ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM
M.E. AERONAUTICAL ENGINEERING

THE VISION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

The Department of Aerospace Engineering shall strive to be a globally known department, committed to its academic excellence, professionalism and societal expectations. The department aims to impart state of the art technical knowledge, practical skills, leadership qualities, team spirit, ethical values and entrepreneurial skills to make all the students capable of taking up any task relevant to the area of Aerospace Engineering.

THE MISSION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

- To prepare the students to have a sound/very good fundamental knowledge to meet the present and future needs of industries.
- To improve the technical knowledge of the students in tune with the current requirements through collaboration with industries and research organization.
- To make the students gain enough knowledge in various aspects of system integration.
- To motivate the students to take up jobs in national laboratories and aerospace industries of our country.
- To stimulate interest to pursue inter and multidisciplinary research, sponsored and consultancy projects with industries and research establishments.
- To encourage the faculty members and students to do research and update themselves with the latest developments in the area of Aerospace Engineering.
- To encourage students to initiate startup companies in Aerospace domain.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: Successful Moulding of Graduate into Aeronautical Engineering Professional: Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Aeronautical Engineering through rigorous post graduate education.

PEO 2: Successful Career Development: Graduates of the programme will require the ability to have successful technical and managerial career in Aircraft industries and the allied management organisations.

PEO 3: Contribution to Aeronautical Engineering Field: Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aircraft industries.

PEO 4: Sustainable interest for Lifelong learning: Graduates of the programme will have sustained interest to learn and adapt to new technology developments to meet the challenging industrial scenarios.

PEO 5: Motivation to pursue research in Aeronautical field: Graduates will have interest and strong desire to undertake research-oriented jobs in industries and doctoral studies in Universities.

PROGRAMME OUTCOMES (POs)

After going through the two years of study, Aeronautical Engineering Post-Graduates will exhibit the following.

PO	Graduate Attribute	Programme outcomes
1.	Engineering knowledge	Postgraduate will be able to use the Engineering knowledge acquired from the basic courses offered in the programme to pursue either doctoral studies or a career as an academician / scientist or engineer.
2.	Conduct investigations of complex problems	Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the Aircraft industry and R&D organizations related to Aeronautical engineering and other professional fields.
3.	The Engineer and society	Postgraduate will be capable of doing research in inter and multidisciplinary areas which will result in more efficient and cheaper products that are beneficial to society.
4.	Environment and sustainability	Postgraduate will exhibit awareness of contemporary issues on environment focusing on the necessity to develop new materials, design and testing methods for the solution of environmental problems related to Aircraft industry.
5.	Individual and team work	Postgraduate will exhibit capability towards design and development of airframes from system integration point of view that requires team work.
6.	Report writing skill	Postgraduate will have the ability to write and present a Comprehensive technical report and research articles.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO 1: The postgraduate will become familiar with approach to analysis for Aeronautical engineering problems and conversant with methods of solutions.

PSO 2: The post graduate will come well versed with usage of modern techniques, and software tools to design and develop Aeronautical systems and products.

PSO 3: The postgraduate will excel as an individual as well as team member in design and research teams in universities and Aircraft industries.

PSO 4: The postgraduate will become an enthusiast to learn new technologies and methods lifelong in the area of Aeronautical engineering and technology.

Mapping of PEOs with Pos

PEO	PO1	PO2	PO3	PO4	PO5	PO6
I	3	3	3	3	3	2
II	3	3		3	3	2
III	3	3	3			3
IV		3	3	3	3	3
V	3	3		3	3	3

MAPPING OF COURSE OUTCOMES WITH PROGRAMME OUTCOMES												
Subjects/PO	**Category**	**Sem/ Year**	**PO**						**PSO**			
			1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
Advanced Mathematical Methods	FC	I/I	3	3	2.75		2.33	2.6	2	2	2	
Research Methodology and IPR	RMC	I/I	3	3	2	-	-	-			3	2
Aircraft Propulsion	PCC	I/I	3	2.4	2	2.33		2.6	2.8	1.6	2	0.4
Aircraft Structures	PCC	I/I	3	2		3		2.6	3	2	2	1
Airplane Aerodynamics	PCC	I/I	3	2		2		2.6	3	3	2	2
Aerodynamics Laboratory	PCC	I/I	3	2	2	1	1	2.6	3	3	2	2
Propulsion Laboratory	PCC	I/I	3	2		3		2.6				
Flight Mechanics and Control	PCC	II/I	3	2.4	3	1	1	2.6	3	2	2	1
CFD Applications for Aeronautical Engineering	PCC	II/I	3	3	3	2.57		2.5	3	3	2	1
Advanced Finite Element Methods	PCC	II/I	2.8	2.8	2			2.6	3	2	2	1
Aircraft Structures Laboratory	PCC	II/I	2	1.6	2.2	1	2	2.6	1.4	2	2	3
Mini Project with Seminar	EEC	II/I										
Project Work I	EEC	III/II										
Project Work II	EEC	IV/II										
Rocketry and Space Mechanics	PEC		2			2		2.6	3	2	2	1
Avionics	PEC		2.2				2	2.8	3	2	2	1
Aerospace Materials for Aeronautical Engineering	PEC		3	1.6		1.6		2.4	2	1	1	
Aircraft Engine Repair and Maintenance	PEC		1.6	1.6	1.6			2.25	2.4	0.2	0.8	1.2
Experimental Aerodynamics	PEC		3	2	1	1.4	1	2.25	3	2	2	1
Computational Heat Transfer for Aeronautical	PEC		3	3	2	2		2.25	3	3	2	2

Engineering												
Mechanics of Composite Materials	PEC		3	3	3	3	3	2.25	3	2	2	1
Introduction to Aerospace Engineering	PEC		3	2	1	1.4	1	2.25	3	2	2	1
Industrial Aerodynamics	PEC		3	2	1	1	1	2.25	3	2	2	1
Theory of Elasticity and Plasticity	PEC		3	3				2.25	3	2	2	1
Helicopter Aerodynamics	PEC		3	2.33	2	2	3	2.6	3	2	2	1
Airworthiness, Standards and Certification	PEC		3	2.8	1.8	2	2	2.6	3	3	2	3
Combustion in Jet and Rocket Engines	PEC		1.4	2		2.6	1	2.6	1.8	0.8	0.8	1
Advanced Propulsion Systems	PEC		3	3	2.2	3	3	2.6	1.6	0.8	0.8	1
Analysis of Composite structures	PEC		3	3				2.4	2	2.6	2	1.2
Airframe Repair and Maintenance	PEC		2	2	1.6			2.75	2.4	1.2	0.8	1.2
Aircraft Systems Engineering	PEC		3				1.5	2.6	2	1	0.8	1.2
Flight Instrumentation	PEC		1.2	1	2	2		2.6	3	3	2	2
Experimental Stress Analysis	PEC		3	3		2		2.6	3	3	2	2
NDT Methods	PEC		1.2	1	2	2		2.6				1.2
Aircraft Structural Mechanics	PEC		3	2.2		3		2.6	3	3	2	2
Multifunctional Materials and their Applications	PEC		3	2.6	3	3	3	2.6	3	3	2	1
Aeroelasticity	PEC		3	2.6	3	3		2.6	3	2	2	1
Theory of Boundary Layers	PEC		3	3		2		2.6	3	3	2	2
Aircraft Control Engineering	PEC		3	3		2.5		2.6	3	3	2	2
High Speed Jet Flows	PEC		3	2	3	3	2	2.6		1	0.4	0.6
Hypersonic Aerodynamics	PEC		3	3				2.6	2.2	2.2	1.8	
Navigation, guidance and Control for Space vehicles	PEC		3	2.8	2.4		2	2.6	1	2		2
Air Traffic Control	PEC		3	3		2		2.5	3	3	2	2

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Hypersonic Propulsion	PEC		3	1.75	3	1.25	3	2.6	2.2	2.2	3	2
Aircraft Regulations and Certifications	PEC		2		3	3	1	2.6	2	1		3
Vibration and Structural Dynamics	PEC		3	2.2	2			2.6	3	3	2	2

ANNA UNIVERSITY, CHENNAI
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CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR SEMESTER I TO IV

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	AL3101	Aircraft Propulsion	PCC	3	0	0	3	3
4.	AL3102	Aircraft Structures	PCC	4	0	0	4	4
5.	AL3103	Airplane Aerodynamics	PCC	4	0	0	4	4
6.		Professional Elective-I	PEC	3	0	0	3	3
PRACTICALS								
7.	AL3111	Aerodynamics Laboratory	PCC	0	0	4	4	2
8.	AL3112	Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**1**	**8**	**29**	**25**

SEMESTER II

S. NO.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	AL3201	Flight Mechanics and Control	PCC	3	1	0	4	4
2.	AL3202	CFD Applications for Aeronautical Engineering	PCC	3	0	2	5	4
3.	AL3203	Advanced Finite Element Methods	PCC	3	0	2	5	4
4.		Professional Elective-II	PEC	3	0	0	3	3
5.		Professional Elective-III	PEC	3	0	0	3	3
PRACTICALS								
6.	AL3211	Aircraft Structures Laboratory	PCC	0	0	4	4	2
7.	AL3212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**15**	**1**	**12**	**28**	**22**

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SEMESTER III

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective-IV	PEC	3	0	0	3	3
2.		Professional Elective-V	PEC	3	0	0	3	3
PRACTICALS								
3.	AL3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**6**	**0**	**12**	**18**	**12**

SEMESTER IV

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.	AL3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 71

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FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA3153	Advanced Mathematical Methods	3	1	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AL3101	Aircraft Propulsion	3	0	0	3	1
2.	AL3102	Aircraft Structures	4	0	0	4	1
3.	AL3103	Airplane Aerodynamics	4	0	0	4	1
4.	AL3111	Aerodynamics Laboratory	0	0	4	2	1
5.	AL3112	Propulsion Laboratory	0	0	4	2	1
6.	AL3201	Flight Mechanics and Control	3	1	0	4	2
7.	AL3202	CFD Applications for Aeronautical Engineering	3	0	2	4	2
8.	AL3203	Advanced Finite Element Methods	3	0	2	4	2
9.	AL3211	Aircraft Structures Laboratory	0	0	4	2	2
10	AL3212	Mini Project with Seminar	0	0	4	2	2
				TOTAL CREDITS		31	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
				TOTAL CREDITS		3	

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PROFESSIONAL ELECTIVES

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AO3054	Rocketry and Space Mechanics	PEC	3	0	0	3	3
2.	AV3024	Avionics	PEC	3	0	0	3	3
3.	AL3001	Aerospace Materials for Aeronautical Engineering	PEC	3	0	0	3	3
4.	AL3002	Aircraft Engine Repair and Maintenance	PEC	3	0	0	3	3
5.	AL3003	Experimental Aerodynamics	PEC	3	0	0	3	3
6.	AL3004	Computational Heat Transfer for Aeronautical Engineering	PEC	3	0	0	3	3
7.	AL3005	Mechanics of Composite Materials	PEC	3	0	0	3	3
8.	AL3006	Introduction to Aerospace Engineering	PEC	3	0	0	3	3
9.	AL3007	Industrial Aerodynamics	PEC	3	0	0	3	3
10.	AL3008	Theory of Elasticity and Plasticity	PEC	3	0	0	3	3
11.	AL3009	Helicopter Aerodynamics	PEC	3	0	0	3	3
12.	AL3051	Airworthiness Standards and Certification	PEC	3	0	0	3	3
13.	AO3057	Combustion in Jet and Rocket Engines	PEC	3	0	0	3	3
14.	AL3010	Advanced Propulsion Systems	PEC	3	0	0	3	3
15.	AL3052	Analysis of Composite Structures	PEC	3	0	0	3	3
16.	AL3011	Airframe Repair and Maintenance	PEC	3	0	0	3	3
17.	AL3012	Aircraft Systems Engineering	PEC	3	0	0	3	3
18.	AV3151	Flight Instrumentation	PEC	3	0	0	3	3
19.	AL3013	Experimental Stress Analysis	PEC	3	0	0	3	3
20.	AL3014	NDT Methods	PEC	3	0	0	3	3
21.	AL3015	Aircraft Structural Mechanics	PEC	3	0	0	3	3
22.	AL3053	Multifunctional Materials and their Applications	PEC	3	0	0	3	3
23.	AL3016	Aeroelasticity	PEC	3	0	0	3	3
24.	AL3017	Theory of Boundary Layers	PEC	3	0	0	3	3
25.	AV3025	Aircraft Control Engineering	PEC	3	0	0	3	3

26.	AL3054	High Speed Jet Flows	PEC	3	0	0	3	3
27.	AO3251	Hypersonic Aerodynamics	PEC	3	0	0	3	3
28.	AO3053	Navigation, guidance and Control for Space vehicles	PEC	3	0	0	3	3
29.	AV3026	Air Traffic Control	PEC	3	0	0	3	3
30.	AO3056	Hypersonic Propulsion	PEC	3	0	0	3	3
31.	AL3018	Aircraft Regulations and Certifications	PEC	3	0	0	3	3
32.	AL3055	Vibration and Structural Dynamics	PEC	3	0	0	3	3

MA3153 ADVANCED MATHEMATICAL METHODS

L	T	P	C
4	0	0	4

OBJECTIVES:

- To familiarize the students in the field of differential equations.
- To enable them to solve boundary value problems associated with engineering applications using transform methods.
- To expose the students to the concepts of calculus of variations.
- To introduce conformal mappings and their applications to fluid flows and heat flows.
- To give the students a complete picture of tensor analysis.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform: Definitions, properties -Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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.

UNIT I CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries -Direct methods – Ritz and Kantorovich methods.

UNIT V TENSOR ANALYSIS 12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient, divergence and curl.

TOTAL: 60 PERIODS

OUTCOMES:

CO1 On successful completion of the course, the students will be able to
CO2 get familiarized with the methods which are required for solving system of linear, Non linear equations and eigenvalue problems.
CO3 develop the mathematical methods of applied mathematics and mathematical physics
CO4 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems
CO5 familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., "Differential Equations and the Calculus of Variations", MIR Publishers, Moscow, 2003.
3. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 44th Edition, New Delhi, 2017.

4. Gupta A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. James G., “Advanced Modern Engineering Mathematics”, Pearson Education, 4th Edition, Horlow, 2016.
6. Burden, R.L., and Faires, J.D., “Numerical Analysis – Theory and Applications”, Cengage Learning, India Edition, New Delhi, 2010.
7. O'Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Ramanaiah, G.T., “Tensor Analysis”, S. Viswanathan Pvt. Ltd., Chennai, 1990.
9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	2	2
CO2	3	3	3	3	2	2
CO3	3	3	3	3	2	2
CO4	3	3	3	3	2	2
CO5	3	3	3	3	2	2

RM3151 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	1	0	3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem

CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data

CO3: Explain the process of data analysis; interpret and present the result in suitable form

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

AL3101	AIRCRAFT PROPULSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable the students

1. To gain knowledge on fundamental principles of aircraft and rocket propulsion.
2. To describe various types of propulsion system with their merits and challenges.
3. To gain adequate knowledge on propellers and its characteristics.
4. To be familiar with the working concept of inlets, nozzles and combustion chamber with their applications in a propulsion system.
5. To gain sufficient information about compressors and turbines. Students also will get an exposure on electric propulsion methods.

UNIT I ELEMENTS OF AIRCRAFT PROPULSION 9

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.

UNIT II PROPELLER THEORIES 9

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.

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS 9

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.

UNIT IV AXIAL AND CENTRIFUGAL FLOW COMPRESSORS, FANS AND TURBINES 9

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- axial flow turbines- geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

UNIT V ROCKET AND ELECTRIC PROPULSION 9

Introduction to rocket propulsion – Reaction principle – Thrust equation – Thrust Coefficient and Characteristic Velocity - Propulsive and Overall Efficiencies - Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance – electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thrusters.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1 Get knowledge on different types of propulsive devices and their advantages and disadvantages

CO2 Understand different propeller theories and performance parameters.

CO3 Be able to distinguish between different types of inlets, nozzles and combustion chambers and the process of combustion.

CO4 Know the difference between axial and centrifugal compressors, and the performance and features of turbines.

CO5 Acquire knowledge on the basics of rockets and electric propulsion systems.

REFERENCES:

1. Hill, PG. & Peterson, CR. “Mechanics & Thermodynamics of Propulsion” Pearson education, 2nd edition, 2009.
2. Oates, GC, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series, 1985.
3. Cohen, H, Saravanamuttoo, HIH., Rogers, GFC, Paul Straznicky and Andrew Nix , “GasTurbine Theory”, Pearson Education Canada; 7th edition, 2017.
4. Gill, WP, Smith, HJ &Ziurys, JE, “Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants”, Oxford & IBH Publishing Co., 1980
5. Saeed Farokhi, “Aircraft Propulsion”, Second Edition, John Wiley & Sons Ltd, 2014.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2				2	3	2	2	
2	3	2				3	3	2	2	
3	3	3	2	3		3	3	2	2	
4	3	3	2	2		3	3	1	2	
5	3	2		2		2	2	1	2	2

AL3102 AIRCRAFT STRUCTURES

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

1. Determination of loads acting on aircraft components
2. Knowledge of the theoretical principles of stressed skin construction
3. Knowledge of the generalized theory of beam bending & an understanding of stress distribution in sandwich beams
4. Exposure to the methods of shear flow analysis in aircraft structures
5. Exposure to the behavior of thin plates under different types of loading

UNIT I AIRCRAFT LOADS 12

Loads Acting on an Aircraft – Balancing Tail Loads – Determination of the Load Factor during Symmetric Manuevers – Inertia Loads – Function of Aircraft Wing & Fuselage Components Airworthiness Requirements – Construction of the V-n Diagram – Effect of Gust

UNIT II PRINCIPLES OF STRESSED SKIN CONSTRUCTION 12

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

UNIT III ANALYSIS OF BEAMS 12

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

UNIT IV SHEAR FLOW ANALYSIS 12

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

UNIT V THIN PLATES 12

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

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Ability to calculate load factors and balancing tail loads
CO2 An understanding on the construction and importance of the V-n diagram
CO3 Understand design philosophies and airworthiness requirements
CO4 Ability to carry out shear flow calculations involving aircraft components
CO5 Knowledge of thin plate behavior and ability to design plate elements

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. Bruce. K. Donaldson, “Analysis of Aircraft Structures: An Introduction”, Cambridge University Press, 2nd edition, 2008.
4. Bruhn. E.H, “Analysis and Design of Flight Vehicles Structures”, Tri-state off-set company, USA, 1985.
5. Peery, D.J and Azar, J.J, “Aircraft Structures”, McGraw - Hill, N.Y, 2012

COs	POs	PSOs

	1	2	3	4	5	6	1	2	3
1	3	1				2			
2	3	2				3			
3	3	2				3			
4	3	3				2			
5	3	2		3		3			

AL3103	AIRPLANE AERODYNAMICS	L	T	P	C
		4	0	0	4

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO AERODYNAMICS 12

Aerodynamic force and moments, lift and Drag coefficients, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, 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

UNIT II INCOMPRESSIBLE FLOW THEORY 12

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.

UNIT III COMPRESSIBLE FLOW THEORY 12

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, Prandtl- Glauert Rule, Linearized supersonic flow, Method of characteristics.

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 12

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.

UNIT V VISCOUS FLOW THEORY 12

Basics of viscous flow theory, Boundary Layer, Flow separation, Displacement, momentum and Energy Thickness, Laminar and Turbulent boundary layers ,Boundary layer over flat plate, Blasius Solution, Estimation of skin friction drag in laminar and turbulent flow, The Reference Temperature Method.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1 Comprehend the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.
CO2 Be able to solve inviscid, incompressible and irrotational flows.
CO3 Be able to apply the conservation equations for fluid flows.
CO4 Be provided with the knowledge on thermodynamic state of the gas behind normal shock waves, oblique shock waves and expansion waves.
CO5 Be provided with adequate knowledge on the basic concepts of laminar and turbulent boundary layers.

REFERENCES:

1. J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 5th edition, 2010.

2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 5th edition, 2013.
3. Shapiro, AH, “Dynamics & Thermodynamics of Compressible Fluid Flow”, Ronald Press, 1982.
4. Houghton, EL and Caruthers, NB, “Aerodynamics for Engineering Students”, Butterworth-Heinemann series, 5th edition 2003.
5. Zucrow, M.J, and Anderson, J.D, “Elements of gas dynamics” McGraw-Hill Book Co., New York, 1989.
6. Rae, WH and Pope, A, “Low speed Wind Tunnel Testing”, John Wiley Publications, 3rd edition, 1999.

COs	**POs**						**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	2		2		3	3	3	2	2
2	3	2		2		2	3	3	2	2
3	3	2		2		3	3	3	2	2
4	3	2		2		2	3	3	2	2
5	3	2		2		3	3	3	2	2

AL3111	AERODYNAMICS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

This laboratory course will enable the students

1. To gain knowledge on the principles of subsonic and supersonic wind tunnel and their operation.
2. To acquire practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
3. To calculate various aerodynamic characteristics of various objects.
4. To characterize laminar and turbulent flows.
5. To get practical exposure on flow visualization techniques pertaining to subsonic flows.

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.

Any 10 experiments may be conducted.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1 Able to operate and calibrate subsonic and supersonic wind tunnel.

CO2 Able to analyse the pressure distribution over the streamlined and bluff bodies.

CO3 Able to carry out measurement of force and moments on aircraft models.

CO4 Capable of measuring boundary layer thickness over various models.

CO5 Able to carry out flow visualization at subsonic speeds.

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

COs	POs						PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	2	2	1	1	3	3	3	2	2
2	3	2	2	1	1	2	3	3	2	2
3	3	2	2	1	1	3	3	3	2	2
4	3	2	2	1	1	3	3	3	2	2
5	3	2	2	1	1	2	3	3	2	2

AL3112	PROPULSION LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

This course will enable the students

1. To gain knowledge on wall pressure distribution on subsonic and supersonic inlets and nozzles.
2. To perform testing on compressor blades.
3. To interpret the experimental data using software.
4. To get practical exposure on flow visualization techniques pertaining to supersonic jets.
5. To gain basic knowledge on cold flow studies.

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.

Only 10 experiments will be conducted.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be

CO1 Able to perform wall pressure distribution on subsonic and supersonic nozzles.

CO2 Able to acquire knowledge on fundamental concepts of low speed and high speed jets and an experimental technique pertains to measurements.

CO3 Provided with adequate knowledge on pressure distribution on cavity models.

CO4 Able to perform wake survey methods.

CO5 Able to carry out flow visualization on supersonic jets.

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	1				2				
2	3	2				2				
3	3	2				3				
4	3	3				3				
5	3	2		3		3				

AL3201 FLIGHT MECHANICS AND CONTROL L T P C

3 1 0 4

COURSE OBJECTIVES: of this course are

1. To gain strong knowledge on aircraft performance in level, climbing, gliding flights.
2. To get familiarize with the equations pertaining to coordinated turn and in accelerated flight modes.
3. To provide adequate knowledge on various parameters that decide the pitch stability level of an airplane.
4. To impart knowledge on the basic aspects of lateral and directional stability and trim.
5. To be familiar with the equations of motion associated with longitudinal, lateral-directional dynamics.

UNIT I STEADY FLIGHT PERFORMANCE 9+3

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.

UNIT II MANEUVER PERFORMANCE 9+3

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 - Take off and landing performance.

UNIT III STATIC LONGITUDINAL STABILITY AND CONTROL 9+3

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.

UNIT IV STATIC LATERAL, DIRECTIONAL STABILITY AND TRIM 9+3

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.

UNIT V AIRCRAFT DYNAMICS 9+3

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.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Assess the performance of aircraft in steady and level flight and draw the hodographs for steady climb, powerless glide.

CO2 Compute the accelerated performance of an aircraft and also construct the V-n diagram with gust loads.

CO3 Perform preliminary design computations to meet static stability and trim requirements of conventional and unconventional aircraft configurations.

CO4 Evaluate dihedral effect of a given airplane and design the rudder by considering certain critical situations.

CO5 Analyse the longitudinal, lateral-directional modes of motion of an airplane and evaluate the associated stability and control derivatives.

REFERENCES:

1. Mc Cormic, 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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3	1	1	3	3	2	2	1
2	3	2	3	1	1	3	3	2	2	1
3	3	2	3	1	1	3	3	2	2	1
4	3	3	3	1	1	2	3	2	2	1
5	3	3	3	1	1	2	3	2	2	1

AL3202 CFD APPLICATIONS FOR AERONAUTICAL ENGINEERING L T P C

3 0 2 4

COURSE OBJECTIVES: The objectives of the course are

1. To introduce the students the governing equations of fluid dynamics in conservative and non-conservative partial differential form and the role of various terms in the equations
2. To expose the students to both structured and unstructured grid generation and the grid generation principles
3. To make the students familiarize with time dependent methods and their applications in engineering problems
4. To introduce the students the basic principles involved in finite volume method and its applications in aeronautics and aerospace engineering
5. To make the students familiarize with the industrial applications of CFD and its role in the design of various components in engineering

UNIT I GOVERNING EQUATIONS OF FLUID FLOW AND NUMERICAL SOLUTIONS 9

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.

UNIT II GRID GENERATION AND ASSESSMENT OF GRID QQUALITY 9

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

UNIT III TIME DEPENDENT METHODS AND THEIR APPLICATIONS 9

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

UNIT IV FINITE VOLUME METHOD AND ITS APPLICATIONS 9

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.

UNIT V INDUSTRIAL APPLICATIONS OF CFD 9

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 heatconduction 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.

EXPERIMENTS IN CFD

LIST OF EXPERIMENTS:
1. Numerical simulation of 1-D diffusion and conduction in fluid flows
2. Numerical simulation of 1-D convection-diffusion problems
3. Numerical simulation of 2-D unsteady state heat conduction problem
4. Numerical simulation of 2-D diffusion and 1-D convection combined problems
5. Structured grid generation over airfoil section
6. 3-D numerical simulation of flow through CD nozzles

NOTE: Any Five experiments can be conducted.

TOTAL : **45Periods+30Periods**

COURSE OUTCOMES: Upon completion of the course students will be able

CO1 To understand the significance of both conservative and non-conservative forms of governing equations for fluid flows
CO2 To apply with diligence the proper boundary conditions for obtaining the solutions for fluid flow solutions
CO3 To analyse the grid quality and assess its suitability for using it for obtaining CFD solutions
CO4 To evaluate the grid generation techniques and grid control methods for obtaining CFD solutions
CO5 To apply suitable time dependent methods with proper numerical schemes for finding solutions either by steady or unsteady approach for aeronautical and aerospace problems
CO6 To evaluate and identify the required flux evaluation schemes while using finite volume methods for numerical solutions
CO7 To understand the importance of parallelization of computer codes and high performance computing for solving large scale aeronautical and aerospace problems

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		2	3	3	2	2
2	3	3		2		3	3	3	2	2
3	3	3		2		3	3	3	2	2
4	3	3		3		2	3	3	2	2
5	3	3	3	3		3	3	3	2	2

AL3203	**ADVANCED FINITE ELEMENT METHODS**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**

COURSE OBJECTIVES:

01. Basic understanding of different methods of analysis for the solution of static structural problems
02. Knowledge of how finite element equations are formulated
03. An understanding of how characteristic matrices are generated
04. Exposure to different finite elements and awareness of element capability
05. Learning the assembly of finite element equations and solving for unknowns

UNIT I BASIC PROCEDURE 9

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

UNIT II 1-D STRUCTURAL ANALYSIS 9

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

UNIT III FLEXURE ELEMENTS 9

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

UNIT IV TWO DIMENSIONAL PROBLEMS 9

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

UNIT V FIELD PROBLEMS 9

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

EXPERIMENTS IN FEM

LIST OF EXPERIMENTS:

1. Static analysis of a uniform bar subject to different loads -1-D element
2. Thermal stresses in a uniform and tapered member – 1-D element
3. Static analysis of trusses / frames under different loads
4. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads
5. Stress concentration in an infinite plate with a small hole
6. Free vibration analysis of a bar / beam

TOTAL : 45 Periods+30 Periods

COURSE OUTCOMES:

CO1 Ability of the student to understand and apply Rayleigh-Ritz, Galerkin and finite difference solution techniques to different problems

CO2 Knowledge and application of the finite element method to static structural problems involving bar, beams and trusses

CO3 Ability to frame the nodal load vector using the principle of work equivalence

CO4 Student would be able to solve planar problems using the finite element method

CO5 Ability of the student to solve 1-D and 2-D heat transfer problems

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3	2			3	3	2	2	1
2	2	3	2			2	3	2	2	1
3	3	3	2			2	3	2	2	1
4	3	3	2			3	3	2	2	1
5	3	2	2			3	3	2	2	1

AL3211 AIRCRAFT STRUCTURES LABORATORY L T P C

0 0 4 2

COURSE OBJECTIVES:

1. Understand the utility of electrical resistance strain gauges
2. An exposure to photo elasticity and its applications in stress analysis
3. Familiarization with practical aspects of symmetrical and unsymmetrical bending of beams
4. Hands-on experience with the fabrication of composite laminates
5. Knowledge in coupon test procedures and non-destructive evaluation of composite materials

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

Any 10 experiments will be conducted from above 15 experiments

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 Develop an ability to handle and utilize various engineering instruments
CO2 Confidently and correctly interpret experimental data and correlate with theory
CO3 An understanding of error analysis and the capability to suggest improvisations in experimental procedures
CO4 Familiarization with modern experimental techniques and software tools
CO5 Ability to carry out bending, buckling and vibration tests

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	2	1	2	1	2	3	1	2	2	3
2	2	1	2	1	2	2	2	2	2	3
3	2	2	2	1	2	3	1	2	2	3
4	2	2	3	1	2	2	1	2	3	3
5	2	2	2	1	2	3	2	2	2	3

		L	T	P	C
AL3212	**MINI PROJECT WITH SEMINAR**	**0**	**0**	**4**	**2**

Seminar is to be given by the student after the completion of a mini project chosen by the student. Topics for the mini projects can be from the aeronautical engineering and allied fields. The mini project can be based on either numerical or analytical solution or design or fully experimental; or a combination of these tasks.

		L	T	P	C
AO3054	**ROCKETRY AND SPACE MECHANICS**				

3 0 0 3

COURSE OBJECTIVES: This course will enable students

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

UNIT I ORBITAL MECHANICS 9

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.

UNIT II SATELLITE DYNAMICS 9

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.

UNIT III ROCKET MOTION 9

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.

UNIT IV ROCKET AERODYNAMICS 9

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.

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able to

CO1 To explain the fundamental laws of orbital mechanics and will be able to analyse the two and three body problems

CO2 To calculate orbital parameters and perform conceptual trajectory designs for geocentric or interplanetary missions.

CO3 To evaluate the planar motion of rockets for different flight conditions.

CO4 To evaluate the forces and moments acting on airframe of a missile.

CO5 To conceptually design an optimal multistage rocket and compare different methods of stage separation

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, 8 th 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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3				1	3	3		3
2	3	3				1	3	3		3
3	3	3	2			1	3	3		3
4	3	3				1	3	3		3
5	3	3	2	2		1	3	3		3

AV3024 AVIONICS L T P C

3 0 0 3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO AVIONICS 9

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.

UNIT II DIGITAL AVIONICS ARCHITECTURE 9

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

UNIT III FLIGHT DECKS AND COCKPITS 9

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.

UNIT IV INTRODUCTION TO NAVIGATION SYSTEMS 9

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.

UNIT V AUTO PILOT AND FMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Explain the need for avionics in aircrafts and explain the functions of basic aircraft systems.

CO2 Select a suitable avionics architecture based on requirements and explain the functions of a data bus.

CO3 Explain the working of cockpit displays and to distinguish the type of technology used in displays.

CO4 Explain the importance of navigation system and operating principles of different navigation systems.

CO5 Explain the functions of autopilot and compare the different types of air speeds.

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., 7thEdition, 2012.
7. Collinson.R.P.G. Introduction to Avionics, Chapman and Hall, 2003.

COs	POs						PSOs			
	1	2		4	5	6	1	2	3	4
1	2					2	2		1	
2	3				2	3	3	2	2	
3	2					3	2			
4	2					3	2			
5	2					3	2			

AL3001	AEROSPACE MATERIALS FOR AERONAUTICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I MATERIAL SCIENCE and MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS 9

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

UNIT II FERROUS AND NON-FERROUS MATERIALS 9

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

UNIT III CERAMICS AND COMPOSITES 9

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.

UNIT IV SMART MATERIALS 9

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

UNIT V HIGH TEMPERATURE MATERIALS 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 provide with the knowledge and skills required to carry out the selection of appropriate materials for a wide range of engineering and other applications and apply the knowledge about the mechanical behaviour of different aircraft & aerospace materials.

CO2 Understand and evaluate the properties of ferrous and non- ferrous materials in aerospace industry

CO3 Explain the applications of Aluminum alloys, Ceramics and Composites Materials.

CO4 Understand and apply the smart materials in aerospace industry

CO5 evaluate the importance of high temperature materials and their characterization.

REFERENCES:

1. Gupta S Chand Balram & Co ,Aerospace material ,2009
2. ParkerER ,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

COs	POs						PSOs			
	1	2	3	4	5	12	1	2	3	4
1	3	1		2		2	2	1	1	
2	3	2		1		3	2	1	1	
3	3	3		2		2	2	1	1	
4	3	1		1		2	2	1	1	
5	3	1		2		3	2	1	1	

AL3002 AIRCRAFT ENGINE REPAIRS AND MAINTENANCE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will make students

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

UNIT I BASIC OF PISTON ENGINE INSPECTION AND MAINTENANCE 9

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

UNIT II PROPELLER INSPECTION AND REPAIR 9

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

UNIT III ENGINE INSPECTION, TESTING AND REPAIR 9

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.

UNIT IV JET ENGINE INSPECTION AND MAINTENANCE 9

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.

UNIT V JET ENGINE OVERHAUL AND TROUBLESHOOTING 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES: Upon completion of this course, the students should be able to

CO1 Understand piston engine principles and identify engine components.
CO2 Perform propeller inspections, repairs, and checks according to criteria.
CO3 Apply engine testing and diagnostic techniques for maintenance and troubleshooting.
CO4 Demonstrate proficiency in jet engine inspection, maintenance, and overhauling.
CO5 Analyze engine performance data and implement appropriate repair procedures.

REFERENCES:

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

COs	POs						PSOs			
	1	2	3	4	5	12	1	2	3	4
1	2	2	1			2	1	2	1	
2	1	2	2			3	3	1		1
3	2		2			3	3	2		2
4	2		1			2	3		2	1
5	1	1	2			2	2	1	1	2

AL3003 EXPERIMENTAL AERODYNAMICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: of this course are

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

UNIT I LOW SPEED TUNNEL 9

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.

UNIT II HIGH SPEED TUNNEL 9

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.

UNIT III FLOW VISUALIZATION TECHNIQUES 9

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.

UNIT IV MEASUREMENTS OF PROPERTIES 10

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.

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS 8

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Have knowledge on measurement of flow properties in wind tunnels and their associated instrumentation.
CO2 Be able to demonstrate and conduct experiments related to subsonic and supersonic flows.
CO3 Gain idea on flow visualization of subsonic and supersonic flows.
CO4 Be familiar with calibration of transducers and other devices used for flow measurement.
CO5 Be able to estimate errors and to perform uncertainty analysis of the experimental data.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	1	1	1	2	3	2	2	1
2	3	2	1	1	1	3	3	2	2	1
3	3	2	1	1	1	3	3	2	2	1
4	3	2	1	3	1	2	3	2	2	1
5	3	2	1	1	1	2	3	2	2	1

AL3004	COMPUTATIONAL HEAT TRANSFER FOR AERONAUTICAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION 7

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.

UNIT II GOVERNING EQUATIONS FOR FLUID FLOW AND HEAT TRANSFER 7

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.

UNIT III FINITE DIFFERENCE FORMULATION FOR CONDUCTIVE HEAT TRANSFER 11

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.

UNIT IV FINITE DIFFERENCE FORMULATION FOR CONVECTIVE AND RADIATIVE HEAT TRANSFER 10

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

UNIT V NUMERICAL APPROACH FOR HEAT TRANSFER PROBLEMS 10

Introduction, Addition and Subtraction of Two Matrices, Program for Solving M × N Matrix, 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.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will

CO1 Have an idea about discretization methodologies for solving heat transfer problems.

CO2 Be able to solve 2-D conduction and convection problems.

CO3 Have an ability to develop solutions for transient heat conduction in simple geometries

CO4 Be capable of arriving at numerical solutions for conduction and radiation heat transfer problems.

CO5 Have knowledge on developing numerical codes for practical engineering heat transfer problems

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.

COs	**POs**						**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	3	2	2		2	3	3	2	2
2	3	3	2	2		3	3	3	2	2
3	3	3	2	2		3	3	3	2	2
4	3	3	2	2		2	3	3	2	2
5	3	3	2	2		2	3	3	2	2

AL3005 MECHANICS OF COMPOSITE MATERIALS

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO COMPOSITE MATERIALS 9

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.

UNIT II MICROMECHANICS OF COMPOSITES 9

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.

UNIT III MACROMECHANICS OF COMPOSITES 9

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.

UNIT IV MONOTONIC STRENGTH AND FRACTURE 9

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.

UNIT V FAILURE ANALYSIS AND DESIGN OF LAMINATES 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 To identify the properties of fiber and matrix materials used in commercial composites.

CO2 To select the most appropriate manufacturing process for fabricating composite components.

CO3 To predict the failure strength of a laminated composite plate

CO4 Understand the linear elasticity with emphasis on the difference between isotropic and anisotropic material behaviour.

CO5 Acquire the knowledge for the analysis, design, optimization and test simulation of advanced composite structures and Components.

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.

COs	**POs**						**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3		3	3	3	2	3	3	2	2
2	3		3			3	3	3	2	2
3	3		3			3	3	3	2	2
4	3	3				2	3	3	2	2
5	3	3			3	2	3	3	2	2

AL3006 INTRODUCTION TO AEROSPACE ENGINEERING

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES: of this course are

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

UNIT I ESSENTIALS OF AERODYNAMICS 9

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.

UNIT II FLIGHT PERFORMANCE 9

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.

UNIT III INTRODUCTION TO STABILITY AND CONTROL 9

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.

UNIT IV AIRCRAFT PROPULSION AND MATERIALS 9

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.

UNIT V FUNDAMENTALS OF ROCKET MOTION 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Determine the properties of atmosphere at a given altitude in ISA and categorize flight vehicle configurations.
CO2 Evaluate the cruise, climbing and gliding capabilities of a given aircraft.
CO3 Ensure longitudinal, directional and lateral stability and trim of a flight vehicle design.
CO4 Select an efficient engine as per the design requirement and identify different structural components of an airplane.
CO5 Calculate the velocity increment of single and multi-stage rockets with given rocket parameters.

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.

COs	POs						PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	2	1	1	1	2	3	2	2	1
2	3	2	1	1	1	3	3	2	2	1
3	3	2	1	1	1	3	3	2	2	1
4	3	2	1	3	1	2	3	2	2	1
5	3	2	1	1	1	2	3	2	2	1

AL3007 **INDUSTRIAL AERODYNAMICS** **L T P C**

3 0 0 3

UNIT I ATMOSPHERE 9

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

UNIT II WIND ENERGY COLLECTORS 9

Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

UNIT III VEHICLE AERODYNAMICS 9

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

UNIT IV BUILDING AERODYNAMICS 9

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.

UNIT V FLOW INDUCED VIBRATIONS 9

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

TOTAL :45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will learn about non-aeronautical uses of aerodynamics such as road vehicle, building aerodynamics and problems of flow induced vibrations.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	1	1	1	2	3	2	2	1
2	3	2	1	1	1	3	3	2	2	1
3	3	2	1	1	1	3	3	2	2	1
4	3	2	1	1	1	2	3	2	2	1
5	3	2	1	1	1	2	3	2	2	1

AL3008 **THEORY OF ELASTICITY AND PLASTICITY**

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION 9

Elasiticity – 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.

UNIT II CONCEPT OF STRESSES AND STRAINS 9

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.

UNIT III POLAR COORDINATES 9

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

UNIT IV AXISYMMETRIC PROBLEMS 9

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

UNIT V INTRODUCTION TO PLASTICITY & YIELD CRITERIA 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Have knowledge of basic elasticity relationships and equations.
CO2 Know how to carry out stress analysis in 2-D and 3-D.
CO3 Get exposure on the formulation of constitutive and governing equations for basic problems in cartesian and cylindrical coordinates.
CO4 Be able to analyse and solve practical problems in cartesian and cylindrical coordinates.
CO5 Be able to determine the stress, strain and displacement field for common axisymmetrical members

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 , 3 rd ed., Academic Press (2014)

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3				2	3	3	2	2
2	3	3				3	3	3	2	2
3	3	3				3	3	3	2	2
4	3	3				2	3	3	2	2
5	3	3				2	3	3	2	2

AL3009 **HELICOPTER AERODYNAMICS** **L T P C**

3 0 0 3

COURSE OBJECTIVES: This course will make students

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

UNIT I HELICOPTER AERODYNAMICS 11

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.

UNIT II PERFORMANCE IN HOVER AND CLIMB 9

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.

UNIT III PERFORMANCE IN HORIZONTAL FLIGHT 9

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.

UNIT IV STABILITY AND CONTROL 8

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

UNIT V AERODYNAMIC DESIGN 8

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able to

CO1 Describe and compare possible helicopter structures and configurations.
CO2 Identify features of aerodynamic components of rotary wing aircraft and its performance.
CO3 Describe the aerodynamic characteristics that affect rotary wing flight.
CO4 Idea about the factors that influence helicopter stability.
CO5 Gain knowledge of helicopter controls and vibration analysis of helicopter blades.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3				3	3	3	2	2
2	3		2		3	2	3	3	2	2
3	3	2	2			3	3	3	2	2
4	3		2	2		2	3	3	2	2
5	3	2		2		3	3	3	2	2

AL3051	AIRWORTHINESS, STANDARDS AND CERTIFICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: of this course are

1. To impart knowledge on the different phases involved in the design and development of avionic systems.
2. To familiarize with aviation standards related to design & development of hardware & software.
3. To impart knowledge on the need for certification and the airworthiness certification process.
4. To impart knowledge on the need for reliability, maintainability and different methods of expressing reliability.
5.

UNIT I AVIONICS SYSTEM ENGINEERING DEVELOPMENT CYCLE 9

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. Stand alone 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.

UNIT II AVIATION STANDARDS 9

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

UNIT III AIRWORTHINESS CERTIFICATION 9

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.

UNIT IV RELIABILITY & MAINTAINABILITY CONCEPTS IN AVIONICS SYSTEMS 9

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

UNIT V QUALITY ASSURANCE PROCESS IN AVIATION 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, Students will be able to

CO1 Explain the different steps involved in the design and development of Avionic systems.

CO2 Apply the aviation standards during the design and development of hardware and software

CO3 Explain the importance of airworthiness certification and differentiate between different certification process

CO4 Explain the importance of system reliability and compare the different methods of expressing reliability and types of maintenance

CO5 Compare and select suitable quality assurance process and management tool for quality assurance.

REFERENCES:

1. IEEE Std 1220-1998, IEEE Standard for Application and Management of the SystemsEngineering 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 andEquipment 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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	1	1	2	3	3	3	2	3
2	3	3	2	2	2	2	3	3	2	3
3	3	3	2	2	2	2	3	3	2	3
4	3	3	2	2	2	3	3	3	2	3
5	3	3	2	3	2	3	3	3	2	3

AO3057 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.

UNIT I THERMODYNAMICS OF COMBUSTION 9

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 equillibrium products of combustion.

UNIT II PHYSICS AND CHEMISTRY OF COMBUSTION 9

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.

UNIT III PREMIXED AND DIFFUSED FLAMES 9

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.

UNIT IV COMBUSTION IN GAS TURBINE , RAMJET AND SCRAMJET 9

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.

UNIT V COMBUSTION IN CHEMICAL ROCKET 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will learn about the thermodynamics, physics and chemistry of combustion.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1	2		3	1	3	1	2	1	
2	1	2				2	1			
3	2			3		3	2	2		3
4	2					2	3		2	
5	1	2		2		3	1		1	2

AL3010 ADVANCED PROPULSION SYSTEMS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS 9

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 –Airbreatning Engine Performance Measures – Aerospace System Performance Measures

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS 8

Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – Integral Ram rocket.

UNIT III SCRAMJET PROPULSION SYSTEM 10

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.

UNIT IV NUCLEAR PROPULSION 9

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.

UNIT V ELECTRIC AND ION PROPULSION 9

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.

TOTAL :45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1: Able to Analyse in detail the thermodynamics cycles of air breathing propulsion systems.

CO2: Able to gain idea on the concepts of supersonic combustion for hypersonic vehicles and its performance.

CO3: Able to demonstrate the fundamental requirements of supersonic combustors.

CO4: Capable of estimating performance parameters of nuclear and electrical rockets

CO5: Able to acquire knowledge on the concepts of engine-body installation on hypersonic vehicles.

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.

COs	POs						PSO			
	1	2	3	4	5	6	1	2	3	4
1	3	3	3			2	3	3	2	
2	3	3	2	3		3	2	3	2	2
3	3	3	2	3		3	2	3	2	
4	3		2		3	3	2	2	2	2
5	3		2	3		2	1	2	2	2

AL3052	ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I BEHAVIOUR OF A UNI-DIRECTIONAL LAMINA 9

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

UNIT II CLASSICAL LAMINATION THEORY 9

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

UNIT III ANALYSIS OF LAMINATED BEAMS AND PLATES 9

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

UNIT IV DESIGN OF COMPOSITE STRUCTURES 9

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

UNIT V CHARACTERIZATION AND NON-DESTRUCTIVE EVALUATION 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to perform theoretical calculations in the micromechanics and macromechanics aspects of a composite lamina

CO2 Sound understanding of the applications of the classical lamination theory

CO3 Ability to design a composite laminate including special laminates

CO4 Good understanding of the possible failure modes of composite beams plates

CO5 Skill in carrying out characterization and non-destructive evaluation studies involving composite materials

REFERENCES:

1. n. Jones, "Mechanics of Composite Materials", CRC Press, 2nd Edition, 2006.

COs	POs						PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	3				2	3	3	2	2
2	3	3				3	3	3	2	2
3	3	3				2	3	3	2	2
4	3	3				3	3	3	2	2
5	3	3				2	3	3	2	2

AL3011 AIRFRAME REPAIR AND MAINTENANCE

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I WELDING IN AIRCRAFT STRUCTURAL COMPONENTS 9

Equipments 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.

UNIT II PLASTICS AND COMPOSITES IN AIRCRAFT 9

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.

UNIT III AIRCRAFT JACKING, ASSEMBLY AND RIGGING 9

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

UNIT IV REVIEW OF HYDRAULIC AND PNEUMATIC SYSTEM 9

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 - Fireprotection systems - Ice protection system - Functionality checks and servicing of position and warning systems-Auxiliary Power Units(APUs).

UNIT V SAFETYPRACTICES 9

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 Preparednes

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students should be able to

CO1 Apply welding principles to inspect, repair, and maintain aircraft structural components.
CO2 Perform effective repairs on plastic and composite materials used in aircraft.
CO3 Demonstrate proficiency in aircraft jacking, assembly, and rigging techniques.
CO4 Inspect, troubleshoot, and maintain hydraulic and pneumatic systems in aircraft.
CO5 Implement safety practices and procedures in aircraft maintenance operations.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	2	2	1			3	1	2	1	
2	3	3	2			3	3	1		1
3	2		2			2	3	2		2
4	2		1			2	3		2	1
5	1	1	2			3	2	1	1	2

AL3012 AIRCRAFT SYSTEMS ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will make students to

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

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING 9

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.

UNIT II THE AIRCRAFT SYSTEMS AND DESIGN 9

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-Missionanalysis

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION 9

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

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL 9

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.

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY 9

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.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Understand and apply systems engineering principles in practical scenarios.
CO2 Evaluate and analyze aircraft systems and their design drivers.
CO3 Develop effective system architectures and integration strategies in aviation.
CO4 Communicate and manage stakeholders effectively in systems engineering projects.
CO5 Enhance system reliability and maintainability through appropriate strategies and practices.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3					2	1	2	1	
2	3					3	2	1		1
3	3				2	2	3	2		3
4	3					3	3		2	1
5	3				1	3	1		1	2

AV3151	FLIGHT INSTRUMENTATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I MEASUREMENT SCIENCE AND DISPLAYS 9

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.

UNIT II AIR DATA INSTRUMENTS AND SYNCHRO TRANSMISSION SYSTEMS 9

Earth's Atmosphere – Basic Air data system – Air Data instruments-airspeed, altitude, Vertical speed indicators - Probes – Posittion 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

UNIT III GYROSCOPIC AND ADVANCED FLIGHT INSTRUMENTS 9

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.

UNIT IV AIRCRAFT COMPASS SYSTEMS & FLIGHT MANAGEMENT SYSTEM 9

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

UNIT V POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING 9

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.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Students will be able to:

CO1 Understand and apply the concept of measurement, classification of aircraft instrumentation, displays and layouts standards

CO2 Explain about the various air data systems and synchronous data transmissions systems

CO3 Apply the principle of gyroscope to various Advanced Aircraft Instruments

CO4 Classify the aircraft magnetism, understand the Compass systems and FMS in 4D flight management in the Avionics domain requirements

CO5 Explain the operation and importance of Power plant & engine instruments and flight data recorder.

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.

COs	**POs**						**PSOs**			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	1		2	2		3	3	3	2	2
2	1		2	2		2	3	3	2	2
3	2			2		3	3	3	2	2
4	1	1		2		3	3	3	2	2
5	1			2		2	3	3	2	2

AL3013 EXPERIMENTAL STRESS ANALYSIS

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

Of this course are

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

UNIT I BASICS OF MECHANICAL MEASUREMENTS 9

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.

UNIT II ELECTRICAL-RESISTANCE STRAIN GAUGES 9

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 Rectangular Rosette for Strain Measurement – Other Types of Strain Gages – Semiconductor Strain Gages-Grid & Brittle Coating Methods of Strain Analysis.

UNIT III STRAIN-GAUGE CIRCUITS & INSTRUMENTATION 9

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.

UNIT IV PHOTOELASTIC METHODS OF STRESS ANALYSIS 9

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.

UNIT V NON-DESTRUCTIVE TESTING 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Analyse the performance of measuring instrumentation.
CO2 Impart knowledge on different methods of strain measurement.
CO3 Design different strain gauge circuits.
CO4 Use photoelasticity for stress analysis.
CO5 Exposure the different types of non-destructive testing methods.

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.

COs	POs								PSOs	
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		2	3	3	2	2
2	3	3		2		3	3	3	2	2
3	3	3		2		3	3	3	2	2
4	3	3		2		2	3	3	2	2
5	3	3		2		3	3	3	2	2

AL3014	NDT METHODS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION 9

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

UNIT II ELECTRON MICROSCOPY 9

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.

UNIT III ACOUSTIC EMISSION AND ULTRASONICS 9

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.

UNIT IV AIRCRAFT INSPECTION 9

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.

UNIT V STRUCTURAL HEALTH MONITORING 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 To realize the importance of various NDT techniques.
CO2 To identify suitable NDT technique for a particular application.
CO3 To demonstrate the physical principles involved in acoustic emission and ultrasonics.
CO4 To have knowledge on the physical principles involved in the various other techniques of NDT.
CO5 To realise the state-of-the-art in NDT testing and structural health monitoring.

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”, 44th 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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	1		2	2		3	3	3	2	2
2	1		2	2		3	3	3	2	2
3	2			2		3	3	3	2	2
4	1	1		2		2	3	3	2	2
5	1			2		2	3	3	2	2

AL3015	AIRCRAFT STRUCTURAL MECHANICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I ENERGY METHOD OF ANALYSIS 9

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

UNIT II ELASTICITY 9

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

UNIT III THEORIES OF FAILURE 9

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

UNIT IV CONNECTIONS & FITTINGS 9

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

UNIT V STRESS ANALYSIS OF AIRCRAFT COMPONENTS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability to solve problems using energy principles
CO2 Knowledge of elasticity equations & solution procedure using theory of elasticity approach
CO3 Knowledge of various theories of failure and their application
CO4 Ability to design riveted and bolted joints
CO5 Understanding of stress analysis procedures involving aircraft components

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.

	POs						PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
CO1	3	1				3	3	3	2	2
CO2	3	2				2	3	3	2	2
CO3	3	2				2	3	3	2	2
CO4	3	3				3	3	3	2	2
CO5	3	3		3		3	3	3	2	2

AL3053	MULTIFUNCTIONAL MATERIALS AND THEIR APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION OF STRUCTURAL HEALTH MONITORING 9

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.

UNIT II OVERVIEW OF SMART MATERIALS 9

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.

UNIT III SMART COMPOSITES 9

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.

UNIT IV INTELLIGENT SYSTEMS AND NEURAL NETWORKS 9

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.

UNIT V ADVANCES IN SMART STRUCTURES &MATERIALS 9

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 .

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 To familiarize with the fundamentals of history of SHM.
CO2 To provide a systematic approach to SHM process.
CO3 CO3: To have knowledge of the various smart materials used for aerospace applications.
CO4 To familiarize with the non-destructive test techniques relevant to SHM.
CO5 To provide hands-on experience with experimental modal analysis

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.

COs	POs						PSOs		
	1	2	3	4	5	6	1	2	3
1	3			3		3	3	2	1
2	3	2	3	3		3	3	2	1
3	3	3		3		2	3	2	1
4	3	3		3		3	3	2	1
5	3			3	3	2	3	2	1

AL3016	AEROELASTICITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I AEROELASTIC PHENOMENA 9

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

UNIT II MODELLING OF AEROELASTIC PHENOMENA 9

Influence and stiffness co-efficients – illustration of aeroelastic phenomena using simplified aerodynamic and structural models – different subsonic and supersonic aerodynamic models for
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

UNIT III STATIC AEROELASTIC PHENOMENA 9

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

UNIT IV FLUTTER CALCULATIONS 9

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.

UNIT V PREVENTION AND CONTROL 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Have knowledge of the role of aeroelasticity in aircraft design.

CO2 Interpret the use of semi-rigid body assumptions and numerical methods in airplane design

CO3 Arrive at the solutions for steady state aeroelastic problem.

CO4 Be knowledge with the concept of flutter analysis of aircraft wings.

CO5 Have knowledge on practical examples of aeroelastic problems.

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 U niversity Press, 2002

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		3		3	3	2	1	1
2	3	2	3	3		2	3	2	1	1
3	3	3				2	3	2	1	1
4	3		3			3	3	2	1	1
5	3		3	3		3	3	2	1	1

AL3017 THEORY OF BOUNDARY LAYERS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: The objectives of the course are

1. 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
2. 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
3. To introduce the basic concepts in laminar boundary layer theory and its applications in engineering to students for flows over flat and curved surfaces.
4. 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.
5. 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.

UNIT I VISCOUS FLOW AND THE GOVERNING EQUATIONS 9

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.

UNIT II VISCOUS FLOW EQUATIONS AND THEIR SOLUTION METHODS 9

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

UNIT III INTRODUCTORY ANALYSIS OF LAMINAR BOUNDARY LAYER 9

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.

UNIT IV FUNDAMENTAL ASPECTS OF TURBULENT BOUNDARY LAYER 9

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

UNIT V CONTROL METHODS FOR BOUNDARY LAYER 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES: Upon completion of the course students will be able

CO1 To understand the basic fluid dynamic character of viscous flows and apply the boundary conditions required for obtaining the solutions

CO2 To apply the governing equations of viscous flows for engineering applications and understand the importance of various terms in the equations

CO3 To understand the importance & application of boundary layers in engineering problems and use the boundary solutions for component design

CO4 To evaluate the nature of the boundary layer and analyze the velocity and temperature profiles and will be able to use boundary layer analysis for conjugate heat transfer problems

CO5 To understand the nature of turbulent flows and will be able to distinguish between laminar and turbulent flows for application to engineering problems

CO6 To apply boundary layer control methods for prevention of separation and delay the transition fordrag reduction in aeronautical and aerospace applications

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		3	3	3	2	2
2	3	3		2		2	3	3	2	2
3	3	3		2		3	3	3	2	2
4	3	3		2		2	3	3	2	2
5	3	3		2		3	3	3	2	2
6	3	3		2		3	3	3	2	2

AV3025 AIRCRAFT CONTROL ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO AIRCRAFT CONTROL 9

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

UNIT II OPEN AND CLOSED LOOP SYSTEMS 9

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

UNIT III TRANSIENT AND STEADY STATE CHARACTERISTICS 9

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

UNIT IV CONCEPT OF STABILITY 9

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

UNIT V AUTOPILOT 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Students will be able to :

CO1 Understand and apply classical and modern feedback control methods to various systems especially Flight control system and concepts of FBW systems

CO2 Acquire knowledge on open and closed loop systems and various forms of representations

CO3 Understand the Transient and steady state analysis and their characteristics

CO4 Apply the concepts of frequency responses for the practical systems and Acquire in-depth knowledge about Stability analysis.

CO5 Develop and design various Autopilots in both longitudinal and lateral modes

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		2	3	3	2	2
2	3	3		2		3	3	3	2	2
3	3	3		2		3	3	3	2	2
4	3	3		3		3	3	3	2	2
5	3	3		3		2	3	3	2	2
6	3	3		3		3	3	3	2	2

AL3054	HIGH SPEED JET FLOWS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will make students

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

UNIT I INTRODUCTION 11

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.

UNIT II TYPES OF JETS 9

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.

UNIT III ACTIVE JET CONTROL METHODS 8

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

UNIT IV PASSIVE JET CONTROL METHODS 8

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

UNIT V JET ACOUSTICS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1 To acquire knowledge on the unique features of jet flows.
CO2 To analyse the characteristics of jets.
CO3 To have through knowledge on active and passive control methods of jets.
CO4 To acquire knowledge on jet acoustics and methods for suppression of jet noise.
CO5 To demonstrate various experimental techniques to determine jet characteristics.

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)

COs	POs						PSOs			
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**
1	3	2		3		2		2		
2	3			3	2	3				
3	3	2	3	3		3			2	
4	3		3	3	2	3		3		3
5	3	2		3		2				

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AO3251 **HYPERSONIC AERODYNAMICS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION TO HYPERSONIC AERODYNAMICS 9

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.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9

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.

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 9

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

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 9

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.

UNIT V VISCOUS INTERACTIONS AND TRANSITION 9

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.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able to

CO1 Apply problem-solving techniques to analyze and solve inviscid and viscous hypersonic flow problems.

CO2 Evaluate the impact of high temperature on hypersonic aerodynamics and its effects.

CO3 Generate and assess different solution methods to mitigate aerodynamic heating challenges in hypersonic vehicles.

CO4 Evaluate and analyze design considerations and issues associated with hypersonic vehicles.

CO5 Demonstrate an understanding of the significance and application of relevant equations in modeling viscous hypersonic flows.

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3					3			2
2	3	3					3			2
3	3	3					3			2
4	3	3					3			2
5	3	3					3			2

AO3053 NAVIGATION, GUIDANCE AND CONTROL FOR SPACE VEHICLES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION **9**

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

UNIT II ATTITUDE SENSORS AND CONTROL ACTUATORS **9**

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

UNIT III INERTIAL NAVIGATION SYSTEMS AND GPS **9**

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

UNIT IV RELATIVE NAVIGATION SYSTEMS **9**

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

UNIT V ATTITUDE DYNAMICS AND STABILIZATION SCHEMES **9**

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able to

CO1 Understand and Apply the concepts of Spacecraft Navigation Guidance and Control subsystems

CO2 Explain the principle of operation various sensors and actuators and their significances

CO3 Explain the principle of operation of Inertial Measurement systems and Satellite Navigation.

CO4 Understand Relative Navigation system and Rendezvous & Docking concepts

CO5 Explain the Attitude dynamics and Stabilization and FBW Control system

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. George M Siouris, ‘Aerospace Avionics System; A Modern Synthesis’, Academic Press Inc., 1993
4. Maxwell Noton, ”Spacecraft navigation and guidance”, Springer (London, New York), 1998
5. Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 1997
6. Collinson R.P.G, ‘Introduction to Avionics’, Chapman and Hall, India, 1996.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3			2	3	3		3
2	3	3	3			3	3	3		3
3	3	3	2			3	3	3		3
4	3	3	2			3	3	3		3
5	3	3	2		2	2	3	3	2	3

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

AV3026	AIR TRAFFIC CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO AIR TRAFFIC CONTROL 9

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

UNIT II AIR TRAFFIC CONTROL SYSTEMS AND SURVEILLANCE 9

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

UNIT III FLIGHT INFORMATION SYSTEMS 9

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

UNIT IV AERODROME DATA 9

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.

UNIT V NAVIGATION , COMMUNICATION AND OTHER SERVICES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Demonstrate knowledge of the roles, responsibilities, and operational procedures of air traffic control personnel, and apply them to ensure safe and efficient air traffic management.

CO2 Evaluate the capabilities and limitations of different surveillance systems, such as radar, Automatic Dependent Surveillance-Broadcast (ADS-B), and satellite-based surveillance, for effective air traffic control and enhanced situational awareness.

CO3 Explore the flight information systems, emergency procedure and air rules followed by air traffic control systems.

CO4 Describe the aerodrome data.

CO5 Demonstrate proficiency in using standard phraseology, communication procedures, and Controller-Pilot Data Link Communications (CPDLC) to facilitate clear and accurate communication between air traffic control and pilots.

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.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2		2	3	3	2	2
2	3	3		2		3	3	3	2	2
3	3	3		2		3	3	3	2	2
4	3	3		2		2	3	3	2	2
5	3	3		2		3	3	3	2	2
6	3	3		2		2	3	3	2	2

AS3056	HYPERSONIC PROPULSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO HYPERSONIC FLOWS AND PROPULSION 9

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

UNIT II RAMJET PROPULSION 9

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

UNIT III SCRAMJET PROPULSION 9

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

UNIT IV ROCKET-BASED HYPERSONIC PROPULSION 9

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

UNIT V HYPERSONIC VEHICLE DESIGN AND TESTING 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES: Upon completion of the course, students will be able

CO1 to describe the characteristics of hypersonic flows, analyze the impact of compressibility effects and shock waves, and discuss the challenges and future applications of hypersonic technology.

CO2 To explain the working principles and performance characteristics of Ramjet engines, analyse design considerations of ramjet and dual mode ramjet engines

CO3 to explain the working principles and performance characteristics of scramjet engines, analyze design considerations for hypersonic intakes and compression systems, and evaluate the challenges involved in scramjet propulsion.

CO4 to differentiate between different rocket propulsion systems for hypersonic flight, analyze combustion processes in high-speed rocket engines, and evaluate the design and optimization of rocket nozzles for hypersonic propulsion.

CO5 to integrate knowledge from various disciplines to design hypersonic vehicles, analyze the multi-disciplinary optimization process, apply experimental techniques for hypersonic vehicle testing, and assess the challenges and future directions in hypersonic vehicle design.

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	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	2	3			3	3	2	3	2
2	3			1		2	2	2	3	2
3	3	2		2		3	2	2	3	2
4	3	2		1		2	2	2	3	2
5	3	1	3	1	3	3	2	3	3	2

AL3018 AIRCRAFT REGULATIONS AND CERTIFICATIONS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO AIRCRAFT RULES AND CERTIFICATIONS 9

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.

UNIT II C.A.R Series 'A' &' B' 9

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.

UNIT III C.A.R. SERIES 'C' & 'D' 9

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.

UNIT IV C.A.R. SERIES 'E' & 'F' 9

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.

UNIT V C.A.R. SERIES 'L'&'M' 9

Issue of AME Licence, its classification and experience requirements, Mandatory Modifications / Inspections.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 To realise the importance of aircraft rules and certifications
CO2 To get exposure on the basic concepts of airworthiness standards.
CO3 To develop test flight and Certification.
CO4 To carry out inspections and can identify the approved materials.
CO5 To analyse the case studies and realise the importance of civil aviation requirements

REFERENCES:

1. "Aircraft Manual (India) Volume" – Latest Edition, The English Book Store, 17-1, Connaught Circus, NewDelhi.
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

COs	POs							PSOs		
	1	2	3	4	5	6	1	2	3	4
1	2		3	3	1	3	2	1	1	3
2	2		3	3	1	2	2	1	1	3
3	2		3	3	1	2	2	1	1	3
4	2		3	3	1	3	2	1	1	3
5	2		3	3	1	3	2	1	1	3

		L	T	P	C
AL3055	**VIBRATION AND STRUCTURAL DYNAMICS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

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

UNIT I FREE VIBRATION OF A SINGLE DEGREE OF FREEDOM SYSTEM 9

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

UNIT II FORCED VIBRATION OF A SINGLE DEGREE OF FREEDOM SYSTEM 9

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

UNIT III TWO DEGREE OF FREEDOM SYSTEMS 9

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

UNIT IV MULTI DEGREE OF FREEDOM SYSTEMS 9

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

UNIT V VIBRATION OF CONTINUOUS SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1 Ability of a student to model a given physical system into a single or multi-degree of freedom system.
CO2 Solve problems involving single and multi degrees of freedom
CO3 Analyze the vibration characteristics of both discrete and continuous systems
CO4 Ability to extract natural frequencies natural frequencies of a multi degree of freedom system using approximate methods
CO5 Students are able predict the response of a physical system to initial excitation

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.

	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
CO1	3	1	2			3	3	3	2	2
CO2	3	2	2			2	3	3	2	2
CO3	3	2	2			2	3	3	2	2
CO4	3	3	2			3	3	3	2	2
CO5	3	3	2			3	3	3	2	2