter Technology, Department of Aerospace Engineering, IIT –Kanpur and Rotary Wing aircraft R&D center, HAL, Bangalore, 1998.
5. Seddon,J, “Basic Helicopter Aerodynamics”, AIAA Education series, Blackwell scientific publications, U.K, 1990.
6. Rathakrishnan, Ethirajan. Helicopter Aerodynamics. PHI Learning Pvt. Ltd., 2018.

CO	Description of CO	PO	PSO1	PSO2
CO1	Describe and compare helicopter structures and configurations.	PO1 (3), PO2 (2)	2	2
CO2	Analyze aerodynamic components and evaluate performance characteristics of rotary wing aircraft.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Explain aerodynamic factors influencing rotary wing flight and helicopter stability.	PO1 (3), PO2 (3)	3	2
CO4	Analyze helicopter control systems and evaluate vibration characteristics of helicopter blades.	PO1 (3), PO3 (3), PO4 (2)	3	3

AO25012	Airworthiness, Standards and Certification	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: of this course are

- To impart knowledge on the different phases involved in the design and development of avionic systems.
- To familiarize with aviation standards related to design & development of hardware & software.
- To impart knowledge on the need for certification and the airworthiness certification process.
- To impart knowledge on the need for reliability, maintainability and different methods of expressing reliability.

Avionics System Engineering Development Cycle: Establishing the Avionics System Requirements by Mission Scenario Analysis, Functional Analysis, Physical Partitioning, Avionics Architectural Design, Specification, Development & Procurement of HW/SW of Sub systems. Standalone testing of subsystems, Certification, Validation, Verification. SW/HW Integration, Systems Engineering Process Outputs, System Analysis and Control, System Work Breakdown Structure, Configuration Management, Flight Testing, Operational Test and Evaluation by user and Deployment.

Aviation Standards: Design Development & Manufacturing Standards Associated with Aircraft & Avionics systems. Aviation Standards of MIL, DEFSTAN-970, AIR - 2004, GOST & FAR Standards. Environmental Testing Standards (MIL-814), IEE Stds.

Design Standards for Airborne Electronic Hardware (DO-254)- Hardware Design Life Cycle Data, Hardware Design Processes, Certification, Validation & Verification Process, Safety Assessment Process, Configuration Management Process.
Standards for Aviation Software Design Phase (DO-170B)- Software Life Cycle, Planning, Certification, Verification, Configuration, Tool Qualification, SW Reliability Models & Assurance Process. Case Studies.
Certification Process During Integration of Aircraft Systems (SAE ARP4754) - Certification Process/Coordination. Safety Assessment, Validation, Verification, Configuration Mgt, Process Assurance. Case Studies

Airworthiness Certification: Civil & Military Aviation Certification, Regulatory and Advisory Agencies, Airworthiness Certification Process/Concepts, Type Records, Type Approval and Certificate of Design & Conformance, DDPMAS- 2022 (Vol 1&11), Certification approach in Re-Engineering & Indigenisation Process. SOFT concepts. Overview of Aircraft & Engine Certification.

Reliability & Maintainability Concepts In Avionics Systems: Reliability Concepts. Failure Rates, Infant Mortality curve, Reliability Definition, Types Reliability with Numerical Concepts of MTBF, MTTF and TBO. Maintainability, Maintenance and Availability concepts, Technical Reviews and Audits, Modeling and Simulation,

Metrics, Risk Management Planning
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)
Quality Assurance Process In Aviation: Concepts and Definitions of Quality, Quality Gurus, Dimensions of Quality, Total Quality Mgt(TQM) Concepts Quality Philosophies and Concepts: Deming 14 Points; Quality Circles, Zero Defects; 5S concepts, Poka Yoka, Kaizen, Lean philosophy etc. Management tools for Quality, 7 QC tools & Six Sigma Concepts. Standards of Quality Process like ISO 9000, AS 9000, ISO 14000, ISO TS 16949. Quality Measurements like SQC and SPC with numerical, Fish Bone Diagram, Parato Analysis with Case studies.

REFERENCES:

1. IEEE Std 1220-1998, IEEE Standard for Application and Management of the Systems Engineering Process, 2005.
2. Systems Engineering Fundamentals, Supplementary Text Prepared By Defence Acquisition University Press Fort Belvoir, Virginia 22060-5565, 2001
3. NASA Systems Engineering Handbook, SP-610S, June 1995
4. INCOSE, Systems Engineering Handbook, A “What To” Guide For All SE Practitioners, INCOSE-TP-2003-016-02, Version 2a, 1 June 2004
5. RTCA DO-178B/EUROCAE ED-12B, Software Considerations in Airborne Systems and Equipment Certification, RTCA Inc., Washington, D.C, 1992.
6. DO-254/EUROCAE ED-80, Design Assurance Guidance For Airborne Electronic Hardware, RTCA Inc., Washington, D.C, April 19, 2000
7. SAE ARP4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, SAE, Warrendale, PA, 1996.
8. SAE ARP4761, Guidelines and Methods for Conducting the Safety Assessment Process on Civil Aircraft Airborne Systems and Equipment, Warrendale, PA, 1996.
9. DDPMAS -2020 (Vol 1& 2)
10. Besterfield, D. H, & Besterfield, M.C., et al. (2018). Total Quality Management. 5th Edition, Pearson Publications.
11. Bedi, K. (2010). Quality Management. New Delhi: Oxford Press Publications.
12. Gaither, N. F.(2002). Production & Operations Management. New Delhi: Thomson Learning Publications.
13. Ramakumar R, ‘Engineering Reliability, Fundamental & Applications’, Pearson Publication, 1992.

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain the steps involved in the design and development of avionic systems.	PO1 (3), PO2 (2)	2	2
CO2	Apply aviation standards in the design and development of avionics hardware and software systems.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO3	Explain the importance of airworthiness certification and differentiate between various certification processes.	PO1 (3), PO4 (2)	2	3
CO4	Analyze system reliability, compare reliability evaluation methods, types of maintenance, and select appropriate quality assurance processes and management tools.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25013	Combustion in Jet and Rocket Engines	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To impart knowledge to the students and basic principles of combustion, types of flames and also make them familiarize the combustion process in gas turbine, ramjet, scram jet and rocket engines.

Thermodynamics Of Combustion: Staichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of thermochemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion.

Physics And Chemistry Of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow. Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

Premixed And Diffused Flames: One-dimensional combustion wave, Laminar premixed flame, burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame. Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.

Combustion In Gas Turbine, Ramjet And Scramjet: Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlled by decision mixing and heat convection.

Combustion In Chemical Rocket: Combustion in liquid propellant rockets. Combustion of solid propellants- application of laminar flame theory to the burning of homogeneous propellants, Combustion in hybrid rockets. combustion instability in rockets.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. D. P. Mishra . “Fundamentals of Combustion”, Prentice Hall of India, New Delhi, 2008.
2. H. S. Mukunda, “Understanding Combustion”, 2nd edition, Orient Blackswan,2009.
3. Kuo K.K. “Principles of Combustion” John Wiley and Sons,2005.
4. Warren C. Strahle, “An Introduction to Combustion”, Taylor & Francis, 1993.

CO	Description of CO	PO	PSO1	PSO2
CO1	Apply thermodynamic principles of combustion including stoichiometry, enthalpy relations, equilibrium analysis, and adiabatic flame temperature calculations.	PO1 (3), PO2 (3)	3	3
CO2	Analyze transport phenomena, reaction kinetics, and governing equations relevant to combustion processes.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Evaluate premixed and diffusion flames, flame stabilization, ignition, spray combustion, and solid fuel combustion mechanisms.	PO1 (3), PO2 (3), PO3 (2)	3	2
CO4	Assess combustion processes in gas turbines, ramjets, scramjets, and chemical rockets including combustion efficiency, instability, and propulsion performance.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25014	Advanced Propulsion Systems	L T P C 3 0 0 3

COURSE OBJECTIVES:

- This course will cover the basic aspects of thermodynamic cycle analysis of air-breathing propulsion systems.
- This course is intended to impart knowledge on advanced air breathing propulsion systems like air augmented rockets.
- This course will give the knowledge on the basic aspects of scramjet propulsion system.
- This course will provide in-depth knowledge about the nozzle performance.
- This course also presents vast knowledge on the operating principles of nuclear, electric and ion propulsion.

Thermodynamic Cycle Analysis of Air-Breathing Propulsion Systems: Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inlet charging process – Subcritical, Critical and Supercritical charging –Airbreathing Engine Performance Measures – Aerospace System Performance Measures

Ramjets and Air Augmented Rockets: Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – Integral Ram rocket.

Scramjet Propulsion System: Fundamental considerations of hypersonic air breathing vehicles – Preliminary concepts in engine airframe integration – calculation of propulsion flow path – flow path integration – Various types of supersonic combustors – fundamental requirements of supersonic combustors – Mixing of fuel jets in supersonic cross flow – performance estimation of supersonic combustors.
Nuclear Propulsion: Nuclear rocket engine design and performance – nuclear rocket reactors – nuclear rocket nozzles – nuclear rocket engine control – radioisotope propulsion – basic thruster configurations – thruster technology – heat source development – nozzle development – nozzle performance of radioisotope propulsion systems.
Electric And Ion Propulsion: Basic concepts in electric propulsion – power requirements and rocket efficiency – classification of thrusters – electrostatic thrusters – plasma thruster– Fundamentals of ion propulsion – performance analysis – ion rocket engine.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)
REFERENCES: 1. Cumpsty, “Jet propulsion”, Cambridge University Press, 2003. 2. Fortescue and Stark, “Spacecraft Systems Engineering”, Wiley, 4th edition, 2011. 3. Sutton, GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 1998. 4. William H. Heiser and David T. Pratt, “Hypersonic Air breathing propulsion”, AIAA Education Series, 2001.

CO	Description of CO	PO	PSO1	PSO2
CO1	Analyze thermodynamic cycles of air-breathing propulsion systems.	PO1 (3), PO2 (3)	3	3
CO2	Analyze concepts of supersonic combustion for hypersonic vehicles and demonstrate fundamental requirements of supersonic combustors.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Estimate performance parameters of advanced propulsion systems including nuclear and electric rockets.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO4	Evaluate engine–body installation effects and integration issues in hypersonic vehicles.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25015	Analysis of Composite Structures	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Theoretical knowledge in the concepts of micromechanics and macromechanics
- Understand the mathematical equations governing the behavior of composite plates
- Study and understand the classical lamination theory and analyze the behavior of composite laminates
- Understand the behavior of special laminates and knowledge of how laminated beams and plates should be designed
- Knowledge of methods of characterization and non-destructive evaluation

Behaviour of a Uni-Directional Lamina: Micromechanics – Prediction of Elastic Constants of a Uni-directional Lamina – Longitudinal Behaviour & Strength – Minimum & Critical Fibre Volume Fractions – Transverse Strength & Stiffness – Macromechanical Behaviour – Compliance & Stiffness Matrices – Transformation Equations for Stress and Strain – Plane Stress Analysis – Lamina Strength – Failure Criteria

Classical Lamination Theory: Governing Differential Equation – Classical Lamination Theory – Assumptions – Stress Resultants – Equilibrium Equations – Variation of Stress & Strain – Determination of Laminate Stiffness Matrix – Types of Laminate Configuration – Design, Response and Behaviour of Special Laminates – Laminate Stress and Failure Analysis – Hygrothermal Effects in a Laminate

Analysis Of Laminated Beams and Plates: Laminated Beam Analysis – Basic Assumptions – Equations of Equilibrium – Bending of a Laminated Beam – Eigenvalue Problem – Transverse Vibrations – Laminated Plate Analysis – Bending of Laminated Plates – Stress and Strength Analysis – Effect of Shear Deformation – Free Vibration Analysis of Composite Plates – Plate Stability Analysis

Design Of Composite Structures: Design of Special Laminates (Symmetric, Anti-symmetric, Balanced and Quasi-Isotropic) – Mathematical Analysis – Design Outline and Procedure – Possible Modes of Failure – Failure Analysis – Design Examples – Composite Stiffener Design – Laminate Design for Strength –Design for Stiffness – Composite Panel Subject to In-Plane and Combined Loading

Characterization And Non-Destructive Evaluation: Testing of Composites – Properties in Tension, Compression and Shear – Coupon Testing – Flexural Properties – 3 Point Bending Test – Measurement of Fracture Toughness – Critical Strain Energy Release Rate – Critical Stress Intensity Factor – J-Integral – Impact Properties – Non-Destructive Evaluation – Ultrasonics – Acoustic Emission – Radiography – Fractography

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)
REFERENCES: 1. n. Jones, “Mechanics of Composite Materials”, CRC Press, 2nd Edition, 2006.

CO	Description of CO	PO	PSO1	PSO2
CO1	Perform theoretical calculations in micromechanics and macromechanics of composite lamina.	PO1 (3), PO2 (3)	3	3
CO2	Apply Classical Lamination Theory (CLT) for analysis of composite laminates.	PO1 (3), PO2 (3), PO3 (2)	2	3
CO3	Design composite laminates including special and tailored laminate configurations.	PO1 (3), PO3 (3), PO5 (2)	3	1
CO4	Analyze failure modes of composite beams and plates, and carry out characterization and non-destructive evaluation of composite materials.	PO1 (3), PO2 (3), PO4 (2)	3	3

AO25016	Airframe Repair and Maintenance	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Understand welding principles and techniques for aircraft structural components.
- Develop proficiency in repairing and maintaining plastic and composite materials.
- Gain knowledge and skills in aircraft jacking, assembly, and rigging procedures.
- Familiarize with hydraulic and pneumatic systems in aircraft and their maintenance.
- Learn and apply safety practices for aircraft maintenance and operations.

Welding In Aircraft Structural Components: Equipment used in welding shop and their maintenance - Ensuring quality welds – Welding jigs and fixtures -Soldering and brazing. Sheet Metal Repair and Maintenance: Selection of materials; Fabrication of replacement patches; Tools-power/hand; Repair techniques; Close tolerance fasteners; Sealing compounds; forming/shaping; Calculation of weight of completed repair; Effect of weight - change on surrounding structure. Sheet metal inspection - N.D.T. Testing. Design considerations for riveted repairs in aircraft structures -Damage Investigation-Reverse engineering.

Plastics And Composites in Aircraft: Plastics in Aircraft: Review of types of plastics used in airplanes - Maintenance and repair of plastic components-Repair of cracks, holes etc., and various repairs schemes-Scopes. Advanced Composites in Aircraft: Tools and Equipment for Composite Repairs Cleaning of fibre reinforced plastic (FRP)materials prior to repair; Break test-Repair Schemes; FRP/honeycomb sandwich materials; laminated FRP structural members and skin panels; Tools/equipment; Vacuum-bag process.

Aircraft Jacking, Assembly and Rigging: Airplane jacking and weighing and C.G. Location. Balancing of control surfaces – Inspection maintenance. Helicopter flight controls. Tracking and balancing of main rotor. Aircraft Assembly Procedures-Rigging of Landing Gear Systems

Review Of Hydraulic and Pneumatic System: Troubleshooting and maintenance practices-Service and inspection-Inspection and maintenance of landing gear systems. - Inspection and maintenance of air-conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing - Inspection. Inspection and maintenance of auxiliary systems – Fire protection systems - Ice protection system - Functionality checks and servicing of position and warning systems-Auxiliary Power Units (APUs).

Safety Practices: Hazardous materials storage and handling, Aircraft furnishing practices - shooting. Theory and practices. Overview of essential safety equipment used in aviation- Types and functions of personal protective equipment (PPE)- Emergency Response and Preparedness

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)
REFERENCES: 1. Larry Reithmeir, “Aircraft Repair Manual ", Palamar Books, Marquette,1992. 2. Brimm D.J. Bogges H.E., "Aircraft Maintenance ", Pitman Publishing corp., NewYork,1940. 3. Delp. Bent and Mckinely “Aircraft Maintenance Repair”, McGraw Hill, NewYork,1987. 4. Kroes, Watkins, Delp, "Aircraft Maintenance and Repair ", McGraw Hill, New York, 1992.

CO	Description of CO	PO	PSO1	PSO2
CO1	Apply welding principles to inspect, repair, and maintain aircraft structural components.	PO1 (3), PO3 (3)	3	3
CO2	Perform repairs on plastic and composite materials used in aircraft structures.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO3	Demonstrate proficiency in aircraft jacking, assembly, and rigging techniques following standard maintenance procedures and safety practices.	PO3 (3), PO5 (3)	3	3
CO4	Inspect, troubleshoot, and maintain hydraulic and pneumatic systems in aircraft while implementing appropriate safety practices.	PO1 (3), PO2 (2), PO4 (2)	3	3

AO25017	Aircraft Systems Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will make students to

- Define and apply key concepts and principles of systems engineering.
- Analyze and evaluate aircraft systems and their design considerations.
- Understand the process of systems integration and architecture development.
- Demonstrate effective communication and stakeholder management skills in systems engineering.
- Apply reliability and maintainability principles to ensure system performance.

Introduction To Systems Engineering: Overview of Systems Engineering- Systems Engineering Concept Map-Interrelationships between different elements of a system-Systems Definition-System elements, interfaces, and interactions-The seven steps Systems Engineering-Conceptual System Design- System Engineering Process-Understanding the overall Systems Engineering process - Iterative nature of Systems Engineering-Role of Systems Engineering in different project phases -Requirements and Management-Trade Studies-Integrated Product And Process Development.

The Aircraft Systems and Design: Introduction- Everyday Examples of Systems-Aircraft Systems –Generic Systems-Product Life Cycle- Different Phases-Whole Life Cycle Tasks- Systems Analysis-Techniques and methodologies for analyzing aircraft systems - Identifying system requirements, constraints, and performance objectives-Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems-Mission analysis

System Architectures and Integration: Introduction- Systems Architectures – Modeling and Trade-Offs Evolution of Avionics Architectures- Systems Integration Definition-Examples of Systems Integration-Integration Skills- Management of Systems Integration-Future Trends in Systems Architectures and Integration

Practical Considerations and Configuration Control: Stakeholders-Communications- Criticism- Configuration Control Process-Portrayal of a System-Varying Systems Configurations- Compatibility-Factors Affecting Compatibility-Design considerations for achieving compatibility–Systems Evolution. Upgrades, modifications, and adaptation of systems to meet changing requirements - Considerations and Integration of Aircraft Systems- Risk Management.

Systems Reliability and Maintainability: Systems and Components-Analysis-Influence, Economics, Design for Reliability-Fault and Failure Analysis-System Life Cycle cost-Case Study-Maintenance Types-Program-Planning and Design.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Andrew P.Sage & James E.Armstrong, "Introduction to Systems Engineering", 1st edition, 2000.
2. Erik Aslaksen & Rod Belcher, "Systems Engineering", Prentice Hall,1992.
3. Ian Moir& Allan Seabridge, "Design and Development of Aircraft Systems", Wiley, 2nd edition,2012.
4. Ian Moir& Allan Seabridge, "Aircraft Systems Mechanical, electrical, and avionics subsystems integration", John Wiley & Sons Ltd,2011.
5. Peter. Sydenham, "Systems Approach to Engineering Design", Artech house, Inc, London, 2003.

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply systems engineering principles in practical aerospace scenarios.	PO1 (3), PO2 (3)	3	3
CO2	Evaluate and analyze aircraft systems and their key design drivers.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Develop system architectures and integration strategies in aviation while enhancing reliability and maintainability.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO4	Communicate effectively and manage stakeholders in systems engineering projects.	PO2 (3), PO3 (3), PO1 (2)	2	3

AO25018 Flight instrumentation

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- To learn the concept of measurement, error estimation and classification of aircraft instrumentation and displays.
- To study air data instruments and synchronous data transmission systems.
- To study gyroscopes and their purposes, aircraft compass system and flight management system.
- To study data compass and flight management systems.
- To impart knowledge about the basic and advanced flight instruments, their construction, and its operation.

Measurement Science and Displays: Instrumentation brief review - Concept of measurement - Functional elements of an instrument system- Transducers - classification of aircraft instruments-Requirements and standards – Instrument Elements and Mechanism - Instrument displays panels and cockpit layout, Aircraft instruments Grouping - Electronic Flight Instrument System.

Air Data Instruments and Synchro Transmission Systems: Earth's Atmosphere – Basic Air data system – Air Data instruments-airspeed, altitude, Vertical speed indicators - Probes – Position Error - Altitude alerting systems, Mach meter, Mach Warning system, Static Air temperature, Angle of attack measurement, Stall Warning system, Stick Shaker - Synchronous data transmission system – Synchros systems – Resolver synchros – Synchrotel

Gyroscopic and Advanced Flight Instruments: Gyroscope and its properties, gyro system, Gyro horizon, Erection systems for Gyro Horizons Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, turn coordinator, acceleration and turning errors, Standby Attitude Director Indicator, Gyro stabilized Direction Indicating Systems, Advanced Direction Indicators, Horizontal Situation Indicator.

Aircraft Compass Systems & Flight Management System: Aircraft magnetism - Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator. FMS- Flight planning-flight path optimization-operational modes-4D flight management

Power Plant Instruments & Flight Data Recording: Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, Engine Fuel Indicators, engine vibration monitoring, Cockpit Voice Recorder and Flight Data Recorder.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Pallet, E.H.J. Aircraft Instruments & Integrated systems, Dorl.ing Kindersley (India) Pvt. Ltd, 2011.
2. David Wyatt. 'Aircraft Flight Instruments and Guidance Systems', Routledge, Taylor & Francis Group, 2015.
3. Harry L. Stilz, Aerospace Telemetry, Vol I to IV, Prentice-Hall Space Technology Series, 1961.
4. Sawhney A.K, 'Electronic Measurements and Instrumentation' Dhanpat Rai & Co, 2017
5. Murthy, D.V.S., Transducers and Measurements, McGraw-Hill, 1995.

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply principles of measurement, classification of aircraft instrumentation, display systems, and layout standards.	PO1 (3), PO2 (2)	2	2
CO2	Explain and analyze air data systems and synchronous data transmission systems used in aircraft.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Apply gyroscopic principles to advanced aircraft instruments and flight systems.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO4	Classify aircraft magnetism effects, analyze compass systems, flight management systems (FMS) in 4D flight management, and evaluate power plant, engine instruments, and flight data recorder systems.	PO1 (3), PO3 (3), PO5 (2)	3	3

AO25019	Experimental Stress Analysis	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

- Be able to understand the various experimental techniques involved for measuring displacements, stresses, strains in structural components.
- To familiarize with the different types of strain gages used.
- To familiarize with the instrumentation system used for strain gauges.
- Be able to use photo elasticity techniques and methods for stress analysis.
- Be able to familiarize with the different NDT techniques.

Basics of Mechanical Measurements: Basic Characteristics and Requirements of a Measuring System – Principles of Measurements– Precision, Accuracy, Sensitivity and Range of Measurements – Sources of Error – Statistical Analysis of Experimental Data – Contact Type Mechanical Extensometers – Advantages and Disadvantages – Examples of Non -Contact Measurement Techniques.

Electrical-Resistance Strain Gauges: Strain Sensitivity in Metallic Alloys – Gage Construction – Gage Sensitivities and Gage Factor-Corrections for Transverse Strain Effects – Performance Characteristics of Foil Strain Gages-Materials Used for Strain Gauges – Environmental Effects – The Three-Element RectangularRosette for Strain Measurement – Other Types of Strain Gages – Semiconductor Strain Gages-Grid & Brittle Coating Methods of Strain Analysis.

Strain-Gauge Circuits & Instrumentation: The Potentiometer Circuit and Its Application to Strain Measurement – Variations from Basic Circuit –Circuit Output – The Wheatstone Bridge Circuit – Current and Constant Voltage Circuits – Analog to Digital Conversion – Calibrating Strain-Gage Circuits – Effects of Lead Wires and Switches – Electrical Noise -– Strain Measurement in Bars, Beams and Shafts – Circuit Sensitivity & Circuit Efficiency.

Photoelastic Methods Of Stress Analysis: Introduction to Photoelastic Methods – Stress-Optic Law – Effects of a Stressed Model in a Plane Polariscope – Effects of a Stressed Model in a Circular Polariscope - Tardy Compensation - Two-Dimensional Photoelastic Stress Analysis – Fringe Multiplication and Fringe Sharpening - Materials for Two-Dimensional Photoelasticity - Properties and Calibration of Commonly Employed Photoelastic Materials – Introduction to Three-Dimensional Photoelasticity.

Non-Destructive Testing: Different types of NDT Techniques - Acoustic Emission Technique – Ultrasonics – Pulse-Echo– Through Transmission – Eddy Current Testing – Magnetic Particle Inspection – X-RayRadiography – Challenges in Non-Destructive Evaluation – Non-Destructive Evaluation in Composites – Image Processing Basics.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Albert S. Kobayashi,' Handbook on Experimental Mechanics, Prentice Hall Publishers,2008.
2. Durelli, A.J.Applied Stress Analysis, Prentice Hall of India Pvt Ltd., New Delhi, 1970.
3. Hetenyi, M., Hand book of Experimental Stress Analysis, John Wiley and Sons Inc.,New York, 1972.
4. James F. Doyle and James W. Phillips, 'Manual on Experimental Stress Analysis', 5th Edition, 1989.

CO	Description of CO	PO	PSO1	PSO2
CO1	Analyze the performance characteristics of measuring instruments and instrumentation systems.	PO1 (3), PO2 (3)	1	3
CO2	Explain and apply different methods of strain measurement.	PO1 (3), PO2 (2), PO4 (2)	3	2
CO3	Design and analyze strain gauge circuits for stress and strain measurement applications.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO4	Apply photoelasticity techniques for stress analysis and evaluate different non-destructive testing (NDT) methods.	PO1 (3), PO2 (3), PO4 (2)	3	3

AO25020	NDT Methods	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To impart knowledge on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods
- To get insights into the basic aspects of electron microscopy.
- To learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods.
- To inspect the aircraft structures using NDT techniques.
- To get basic knowledge on the structural health monitoring of aerospace structures.

Introduction: Need for non-destructive evaluation (NDT) – Applications – Structural inspection – Structural deterioration due to corrosion and fatigue – Crack growth – Fabrication defects – Overloading – Detailed visual inspection – Unaided and aided – Aircraft wing and fuselage inspection using various NDT techniques – Overview and relative comparison of NDT methods – Jet engine inspection – Critical locations

Electron Microscopy: Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM.

Acoustic Emission and Ultrasonics: Sources of acoustic emission – Physical principals involving acoustic emission and ultrasonics – Configuration of ultrasonic sensors – Phased array ultrasonics – Instrument parts and features for acoustic emission and ultrasonics – Defect characterization – A-Scan, B-scan, C-scan – Inspection of cracks and other flaws in metals and composites – Interpretation of data – Image processing – Concepts and application.

Aircraft Inspection: Inspection Levels – General Visual Inspection – During pre, or post flight – Detailed Visual Inspection (DET) – Periodic inspection – Special Detailed Inspection (SDET) – Uses of NDT Methods – Jet Engine Inspection – Engine overhaul – Fluorescent penetrate inspection – Airframe Loading – Fuselage Inspection – Critical Locations – Comparison of different methods of NDT – Visual – Radiography – Xero-Radiography, Computed Radiography, Computed Tomography – Eddy Current Testing – Liquid Penetrant Testing – Remote Testing - Landing Gear Inspection.

Structural Health Monitoring: An Overview of Structural Health Monitoring – Structural Health Monitoring and Role of Smart Materials – Structural Health Monitoring versus Non-Destructive Evaluation – A Broad Overview of Smart Materials Applications – Notable Applications of SHM in Aerospace Engineering – Structural health monitoring of composites – Repair investigation using SHM – Current limits and future trends.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Richard Brundle. C, Charles A. Evans, Jr., Shaun Wilson, "Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films", Butterworth-Heinemann, Boston, USA, 1992. 58
2. Williams, DB & Barry Carter,C, "Transmission electron microscopy, vol. 4", Springer, USA, 1996.
3. Non-destructive Testing Handbook – ASNT Series – Volume 1 – 6..Grewal B.S., "Higher Engineering Mathematics", 44^{th} Edition, New Delhi, 2017. Khanna Publishers.
4. Cullity, BD & Stock, SR, "Elements of X-ray diffraction", Prentice Hall, Inc. USA, 2001.
5. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, "Structural Health Monitoring", WileyISTE, 2006.
6. Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007.
7. Douglas B. Murphy, "Fundamentals of light microscopy and electronic imaging", Wiley-Liss, Inc. USA, 2001.

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain the importance and applications of various Non-Destructive Testing (NDT) techniques.	PO1 (3), PO2 (2)	2	2
CO2	Identify and select suitable NDT techniques for specific engineering applications.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO3	Demonstrate understanding of physical principles involved in acoustic emission and ultrasonic testing methods.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO4	Analyze physical principles of advanced NDT techniques and evaluate state-of-the-art methods in NDT and structural health monitoring.	PO1 (3), PO2 (3), PO4 (3)	3	3

AO25021	Aircraft Structural Mechanics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Teach the student different energy principles & its various applications
Knowledge of stress-strain equations in 2-D and 3-D
Allow the student to differentiate and understand different failures theories
Understand how riveted and bolted joints should be designed
Gain knowledge on the stress analysis techniques of different structural components

Energy Method of Analysis: Determination of Strain Energy in Structural Members – Castigliano's Theorems – Dummy Load & Unit Loads Methods – Application of Energy Principles to Statically Determinate and Indeterminate Trusses, Beams, Rings and Frames – Determination of Deflection – Practical Stress Analysis of Aircraft Components Using Energy Methods of Analysis

Elasticity: Stress & Strain Components in 2D & 3D – Stress-strain Relations – Equations of Equilibrium – Compatibility Equations – Relation Between Elastic Constants – Stresses on Inclined Planes – Principal Stresses and Strains in 2D & 3D – Maximum Shear Stress –Planar Problems in Cartesian and Polar Coordinates

Theories of Failure: Significance of Failure Theories – Principal Stresses in 2-D & 3-D – Maximum Normal Stress, Normal Strain and Maximum Shear Stress Failure Theories – Failure Envelope – Distortion Energy Failure Theory – Octahedral Shear Stress Failure Theory – Fatigue Failure – S-N Curve

Connections & Fittings: Determination of Stresses in Riveted and Bolted Joints – Failure of Riveted and Bolted Joints – Joint Efficiency – Design of Joints – Application of Failure Theories – Design of Aircraft Joints

Stress Analysis of Aircraft Components: Stresses in Beams & Shafts due to Combined Loading – Determination of Principal Stress and Maximum Shear Stress – Stress Analysis of a Wing Spar – Tapered Wings – Fuselage Skin Stress Analysis – Effect of Cut-outs – Concept of Shear Lag – Elements of Aeroelasticity

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", WCB-McGraw Hill, 1997.
2. Rivello, R.M, "Theory and Analysis of Flight Structures", 4th Edition, McGraw Hill, 2007.
3. E J Hearn, "Mechanics of Materials", Butterworth Heinemann, Volume-1, 1995.L.S.
4. Srinath, "Advanced Mechanics of Solids", Tata McGraw Hill, 3rd Edition, 2017

5. Bruhn. E.H, “Analysis and Design of Flight Vehicles Structures”, Tri-state off-set company, USA, 1985.
6. Peery, D.J and Azar, J.J, “Aircraft Structures”, McGraw – Hill, N.Y, 2012
7. Megson T M G, “Aircraft Structures for Engineering Students”, Butterworth-Heinemann; 5th edition, 2012
8. R.K. Rajput. “Strength of Materials”, S. Chand Ltd, 6th Edition, 2015.

CO	Description of CO	PO	PSO1	PSO2
CO1	Apply energy principles to solve engineering mechanics and structural problems.	PO1 (3), PO2 (3)	3	3
CO2	Apply elasticity equations and solution procedures using the theory of elasticity for stress analysis of engineering and aircraft components.	PO1 (3), PO2 (3), PO3 (2)	2	3
CO3	Analyze and apply various theories of failure in the design of structural components.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Design riveted and bolted joints considering strength and safety requirements.	PO1 (3), PO3 (3), PO5 (2)	3	2

<table>
<tr><td rowspan="2">AO25022</td><td rowspan="2">Multifunctional Materials and their Applications</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td></tr>
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COURSE OBJECTIVES:

- To get basic idea on the fundamentals of structural health monitoring.
- To impart knowledge in the areas of vibration-based techniques in structural health monitoring, fibre optics and piezo electric sensors
- To gain knowledge on the fundamentals of fabrication, modelling, analysis, and design of smart materials and structures
- To get exposed to the state of the art of smart materials and systems,
- To impart knowledge on spanning piezoelectrics, shape memory alloys, electro active polymers, mechanochromic materials and fibre optics

Introduction Of Structural Health Monitoring: Need of Structural Health Monitoring, Definition & Concept of Structural Health Monitoring- Structural Health Monitoring versus Non-Destructive Evaluation- Types & Components of SHM, Procedure of SHM, Objectives & Operational Evaluations of SHM - Application Potential of SHM Notable Applications of SHM – Aerospace Engineering. Structural health monitoring of composites – Repair investigation using SHM.

Overview Of Smart Materials: Introduction to Smart Materials, - components and classification of smart structures - Application areas of smart systems - Principles of Piezoelectricity, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids.

Smart Composites: Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams , Wing Morphing Design Using Macrofiber Composites - Analyses of Multifunctional Layered Composite Beams - Vibration Control using SHM –.Delamination Sensing using Piezo Sensory Layer – modeling of smart composite beam.

Intelligent Systems And Neural Networks: Operational evaluation -.Data acquisition-piezo electric inchworm devices- Feature extraction-Statistical model development for feature discrimination -Data Cleansing – Normalization-Data Fusion – Compression – Statistical model building - Supervised pattern recognition - Unsupervised pattern recognition – Signal processing – Fuzzy C means- K means – Kohenon's Self organization mapping- Fundamentals of Wavelet analysis –Life Prediction – Smart Nano composites- Nano and multifunctional materials - In Situ Health Monitoring.

Advances In Smart Structures &Materials: Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design of Chemical and Biochemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems and Distributed measurement.
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%
Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Brian Culshaw, “Smart Structures, and Materials”, Artech House, 2000.
2. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, “Structural Health Monitoring”, Wiley -ISTE, 2006.
3. Douglas E Adams, “Health Monitoring of Structural Materials and Components-Methods with Applications”, John Wiley and Sons, 2007.
4. Gandhi and Thompson, “Smart Materials and Structures”, Springer Netherlands, 1992.
5. Laurene Fausett, “Fundamentals Of Neural Networks”, Pearson publishers, 1994
6. Victor Giurglutiu, “Structural Health Monitoring with Wafer Active Sensors”, Academic Press Inc, 2007.

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain the fundamentals and historical development of Structural Health Monitoring (SHM).	PO1 (3), PO2 (2)	2	2
CO2	Apply a systematic approach to the Structural Health Monitoring (SHM) process in aerospace applications.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Demonstrate knowledge of smart materials used in aerospace applications for SHM systems.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO4	Apply non-destructive testing (NDT) techniques and perform experimental modal analysis relevant to SHM.	PO1 (3), PO2 (3), PO4 (3)	3	3

AO25023	Aeroelasticity	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- This course provides the basic knowledge on aero elastic phenomena and its impact on aircraft design.
- This course will make students to illustrate the aeroelastic phenomena using simplified aerodynamic and structural models.
- This course provides insight into both static and dynamic aeroelastic phenomena and possible prevention methods.
- This course imparts knowledge on the flutter phenomena in detail.
- This course provides the basic knowledge on prevention and control of aeroelastic Instabilities.

Aeroelastic Phenomena: introduction to aeroelasticity and aeroelastic phenomena – Free vibration analysis of basic structural members with different boundary conditions, analytical and approximate solutions, response of basic structural members to periodic and non-periodic forces-Examples of aeroelastic phenomena – Galloping of transmission lines – Flow induced vibrations of tall slender structures – Instability of suspension bridges – Fluid structure interaction – The aeroelastic triangle of forces – Prevention of aeroelastic instabilities

Modelling of Aeroelastic Phenomena: Influence and stiffness co-efficients – illustration of aeroelastic phenomena using simplified aerodynamic and structural models – different subsonic and supersonic aerodynamic models of aeroelastic analysis – modelling techniques – aeroelastic models in state-space format Flexure – torsional oscillations of beams – Governing differential equation of motion and its solution - Bending, torsional and shear stiffness curves

Static Aeroelastic Phenomena: Simple two-dimensional idealisation – Strip theory – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions – Successive approximation method –Numerical approximations using matrix equations – divergence of a typical airfoil section Aileron effectiveness in terms of wing -tip helix angle- Critical aileron reversal speed- Rate of change of local pitching moment coefficient with aileron angle – Control Effectiveness – Wing deformations of swept wings

Flutter Calculations: Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasi-steady aerodynamic derivatives – Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter Calculation – U-g Method – P-k Method – Exact Treatment of Bending –Torsion Flutter of a Uniform Wing – Flutter Analysis by Assumed Mode Method-Determination of critical flutter speed.

Prevention And Control: Stiffness criteria – dynamic mass balancing – dimensional similarity laws- Flutter model similarity law – effect of elastic deformation on static longitudinal stability – introduction to aeroelastic control – aeroelastic aspects in the design of aircraft – Panel flutter and its control – Prevention of tail buffeting – Aeroelastic instabilities in helicopter and engine blades and prevention methods

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Bisplinghoff.RL, Ashley,H and Halfmann,RL, “Aeroelasticity”, 2nd Edition, Addison Wesley Publishing Co., Inc., 1996.
2. Blevins, RD,”Flow Induced Vibrations”, Krieger Pub Co., 2001.
3. Broadbent,EG, “Elementary Theory of Aeroelasticity”, Bun Hill Publications Ltd., 1986.
4. Fung,YC, “An Introduction to the Theory of Aeroelasticity”, John Wiley & Sons Inc., New York, 2008.
5. Scanlan, RH and R.Rosenbaum, “Introduction to the study of Aircraft Vibration and Flutter”, Macmillan Co., New York, 1981.
6. Dewey H. Hodges, and G. Alvin Pierce, “Introduction to structural dynamics and aeroelasticity,” Cambridge University Press, 2002

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain the role of aeroelasticity in aircraft design and its practical significance.	PO1 (3), PO2 (2)	2	2
CO2	Apply semi-rigid body assumptions and numerical methods in aeroelastic analysis of aircraft structures.	PO1 (3), PO2 (3), PO5 (2)	3	3
CO3	Formulate and solve steady-state aeroelastic problems in aircraft wings and structures.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO4	Analyze flutter phenomena in aircraft wings and interpret practical aeroelastic case studies.	PO1 (3), PO2 (3), PO4 (2)	3	3

AO25024	Theory of Boundary Layers	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: The objectives of the course are

- To familiarize the students with the fundamental concepts in boundary layer flow and with the governing equations of viscous flow and to introduce to students the similarity parameters of viscous flow
- To make students understand the methods for obtaining analytical solutions and the role of shear layers for low-speed viscous flow problems commonly found in engineering applications
- To introduce the basic concepts in laminar boundary layer theory and its applications in engineering to students for flows over flat and curved surfaces.
- To give knowledge to students on the intricacies of various phenomena in turbulent boundary layers and in turbulence modelling and the utilization of turbulence models.
- To give sufficient exposure to students on the techniques used for boundary layer control and separation aspects and also on the methods to delay or prevent transition.

Viscous Flow and the Governing Equations: Governing equations of viscous flow - Conservation of mass, momentum and energy equations-Stokes hypothesis - Navier-Stokes equations - Mathematical character of the governing equations-similarity parameters in viscous flow –dimensional analysis of governing equations implementation of boundary conditions - vorticity in viscous flow –introduction to creeping flow and boundary layer flow.

Viscous Flow Equations and Their Solution Methods: Solutions of viscous flows such as Couette flows, Hagen-Poisuelle flow and Flow between rotating concentric cylinders- Solution of Combined Couette-Poiseuille Flow between parallel plates- Analysis of Creeping motion and Stokes solution for an immersed sphere-Shear layers in practical engineering problems – Definitions of Displacement thickness, momentum and energy thickness of a boundary layer

Introductory Analysis of Laminar Boundary Layer: Hierarchy of boundary layer equations – Solution of Prandtl's boundary layer equations -flow over a flat plate and Flat plate Integral analysis of Karman and Integral analysis of energy equation -similarity solutions, Blasius solution for flat-plate flow– boundary layer over a curved body-Flow separation- Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature –Reynold's analogy - Integral equation of Boundary layer – Pohlhausen method – Thermal boundary layer calculations.

Fundamental Aspects of Turbulent Boundary Layer: Nature of Turbulence and how to account for turbulence effect-Two-dimensional turbulent boundary layer equations – – Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient – Fundamentals of turbulence modelling – Concepts of Eddy Viscosity, mixing length –Classification of Turbulence models

Control Methods for Boundary Layer: Practical control methods for laminar boundary layer - Motion of the solid wall-Acceleration of the boundary layer-Injection of mass and momentum in boundary layer - Suction- Injection of different gas-Prevention and delay of transition-Cooling of the wall-Boundary layer suction-Injection of a different gas – Introduction to moving and chemically reacting boundary layers and their control

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Schlicting, H., "Boundary Layer Theory", McGraw-Hill, 7th Edition, 2014.
2. Reynolds, A, J., "Turbulent Flows Engineering", John Wiley and Sons, New York, 1988.
3. White, F. M., "Viscous Fluid Flow", McGraw-Hill, 3rd Edition, 2005.

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand the fundamental characteristics of viscous flows and apply appropriate boundary conditions for analytical solutions.	PO1 (3), PO2 (3)	1	3
CO2	Apply governing equations of viscous flows to engineering problems and interpret the physical significance of various terms.	PO1 (3), PO2 (3), PO3 (2)	2	3
CO3	Analyze boundary layer behavior including velocity and temperature profiles, and apply boundary layer theory to engineering design and conjugate heat transfer problems.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Evaluate turbulent flow characteristics, distinguish between laminar and turbulent regimes, and apply boundary layer control techniques for drag reduction and separation control in aerospace applications.	PO1 (3), PO2 (3), PO4 (2)	3	3

AO25025	Aircraft Control Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To introduce the mathematical modelling of systems and understand the basics of Fly-by-wire control
- To introduce open loop and closed loop systems and analyses in time domain and frequency domain.
- To introduce the transient and steady state characteristics of a system
- To impart the knowledge on the concept of stability and the various methods to analyze stability in both time and frequency domain.
- To introduce about the design of various Autopilots

Introduction To Aircraft Control: Historical review, Simple pneumatic, hydraulic and thermal systems, Series and parallel system, Analogies, mechanical and electrical components, Mathematical Modelling – Transfer function - Development of Equations of motion of an Aircraft – Linearization – Separations of Equations of motion – Introduction to Autopilot systems. - Fly-by-wire concepts

Open And Closed Loop Systems: Feedback control systems – Control system components - Block diagram representation of control systems, Reduction of block diagrams, Signal flow graphs, Output to input ratios.

Transient And Steady State Characteristics: Response of systems to different inputs viz., Step impulse, pulse, parabolic and sinusoidal inputs, Time response of first and second order systems, steady state errors and error constants of unity feedback circuit

Concept Of Stability: Necessary and sufficient conditions, Routh-Hurwitz criteria of stability, Root locus and Bode techniques, Concept and construction, frequency response

Autopilot: Longitudinal Oscillatory motions - Introduction to Displacement Autopilot - Pitch Orientation Control system - Landing Geometry - Autopilot for Automatic Glide Slope Control system - Lateral Oscillatory motions – Dampers – Introduction to different methods of co-ordination -Yaw Orientation Control system

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Kuo, B.C. Automatic control systems, Prentice-Hall of India Pvt. Ltd., New Delhi, 2017.
2. Naresh K Sinha, Control Systems, New Age International Publishers, New Delhi,2008.
3. Nagrath I.J & Gopal M Control System Engineering, New Age International Publishers, 4th Edition, 2006.

4. OGATO, Modern Control Engineering, Prentice-Hall of India Pvt. Ltd., New Delhi, 5th Edition, 2010

CO	Description of CO	PO	PSO1	PSO2
CO1	Apply classical and modern feedback control techniques to flight control systems including Fly-By-Wire (FBW) concepts.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO2	Analyze open-loop and closed-loop systems using various system representations and evaluate transient and steady-state responses.	PO1 (3), PO2 (3)	2	3
CO3	Apply frequency response methods and stability analysis techniques to practical control systems.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO4	Design and develop autopilot systems for longitudinal and lateral flight control modes.	PO1 (3), PO3 (3), PO5 (2)	1	3

AO25026	High Speed Jet Flows	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will make students

- To get insight into the basic aspects of jets and types of jets.
- To learn the basic properties of jets and its characteristics.
- To get knowledge on various active and passive jet control methods.
- To gain knowledge into the basic aspects of jet acoustics
- To acquire in-depth knowledge on how and what type of control methods can be implemented practically.

Introduction: Properties of Turbulent Jets-Fundamental Concepts, Submerged Jets- Velocity Profiles in a Submerged Jet- Spread of a turbulent submerged jet- Lines of Constant Velocity in a Submerged Jet. Velocity Variation along the Axis of a Submerged jet, Velocity, Temperature, and Concentration Profiles in a Turbulent Jet Spreading into an External Stream of Fluid- Spread of a Turbulent Jet into a Co-flowing or Counter-flowing External Stream- Turbulence Characteristics in a Free Jet.

Types Of Jets: Types of Jets - Plane free-jets. Round jets. Plane jets in a co-flowing stream. Round jet in Co flowing stream- Swirling Jets-Radial jets- Wall jets- Jet Characteristics centerline velocity, Radial profile and iso contours of symmetric and asymmetric jets. Under expanded and over expanded jet shock cell structure analysis using different types of visualization techniques.

Active Jet Control Methods: Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS, Synthetic Jets, Controls and Sensors, Active controls techniques by air tabs - applications.

Passive Jet Control Methods: Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches and wires, vortex generators and physics of their jet characterizers. Optical Flow Visualization, Applications.

Jet Acoustics: Introduction to Jet Acoustics – Types of jet noise – Source of generation- Travelling wave solution, standing wave solution – multi-dimensional acoustics- Theoretical Concepts of Jet Noise Generation and Suppression–Jet Noise suppression techniques – anechoic chamber design and instrument for the measurement of nose

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Ethirajan Rathakrishnan, “Applied Gas Dynamics”, John Wiley, New York, 2010.
2. Liepmann and Roshko, “Elements of Gas Dynamics”, Dover Publishers, 2017.
3. Genrikh Abramovich, ”The Theory of Turbulent Jets” MIT Press, 1963

4. Shapiro, AH, “Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I & II”, Ronald Press, New York, 1953.
5. H. Schlichting, K. Gersten, “Boundary Layer Theory” Springer 2017
6. Ginevsky A .S. “Acoustic Control of Turbulent Jets” Springer; Softcover reprint of hardcover 1st ed. 2004 edition (8 December 2010)

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain and analyze the unique features and characteristics of jet flows.	PO1 (3), PO2 (3)	3	3
CO2	Evaluate active and passive control methods for jet flows in engineering applications.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Analyze jet acoustics and apply methods for suppression of jet noise.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO4	Demonstrate experimental techniques for determining jet flow characteristics and performance.	PO1 (3), PO3 (3), PO5 (2)	3	3

AO25027	Hypersonic Aerodynamics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

- To realise the importance of studying the peculiar hypersonic speed flow characteristics pertaining to flight vehicles.
- To provide knowledge on various surface inclination methods for hypersonic inviscid flows.
- To arrive at the approximate solution methods for hypersonic flows.
- To impart knowledge on hypersonic viscous interactions.
- To impart knowledge on the effect on aerodynamic heating on hypersonic vehicles.

Introduction To Hypersonic Aerodynamics: Importance of Hypersonic flow - Peculiarities of Hypersonic flows – Thin shock layers – entropy layers – viscous Interactions - High temperature flows – low density and high-density flows – hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows – velocity vs altitude map for hypersonic vehicles.

Surface Inclination Methods for Hypersonic Inviscid Flows: Local surface inclination methods – modified Newtonian Law – Newtonian theory – centrifugal force corrections to Newtonian theory - tangent wedge tangent cone and shock expansion methods – Calculation of surface flow properties – practical application of surface inclination methods – hypersonic independence principle.

Approximate Methods for Inviscid Hypersonic Flows: Assumptions in approximate methods hypersonic small disturbance equation and theory – Maslen''s theory– blast wave theory – hypersonic equivalence principle- entropy effects – rotational method of characteristics – hypersonic shock wave shapes and correlations

Viscous Hypersonic Flow Theory: Peculiarities of hypersonic boundary layers – boundary layer equations – hypersonic boundary layer theory – Self similar solutions – Flat plate case; Non similar hypersonic boundary layers – Local similarity method and finite difference method – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating.

Viscous Interactions and Transition: Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Parameters affecting hypersonic boundary layer transition – Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series, 1994.
2. John T. Bertin, Hypersonic Aerothermodynamics, AIAA Education Series, 1993
3. Anderson, JD, “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd edition, 2006.
4. Anderson, JD, “Modern compressible flow: with Historical Perspective”, McGraw Hill Education, 3rd edition, 2017

CO	Description of CO	PO	PSO1	PSO2
CO1	Apply governing equations and problem-solving techniques to analyze inviscid and viscous hypersonic flow problems.	PO1 (3), PO2 (3)	2	3
CO2	Evaluate high-temperature effects in hypersonic aerodynamics and their impact on flow behavior and vehicle performance.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Develop and assess solution strategies to mitigate aerodynamic heating challenges in hypersonic vehicles.	PO1 (3), PO3 (3), PO5 (2)	2	1
CO4	Analyze design considerations and multidisciplinary issues associated with hypersonic vehicle development.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25028	Navigation, Guidance and Control for Space Vehicles	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

- To learn about the concepts of Spacecraft Navigation Guidance and Control subsystems and understand their significance
- To know the operating principle of various sensors and actuators
- To have an exposure on various Navigation systems such as Inertial Measurement systems and Satellite Navigation
- To study longitudinal dynamics and to design the longitudinal autopilot
- To study about the Relative Navigation Systems
- To understand the Attitude dynamics and Stabilization Control system

Introduction: Need for Navigation, Guidance, & Control (NGC) subsystems - Position Fixing - Attitude Determination and Control System (ADCS) - Geometric concepts of Navigation - Different Coordinate Reference Systems – Coordinates Transformation Techniques

Attitude Sensors and Control Actuators: Orbit sensors - Attitude sensors - Inertial sensors - Electro-optical sensors - Altimeters - Reaction Wheels - Magnetic Torquers - Thrusters - Star Trackers - Magnetometers - Sun Sensors

Inertial Navigation Systems and GPS: Basic Principles of Inertial Navigation – Types - Platform and Strap down - Mechanization INS system GPS overview – Concept – GPS Signal – Signal Structure- GPS data – DGPS Concepts - LAAS & WAAS Technology – Hybrid Navigation – Case

Relative Navigation Systems: Relative Navigation – fundamentals – Equations of Relative Motion for circular orbits (Clohessy Wiltshire Equations) – Rendezvous& Docking - Sensors for Rendezvous Navigation -Relative Satellite Navigation - Differential GPS - Relative GPS

Attitude Dynamics and Stabilization Schemes: Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics - Drag - Pressure Spin - Dual spin - Gravity gradient - Zero momentum system - Momentum Biased system - Reaction control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer – Introduction to Digital Fly-by-wire control - Modern spacecraft GNC

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Slater, J.M. Donnel, C.F.O and others, “Inertial Navigation Analysis and Design”, McGraw-Hill Book Company, New York, 1964.
2. Albert D. Helfrick, ‘Modern Aviation Electronics’, Second Edition, Prentice Hall Career & Technology,1994
3. Maxwell Noton, ”Spacecraft navigation and guidance”, Springer (London, New York), 1998
4. Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 1997
5. Collinson R.P.G, ‘Introduction to Avionics’, Chapman and Hall, India, 1996.

CO	Description of CO	PO	PSO1	PSO2
CO1	Understand and apply the concepts of spacecraft Navigation, Guidance, and Control (NGC) subsystems.	PO1 (3), PO2 (3)	3	3
CO2	Explain the principles of operation of spacecraft sensors, actuators, inertial measurement systems, and satellite navigation systems.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Analyze relative navigation, rendezvous, and docking concepts for space missions.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO4	Analyze spacecraft attitude dynamics, stabilization methods, and Fly-By-Wire (FBW) control systems.	PO1 (3), PO2 (3), PO3 (3)	3	3

AO25029	Air Traffic Control	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Gain a comprehensive understanding of the fundamental principles, functions, and regulatory framework of air traffic control.
- Develop an understanding of the various air traffic control systems and surveillance technologies used for aircraft tracking and monitoring.
- Acquire knowledge of air traffic flow management principles and techniques to optimize airspace capacity and maintain efficient air traffic flow.
- Understand the communication systems and protocols used in air traffic control and their critical role in ensuring effective coordination and information exchange.
- Recognize the importance of safety management systems and human factors considerations in maintaining a safe and error-free air traffic control environment.

Introduction To Air Traffic Control: Fundamentals of Air Traffic Control - Airspace and Air Traffic Management - Air Traffic Control Systems and Technologies - ATC Operations and Procedures - Human Factors in Air Traffic Control Parts of ATC services – Scope and Provision of ATCs – VFR & IFR operations – Classification of ATS air spaces – Various kinds of separation – Altimeter setting procedures – Establishment, designation and identification of units providing ATS – Division of responsibility of control-In-flight contingencies- Time in air traffic services- Safety management

Air Traffic Control Systems and Surveillance: Primary and Secondary Surveillance Radar - Automatic Dependent Surveillance-Broadcast - Multilateration and Wide Area Multilateration - Satellite-Based Surveillance Systems - Future Surveillance Technologies –ATC clearances – Flight plans – position report- Air traffic control clearances - Use of surface movement radar- Air Traffic Flow Management

Flight Information Systems: Application - Radar service, Basic radar terminology – Identification procedures using primary / secondary radar – performance checks – use of radar in area and approach control services – assurance control and co-ordination between radar / non radar control – emergencies – Flight information and advisory service – Alerting service – Co-ordination and emergency procedures – Rules of the air- VOLMET broadcasts and D-VOLMET service

Aerodrome Data: Aerodrome data – Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction.

Navigation , Communication And Other Services: Aerodrome data – Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction- Aeronautical mobile service- Aeronautical fixed service -Surface movement control service- Aeronautical radio navigation service

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. "PANS – RAC – ICAO DOC 4444", Latest Edition, The English Book Store, 17-1, Connaught Place, New Delhi.
2. Michael S. Nolan., "Fundamentals of Air Traffic Control", Cengage Learning.
3. Wells. A-Airport Planning and Management, 4th Edition- McGraw-Hill, London-2000.
4. P S Senguttuvaan, "Fundamentals of Air Transport Management", McGraw-Hill, 2003.
5. AIP (India) Vol. I & II, "The English Book Store", 17-1, Connaught Place, New Delhi.
6. "Aircraft Manual (India) Volume I", Latest Edition – The English Book Store, 17-1, Connaught Place, New Delhi.

CO	Description of CO	PO	PSO1	PSO2
CO1	Demonstrate knowledge of roles, responsibilities, and operational procedures of air traffic control personnel to ensure safe and efficient air traffic management.	PO1 (3), PO6 (2), PO11 (2)	2	3
CO2	Evaluate capabilities and limitations of surveillance systems such as radar, ADS-B, and satellite-based systems for enhanced situational awareness.	PO1 (3), PO2 (3), PO4 (2)	3	3
CO3	Explain flight information services, emergency procedures, air rules, and aerodrome data relevant to air traffic control operations.	PO1 (3), PO2 (2), PO7 (2)	2	3
CO4	Demonstrate proficiency in standard phraseology, communication procedures, and Controller–Pilot Data Link Communications (CPDLC) for effective ATC–pilot coordination.	PO9 (3), PO10 (3), PO11 (2)	2	3

AO25030	Hypersonic Propulsion	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To develop a deep understanding of the principles and technologies related to hypersonic flows and propulsion.
- To explore the design considerations and challenges associated with ramjet propulsion systems.
- To explore the design considerations and challenges associated with scramjet propulsion systems.
- To examine the characteristics and design principles of rocket-based hypersonic propulsion.
- To equip students with the knowledge and skills required for hypersonic vehicle design and testing.

Introduction to Hypersonic Flows and Propulsion: Overview of hypersonic flight and its significance - Characteristics of hypersonic flows: compressibility effects, shock waves, and boundary layer behavior - Thermodynamics of high-temperature gases and their impact on hypersonic propulsion - Review of basic gas dynamics and aerothermodynamics - Introduction to hypersonic propulsion systems and their challenges

Ramjet Propulsion: Operating principle - Sub critical, critical and supercritical operation - Combustion in ramjet engine - Turbo Ramjet - Ramjet performance - Dual mode Ramjet (DMRJ) - Integral ram- rocket - Sample ramjet design calculations - Numerical problems

Scramjet Propulsion: supersonic combustion- need for supersonic combustion for hypersonic propulsion – salient features of scramjet engine and its applications for hypersonic vehicles – problems associated with supersonic combustion – engine/airframe integration aspects of hypersonic vehicles – various types of scramjet combustors – fuel injection schemes in scramjet combustors - Design considerations and challenges in a Scramjet engine - Numerical problems

Rocket-Based Hypersonic Propulsion: Rocket engines for hypersonic flight: solid and liquid propulsion systems - Thrust augmentation methods for hypersonic rockets - Combustion processes in high-speed rocket engines - Nozzle design and optimization for hypersonic propulsion - Propellant choices and their impact on performance

Hypersonic Vehicle Design and Testing: Hypersonic vehicle design considerations: aerodynamics, propulsion, structures, and controls - multi-disciplinary optimization for hypersonic vehicle design - Hypersonic wind tunnel testing and experimental techniques - Hypersonic testing facilities and capabilities - Challenges and future directions in hypersonic vehicle design and testing

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. John D. Anderson Jr., “Hypersonic and High-Temperature Gas Dynamics”, 3rd Edition, 2019. AIAA Education Series
2. W. Heiser, D. Pratt, D. Daley, and U. Mehta, ‘Hypersonic Airbreathing Propulsion”, 1st Edition, 1994. AIAA Education Series
3. Wallace D. Hayes and Ronald F. Probstein, “Hypersonic Flow Theory”, 1st Edition, 1966, Academic Press.
4. Nguyen X. Vinh, Adolf Busemann, and Robert D. Culp, “Hypersonic and Planetary Entry Flight Mechanics”, 1st Edition, 1980, University of Michigan Press.

CO	Description of CO	PO	PSO1	PSO2
CO1	Analyze hypersonic flow characteristics, compressibility effects, and shock waves.	PO1 (3), PO2 (3)	3	3
CO2	Evaluate ramjet and scramjet engine principles and design considerations.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO3	Analyze rocket propulsion systems and nozzle design for hypersonic flight.	PO1 (3), PO2 (3), PO3 (3)	3	3
CO4	Integrate multidisciplinary concepts for hypersonic vehicle design and optimization.	PO1 (3), PO2 (3), PO5 (2)	3	3

AO25031	Aircraft Regulations and Certifications	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To get insight into the basic aspects of aircraft rules and certifications.
- To gain knowledge on the basic concepts of airworthiness.
- To learn the basic aspects on certification and publication procedures
- To impart knowledge on licensing and material selections.
- To provide with the concepts of case studies and civil aviation requirements

Introduction To Aircraft Rules And Certifications: Airworthiness requirements for civil and military aircraft – CAA, FAA, JAR and ICAO regulations – Defence standards – Military standards and specifications- Procedure for development and test flight and Certification – Certificate of Flight release – Certificate of Maintenance – Approved Certificates – Technical Publications – Aircraft Manual – Flight Manual – Aircraft Schedules – Registration Procedure, Certification, Identification and Marking of Aircraft.

C.A.R Series 'A' &' B': Responsibilities of operators / owners; Procedure of CAR issue, amendments etc., Objectives and targets of airworthiness directorate; Airworthiness regulations and safety oversight of engineering activities of operators. C.A.R. SERIES B –Deficiency list (MEL and CDL); Preparation and use of cockpit check list and emergency list.

C.A.R. Series 'C' & 'D': Defect recording, reporting, investigation, rectification and analysis; Flight report; Reporting and rectification of defects observed on aircraft; Analytical study of in-flight readings & recordings; Maintenance control by reliability Method. C.A.R. SERIES 'D' – Reliability Programmes (Engines); Aircraft maintenance programme & their approval; On condition maintenance of reciprocating engines; TBO – Revision programme; Maintenance of fuel and oil uplift and consumption records – Light aircraft engines; Fixing routine maintenance periods and component TBOs – Initial & revisions.

C.A.R. Series 'E' & 'F': Approval of organizations in categories A, B, C, D, E, F, & G - Requirements of infrastructure at stations other than parent base. C.A.R. SERIES 'F' – Procedure relating to registration of aircraft; Procedure for issue / revalidation of Type Certificate of aircraft and its engines / propeller; Issue / revalidation of Certificate of Airworthiness; Requirements for renewal of Certificate of Airworthiness.

C.A.R. Series 'L'&'M': Issue of AME Licence, its classification and experience requirements, Mandatory Modifications / Inspections.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. “Aircraft Manual (India) Volume” – Latest Edition, The English Book Store, 17-1, Connaught Circus, New Delhi.
2. DGCA, “Advisory Circulars”2003.
3. DGCA, “Civil Aviation Requirements with latest Amendment (Section 2 Airworthiness)” New Delhi 2000, – Published by, The English Book Store, 17-1
4. DGCA, “Aeronautical Information Circulars (relating to Airworthiness)” 2000

CO	Description of CO	PO	PSO1	PSO2
CO1	Explain aircraft rules, certifications, and airworthiness standards.	PO1 (3), PO6 (2)	2	3
CO2	Develop understanding of test flight procedures and certification processes.	PO1 (3), PO2 (2), PO11 (2)	2	3
CO3	Perform inspections and identify approved materials as per regulatory requirements.	PO1 (3), PO3 (3), PO5 (2)	3	3
CO4	Analyze case studies to understand civil aviation requirements and compliance.	PO1 (3), PO2 (3), PO7 (2)	2	3

AO25032	Vibration and Structural Dynamics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Impart knowledge to the student on the fundamentals and importance of vibration theory
- Familiarization with the applications of the convolution integral
- Ability to calculate natural frequencies and mode shapes for simple systems
- Familiarization with approximate solution techniques in vibration problems
- Knowledge and ability to derive the governing differential equations of a continuous system

Free Vibration of a Single Degree of Freedom System: Basic Concepts & Terminology – Degrees of Freedom – Types of Vibration – Spring, Mass & Damping Elements – Free Vibration of a Single Degree of Freedom System – Harmonic Motion – Effect of Damping – Different Types of Damping – Free Vibration of a Torsional System

Forced Vibration of a Single Degree of Freedom System: Harmonic Excitation – Response of a Undamped SDOF System Under Harmonic Force – Response of a Damped SDOF System Under Periodic Force – Base Excitation – Transmitted Force – Response of a System Under Rotating Unbalance – Convolution Integral – Impulse Response – Practical Examples – Response due to Arbitrary Excitation

Two Degree of Freedom Systems: Practical Examples – Modeling – Governing Equations of Motion – Free Vibration Analysis of Translational and Torsional Systems – Frequency Response Curves – Resonance – Coordinate Coupling & Principal Coordinates – Principal Modes of Vibration – Orthogonality of Mode Shapes –Effect of Damping – Design of a Vibration Absorber

Multi Degree of Freedom Systems: System Equations in Matrix Form – Use of Lagrange's Equations – Generalized Coordinates – Influence Coefficients –– Eigenvalue Problem – Natural Frequencies – Orthogonality of Normal Modes – Matrix Iteration Method – Rayleigh Method – Holzer Methods – Jacobi Method

Vibration of Continuous Systems: Transverse Vibrations of a Cable – Axial Vibrations of a Bar – Torsional Vibrations of a Shaft – Lateral Beam Vibration – Membrane Vibration – Rayleigh's Method – Rayleigh-Ritz Method – Beams with Concentrated Loads – Natural Frequencies and Mode Shapes

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Quiz (10%), Assignments (20%), Case Study report (15%), Flipped Classroom - 5%, Internal Examinations (50%)

REFERENCES:

1. Leonard Meirovitch, " Elements of Vibration Analysis"–McGraw Hill International Edition,2007.
2. Morse and Hinkle, "Mechanical Vibrations Theory and Applications", Allyn and Bacon, 2nd Edition, 2004.
3. William Weaver, Stephen P.Timoshenko, Donovan H.Young, "Vibration Problems in Engineering", John Wiley and Sons, New York, 2007.
4. Den Hartog, "Mechanical Vibrations", Crastre Press, 3rd Edition 2011.
5. S S Rao, "Mechanical Vibrations", 6th Edition, Pearson, India, 2018
6. William T. Thomson & Marie Dillon Dahleh, "Theory of Vibration with Application", Prentice Hall publishers, 5th edition, 2008.
7. Grover, G.K. "Mechanical Vibrations", 8th Edition, Nem Chand Brothers, Roorkee, India, 2009.

CO	Description of CO	PO	PSO1	PSO2
CO1	Model physical systems into single and multi-degree of freedom systems.	PO1 (3), PO2 (3)	3	2
CO2	Solve vibration problems involving single and multi-degree of freedom systems.	PO1 (3), PO2 (3)	3	2
CO3	Analyze vibration characteristics of discrete and continuous systems.	PO1 (3), PO2 (3), PO5 (2)	3	3
CO4	Determine natural frequencies using approximate methods and predict system response.	PO1 (3), PO2 (3), PO3 (2)	3	3