ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2015
CHOICE BASED CREDIT SYSTEM
M.E. AERONAUTICAL ENGINEERING (FT/PT)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. **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.

II. **PEO 2:** Successful Career Development: Graduates of the programme will have successful technical and managerial career in Aeronautical Engineering industries and the allied management.

III. **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 Aviation industries.

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

PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

1. Post Graduate will acquire the ability to design and conduct experiments, as well as to analyze and interpret data in the field of Aeronautical Engineering.
2. Post Graduate will have the ability to design a system or a component to meet the design requirements with constraints exclusively meant for Aeronautical Engineering.
3. Post Graduate will become familiar with modern engineering tools and analyze problems within the domains of Aeronautical Engineering
4. Post Graduate will acquire an understanding of professional and ethical responsibility with reference to their career in the field of Aeronautical Engineering and other allied professional fields.
5. Post Graduate will be able to communicate effectively both in verbal and nonverbal forms.
6. Post Graduate will be trained towards developing and understanding the importance of design and development of Airplanes from system integration point of view.
7. Post Graduate will be capable of understanding the value of lifelong learning.

8. Post Graduate will exhibit the awareness of contemporary issues focusing on the necessity to develop new materials, design and testing methods for the solution of problems related to aircraft industry.
9. Post Graduate will have a firm scientific, technological and communication base that helps him to find a placement in the aircraft industry and Research & Development organizations related to Aeronautical Engineering and other professional fields.
10. Post Graduate will be capable of doing doctoral studies and research in inter and multidisciplinary areas.

Mapping of PEOs with POs

Programme Educational Objectives	**Programme Outcomes**									
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
I	✓	✓	✓	✓				✓		✓
II				✓	✓	✓		✓	✓	
III		✓		✓		✓		✓	✓	
IV			✓				✓	✓		✓

			PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
YEAR 1	**SEM 1**	Advanced Mathematical Methods	✓						✓		✓	
		Aerospace Propulsion	✓						✓		✓	
		Aerospace Structures	✓						✓		✓	
		Flight Vehicle Aerodynamics	✓						✓		✓	
		Rocketry and space mechanics	✓					✓				✓
		Theory of Elasticity		✓				✓		✓		✓
		Aerodynamics- Propulsion Laboratory	✓	✓	✓	✓	✓	✓	✓	✓		
	SEM 2	Advanced Propulsion systems	✓	✓	✓			✓				
		Airplane Performance, stability and control	✓	✓				✓	✓			
		Computational Fluid Dynamics for Aerospace applications	✓	✓	✓			✓	✓			✓
		Composite Materials and structures	✓	✓				✓	✓			✓
		Finite Element Analysis	✓	✓	✓			✓	✓			✓
		Professional Elective-I										
		Aerospace Structures laboratory	✓	✓	✓	✓	✓	✓	✓	✓		
YEAR 2	**SEM 3**	Professional Elective-II										
		Professional Elective-III										
		Professional Elective-IV										
		Technical Seminar				✓	✓				✓	
		Project phase-I	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	SEM 4	Project Phase-II	✓	✓	✓	✓	✓	✓	✓	✓	✓	
PROFESSIONAL ELECTIVES		Chemical Rocket Technology		✓	✓							✓
		Computational Heat Transfer		✓	✓			✓				
		Design of Turbo machines	✓	✓	✓			✓		✓		
		Experimental Aerodynamics	✓	✓				✓	✓	✓	✓	
		Experimental Stress Analysis	✓	✓				✓	✓	✓	✓	
		Transonic Aerodynamics		✓	✓							✓

	Advanced Computational Fluid Dynamics and Heat Transfer		✓	✓							✓
	Advanced Flight Structures		✓	✓							✓
	Aero elasticity		✓				✓				
	Aerospace Materials		✓	✓			✓		✓	✓	
	Aircraft Design	✓	✓	✓	✓		✓	✓	✓	✓	
	Combustion in Jet and Rocket Engines		✓							✓	
	Fatigue and Fracture Mechanics	✓	✓	✓			✓		✓		
	Helicopter Aerodynamics		✓				✓				
	High Speed Jet Flows		✓	✓							
	High Temperature Gas Dynamics		✓	✓							✓
	Hypersonic Aerodynamics		✓	✓			✓				✓
	Missile Aerodynamics		✓	✓							✓
	Non Destructive Testing and Evaluation	✓	✓	✓			✓		✓		
	Orbital Mechanics and Space Flight		✓					✓		✓	✓
	Structural Dynamics	✓	✓	✓					✓		
	Theory of Boundary Layers		✓							✓	✓
	Theory of Plates and shells		✓								✓
	Wind Turbine Engineering	✓	✓	✓			✓				

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. AERONAUTICAL ENGINEERING (FT/PT)

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL 7101	Theory of Elasticity	PC	3	3	0	0	3
2.	AL 7151	Aerospace Propulsion	FC	4	4	0	0	4
3.	AL7152	Aerospace Structures	FC	4	4	0	0	4
4.	AL7153	Flight Vehicle Aerodynamics	FC	3	3	0	0	3
5.	AL7154	Rocketry and Space Mechanics	PC	3	3	0	0	3
6.	MA7161	Advanced Mathematical Methods	FC	4	4	0	0	4
PRACTICALS								
7	AL 7161	Aerodynamics Propulsion Laboratory	PC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL 7201	Advanced Propulsion Systems	PC	3	3	0	0	3
2.	AL7202	Airplane Performance, Stability and Control	PC	4	4	0	0	4
3.	AL 7203	Finite Element Analysis	PC	4	4	0	0	4
4.	AL 7251	Composite Materials and Structures	PC	3	3	0	0	3
5.	AL 7252	Computational Fluid Dynamics for Aerospace Applications	PC	4	4	0	0	4
6.		Elective-I	PE	3	3	0	0	3
PRACTICALS								
7	AL7261	Aerospace Structures Laboratory	PC	4	0	0	4	2
			TOTAL	**25**	**21**	**0**	**4**	**23**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective-II	PE	3	3	0	0	3
2.		Elective-III	PE	3	3	0	0	3
3.		Elective-IV	PE	3	3	0	0	3
PRACTICALS								
4	AL 7311	Technical Seminar	EEC	4	0	0	4	2
5	AL 7312	Project Work Phase-I	EEC	12	0	0	12	6
			TOTAL	**25**	**9**	**0**	**16**	**17**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	AL 7411	Project Work Phase II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE =75

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. AERONAUTICAL ENGINEERING (PART TIME)

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA7161	Advanced Mathematical Methods	FC	4	4	0	0	4
2.	AL 7151	Aerospace Propulsion	FC	4	4	0	0	4
3.	AL 7153	Flight Vehicle Aerodynamics	FC	3	3	0	0	3
PRACTICALS								
4	AL 7161	Aerodynamics Propulsion Laboratory	PC	4	0	0	4	2
			TOTAL	**15**	**11**	**0**	**4**	**13**

SEMESTER II

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL7152	Aerospace Structures	FC	4	4	0	0	4
2.	AL7154	Rocketry and Space Mechanics	PC	3	3	0	0	3
3.	AL7101	Theory of Elasticity	PC	3	3	0	0	3
PRACTICALS								
4	AL7261	Aerospace Structures Laboratory	PC	4	0	0	4	2
			TOTAL	**14**	**10**	**0**	**4**	**12**

SEMESTER III

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL7201	Advanced Propulsion Systems	PC	3	3	0	0	3
2.	AL7202	Airplane Performance, Stability and Control	PC	4	4	0	0	4
3.	AL7252	Computational Fluid Dynamics for Aerospace Applications	PC	4	4	0	0	4
4.		Elective-I	PE	3	3	0	0	3
			TOTAL	**14**	**14**	**0**	**0**	**14**

SEMESTER IV

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL7251	Composite Materials and Structures	PC	3	3	0	0	3
2.	AL7203	Finite Element Analysis	PC	4	4	0	0	4
3.		Elective-II	PE	3	3	0	0	3
4.		Elective-III	PE	3	3	0	0	3
			TOTAL	**13**	**13**	**0**	**0**	**13**

SEMESTER V

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.		Elective-IV	PE	3	3	0	0	3
PRACTICALS								
2	AL7311	Technical Seminar	EEC	4	0	0	4	2
3	AL7312	Project Work Phase-I	EEC	12	0	0	12	6
			TOTAL	**19**	**3**	**0**	**16**	**11**

SEMESTER VI

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
PRACTICALS								
1	AL7411	Project Work Phase-II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF DEGREE =75

FOUNDATION COURSES (FC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Advanced Mathematical Methods	FC	4	4	0	0	4
2.		Aerospace Propulsion	FC	4	4	0	0	4
3.		Aerospace Structures	FC	4	4	0	0	4
4.		Flight Vehicle Aerodynamics	FC	3	3	0	0	3

PROFESSIONAL CORE (PC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.		Rocketry and Space Mechanics	PC	3	3	0	0	3
2.		Theory of Elasticity	PC	3	3	0	0	3
3.		Aerodynamics-Propulsion Laboratory	PC	4	0	0	4	2
4.		Advanced Propulsion Systems	PC	3	3	0	0	3
5.		Airplane Performance, Stability and Control	PC	4	4	0	0	4
6.		Computational Fluid Dynamics for Aerospace Applications	PC	4	4	0	0	4
7.		Composite Materials and Structures	PC	3	3	0	0	3
8.		Finite Element Analysis	PC	4	4	0	0	4
9		Aerodynamics Structures Laboratory	PC	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1.	AL 7001	Advanced Computational Fluid Dynamics and Heat Transfer	PE	3	3	0	0	3
2.	AL 7002	Advanced Flight Structures	PE	3	3	0	0	3
3.	AL 7003	Aero elasticity	PE	3	3	0	0	3
4.	AL 7004	Aerospace Materials	PE	3	3	0	0	3

5.	AL7005	Aircraft Design	PE	3	3	0	0	3
6.	AL7006	Design of Turbo machines	PE	3	3	0	0	3
7.	AL 7007	Experimental Aerodynamics	PE	3	3	0	0	3
8.	AL 7008	Experimental Stress Analysis	PE	3	3	0	0	3
9.	AL 7009	Helicopter Aerodynamics	PE	3	3	0	0	3
10.	AL7010	High Temperature Gas Dynamics	PE	3	3	0	0	3
11.	AL 7011	Missile Aerodynamics	PE	3	3	0	0	3
12.	AL7012	Non Destructive Testing and Evaluation	PE	3	3	0	0	3
13.	AL 7013	Structural Dynamics	PE	3	3	0	0	3
14.	AL 7014	Theory of Plates and shells	PE	3	3	0	0	3
15.	AL 7015	Transonic Aerodynamics	PE	3	3	0	0	3
16.	AL 7016	Wind Turbine Engineering	PE	3	3	0	0	3
17.	AL 7071	Combustion in Jet and Rocket Engines	PE	3	3	0	0	3
18.	AL 7072	Fatigue and Fracture Mechanics	PE	3	3	0	0	3
19.	AL 7073	High Speed Jet Flows	PE	3	3	0	0	3
20.	AL 7074	Orbital Mechanics and Space Flight	PE	3	3	0	0	3
21.	AL 7075	Theory of Boundary Layers	PE	3	3	0	0	3
22.	AS 7151	Computational Heat Transfer	PE	3	3	0	0	3
23.	AS 7251	Chemical Rocket Technology	PE	3	3	0	0	3
24.	AS7253	Hypersonic Aerodynamics	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
1		Technical Seminar	EEC	4	0	0	4	2
2		Project Work Phase I	EEC	12	0	0	12	6
3.		Project Work Phase II	EEC	24	0	0	24	12

AL 7101 THEORY OF ELASTICITY **L T P C**
3 0 0 3

OBJECTIVE:

- To impart knowledge to students on basic governing equations of elasticity, solving of 2D problems in Cartesian and polar coordinates and also to introduce various theories and methods to solve torsion related problems.

UNIT I INTRODUCTION 6

Definition, notations and sign conventions for stress and strain – Stress - strain relations,Strain-displacement relations- Elastic constants.

UNIT II BASIC EQUATIONS OF ELASTICITY 10

Equations of equilibrium – Compatibility equations in strains and stresses –Boundary Conditions - Saint-Venant's principle - Stress ellipsoid – Stress invariants – Principal stresses in 2-D and 3-D.

UNIT III 2- D PROBLEMS IN CARTESIAN COORDINATES 9

Plane stress and plain strain problems - Airy's stress function – Biharmonications – 2-D problems– Cantilever and simply supported beams.

UNIT IV 2- D PROBLEMS IN POLAR COORDINATES 12

Equations of equilibrium – Strain – displacement relations – Stress – strain relations – Airy's stress function - Axisymmetric problems - Bending of curved bars - Thick cylinder - Rotating discs - Solid annular discs - Kirsh Boussingasque's and Michell's problems.

UNIT V TORSION 8

Stress function approach and warping function approach – Torsion of Circular, Elliptical and Triangular sections - Membrane analogy.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the basic concepts of obtaining exact solution for structural mechanics problems.

REFERENCES

1.Ugural, A.C and Fenster, S.K, Advanced Strength and Applied Elasticity, Prentice hall, 2003
2.Wang, C.T. Applied elasticity, McGraw Hill 1993
3.EnricoVolterra and Caines, J.H, Advanced strength of Materials, Prentice Hall, 1991.
4.S.P. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw-Hill, 1985.
5.E. Sechler, "Elasticity in Engineering" John Wiley & Sons Inc., New York, 1980.

AL 7151 AEROSPACE PROPULSION **L T P C**
4 0 0 4

OBJECTIVES:

- To impart knowledge to students about fundamental principles of aircraft hypersonic and rocket propulsion and also to make them familiarize with electric nuclear and solar space propulsion methods.

UNIT I ELEMENTS OF AIRCRAFT PROPULSION 12

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 of turboprop, turbofan and turbojet , Ram jet, Scram jet – Methods of Thrust augmentation.

UNIT II PROPELLER THEORY 12

Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts.

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS 12

Subsonic and supersonic inlets – 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.

UNIT IV AXIAL FLOW COMPRESSORS, FANS AND TURBINES 12

Introduction to centrifugal compressors- Axial flow compressor- geometry- twin spools- three spools- stage analysis- velocity polygons- degree of reaction – radial equilibrium theory- performance maps- axial flow turbines- geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

UNIT V ROCKET AND ELECTRIC PROPULSION 12

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

TOTAL: 60 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the principles of operation and design of aircraft and spacecraft power plants.

REFERENCES

1. P.G Hill, and Peterson, C.R. Mechanics and Thermodynamics of Propulsion, Addison – Wesley Longman Inc. 1999
2. H Cohen,. G.F.C. Rogers, and H.I.H Saravanamuttoo, Gas Turbine Theory, Longman, 6t h Edition, 2008
3. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 1985.
4. G.P.Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th Edition, 2010.
5.W.P.Gill, H.J.Smith & J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980.

AL7152 AEROSPACE STRUCTURES L T P C
OBJECTIVE: 4 0 0 4

- To make students learn important technical aspects on theory of bending, shear flow in open and closed sections, stability problems in structures with various modes of loading and also impart knowledge on how to analyze aircraft structural components under various forms of loading.

UNIT I BENDING OF BEAMS 12

Elementary theory of bending – Introduction to semi-monocoque structures - Stresses in beams of symmetrical and unsymmetrical sections -Box beams – General formula for bending stresses- principal axes method – Neutral axis method.

UNIT II SHEAR FLOW IN OPEN SECTIONS 9

Shear stresses in beams – Shear flow in stiffened panels - Shear flow in thin walled open tubes – Shear centre – Shear flow in open sections with stiffeners.

UNIT III SHEAR FLOW IN CLOSED SECTIONS 15

Shear flow in closed sections with stiffeners– Angle of twist - Shear flow in two flange and three flange box beams – Shear centre - Shear flow in thin walled closed tubes - Bredt-Batho theory - Torsional shear flow in multi cell tubes - Flexural shear flow in multi cell stiffened structures.

UNIT IV STABILITY PROBLEMS 12

Stability problems of thin walled structures– Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham's and Gerard's methods–Sheet stiffener panels-Effective width, Inter rivet and sheet wrinkling failures-Tension field web beams(Wagner's).

UNIT V ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS 12

Loads on Wings – Schrenk's curve - Shear force, bending moment and torque distribution along the span of the Wing. Loads on fuselage - Shear and bending moment distribution along the length of the fuselage. Analysis of rings and frames.

L : 45, T : 15, TOTAL: 60 PERIODS

OUTCOMES:

Upon completion of the course, students will get knowledge on different types of beams and columns subjected to various types of loading and support conditions with particular emphasis on aircraft structural components.

REFERENCES

1.E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
2.Megson, T.M.G; Aircraft Structures for Engineering Students, Elsevier Aerospace Engineering Series, 5th Edition,2012.
3.Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.
4.Stephen P. Timmoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.
5.Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993.

AL7153 FLIGHT VEHICLE AERODYNAMICS L T P C

OBJECTIVES: 3 0 0 3

- To introduce the students the fundamental concepts and topic related to aerodynamics of flight vehicles like fundamental forms of flow, aerodynamic coefficient, incompressible and compressible flow theories, viscous flow measurements and various configuration of aircraft and wings.

UNIT I INTRODUCTION TO AERODYNAMICS 12

Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, 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 9

Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, lifting line theory

UNIT III COMPRESSIBLE FLOW THEORY 9

Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 6

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes

UNIT V VISCOUS FLOW AND FLOW MEASUREMENTS 9

Basics of viscous flow theory – Boundary Layer – Displacement, momentum and Energy Thickness – Laminar and Turbulent boundary layers – Boundary layer over flat plate – Blasius Solution - Types of wind tunnels – Flow visualization techniques– Measurement of force and moments in wind tunnels.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.

REFERENCES

1.J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 5th edition 2010.
2.Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 5th edition, 2013.
3.Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.
4.E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Butterworth-Heineman series, 5th edition 2003.
5.Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989.
6.W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd Edition 1999.

AL7154	**ROCKETRY AND SPACE MECHANICS**	**L T P C**
		3 0 0 3

OBJECTIVES:

- To familiarize the students on fundamental aspects of rocket propulsion, multi stating of rocket vehicle and spacecraft dynamics.

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

Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – methods to calculate perturbations- Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements

UNIT III ROCKET MOTION 10

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 – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – conical and bell shaped nozzles – adapted nozzles – rocket dispersion – launching problems.

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 8

Need for multi staging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles - SITVC.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will have an idea about solar system, basic concepts of orbital mechanics with particular emphasis on interplanetary trajectories.

REFERENCES

1. G.P.Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2010..
2.J.W. Cornelisse, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982
3.Van de Kamp, “Elements of astromechanics”, Pitman Publishing Co., Ltd., London, 1980.
4. E.R. Parker, “Materials for Missiles and Spacecraft”, McGraw-Hill Book Co., Inc., 1982.

MA7161 ADVANCED MATHEMATICAL METHODS L T P C
4 0 0 4

OBJECTIVES:

- To familiarize the students in differential equations for solving boundary value problems associated with engineering applications.
- To expose the students to calculus of variation, conformal mappings and tensor analysis.

UNIT I 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 II 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 III CALCULUS OF VARIATIONS 12

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

UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12

Introduction to conformal mappings and bilinear transformations - Schwarz - Christoffel transformation – Transformation of boundaries in parametric form- Physical applications: Fluid flow heat flow problems .

UNIT V TENSOR ANALYSIS 12

Summation convention – contra variant and covariant vectors – contraction of vectors – inner product – quotient law – metric tensor – christoffel symbols – covariant differentiation – gradient divergence and curl.

TOTAL: 60 PERIODS

OUTCOME:

- This subject helps to develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.

TEXT BOOKS:

1.Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., New Delhi,1997.
2.Gupta A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., New Delhi,1997.
3. Spiegel M.R., “Theory and Problems of Complex Variables and its Application” (Schaum’s Outline Series), McGraw Hill Book Co., Singapore,1981.
4.Ramanaiah, G.T., “Tensor Analysis”, S. Viswanatthan Pvt. Ltd., 1990.
5.James G., “Advanced Modern Engineering Mathematics”, Pearson Education, Third Edition, 2004.
6.O'Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., Singapore, 2003.

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, 1973.
3.Mathews J.H. and Howell R.W., “Complex Analysis for Mathematics and Engineering”, Narosa Publishing House, New Delhi,1997.
4.Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, Fortieth Edition, 2007

AL7161 AERODYNAMICS PROPULSION LABORATORY L T P C

0 0 4 2

OBJECTIVE:

- To expose students with a practical knowledge on various aerodynamic principles related to inviscid incompressible fluids, aerodynamic measurement techniques and testing of sub systems and components of aircraft at low speed.

LIST OF EXPERIMENTS :

1. Calibration of subsonic wind tunnel
2. Pressure distribution over a cambered aerofoil section
3. Force and moment measurements using wind tunnel balance
4. Pressure distribution over a wing of symmetric aerofoil section
5. Pressure distribution over a wing of cambered aerofoil section
6. Supersonic flow visualization studies
7 Total pressure measurements along the jet axis of a circular supersonic jet
8. Cold flow studies of a wake region behind flame holders
9. Wall pressure measurements of a noncircular combustor
10. Wall pressure measurements of a subsonic diffuser
11. Cascade testing of compressor blades.

Only 10 experiments need to be conducted.

TOTAL: 60 PERIODS

OUTCOMES:

- Upon completion of the course, students will be in a position to use wind tunnel for pressure and force measurements on various models.

ONLY 10 EXPERIMENTS WILL BE CONDUCTRED

LABORATORY EQUIPMENTS REQUIREMENTS

1.Subsonic wind tunnel
2.Rough and smooth cylinder
3.Symmetrical Cambered aerofoil
4.Wind tunnel balance
5.Schlieren system
6.Pressure Transducers

AL7201 ADVANCED PROPULSION SYSTEMS **L T P C**
3 0 0 3

OBJECTIVES:

- To familiarize the students on advanced air breathing propulsion systems like air augmented rockets, scramjets and also to introduce the students various technical details and operating principles of nuclear and electric propulsion.

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS 8

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.

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 12

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 8

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

OUTCOMES:

- Upon completion of the course, students will learn in detail about gas turbines, ramjet, fundamentals of rocket propulsion and chemical rockets.

REFERENCES

1. G.P. Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 1998.
2.William H. Heiser and David T. Pratt, Hypersonic Airbreathing propulsion, AIAA Education Series, 2001.
3.Fortescue and Stark, Spacecraft Systems Engineering, 1999.
4.Cumpsty, Jet propulsion, Cambridge University Press, 2003.

AL7202 AIRPLANE PERFORMANCE,STABILITY AND CONTROL **L T P C 4 0 0 4**

OBJECTIVE:

- To impart knowledge to students on aircraft performance in level, climbing, gliding and accelerated flight modes and also various aspects of stability and control in longitudinal, lateral and directional modes.

UNIT I PRINCIPLES OF FLIGHT 12

Physical properties and structure of the atmosphere, International Standard Atmosphere, Temperature, pressure and altitude relationship, Measurement of speed – True, Indicated and Equivalent air speed, Streamlined and bluff bodies, Various Types of drag in airplanes, Drag polar, methods of drag reduction of airplanes.

UNIT II AIRCRAFT PERFORMANCE IN LEVEL, CLIMBING AND GLIDING FLIGHTS 11

Straight and level flight, Thrust required and available, Power required and available, Effect of altitude on thrust and power, Conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and Endurance

UNIT III ACCELERATED FLIGHT 10

Take off and landing performance, Turning performance, horizontal and vertical turn, Pull up and pull down, maximum turn rate, V-n diagram with FAR regulations.

UNIT IV LONGITUDINAL STABILITY AND CONTROL 15

Degrees of freedom of a system, static and dynamic stability, static longitudinal stability, Contribution of individual components, neutral point, static margin, Hinge moment, Elevator control effectiveness, Power effects, elevator angle to trim, elevator angle per g, maneuver point, stick force gradient, aerodynamic balancing, Aircraft equations of motion, stability derivatives, stability quartic, Phugoid motion

UNIT V LATERAL, DIRECTIONAL STABILITY AND CONTROL 12

Yaw and side slip, Dihedral effect, contribution of various components, lateral control, aileron control power, strip theory, aileron reversal, weather cock stability, directional control, rudder requirements, dorsal fin, One engine inoperative condition, Dutch roll, spiral and directional divergence, autorotation and spin

L : 45, T:15 , TOTAL: 60 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the static, dynamic longitudinal, directional and lateral stability and control of airplane, effect of maneuvers.

REFERENCES

1.Houghton, E.L., and Caruthers, N.B., Aerodynamics for engineering students, Edward Arnold Publishers, 1988.

2.Perkins C.D., & Hage, R.E. Airplane performance, stability and control, Wiley Toppan, 1974.
3.Kuethe, A.M., and Chow, C.Y., Foundations of Aerodynamics, John Wiley & Sons, 1982.
4.Clancey,L.J. Aerodynamics, Pitman, 1986.
5.Babister, A.W. Aircraft stability and response, Pergamon Press, 1980.
6.Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 1989.
7.McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.

AL7203 FINITE ELEMENT ANALYSIS L T P C
4 0 0 4

OBJECTIVES:

- To make students learn using Finite element techniques to solve problems related to discrete, continuum and isoparametric elements. And also to introduce solution schemes for static, dynamic and stability problems.

UNIT I INTRODUCTION 12

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods - Stiffness and flexibility matrices for simple cases - Basic concepts of finite element method - Formulation of governing equations and convergence criteria.

UNIT II DISCRETE ELEMENTS 14

Structural analysis of bar and beam elements for static and dynamic loadings. Bar of varying section – Temperature effects. Program Development and use of software package for application of bar and beam elements for static, dynamic and stability analysis. Solution for 2-D problems (static analysis and heat transfer) using software packages.

UNIT III CONTINUUM ELEMENTS 14

Plane stress, Plane strain and Axisymmetric problems – CST Element – LST Element. Consistent and lumped load vectors. Use of local co-ordinates. Numerical integration. Application to heat transfer problems.

UNIT IV ISOPARAMETRIC ELEMENTS 12

Definition and use of different forms of 2-D and 3-D elements. - Formulation of element stiffness matrix and load vector.Solution for 2-D problems (static analysis and heat transfer) using software packages.

UNIT V SOLUTION SCHEMES 8

Different methods of solution of simultaneous equations governing static, dynamics and stability problems. General purpose Software packages.

L : 45, T:15 TOTAL: 60 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the concept of numerical analysis of structural components

REFERENCES

1.Segerlind,L.J. “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.
2.Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002
3.S.S.Rao, “Finite Element Method in Engineering”, Butterworth, Heinemann Publishing, 3rd Edition, 1998
4.Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt “Concepts and Applications of Finite Element Analysis”, 4th Edition, John Wiley & Sons, 2002.

5.K.J. Bathe and E.L. Wilson, “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India Ltd., 1983.
6.C.S. Krishnamurthy, “Finite Elements Analysis”, Tata McGraw-Hill, 1987.

AL7251 COMPOSITE MATERIALS AND STRUCTURES L T P C

OBJECTIVE: 3 0 0 3

- To impart knowledge to the students on the macro mechanics of composite materials, analysis and manufacturing methods of composite materials and introduce failure theories of composites.

UNIT I INTRODUCTION 10

Classification and characteristics of composite materials - Types of fiber and resin materials, functions and their properties – Application of composite to aircraft structures-Micromechanics-Mechanics of materials, Elasticity approaches-Mass and volume fraction of fibers and resins-Effect of voids, Effect of temperature and moisture.

UNIT II MACROMECHANICS 10

Hooke’s law for orthotropic and anisotropic materials-Lamina stress-strain relations referred to natural axes and arbitrary axes.

UNIT III ANALYSIS OF LAMINATED COMPOSITES 10

Governing equations for anisotropic and orthotropic plates- Angle-ply and cross ply laminates-Analysis for simpler cases of composite plates and beams - Interlaminar stresses.

UNIT IV MANUFACTURING & FABRICATION PROCESSES 8

Manufacture of glass, boron and carbon fibers-Manufacture of FRP components- Open mould and closed mould processes. Properties and functions of resins.

UNIT V OTHER METHODS OF ANALYSIS AND FAILURE THEORY 7

Netting analysis- Failure criteria-Flexural rigidity of Sandwich beams and plates – composite repair- AE technique.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the fabrication, analysis and design of composite materials & structures

REFERENCES

1.R.M. Jones, “Mechanics of Composite Materials”, 2nd Edition, Taylor & Francis, 1999
2.L.R. Calcote, “Analysis of laminated structures”, Van Nostrand Reinhold Co., 1989.
3 Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997
4.G.Lubin, “Hand Book on Fibre glass and advanced plastic composites”, Van Nostrand Co., New York, 1989.
5.B.D. Agarwal and L.J. Broutman, “Analysis and Performance of fiber composites”, John-Wiley and Sons, 1990.

AL7252 COMPUTATIONAL FLUID DYNAMICS FOR AEROSPACE APPLICATIONS

L T P C
4 0 0 4

OBJECTIVES:

- To introduce to the students various numerical solution methods pertaining to grid generation, time dependant and panel methods and also techniques pertaining to transonic small perturbation force.

UNIT I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS 12

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, Stability analysis of linear system. Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations.

UNIT II GRID GENERATION 12

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 for geometries like airfoil and CD nozzle.

UNIT III TRANSONIC RELAXATION TECHNIQUES 12

Small perturbation flows, Transonic small perturbation (TSP) equations, Central and backward difference schemes, conservation equations and shock point operator, Line relaxation techniques, Acceleration of convergence rate, Jameson's rotated difference scheme -stretching of coordinates, shock fitting techniques Flow in body fitted coordinate system.
Numerical solution of 1-D conduction- convection energy equation using time dependent methods using both implicit and explicit schemes – application of time split method for the above equation and comparison of the results.

UNIT IV TIME DEPENDENT METHODS 12

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time dependent solutions of gas dynamic problems. Numerical solution of unsteady 2-D heat conduction problems using SLOR methods

UNIT V PANEL METHODS 12

Elements of two and three dimensional panels, panel singularities. Application of panel methods to incompressible, compressible, subsonic and supersonic flows.
Numerical solution of flow over a cylinder using 2-D panel methods using both vertex and source panel methods for lifting and non lifting cases respectively.

L : 45, T: 15 TOTAL: 60 PERIODS

OUTCOMES:

Upon completion of the course, students will learn the flow of dynamic fluids by computational methods.

REFERENCES

1.T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
2.C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
3.A.A. Hirsch, 'Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.
4.T.K.Bose, "Computation Fluid Dynamics" Wiley Eastern Ltd., 1988.
5.H.J. Wirz and J.J. Smeldern "Numerical Methods in Fluid Dynamics", McGraw-Hill & Co., 1978.
6.John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.

AL7261 AEROSPACE STRUCTURES LABORATORY

L T P C
0 0 4 2

OBJECTIVES:

- To impart practical knowledge to the students on calibration of photoelastic materials determination of elastic constant for composite lamina, unsymmetrical bending of beams, determination of shear centre locations for closed and open sections and experimental studies.

LIST OF EXPERIMENTS

1. Constant strength Beams
2. Buckling of columns
3. Unsymmetrical Bending of Beams
4. Shear Centre Location for Open Section
5. Shear Centre Location for Closed Section
6. Flexibility Matrix for Cantilever Beam
7. Combined Loading
8. Calibration of Photo Elastic Materials
9. Stresses in Circular Disc Under Diametrical Compression – Photo Elastic Method
10. Vibration of Beams with Different Support Conditions
11. Fabrication of composite laminates.
12. Characterization of composite laminates
13. Wagner beam

NOTE: Any TEN experiments will be conducted out of 13.

TOTAL: 60 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the concept of numerical analysis of structural components

LABORATORY EQUIPMENTS REQUIREMENTS

1. Constant strength beam setup
2. Column setup
3. Unsymmetrical Bending setup
4. Experimental setup for location of shear centre (open & close section)
5. Cantilever beam setup
6. Experimental setup for bending and torsional loads
7. Diffuser transmission type polariscope with accessories
8. Experimental setup for vibration of beams
9. Universal Testing Machine
10. Wagner beam setup

AL7001 ADVANCED COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER

L T P C
3 0 0 3

OBJECTIVES:

- Students will learn computational methods pertaining to compressible, incompressible flow using finite volume method, students will also learn modern computing methods and the computation of chemically reacting flows and combustion.

UNIT I COMPUTATION OF INCOMPRESSIBLE VISCOUS FLOWS: 9

General - Artificial compressibility methods - Pressure correction methods - Semi-implicit method for pressure linked equations (SIMPLE) - Pressure implicit with splitting of operators - Marker and Cell (MAC) method - Vortex methods.

UNIT II COMPUTATION OF COMPRESSIBLE INVISCID FLOWS: 9

Potential equation - Euler equations - Central schemes with combined space time discretization - Central schemes with independent space time discretization - First order upwind schemes - Second order upwind schemes with low resolution - second order upwind schemes with high resolution - Essentially nonoscillatory scheme - Flux corrected transport schemes.

UNIT III COMPUTATION OF COMPRESSIBLE VISCOUS FLOWS: 9

Navier-Stokes system of equations - Preconditioning process for compressible and incompressible - Flowfield dependent variation methods - Artificial viscosity flux limiters - Fully implicit high order accurate schemes - Point implicit methods

UNIT IV MODERN COMPUTING METHODS 9

Domain decomposition methods - Multigrid methods - Parallel processing - Development of parallel algorithms - Parallel processing with domain decomposition and multigrid methods - Load balancing - Solution of Poisson equation with domain decomposition parallel processing - Solution of Navier-Stokes system of equations with multithreading.

UNIT V COMPUTATION OF CHEMICALLY REACTIVE FLOWS AND COMBUSTION 9

Governing equations in reactive flows - Chemical equilibrium computations - Solution methods of stiff chemical equilibrium equations - Applications to chemical kinetics calculations - Hypersonic reactive flows - Vibrational and electronic energy in non-equilibrium .

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course students will learn the use of and application of finite volume methods for both incompressible and compressible flows for solution of flow problems and combustion problems.

REFERENCES

1. T.J.Chung, Computational Fluid Dynamics, Cambridge University Press, First South Asian Edition 2003
2. Malalasekara, **“**An Introduction to Computational Fluid Dynamics: The Finite Volume Method**”,** second edition, Pearson prentice hall, 2007.
3. Charles Hirsch**,”** Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Second Edition, 2007.
4. Suhas V. *Patankar,”* Numerical Heat Transfer and Fluid Flow” CRC Press,1980

AL7002 ADVANCED FLIGHT STRUCTURES

L	T	P	C
3	0	0	3

OBJECTIVES:

To make students learn the methodology to carry out structural design and analysis of advanced aerospace structures used in modern aircraft, missiles and spacecraft.

UNIT I REVIEW 6

Aerospace Structural Design Principles (Energy Methods, Beam Bending)

Unit II PLATE THEORY 9

Thin Plate Theory, Stress Resultants and Kinematics - Thin Plate Governing Equations and Boundary Conditions

UNIT III ADVANCED CONCEPTS IN BUCKLING OF LIGHTWEIGHT STRUCTURES 6

Thin Plate Solutions and Plate Buckling - Local and Global-Local Buckling of Thin Walled Structures

UNIT IV COMPOSITE MATERIALS 12

Introduction to Advanced Fiber Composites - Analysis of Orthotropic Composite Plies Analysis of Composite Laminates – Stiffness Matrix - Analysis of Composite Laminates – Stress and Strain - Analysis of Composite Laminates – Thermal Expansion - Failure Mechanisms and Analysis

UNIT V INTRODUCTORY STRUCTURAL DYNAMICS AND AERO ELASTICITY 12

Introduction to Structural Vibration, Beam Free Vibration -Forced Response of a Beam Structure - Airfoil and Wing Divergence ,Wing Divergence, Swept Wings - Control Effectiveness and Reversal - Airfoil Flutter, Wing Flutter, Swept Wings

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course students will be able to carry out structural analysis of complex aerospace structures.

TEXT BOOK:

Megson, T.H.G., Aircraft Structures for Engineering Students 4th Ed., Wiley, 2007

REFERENCE BOOKS:

1. Curtis, H.D., Fundamentals of Aircraft Structural Analysis, Irwin, 1997.
2. Hoskin, B.C. and Baker A.A., Composite Materials for Aircraft Structures, AIAA, 1986.
3. Allen, D.D. and Haisler, W.E., Introduction to Aerospace Structural Analysis, Wiley, 1985.
4. D.K. Donaldson, Analysis of Aircraft Structures: An Introduction, McGraw-Hill, 1982
5. Rivello, R.M., Theory and Analysis of Flight Structures, McGraw-Hill, 1969.
6. Agarwal, B.D. and Broutman, L.J., Analysis and Performance of Fiber Composites, Wiley,1980.
7. Sarafin and W. and Larson, Kluwer, Spacecraft Structures and Mechanisms, Academic Publishers, 1995.

AL7003 AERO ELASTICITY L T P C
3 0 0 3

OBJECTIVES:

- To make the students understand aero elastic phenomena, flutter and to make them to solve steady state aero elastic problems.

UNIT I AEROELASTIC PHENOMENA 6

Stability versus response problems – The aero-elastic triangle of forces – Aeroelasticity in Aircraft Design – Prevention of aeroelastic instabilities. Influence and stiffness co-efficients. Flexure – torsional oscillations of beam – Differential equation of motion of beam.

UNIT II DIVERGENCE OF A LIFTING SURFACE 10

Simple two dimensional idealisations-Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions – Generalised coordinates – Successive approximations – Numerical approximations using matrix equations.

UNIT III STEADY STATE AEROLASTIC PROBLEMS 9

Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory and successive approximations – Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability.

UNIT IV FLUTTER PHENOMENON 14

Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow –

Quasisteady 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 prevention and control.

UNIT V EXAMPLES OF AEROELASTIC PROBLEMS 6

Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, Students can understand the theoretical concepts of material behaviour with particular emphasis on their elasticity property.

REFERENCES

1.Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.
2.E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.
3.R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
4.R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
5.R.D.Blevins, "Flow Induced Vibrations", Krieger Pub Co., 2001

AL7004 AEROSPACE MATERIALS L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge to the students on mechanical behaviour, corrosion & heat treatment of aerospace materials and also to expose them to applications of ceramic & composites and high temperature characterization.

UNIT I ELEMENTS OFAEROSPACEMATERIALS 9

Structureofsolidmaterials–Atomicstructureofmaterials–Crystalstructure–Millerindices–Density – Packing factor–Spacelattices–X-raydiffraction–Imperfectionincrystals–general requirements of materials for aerospace applications

UNIT II MECHANICAL BEHAVIOUR OF MATERIALS 9

Linear and nonlinear elastic properties–Yielding, strain hardening, fracture, Bauchinger's effect–Notch effect testing and flaw detection of materials and components–Comparative study of metals, ceramics plastics and composites.

UNIT III CORROSION & HEATTREATMENT OF METAL SAND ALLOYS 10

Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles Heat treatment of carbon steels–aluminium alloys, magnesium alloys and titanium alloys–Effect of alloying treatment, heat resistance alloys– tool and die steels, magnetic alloys, powder metallurgy.

UNIT IV CERAMICS AND COMPOSITES 9

Introduction–physicalmetallurgy–modernceramicmaterials–cermets-cuttingtools–glassceramic – production of semi fabricated forms-Plastics and rubber–Carbon/ Carbon composites, Fabrication processes involved in metal matrix composites-shape memory alloys–applications in aerospace vehicle design

UNIT V HIGH TEMPERATURE MATERIALS CHARACTERIZATION 8

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–super alloys–High temperature material characterization.

TOTAL:45 PERIODS

OUTCOMES:

- Uponcompletionofthiscourse,studentswillunderstandtheadvancedconceptsofaerospacematerials to the engineers and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such elements of aerospace materials, mechanical behavior of materials, ceramics and composites and will be able to deploy these skills effectively in the understanding of aerospace materials.

REFERENCES

1. Titterton.G., Aircraft Materials and Processes,VEdition, PitmanPublishingCo., 1995.
2. Martin,J.W., Engineering Materials, Their properties and Applications, Wykedham Publications (London)Ltd., 1987.
3. VanVlack.L.H., MaterialsScienceforEngineers,AddisonWesley,1985.
4. Raghavan.V., Materials Science and Engineering, Prentice Hall of India,NewDelhi,1993

AL7005	AIRCRAFT DESIGN	L T P C
		3 0 0 3

OBJECTIVES:

- To impart knowledge to the students on various types of power plant types and also to expose them principles of aerodynamics and structural design aspects.

UNIT I REVIEW OF DEVELOPMENTS IN AVIATION 9

Categories and types of aircrafts – various configurations – Layouts and their relative merits – strength, stiffness, fail safe and fatigue requirements – Maneuvering load factors – Gust and maneuverability envelopes – Balancing and maneuvering loads on tail planes.

UNIT II POWER PLANT TYPES AND CHARACTERISTICS 9

Characteristics of different types of power plants – Propeller characteristics and selection – Relative merits of location of power plant.

UNIT III PRELIMINARY DESIGN 9

Selection of geometric and aerodynamic parameters – Weight estimation and balance diagram – Drag estimation of complete a ircraft – Level flight, climb, takeoff and landing calculations – range and endurance – static and dynamic stability estimates – control requirements.

UNIT IV SPECIAL PROBLEMS 9

Layout peculiarities of subsonic and supersonic aircraft – optimization of wing loading to achieve desired performance – loads on undercarriages and design requirements.

UNIT V STRUCTURAL DESIGN 9

Estimation of loads on complete aircraft and components – Structural design of fuselage, wings and undercarriages, controls, connections and joints. Materials for modern aircraft – Methods of analysis, testing and fabrication.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will get the basic concept of aircraft design.

REFERENCES

1. D.P. Raymer, “Aircraft conceptual design”, AIAA Series, 1988.
2. G. Corning, “Supersonic & Subsonic Airplane Design”, II Edition, Edwards Brothers Inc., Michigan, 1953.
3. E.F. Bruhn, “Analysis and Design of Flight Vehicle Structures”, Tristate Offset Co., U.S.A., 1980.
4. E. Torenbeek, “Synthesis of Subsonic Airplane Design”, Delft University Press, London, 1976.
5. H.N.Kota, Integrated design approach to Design fly by wire” Lecture notes Interline Pub. Bangalore, 1992.

AL7006 DESIGN OF TURBO MACHINES **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the students the basic design aspects of gas turbine engine components like compressor, turbine, combustion chamber, inlet and nozzle and also to introduce them to engine parametric analysis.

UNIT I INTRODUCTION TO TURBO MACHINES 9

Introduction to turbo machines -Types - Dimensional Analysis - Dimensions and Equations - The Buckingham π theorem - Model testing - Energy transfer - Components - Euler turbine equations.

UNIT II HYDRAULIC PUMPS & TURBINES 9

Centrifugal pumps-Slip factor-Pump losses - effect of blade shape-Volute Collector - Vane and Vane less diffuser - Cavitation-Suction specific speed-Axial flow pump-Pumping system design-life cycle analysis - Changing pump Speed Operation-Multi pump operation.

Pelton wheel - velocity triangles - Losses and Efficiencies - Reaction turbines - Losses-characteristics - Axial flow turbine - Cavitation.

UNIT III CENTRIFUGAL COMPRESSORS AND FANS 9

Centrifugal Compressor - Effect of Blade Shape on Performance - Velocity diagrams **-** Slip factor - Work done - diffuser - Compressibility effects - Mach number in the Diffuser - Centrifugal Compressor Characteristics - Stall - Surging- Chocking

UNIT IV AXIAL FLOW COMPRESSORS AND FANS 9

Velocity diagrams - Degree of reaction - Stage Loading - Lift and Drag Characteristics - Cascade nomenclature and terminology - 3- D Consideration - Multi Stage Performance - Axial Compressor Characteristics

UNIT V AXIAL FLOW AND RADIAL FLOW TURBINES 9

Introduction- velocity triangles and work output - Degree of reaction Blade loading coefficient - Stator and rotor losses - Free vortex design - Constant angle design.

Radial flow turbine - Velocity and Thermodynamic analysis - Spouting Efficiency - Turbine Efficiency - Application Specific Speed

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course students will be able to carry out the preliminary design of gas turbine engine components like inlets & diffusers, combustion chambers, compressors and turbines.

REFERENCES:
1. Rama S.R. Gorla, Aijaz A. Khan, " Turbo machinery: Design and Theory ", CRC Press 2003.
2. George F. Round," Incompressible Flow Turbo machines : Design, Selection, Applications, And Theory", Elsevier (2011)
3. Grant ingaram," Basic Concepts in Turbomachinery",1st Edition,2012.
4. Turton R.K.," Principles of Turbo machinery, 2nd Edition, SPRINGER (SIE)
5. G. T. Csanady, "Theory of Turbo machines, McGraw-Hill *Book* Co., New York (1964)

AL7007 EXPERIMENTAL AERODYNAMICS **L T P C**
3 0 0 3

OBJECTIVES:

- To make the students learn basic wind tunnel measurements and flow visualization methods, flow measurement variables and data acquisition method pertaining to experiments in aerodynamics.

UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS 8
Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization –Components of measuring systems – Importance of model studies - Experiments on Taylor- Proudman theorem and Ekman layer – Measurements in boundary layers.

UNIT II WIND TUNNEL MEASEUREMENTS 8
Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation and calibration of wind tunnels – Turbulence- Wind tunnel balance – Principle and application and uses – Balance calibration.

UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS 10
Visualization techniques – Smoke tunnel – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Shadowgraph - Schlieren system – Background Oriented Schliren (BOS)system - Hydraulic analogy - Hydraulic jumps - Electrolytic tank.

UNIT IV PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS 10
Pitot-Static tube characteristics - Velocity measurements - Hot-wire anemometry – Constant current and Constant temperature Hot-Wire anemometer – Hot-film anemometry – Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV) – Pressure Sensitive Paints - Pressure measurement techniques - Pressure transducers – Temperature measurements.

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS 9
Data acquisition and processing – Signal conditioning - Estimation of measurement errors – Uncertainty calculation - Uses of uncertainty analysis.

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course, students will learn about the measurement of flow properties in wind tunnels and their associated instrumentation.

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.

AL7008 **EXPERIMENTAL STRESS ANALYSIS** **L T P C**
3 0 0 3

OBJECTIVE:

- To make the students learn basic principles of operation, electrical resistance strain gauges, photoelasticity and interferometric techniques and non destructive methods.

UNIT I INTRODUCTION 8

Principle of measurements-Accuracy, sensitivity and range- Mechanical, Optical, Acoustical and Electrical extensometers.

UNIT II ELECTRICAL RESISTANCE STRAIN GAUGES 12

Principle of operation and requirements-Types and their uses-Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis-Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements-Strain indicators- Application of strain gauges to wind tunnel balance.

UNIT III PRINCIPLES OF PHOTOELASTICITY 9

Two dimensional photo elasticity-Concepts of photoelastic effects-Photoelastic materials-Stress optic law-Plane polariscope–Circular polariscope-Transmission and Reflection type-Effect of stressed model in Plane and Circular polariscope. Interpretation of fringe pattern Isoclinics and Isochromatics.- Fringe sharpening and Fringe multiplication techniques-Compensation and separation techniques- Introduction to three dimensional photo elasticity.

UNIT IV PHOTOELASTICITY AND INTERFEROMETRY TECHNIQUES 9

Fringe sharpening and Fringe multiplication techniques-Compensation and separation techniques-Calibration methods –Photo elastic materials. Introduction to three dimensional photoelasticity. Moire fringes – Laser holography – Grid methods-Stress coat

UNIT V NON DESTRUCTIVE TECHNIQUES 7

Radiography- Ultrasonics- Magnetic particle inspection- Fluorescent penetrant technique-Eddy current testing– thermography– MICRO FOCUS CT scan.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will be able to appreciate use of strain gauges and its principles, principle of photo elasticity and its use, NDT techniques

REFERENCES

1.J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New York, 1988.
2.Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3.P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.
4.M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
5.G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
6.A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

AL7009 HELICOPTER AERODYNAMICS **L T P C 3 0 0 3**

OBJECTIVES:

- To impart knowledge to the students and fundamental aspects of helicopter aerodynamics, performance of helicopters, stability and control aspects and also to expose them basic and aerodynamic design aspects.

UNIT I INTRODUCTION 7

Types of rotorcraft – autogyro, gyrodyne, helicopter, Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti torque pedals.

UNIT II HELICOPTER AERODYNAMICS 12

Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, vortex theory, rotor in hover, rotor model with cylindrical wake and constant circulation along blade, free wake model, Constant chord and ideal twist rotors, Lateral flapping, Coriolis forces, reaction torque, compressibility effects, Ground effect.

UNIT III PERFORMANCE 9

Hover and vertical flight, forward level flight, Climb in forward flight, optimum speeds, Maximum level speed, rotor limits envelope – performance curves with effects of altitude

UNIT IV STABILITY AND CONTROL 9

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

OUTCOMES:

- Upon completion of the course, students will learn about the basic ideas of evolution, performance and associated stability problems of helicopter.

REFERENCES

1.J. Seddon, “ Basic Helicopter Aerodynamics”, AIAA Education series, Blackwell scientific publications, U.K, 1990.
2.A. Gessow and G.C.Meyers, “Aerodynamics of the Helicopter”, Macmillan and Co., New York, 1982.
3.John Fay, “The Helicopter”, Himalayan Books, New Delhi, 1995.
4.Lalit Gupta, “Helicopter Engineering”, Himalayan Books, New Delhi, 1996.
5.Lecture Notes on “Helicopter Technology”, Department of Aerospace Engineering, IIT –Kanpur and Rotary Wing aircraft R&D center, HAL, Bangalore, 1998.

AL7010 HIGH TEMPERATURE GAS DYNAMICS **L T P C 3 0 0 3**

OBJECTIVES:

- To make the students learn the kinetic theory of hypersonic flows and statistical thermodynamic aspects of flows at very high temperatures and also to make them familiarize the calculations transport properties of gases high temperature.

UNIT I INTRODUCTION 8

Nature of high temperature flows – Chemical effects in air – Real perfect gases – Gibb’s free energy and entropy by chemical and non equilibrium – Chemically reacting mixtures and boundary layers.

UNIT II STATISTICAL THERMODYNAMICS 8

Introduction to statistical thermodynamics – Relevance to hypersonic flow - Microscopic description of gases – Boltzman distribution – Cartesian function

UNIT III KINETIC THEORY AND HYPERSONIC FLOWS 9

Chemical equilibrium calculation of equilibrium composition of high temperature air – equilibrium properties of high temperature air – collision frequency and mean free path – velocity and speed distribution functions.

UNIT IV INVISCID HIGH TEMPERATURE FLOWS 10

Equilibrium and non – equilibrium flows – governing equations for inviscid high temperature equilibrium flows – equilibrium normal and oblique shock wave flows – frozen and equilibrium flows – equilibrium conical and blunt body flows – governing equations for non equilibrium inviscid flows.

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 10

Transport coefficients – mechanisms of diffusion – total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting and absorbing gases.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn statistical thermodynamics and the transport properties of high temperature gases.

REFERENCES

1.John D. Anderson, Jr., Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2.John D. Anderson, Jr., Modern Compressible Flow with Historical perspective McGraw Hill Series, New York, 1996.
3. William H. Heiser and David T. Pratt, Hypersonic Air breathing propulsion, AIAA Education Series.
4. John T. Bertin, Hypersonic Aerothermodynamics publishers - AIAA Inc., Washington, D.C.,1994.
5. T.K.Bose, High Temperature Gas Dynamics,

AL7011 MISSILE AERODYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge to students on basic missile configurations and preliminary drag estimation. The objective is also to introduce slender body aerodynamics, aerodynamic aspects during launching phase and stability and control aspects of missile.

UNIT I BASICS ASPECTS OF MISSILE AERODYNAMICS 9

Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air to surface missiles and surface to air missiles-Missile trajectories-fundamental aspects of hypersonic aerodynamics.

UNIT II MISSILE CONFIGURATIONS AND DRAG ESTIMATION 9

Types of Rockets and missiles-various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation

UNIT III AERODYNAMICS OF SLENDER AND BLUNT BODIES 9
Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

UNIT IV AERODYNAMIC ASPECTS OF LAUNCHING PHASE 9
Booster separation-cross wind effects-specific considerations in missile launching-missile integration and separation-methods of evaluation and determination- Wind tunnel tests – Comparison with CFD Analysis.

UNIT V STABILITY AND CONTROL OF MISSILES 9
Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

TOTAL: 45 PERIODS

OUTCOMES:
Upon completion of the course, Students will learn the concept of high speed aerodynamics and Configurations of missiles.

REFERENCES:
1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985.
2. Chin SS, Missile Configuration Design, McGraw Hill, New York, 1961.
3. Anderson, J.D., "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series.
4. Nielson, Jack N, Stever, Gutford, "Missile Aerodynamics", McGraw Hill, New York, 1960.
5. Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York, 1999.

AL7012 NON DESTRUCTIVE TESTING AND EVALUATION L T P C
3 0 0 3

OBJECTIVE:
To impart knowledge to students on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods and the structural health monitoring of aerospace structures. Students will also learn modern NDT techniques like acoustic emission, ultrosonic and thermographic testing methods.

UNIT I INTRODUCTION 9
Definition -Need for NDT¬ NDT in PAF¬NDT application- Structure Inspection - Detecting manufacturing or service- induced damage- Structural Deterioration- Structural Deterioration - Corrosion¬ Fatigue (cyclic loading)¬ Fabrication defects¬ Operation and Maintenance¬Unforeseen loading (overloads)- Inspection Levels- General Visual Inspection¬ During pre, tru or post flight- Detailed Visual Inspection (DET) - During periodic inspection- Special Detailed Inspection (SDET) - Uses of NDT Methods.

UNIT II AIRCRAFT INSPECTION 6
During manufacturing of aircraft- Jet Engine Inspection- Engine overhaul- Fluorescent penetrate inspection- Airframe Loading- Critical Locations-Non-destructive testing- Methods of NDT Visual- Radiography¬ Eddy Current¬ Ultrasonic¬ Magnetic¬ Liquid Penetrate¬ Visual Inspection – Types- Remote Visual Testing

UNIT III MODERN NDT TECHNIQUES 12
Sensor Based Inspections- Principle Excitation Source Signal - Image Display Recognition Result Input transducer Measurement Signal – Image transducer Processing- Infrared and thermal testing (IR)¬ Impulse excitation technique (IET)¬ Guided wave testing (GWT)¬ Ellipsometry¬ Remote field testing (RFT)-Magnetic flux leakage testing (MFL) - Direct current potential drop

measurement (DCPD) - Alternating current potential drop measurement (ACPD) - Alternating current field measurement (ACFM) -Electromagnetic testing (ET) ¬Acoustic emission testing (AE or AT)- Wire Rope NDT- Phased Array (PA) Ultrasonic's- Thermo graphic Testing

UNIT IV FUSELAGE INSPECTION 9

Digital Radiography- High Density Line Scan Solid State detectors-Flat Panel detectors (FPDs)-Pulsed Eddy Current Inspection- Shearography.

UNIT V STRUCTURAL HEALTH MONITORING 9

SHM- Continuous monitoring - fatigue, corrosion, excessive loads, impact – Advantages-Production parameters¬ Environmental conditions¬ Flight parameters and conditions¬ Loads/Strains¬Damages- Structural Health Monitoring/Management -Automated assessment and prognostic of the health of aircraft

TOTAL : 45 PERIODS

OUTCOMES:

- Upon completion of the course students will be capable of using or operating some non destructive methods like acoustic emission, ultrasonic and other structural health monitoring methods.

TEXT BOOKS:

1. Douglas C. Latia and, Dale Crane," Nondestructive Testing For Aircraft",2001
2. Abbas Fahr," Aeronautical Applications of Non-destructive Testing", DEStech Pulications.
3. Larry Reithmaier and Ron Sterkenburg," Standard Aircraft Handbook for Mechanics and Technicians, Seventh Edition,2013.

REFERENCES:

1. ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
2. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd edition New Jersey, 2005
3. Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.
4. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing
5. Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
6. Ravi Prakash, "Non-Destructive Testing Techniques", New Age International Publishers, 1st revised edition, 2010.

AL7013 STRUCTURAL DYNAMICS L T P C
3 0 0 3

OBJECTIVE:

- To introduce the students the force deflection properties of structures, natural modes of vibration, principles of dynamics and energy and approximate methods for aerospace structures.

UNIT I FORCE DEFLECTION PROPERTIES OF SYSTEMS 9

Constraints and Generalized coordinates – Virtual work and generalized forces – Force – Deflection influence functions – stiffness and flexibility methods.

UNIT II PRINCIPLES OF DYNAMICS 9

Free and forced vibrations of systems with finite degrees of freedom – Response to periodic excitation – Impulse Response Function – Convolution Integral

UNIT III NATURAL MODES OF VIBRATION 9

Equations of motion for Multi degree of freedom Systems - Solution of Eigen value problems – Normal coordinates and orthogonality Conditions. Modal Analysis

UNIT IV ENERGY METHODS 9

Rayleigh's principle – Rayleigh – Ritz method – Coupled natural modes – Effect of rotary inertia and shear on lateral vibrations of beams – Natural vibrations of plates.

UNIT V APPROXIMATE METHODS 9

Approximate methods of evaluating the Eigen frequencies and eigen vectors by reduced, subspace, Lanczos, Power, Matrix condensation and QR methods.

TOTAL: 45 PERIODS

OUTCOMES:

- To study the effect of periodic and aperiodic forces on mechanical systems with matrix approach and also to get the natural characteristics of large sized problems using approximate methods.

TEXT BOOKS:

1. F.S. Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibrations: Theory and Applications" ,Prentice Hall of India Pvt. Ltd, New Delhi, 2004.
2. W.C. Hurty and M.F. Rubinstein, "Dynamics of Structures", Prentice Hall of India Pvt. Ltd.,New Delhi 1987.

REFERENCES:

1. R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co Harper & Row Publishers, New York, U.S.A. 1989.
2. S.P. Timoshenko ad D.H. Young, "Vibration Problems in Engineering", John Willey & Sons Inc., 1984.
3. V.Ramamurthi, "Mechanical Vibration Practice and Noise Control" Narosa Publishing House Pvt. Ltd, 2008

AL7014 THEORY OF PLATES AND SHELLS L T P C
3 0 0 3

OBJECTIVES:

- Gives exposure to formulation of governing equations, various types of analyses plate problems and the methods of solution.

UNIT I CLASSICAL PLATE THEORY 8

Classical Plate Theory – Assumptions – Governing Equation – Boundary Conditions.

UNIT II PLATES OF VARIOUS SHAPES 10

Navier's Method of Solution for Simply Supported Rectangular Plates – Levy's Method of Solution for Rectangular Plates under Different Boundary Conditions – Circular plates.- Different edge conditions and loads.

UNIT III FREE VIBRATION ANALYSIS 8

Stability and Free Vibration Analysis of Rectangular Plates with various end conditions.

UNIT IV APPROXIMATE METHODS 10

Rayleigh – Ritz, Galerkin Methods– Finite Difference Method – Application to Rectangular Plates for Static, Free Vibration and Stability Analysis.

UNIT V SHELLS 9

Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will acquire knowledge on the analysis of plates and shells with different geometry under various types of loads.

REFERENCES

1. Timoshenko, S.P. Winowsky. S., and Kreger, Theory of Plates and Shells, McGraw Hill Book Co., 1990.
2. T.K.Varadan& K. Bhaskar, “Análysis of plates – Theory and problems”, Narosha Publishing Co., 2001.
3. Flugge, W. Stresses in Shells, Springer – Verlag, 1985.
4. Timoshenko, S.P. and Gere, J.M., Theory of Elastic Stability, McGraw Hill Book Co. 2010.
5. Harry Kraus, ‘Thin Elastic Shells’, John Wiley and Sons, 1987.

AL7015 TRANSONIC AERODYNAMICS L T P C
3 0 0 3

OBJECTIVES:

- Students will be exposed to linearized theory and unsteady flow characteristics of transonic flow.
- Students will also learn transonic expansion procedures and design and operation of transonic wind tunnels

UNIT I INTRODUCTION 6

Concepts and Properties of Transonic flow-Fundamental Equations-Similarity rule.

UNIT II LINEARIZED THEORY 9

Equations of Acoustics. Galilean Transformation - Uniform Translation. Slender Body Theory - Acoustics. Exact Equations of Planar Flow; Shock Waves and Entropy Jump. Linearized Theory for Thin Airfoils.

UNIT III TRANSONIC EXPANSION PROCEDURES 12

Simple Solutions, Integral Relations - Expansion Procedure for Steady Flow Past Airfoils. Expansion Procedure Applied to the Basic System of Equations. Expansion Procedures for Jet Flows. Transonic Similarity Rules. Hodograph Equations for Planar Flow. Simple Waves, Shock Waves, Detachment. Nozzle Flow, Branch Lines, Limit Lines. Subsonic and Sonic Jets. Transonic Slender Bodies; Expansion Procedure, Area Rule. Lift and Drag Integrals. Unsteady Transonic Flow.

UNIT IV TRANSONIC AIRFOIL THEORY 9

Problem Formulation. Nose Singularity. Shock Waves at a Curved Surface. Numerical Methods-TSP equations - Solution Methods - Physical Plane, Steady Flow. Airfoils at Sonic Velocity. The Stabilization Law.

UNIT V TRANSONIC WIND TUNNELS 9

Wind tunnels- Wide slots, Narrow slots- slotted walls - Slotted walls with perforated Cover Plates-Transonic testing with wing flow Technique-Movable walls, Slotted walls, Perforated walls.

TOTAL : 45 PERIODS

OUTCOMES:

- Upon completion of the course students will learn operational procedures of transonic wind tunnels and also transonic expansion procedures which will be useful in handling the flows containing both subsonic and supersonic regimes.

REFERENCES:

1. Cole and Cook, "Transonic Aerodynamics", 1st Edition,1975.
2. Bernhard H.Goethert "Transonic Wind tunnel Testing" Pergamon Press,1961.
3. K. Gottfried Guderley," The theory of transonic flow", Pergamon Press, 1962

AL7016 WIND TURBINE ENGINEERING L T P C
3 0 0 3

OBJECTIVES:

- To make students learn the aerodynamic design aspects and controlling methods of wind turbines and also environmental aspects of wind energy production estimating methods.

UNIT I INTRODUCTION TO WINDENERGY 8

Background, Motivations, and Constraints, Historical perspective, Modern wind turbines, Components and geometry, Power characteristics.

UNIT II WIND CHARACTERISTICS AND RESOURCES 8

General characteristics of the wind resource, Atmospheric boundary layer characteristics, Wind data analysis and resource estimation, Wind turbine energy production estimates using statistical techniques

UNIT III AERODYNAMICS OF WIND TURBINES 11

Overview , 1-D Momentum theory, Ideal horizontal axis wind turbine with wake rotation, Airfoils and aerodynamic concepts -Momentum theory and blade element theory General rotor blade shape performance prediction - Wind turbine rotor dynamics

UNIT IV WIND TURBINE DESIGN& CONTROL 9

Brief design overview – Introduction -Wind turbine control systems -Typical grid-connected turbine operation -Basic concepts of electric power- Power transformers -Electrical machines

UNIT V ENVIRONMENTAL AND SITE ASPECTS 9

Overview- Wind turbine sitting - Installation and operation- Wind farms- Overview of wind energy economics - Electromagnetic interference - noise - Land use impacts - Safety-Concepts in wind turbine development.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn about aerodynamics, design and control of wind turbines.

REFERENCES:

1.Emil Simiu & Robert H Scanlan, Wind effects on structures - fundamentals and applications to design, John Wiley & Sons Inc New York, 1996.
2.Tom Lawson," Building Aerodynamics", Imperial College Press London, 2001
3.N J Cook, Design Guides to wind loading of buildings structures Part I & II, Butterworths, London, 1985
4.IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AL7071 COMBUSTION IN JET AND ROCKET ENGINES **L T P C**
3 0 0 3

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 8
Stoichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of thermochemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion.

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 12
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 8
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 8
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

OUTCOMES:

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

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

AL7072 FATIGUE AND FRACTURE MECHANICS **L T P C**
3 0 0 3

OBJECTIVE:

- To make the students learn about fundamentals of fatigue & fracture mechanics, statistical aspects of fatigue behaviour & fatigue design and testing of aerospace structures.

UNIT I FATIGUE OF STRUCTURES 10
S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Neuber’s stress concentration factors – plastic stress concentration factors – Notched S-N curves.

UNIT II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR 8
Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner's theory – other theories.

UNIT III PHYSICAL ASPECTS OF FATIGUE 5
Phase in fatigue life – Crack initiation – Crack growth – Final fracture – Dislocations – Fatigue fracture surfaces.

UNIT IV FRACTURE MECHANICS 15
Strength of cracked bodies – potential energy and surface energy – Griffith's theory – Irwin – Orwin extension of Griffith's theory to ductile materials – Stress analysis of cracked bodies – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries.

UNIT V FATIGUE DESIGN AND TESTING 7
Safe life and fail safe design philosophies – Importance of Fracture Mechanics in aerospace structure – Application to composite materials and structures.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn about fracture behaviour, fatigue design and testing of structures.

REFERENCES

1.D.Brock, "Elementary Engineering Fracture Mechanics", Noordhoff International Publishing Co., London, 1994.
2.J.F.Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London, 1983.
3.W.Barrois and L.Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.
4.C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

AL7073 HIGH SPEED JET FLOWS L T P C
3 0 0 3

OBJECTIVES:

- To make the students learn about various jet control methods, jet acoustics aspects and free shear layer flow theory pertaining to turbulent jets with high speed.

UNIT I INTRODUCTION 9
Types of nozzles – over expanded and under expanded flows - Isentropic flow through nozzles– Interaction of nozzle flows over adjacent surfaces – Mach disk - Jet flow – types - Numerical problems.

UNIT II COMPRESSIBLE FLOW THEORY 9
One-dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers –normal and oblique shock waves and calculation of flow and fluid properties across the shocks and expansion fans. Interaction of shocks with solid and fluid surface.

UNIT III JET CONTROL 9
Types of jet control - single jet, multi jet, co-flow jet, parallel flow jet. Subsonic jets- Mathematical treatment of jet profiles- Theory of Turbulent jets- Mean velocity and mean temperature-

Turbulence characteristics of free jets- Mixing length- Experimental methods for studying jets and the Techniques used for analysis- Expansion levels of jets- Overexpanded, Correctly expanded, Underexpanded jets - Control of jets. Centre line decay, Mach number Profile, Iso-Mach (or iso-baric) contours, Shock cell structure in underexpanded and overexpanded jets, Mach discs.

UNIT IV BOUNDARY LAYER CONCEPT 9

Boundary Layer – displacement and momentum thickness- laminar and turbulent boundary layers over flat plates – velocity distribution in turbulent flows over smooth and rough boundaries- laminar sublayer. Shock-boundary layer interactions.

UNIT V JET ACOUSTICS 9

Introduction to Acoustic – Types of noise – Source of generation- Traveling wave solution- standing wave solution – multi-dimensional acoustics -Noise suppression techniques– applications to problems.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the basics of nozzle flows, methods of jet control and acoustics of jet.

REFERENCES

1. Ethirajan Rathakrishnan, “Applied Gas Dynamics”, John Wiley, NY,, 2010.
2. Shapiro, AH, “Dynamics and Thermodynamics of Compressible Fluid Flow”, Vols. I & II, Ronald Press, New York, 1953.
3. Rathakrishnan E., “Gas Dynamics”, Prentice Hall of India, New Delhi, 2008.
4. Liepmann and Roshko, “Elements of Gas Dynamics”, John Wiley, NY, 1963.

AL7074 ORBITAL MECHANICS AND SPACE FLIGHT

L	T	P	C
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OBJECTIVE:

- To introduce concepts of satellite injection and satellite perturbations, trajectory computation for interplanetary travel and flight of ballistic missiles based on the fundamental concepts of orbital mechanics.

UNIT I SPACE ENVIRONMENT 8

Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time

UNIT II BASIC CONCEPTS AND THE GENERAL N- BODY PROBLEM 10

The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – Kepler’s laws of planetary motion and proof of the laws – Newton’s universal law of gravitation - the many body problem - Lagrange-Jacobi identity – the circular restricted three body problem – libration points – the general N-body problem – two body problem – relations between position and time.

UNIT III SATELLITE INJECTION AND SATELLITE PERTURBATIONS 10

General aspects of satellite injection – satellite orbit transfer – various cases – orbit deviations due to injection errors – special and general perturbations – Cowell’s method and Encke’s method – method of variations of orbital elements – general perturbations approach.

UNIT IV INTERPLANETARY TRAJECTORIES 8

Two-dimensional interplanetary trajectories – fast interplanetary trajectories – three dimensional interplanetary trajectories – launch of interplanetary spacecraft – trajectory estimation about the target planet – concept of sphere of influence – Lambert's theorem

UNIT V BALLISTIC MISSILE TRAJECTORIES 9

Introduction to ballistic missile trajectories – boost phase – the ballistic phase – trajectory geometry – optimal flights – time of flight – re-entry phase – the position of impact point – influence coefficients.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course student will be to perform basic trajectory computations pertaining to interplanetenary flight, ballistic missile flight and will be able to learn computational methods for satellite injection and satellite perturbations.

TEXT BOOKS:

1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co, Ltd, London, 1982
2. Parker, E.R., "Materials for Missiles and Spacecraft", Mc.Graw Hill Book Co. Inc., 1982.

REFERENCES:

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8th Edition, 2010.

AL7075 THEORY OF BOUNDARY LAYERS L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge to students on growth of boundary layer and its effect on the aerodynamic design of airframe of flight vehicles and also to introduce them the solution methods for boundary layer problems.

UNIT I FUNDAMENTAL EQUATIONS OF VISCOUS FLOW 8

Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum-Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow, Non-dimensionalising the basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow

UNIT II SOLUTIONS OF VISCOUS FLOW EQUATIONS 10

Solutions of viscous flow equations, Couette flows, Hagen-Poisuelle flow, Flow between rotating concentric cylinders, Combined Couette-Poiseuille Flow between parallel plates, Creeping motion, Stokes solution for an immersed sphere, Development of boundary layer, Displacement thickness, momentum and energy thickness.

UNIT III LAMINAR BOUNDARY LAYER 10

Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body-Flow separation- similarity solutions, Blasius solution for flat-plate flow, 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 TURBULENT BOUNDARY LAYER 10

Turbulence-physical and mathematical description, 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, Eddy Viscosity, mixing length , Turbulence modelling

UNIT V BOUNDARY LAYER CONTROL 7

Boundary layer control in laminar flow-Methods of Boundary layer control: Motion of the solid wall-Acceleration of the boundary layer-Suction- Injection of different gas-Prevention of transition-Cooling of the wall-Boundary layer suction-Injection of a different gas.

TOTAL: 45 PERIODS

OUTCOMES:

- To make the student understand the importance of viscosity and boundary layer in fluid flow. To introduce the theory behind laminar and turbulent boundary layers.

TEXT BOOKS:

1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York. 2008.

REFERENCES:

1. Schlicting, H., Boundary Layer Theory, McGraw-Hill, New York, 1979.
2. Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.

AS7151 COMPUTATIONAL HEAT TRANSFER L T P C
3 0 0 3

OBJECTIVES:

- To make the students learn to solve conductive, transient conductive, convective, radiative heat transfer problems using computational methods.

UNIT I INTRODUCTION 9

Finite Difference Method-Introduction-Taylor's series expansion-Discretisation Methods Forward, backward and central differencing scheme for Ist 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 CONDUCTIVE HEAT TRANSFER 9

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.

UNIT III TRANSIENT HEAT CONDUCTION 9

Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes Computation(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 CONVECTIVE HEAT TRANSFER 9

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.

UNIT V RADIATIVE HEAT TRANSFER 9

Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method -Montacalro 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.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the concepts of computation applicable to heat transfer for practical applications

REFERENCES

1. Richard H. Pletcher, John C. Tannehill, Dale Anderson**,"**Computational Fluid Mechanics and Heat Transfer, Third Edition, CRC Press**,** 2012

2.Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill Edition, 2003.
3.S.C. Sachdeva, "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi, 1981.
4.John H. Lienhard, "A Heat Transfer Text Book", Prentice Hall Inc., 1981.
5.J.P. Holman, "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.
6.John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.
7.T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
8.C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.

AS7251 CHEMICAL ROCKET TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

- To make student to acquire in depth knowledge in solid, liquid, hybrid rocket propulsion systems and also testing and performance of rocket propellants.

UNIT I SOLID ROCKETPROPULSION 9

Various subsystems of Solid rocket motor and their functions-Propellant grain design-erosive burning– L*instability –internal ballistics of solid rocket motor–types of ignites- igniter design considerations– special problems of solid rocket nozzles.

UNIT II LIQUID ROCKETPROPULSION 12

Classification of liquid rocket engines– rocket thrust control– thrust chamber and injector design considerations–various types of liquids rocket injectors– thrust chamber cooling-cryogenic rocket propulsion –problem speculiarto cryogenic engines-propellants losh-combustion instability.

UNIT III HYBRID ROCKETPROPULSION 8

Standard and reverse hybrid propulsion systems– applications – current status and limitations –combustion mechanism–propellant system selection–internal ballistics of hybrid rocket systems.

UNIT IV PROPELLANTTECHNOLOGY 8

Selection criteria for solid and liquid rocket propellants–calculation of adiabatic flame temperature– assessment of rocket performance-selections of propellant formulation–determination of propellant burnrate and factors influencing the burnrate–solid propellant processing

UNIT V TESTINGAND SAFETY 8

Static testing of rocket–instrumentation required–thrust Vs time–pressure Vs time diagrams–specific impulse calculation–safetyproceduresfortestingofrocketsandsolidpropellants–ignition delay testing.

TOTAL: 45PERIODS

OUTCOMES:

Upon completion of this course, students acquire knowledge in depth about chemical rocket propulsion

REFERENCES

1. G.P.Sutton, "Rocket Propulsion Elements". JohnWiley&SonsInc., NewYork, 5thEdition,1986.
2. Cornelisse.,J.W.,"Rocket Propulsion and spaceDynamics" J.W.Freemav&Co.Ltd.,London, 1982.
3. G.COates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education. Series 1985.
4. Mathur and Sharma R.P. "Gas turbine, Jet and Rocket Propulsion standard publishers and Distributors Delhi,1988.

AS7253 HYPERSONIC AERODYNAMICS

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OBJECTIVES:

• To make students learn the peculiar hypersonic speed flow characteristics pertaining to flight vehicles and the approximate solution methods for hypersonic flows. The objective is also to impart knowledge on hypersonic viscous interactions and their effect on aerodynamic heating.

UNIT I BASICS OF HYPERSONIC AERODYNAMICS 9

Thin shock layers – entropy layers – low density and high density flows – hypersonic flight paths hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9

Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 9

Approximate methods hypersonic small disturbance equation and theory – thin shock layer theory – blast wave theory - entropy effects - rotational method of characteristics - hypersonic shock wave shapes and correlations.

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 9

Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux estimation.

UNIT V VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9

Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn basics of hypersonic flow, shock wave-boundary layer interaction and hypersonic aerodynamic heating.

REFERENCES

1. John D. Anderson, Jr, Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2.John.D.Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series.
3.William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series
. 4.John T. Bertin, Hypersonic Aerothermodynamics, 1994 AIAA Inc., Washington D.