ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

CHOICE BASED CREDIT SYSTEM

REGULATIONS – 2015

M. E. AEROSPACE TECHNOLOGY

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs) :

I. **PEO 1:** Successful Moulding of Graduate into Aerospace related technical Professional: Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of launch vehicle technology through rigorous post graduate education.

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

III. **PEO 3:** Contribution to Aerospace Engineering & Technology: Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aerospace 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 Aerospace technology especially launch vehicle technology.
2. Post Graduate will have the ability to design a system or a component to meet the design requirements with constraints exclusively meant for Aerospace Engineering.
3. Post Graduate will become familiar with modern engineering tools and analyze problems within the domains of Aerospace Engineering
4. Post Graduate will acquire an understanding of professional and ethical responsibility with reference to their career in the field of Aerospace Engineering and Technology 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 launch vehicles 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 aerospace industry.
9. Post Graduate will have a firm scientific, technological and communication base that helps him/her to find a placement in the aerospace industry and Research & Development organizations related to Aerospace Engineering and Technology.
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	✓					✓				✓
		Computational Heat Transfer		✓	✓			✓		✓		✓
		Aerodynamics- Propulsion Laboratory	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	SEM 2	Missile Guidance and Control	✓	✓				✓				✓
		Elements of Satellite Technology	✓	✓				✓			✓	✓
		Launch Vehicle Aerodynamics	✓	✓				✓	✓			✓
		Chemical Rocket Technology	✓	✓				✓				✓
		Hypersonic Aerodynamics	✓	✓	✓			✓	✓			✓
		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		High Temperature Materials		✓	✓			✓		✓	✓	
		Reliability and Quality assurance				✓				✓	✓	
		Composite materials and structures	✓	✓	✓			✓	✓			✓
		Propellant Technology	✓	✓								
		Principles of Aerospace Navigation						✓			✓	
		Computational Fluid Dynamics for Aerospace Applications	✓	✓	✓			✓		✓		✓
		Fatigue and Fracture Mechanics	✓	✓	✓			✓		✓		
		Vibration and Aero elasticity	✓	✓	✓					✓		
		Space Propulsion systems	✓	✓	✓			✓				

	High Speed -Jet Flows	✓	✓	✓			✓				
	Orbital Mechanics and space flight		✓					✓		✓	✓
	Combustion in jet and Rocket Engines		✓							✓	
	Theory of Boundary Layers		✓							✓	✓
	High enthalpy gas dynamics		✓								✓
	Applied finite element Analysis	✓	✓	✓			✓	✓	✓		✓
	Cryogenic Technology		✓	✓			✓				
	Spacecraft attitude dynamics and control		✓					✓		✓	✓

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS – 2015

CHOICE BASED CREDIT SYSTEM

CURRICULA AND SYLLABI

M.E. AEROSPACE TECHNOLOGY

SEMESTER I

S. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	AL7151	Aerospace Propulsion	FC	4	4	0	0	4
2.	AL 7152	Aerospace Structures	FC	4	4	0	0	4
3.	AL 7153	Flight Vehicle Aerodynamics	FC	3	3	0	0	3
4.	AL 7154	Rocketry and Space Mechanics	PC	3	3	0	0	3
5.	AS 7151	Computational Heat Transfer	PC	3	3	0	0	3
6.	MA 7161	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.	AS 7201	Launch Vehicle Aerodynamics	PC	3	3	0	0	3
2.	AS 7251	Chemical Rocket Technology	PC	3	3	0	0	3
3.	AS 7252	Elements of Satellite Technology	PC	3	3	0	0	3
4.	AS7253	Hypersonic Aerodynamics	PC	3	3	0	0	3
5.	AS 7254	Missile Guidance and Control	PC	3	3	0	0	3
6.		Elective I	PE	3	3	0	0	3
PRACTICALS.								
7.	AL 7261	Aerospace Structures Laboratory	PC	4	0	0	4	2
			TOTAL	**22**	**18**	**0**	**4**	**20**

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

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.	AS 7311	Technical Seminar	EEC	4	0	0	4	2
5.	AS 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
PRACTICALS.								
1.	AS 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 = 72

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.		Computational Heat Transfer	PC	3	3	0	0	3
3.		Aerodynamics - Propulsion Laboratory	PC	4	0	0	4	2
4.		Missile guidance and control	PC	3	3	0	0	3
5.		Elements of satellite Technology	PC	3	3	0	0	3
6.		Launch vehicle Aerodynamics	PC	3	3	0	0	3
7.		Chemical Rocket Technology	PC	3	3	0	0	3
8.		Hypersonic Aerodynamics	PC	3	3	0	0	3
9.		Aerospace 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 7071	Combustion in Jet and Rocket Engines	PE	3	3	0	0	3
2.	AL7072	Fatigue and Fracture Mechanics	PE	3	3	0	0	3
3.	AL 7073	High Speed Jet Flows	PE	3	3	0	0	3
4.	AL 7074	Orbital Mechanics and Space Flight	PE	3	3	0	0	3
5.	AL 7075	Theory of Boundary Layers	PE	3	3	0	0	3
6.	AL7251	Composite Materials and Structures	PE	3	3	0	0	3
7.	AL 7252	Computational Fluid Dynamics for Aerospace Applications	PE	4	4	0	0	4
8.	AS 7001	Applied Finite Element Analysis	PE	3	3	0	0	3
9.	AS 7002	Cryogenic Technology	PE	3	3	0	0	3
10.	AS 7003	High Enthalpy Gas Dynamics	PE	3	3	0	0	3
11.	AL 7004	High Temperature Materials	PE	3	3	0	0	3
12.	AS7005	Principles of Aerospace Navigation	PE	3	3	0	0	3
13.	AS 7006	Propellant Technology	PE	3	3	0	0	3
14.	AS 7007	Reliability and Quality Assurance	PE	3	3	0	0	3

15.	AS 7008	Space Propulsion Systems	PE	3	3	0	0	3
16.	AS7009	Spacecraft Attitude Dynamics and Control	PE	3	3	0	0	3
17.	AS7010	Vibration and Aeroelasticity	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

AL7151 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**
4 0 0 4

OBJECTIVE:

- 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
3 0 0 3

OBJECTIVES:

- 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.

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.

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

AS7201 LAUNCH VEHICLE AERODYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVE:

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

UNIT I BASICS OF HIGH SPEED AERODYNAMICS 9

Compressible flows-Isentropic relations-mathematical relations of flow properties across shock and expansion waves-fundamentals of Hypersonic Aerodynamics

UNIT II BOUNDARYLAYER THEORY 9

Basics of boundary layer theory-compressible boundary layer-shock shear layer interaction-Aerodynamic heating-heat transfer effects

UNIT III LAUNCH VEHICLE CONFIGURATIONS AND DRAG ESTIMATION 9

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

UNIT IV AERODYNAMICS OF SLENDER AND BLUNTBODIES 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 V AERODYNAMIC ASPECTS OF LAUNCHING PHASE 9

Booster separation-crosswind effects-specific consideration sin missile launching-missile integration and separation-methods of evaluation and determination-Stability and Control Characteristics of Launch Vehicle Configuration-Wind tunnel tests –Comparison with CFD Analysis.

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. Anderson, J.D., “Fundamentals of Aerodynamics”, McGraw-Hill BookCo.,NewYork, 2010.
2. Chin SS, Missile Configuration Design, Mc GrawHill,NewYork,1961.
3. Anderson, J.D., “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series.
4. Nielson, JackN, Stever, Gutford, “Missile Aerodynamics”,Mc Graw Hill,New York, 1960.
5. Anderson Jr.,D.,–“Modern compressible flows”, McGraw-Hill BookCo.,NewYork1999.
6. Charles D.Brown, “Spacecraft Mission Design”, AIAA Education Series, Published by AIAA, 1998
7. Elements of Space Technology for Aerospace Engineers”, Meyer Rudolph X, Academic Press,1999

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

OBJECTIVE:

- To impart knowledge to the students on solid, liquid and hybrid rocket propulsion. And also the testing and safety procedures for rockets.

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–type sofignites- 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–varioustypesofliquidsrocketinjectors–thrustchambercooling-cryogenicrocket propulsion–problem speculiar to cryogenic engines- propellant slosh-combustion instability.

UNIT III HYBRID ROCKETPROPULSION 8

Standardand 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–specificimpulsecalculation–safetyproceduresfortestingofrocketsandsolidpropellants–ignition delay testing.

TOTAL: 45 PERIODS

OUTCOMES:

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

REFERENCES

1. G.P.Sutton, “Rocket Propulsion Elements”. John Wiley& SonsInc., NewYork, 8th Edition,2010.
2. Cornelisse.,J.W.,“Rocket Propulsion and space Dynamics” J.W.Freemav & Co.Ltd., London, 1982.
3. G.Coates, “Aerothermodynamics of Aircraft Engine Components“, AIAAEducation.Series1985.
4. Mathur and Sharma R.P. “Gas turbine, Jet and Rocket Propulsion standard publishers and Distributors Delhi,1988.

AS7252 **ELEMENTS OF SATELLITE TECHNOLOGY** **L T PC**
3 0 0 3

OBJECTIVES:

- To make students learn the satellite configurations, power systems and orbit control systems. and also to learn spacecraft configurations and telemetry systems.

Attested

DIRECTOR
Centre For Academic Courses
Anna University, Chennai-600 025.

UNIT I SATELLITE MISSIONAND CONFIGURATION 9

Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration-Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions andTrade-offs–Spacecraftconfigurationprocess–BroaddesignofSpacecraftBus–Subsystem layout–Types of Satellites–Constellations–Applications

UNIT II POWER SYSTEM 8

Power sources–Energy storage–Solar panels–Deployable solar panels–Spacecraft Power management –Power distribution–Deep Space Probes

UNIT III ATTITUDE AND ORBITCONTROLSYSTEM (AOCS) 9

Coordinate system –AOCS requirements–Environment effects – Attitude stabilization – Attitude sensors –Actuators–Design of control algorithms.

UNIT IV PROPULSION SYSTEMS,STRUCTURES AND THERMAL CONTROL 11

Systems Trade-off–Mono-propellant systems –Thermal consideration–System integration design factors – Pre-flight test requirements–Systemreliability Configuration design of Spacecraft structure– Structuralelements–Materialselection–EnvironmentalLoads-Vibrations–Structural fabrication– Orbital environments -Average temperature in Space–Transient temperature evaluation– Thermal control techniques– Temperature calculation for a spacecraft–Thermal design and analysis program structure –Thermal design verification–Active thermal control techniques.

UNIT V TELEMETRY SYSTEMS 8

Base Band Telemetry system– Modulation– TT & CRF system–Telecommand system–Ground Control Systems

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students can acquire knowledge about satellite orbit control and telemetry systems.

REFERENCES:

1. James R.Wertzand WileyJ.Larson,” Space Mission Analysis and Design”, (Third Edition),1999.
2. James R.Wertz“ Spacecraft Attitude Determination and Control”, Kluwer Academic Publisher, 1988.
3. Marcel J.Sidi “Spacecraft Dynamics and Control”, Cambridge Universitypress,1997.
4. Lecture notes on“ Satellite Architecture”, ISRO Satellite Centre Bangalore–560017

AS7253 HYPERSONIC AERODYNAMICS L T P C

3 0 0 3

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.

Attested

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Centre For Academic Courses
Anna University, Chennai-600 025.

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.

AS7254 MISSILE GUIDANCE AND CONTROL

L	T	P	C
3	0	0	3

OBJECTIVE:

- 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 MISSILE SYSTEMS INTRODUCTION 8
History of guided missile for defence applications- Classification of missiles– The Generalized Missile Equations of Motion- Coordinate Systems- Lagrange's Equations for Rotating Coordinate Systems-Rigid-Body Equations of Motion-missile system elements, missile ground systems.

UNIT II MISSILE AIRFRAMES, AUTOPILOTS AND CONTROL 9
Missile aerodynamics- Force Equations, Moment Equations, Phases of missile flight. Missile control configurations. Missile Mathematical Model. Autopilots — Definitions, Types of Autopilots, Example Applications. Open-loop autopilots. Inertial instruments and feedback. Autopilot response, stability, and agility- Pitch Autopilot Design, Pitch-Yaw-Roll Autopilot Design.

UNIT III MISSILE GUIDANCE LAWS 10
Tactical Guidance Intercept Techniques, Derivation of the Fundamental Guidance Equations, explicit, Proportional Navigation, Augmented Proportional Navigation, beam riding, bank to turn missile guidance, Three-Dimensional Proportional Navigation, comparison of guidance system performance, Application of Optimal Control of Linear Feedback Systems.

Attested

UNIT IV STRATEGIC MISSILES 10

Introduction, The Two-Body Problem, Lambert's Theorem, First-Order Motion of a Ballistic Missile , Correlated Velocity and Velocity- to-Be-Gained Concepts, Derivation of the Force Equation for Ballistic Missiles, Atmospheric Reentry, Ballistic Missile Intercept, Missile Tracking Equations of Motion, Introduction to Cruise Missiles , The Terrain-Contour Matching (TERCOM) Concept.

UNIT V WEAPON DELIVERY SYSTEMS 8

Weapon Delivery Requirements, Factors Influencing Weapon Delivery Accuracy, Unguided Weapons, The Bombing Problem, Guided Weapons, Integrated Flight Control in Weapon Delivery, Missile Launch Envelope, Mathematical Considerations Pertaining to the Accuracy of Weapon Delivery Computations

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of this course, students will understand the advanced concepts of missile guidance and control to the engineers and to provide the necessary mathematical knowledge that are needed in understanding the physical processes. The students will have an exposure on various topics such as missile systems, missile airframes, autopilots, guidance laws and will be able to deploy these skills effectively in the understanding of missile guidance and control.

REFERENCES:

1. Siouris, G.M. "Missile Guidance and control systems", Springer, 2003.
2. Blakelock, J. H.; Automatic Control of Aircraft and Missiles, 2nd Edition, John Wiley & Sons, 1990.
3. Fleeman, Eugene L.; Tactical Missile Design, First Edition, AIAA Education series, 2001.
4. Garnell, P., "Guided Weapon Control Systems", 2nd Edition, Pergamon Press, 1980.
5. Joseph Ben Asher and Isaac Yaesh "Advances in Missile Guidance Theory" AIAA Education series, 1998
6. Paul Zarchan "Tactical and Strategic Missile Guidance" AIAA Education series,2007

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 acquire experimental knowledge on the unsymmetrical bending of beams, finding the location of shear centre, obtaining the stresses in circular discs and beams using photo elastic techniques, calibration of photo – elastic materials.

LABORATORYEQUIPMENTSREQUIREMENTS

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 tensional loads
7. Diffuser transmission type Polaris cope with accessories
8. Experimental setup for vibration of beams
9. Universal Testing Machine
10. Wagner beam setup

AL7071 COMBUSTION INJET 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**

OBJECTIVES:

- 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, 2003.
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 sub layer. 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. EthirajanRathakrishnan, “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

3 0 0 3

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:

- 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.

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, 5th Edition, 1993.

AL7075 THEORY OF BOUNDARY LAYERS

L	T	P	C
3	0	0	3

OBJECTIVES

- 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.

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:

- Upon completion of the course, students will understand the boundary layer concepts for the flow past over the various bodies and its effects.

TEXT BOOKS:

1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York. 2005.

REFERENCES:

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

AL7251 COMPOSITE MATERIALS AND STRUCTURES L T P C
3 0 0 3

OBJECTIVE:

- 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.

AS7001	**APPLIED FINITE ELEMENT ANALYSIS**	**L T P C**
		3 0 0 3

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.

TOTAL : 45 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, 2004.
2. Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2008
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, 2007.

AS7002 CRYOGENIC TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES:

- To make the students learn various thermodynamic cycles for cryogenic plants and the problems associated with a cryopropellants and calculation of efficiencies of cryogenic systems. Students will also learn the preliminary aspects on the design of cryogenic rocket engines.

UNIT I FUNDAMENTALS OF CRYOGENICS 10

Theory behind the production of low temperature - expansion engine - heat exchangers - Cascade process - Joule Thomson and magnetic effects - cryogenic liquids as cryogenic propellants for cryogenic rocket engines - properties of various cryogenic propellants - handling problems associated with cryogenic propellants.

UNIT II CRYOGENIC SYSTEMS EFFICIENCY 8

Types of losses and efficiency of cycles - amount of cooling - the features liquefied - cooling coefficient of performance - Thermodynamic efficiency - The energy balancing method.

UNIT III THERMODYNAMIC CYCLES FOR CRYOGENIC PLANTS 8

Classification of cryogenic cycles - The structure of cycles Throttle expansion cycles - Expander cycles - Mixed throttle expansion and expander cycles - Thermodynamic analysis - Numerical problems.

UNIT IV PECULIAR PROBLEMS ASSOCIATED WITH CRYOPROPELLANTS 10

Storage problems of cryogenic propellants - zero gravity problems associated with cryopropellants - phenomenon of tank collapse - geysering effect - material strength consideration.

UNIT V CRYOGENIC ROCKET ENGINES 9

Peculiar design difficulties associated with the design of feed system, injector and thrust chamber of cryogenic rocket engines - Relative performance of cryogenic engines when compared to non-cryo engines.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the concepts of cryogenic propulsion systems and the design aspects of cryogenic rocket engines.

TEXT BOOKS

1. Haseldom.G., Cryogenic Fundamentals, Academic press, 2001.
2. Hazel.K & Hungdh, "Design of Liquid Propellant Rocket Engines", NASA special publications, 125, 1971

REFERENCES

1. Sutton.G.P., "Rocket Propulsion Elements", John Wiley, 8TH Edition,2010
2. Barron.R.F. Cryogenic systems, Oxford University, 1985
3. Parner.S.F., Propellant Chemistry Reinfold Publishing Corproation New York, 1985.

AS7003 HIGH ENTHALPY 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 enthalpy and also to make them familiarize the calculations transport properties of gases.

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, 2006.
2.John D. Anderson, Jr., Modern Compressible Flow with Historical perspective McGraw Hill Series, New York, 2008.

AS7004 HIGH TEMPERATURE 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.

UNITI ELEMENTS OFAEROSPACEMATERIALS 9

Structureofsolidmaterials–Atomicstructureofmaterials–Crystalstructure–Millerindices–Density–Packing factor–Space lattices– X-ray diffraction–Imperfection in crystals–general requirements of materials for aerospace applications

UNITII MECHANICALBEHAVIOUROFMATERIALS 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.

UNITIII CORROSION & HEATTREATMENTOF METALSANDALLOYS 10

Types of corrosion – Effect of corrosion on mechanical properties – Stress corrosion cracking – Corrosion resistance materials used for space vehicles Heat treatment of carbonsteels–aluminiumalloys,magnesiumalloysandtitaniumalloys–Effectof alloying treatment, heat resistance alloys– tool and die steels, magnetic alloys, powder metallurgy.

UNITIV CERAMICSAND COMPOSITES 9

Introduction–physical metallurgy–modern ceramic materials–cermets- cutting tools–glass ceramic –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

UNITV HIGH TEMPERATURE MATERIALS CHARACTERIZATION 8

Classification, production and characteristics– Method sand 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:

- Upon completion of this course, students will understand the advanced concepts of aerospace materials 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, 5th Edition, Pitman Publishing Co., 1995.
2. Martin,J.W., Engineering Materials, Their properties and Applications, Wykedham Publications (London)Ltd., 1987.
3. VanVlack.L.H., Materials Science for Engineers, AddisonWesley, 1985.
4. Raghavan.V., Materials Science and Engineering, Prentice Hall of India,NewDelhi,1993.

AS7005	PRINCIPLES OF AEROSPACE NAVIGATION	L T P C
		3 0 0 3

OBJECTIVES:
- To make students learn the navigation systems pertaining to spacecraft such as inertial navigation-GPS and also to introduce them the methods for analysis of navigation systems.

UNIT I NAVIGATION CONCEPTS 9

Fundamentals of spacecraft navigation systems and Position Fixing – Geometric concepts of Navigation – Elements - The Earth in inertial space - Earth's Rotation - Revolution of Earth - Different Coordinate Systems – Coordinates Transformation - Euler angle formulations - Direction cosine formulation - Quaternion formulation.

UNIT II GYRO SYSTEMS 9

Gyroscopes -Types – Mechanical - Electromechanical-Optical Gyro -Ring Laser gyro- Fiber optic gyro - Rate Gyro, Rate Integrating Gyro, Free Gyro, Vertical Gyro, Directional Gyro, Analysis & Applications

UNIT III INERTIAL NAVIGATION SYSTEMS 9

Accelerometers – Pendulous type – Force Balance type – MEMs Accelerometers- Basic Principles of Inertial Navigation – Types - Platform and Strap down - Block diagram- Acceleration errors – -Coriolis effect - Mechanization INS system- Schuler Tuning - Cross coupling - Gimbal lock.

UNIT IV GPS & HYBRID NAVIGATION SYSTEMS 9

GPS overview – Concept – GPS Signal – Signal Structure- GPS data – Signal Processing – GPS Clock – GPS for position and velocity determination – DGPS Concepts - LAAS & WAAS Technology - Hybrid Navigation - Introduction to Kalman filtering – Case Studies -Integration of GPS and INS using Kalman Filter.

UNIT V RELATIVE NAVIGATION SYSTEMS 8

Relative Navigation – fundamentals – Equations of Relative motion for circular orbits Navigation - Differential GSP - Relative GPS- Optical rendezvous sensors (Laser type and Camera type) -Formation Flying - Figure of Merit (FOM)

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course, students will understand the advanced concepts of Spacecraft Navigation and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various Navigation systems such as Inertial Measurement systems, Satellite Navigation – GPS ; and will be able to deploy these skills effectively in the analysis and understanding of navigation systems in an spacecraft.

REFERENCES:
1. Maxwell Noton, "Spacecraft navigation and guidance", Springer (London, New York), 1998.

2. Slater, J.M. Donnel, C.F.O and others, “Inertial Navigation Analysis and Design”, McGraw-Hill Book Company, New York, 1964.
3. Albert D. Helfrick, ‘Modern Aviation Electronics’, Second Edition, Prentice Hall Career & Technology, 1994
4. George M Siouris, ‘Aerospace Avionics System; A Modern Synthesis’, Academic Press Inc., 1993
5. Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 1997
6. Tsui. J. B.Y, ”Fundamentals of Global Positioning System Receiver”, John Wiley an Sons Inc, 2000

AS7006 PROPELLANT TECHNOLOGY **L T P C**
3 0 0 3

OBJECTIVES:

- To impart knowledge to students on internal ballistic process in a solid rocket motor, various types of solid, liquid and gas generator propellants and also to familiarize the students with the calculation of propellant performance and testing.

UNIT I FUNDAMENTALS OF PROPELLANTS 9
Classification of Propellants-Applications -Examples - Fundamental concepts - Internal ballistic missiles of rocket motors-Selection criteria for solid and liquid propellants

UNIT II SOLID PROPELLANTS 9
Classification of solid propellants- examples-Preparation of solid propellants-grains- propellant processing - -Various grain shapes and applications- Fundamental aspects of solid propellant combustion- Instabilities

UNIT III LIQUID PROPELLANTS 9
Classifications liquid propellants - examples - mono and bi propellants combinations - Liquid propellant injectors - types liquid propellant feed systems - Liquid propellant combustion and combustion instabilities-Use of cryogenics.

UNIT IV GAS GENERATOR PROPELLANTS 9
Application of gas generator propellants in aerospace-Various generator systems - types - selection of generator propellants

UNIT V PROPELLANT PERFORMANCE AND TESTING 9
Calculation of adiabatic flame temperature for propellants - Static firing tests - Solid and liquid propellants - Biological and mechanical testing of solid propellants- Thermal analysis of solid and liquid propellants - NDT for solid propellant grains.

TOTAL : 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the ballistic process in solid rocket motor and various types of propellants.

REFERENCES:

1. G.P.Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2010.
2. A.Davenas, "Solid Rocket Propulsion Technology", Pergamon Press, London,1988.
3. Fundamental Aspects of Solid Propellant Rocket – William, F. A., Barrere, M. & Huang, N. C.
4. Shorr, M. & Zaehringer, A. J,”Solid Rocket Technology”, 1996

AS7007 RELIABILITY AND QUALITY ASSURANCE L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge to students in statistical quality control, total quality management, failure data analysis and in quality systems.

UNIT I STATISTICAL QUALITYCONTROL 9

Methods and Philosophy of statistical process control–Control charts for variables Attributes – Cumulative sum and exponentially weighted moving average control charts– Other SPC Techniques– Process–Capability analysis.

UNIT II ACCEPTANCE SAMPLING 9

Acceptance sampling problem–Single sampling plans for attributes– double multiple ands equential sampling–Militaryst and ards–The Dodge Roamings ampling plans.

UNIT III INTRODUCTION TO TQM 9

Need for quality –Definition of quality –Continuous process improvement– Contributions of Deming, Juranand Crosby -Basic concepts of TQM –Six Sigma: concepts, methodology, application to manufacturing

UNIT IV FAILUREDATA ANALYSIS RELIABILITY PREDICTION 9

Repair time distributions –Exponential, normal, log normal, gamma and Weibull – reliability data requirements– Graphical evaluation-Failure rate estimates–Effect of environment and stress–Series and Parallel systems– RDB analysis–Stand by systems–Complex systems–Reliability demonstration testing–Reliability growth testing–Duanecurve–Risk assessment–FMEA, Fault tree.

UNIT V QUALITYSYSTEMS 9

NeedforISO9000,ISO 9000-2000 Quality system– Elements, Documentation, Quality auditing–QS 9000–ISO14000–Concepts, Requirements and Benefits–Case studies of TQM implementation in manufacturing and service sectors including IT.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of this course, students will understand the advanced concepts of reliability and quality assurance manned space missions 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 as missile space stations, space vs earth environment, life support systems, mission logistics and planning and will be able to deploy these skills effectively in the understanding of reliability and quality assurance.

REFERENCES:

1. John Bank, The Essence of Total Quality Management, Prentice Hall of IndiaPvtltd.,1995
2. MohamedZairi, Total Quality Management for Engineers, Wood head PublishingLtd.,1991
3. HarvidNoori and Russel, Production and Operations Management – Total Quality and Responsiveness,McGrawHillInc., 1995
4. Suresh Dalela and Saurabh, ISO900, A manual for Total Quality Management, S. Chandand CompanyLtd.,1997.

AS7008 SPACE PROPULSION SYSTEMS L T P C
3 0 0 3

OBJECTIVES:

- To impart knowledge to students on physics of ionized gases, electro-thermal, electromagnetic and electrostatic propulsion systems.

UNIT I INTRODUCTION TO THE BASIC PHYSICS OF ELECTRIC PROPULSION SYSTEMS 9

Historical outline - Definition of Electric Propulsion - High impulse Space Missions - Exhaust velocity and specific impulse - Power supply penalty – Electric charges and Electrostatic fields - Currents and Magnetic interactions - Time dependent fields and Electromagnetic wave propagation - Application to ionized gas flows

UNIT II PHYSICS OF IONIZED GASES 6

Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas - Electrical conductivity of an ionized gas - Kinetic Theory

UNIT III ELECTRO-THERMAL PROPULSION 9

One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency - Resistojets - Electrical discharges - Arcjets - Operation and Analysis - Materials - Advantages and Disadvantages

UNIT IV ELECTROMAGNETIC PROPULSION 12

The Lorentz force - Magnetogasdynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self induced fields - Sources of the conducting gas - The magnetoplasmadynamic arc - Magneto- plasmadynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Traveling wave acceleration

UNIT V ELECTROSTATIC PROPULSION 9

One dimensional space-charge flows - Basic relationships - The acceleration- deceleration concept - Ion engines - Design and Performance - Hall effect – Hall thrusters - Field emission electric propulsion (FEEP) - Colloid thrusters

TOTAL : 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the governing physics of electric propulsion, working and performance of electro-thermal, electrostatic and electromagnetic thrusters.

REFERENCES

1. Robert G. Jahn, “Physics of Electric Propulsion”, McGraw-Hill Series, New York, 1968.
2. George W. Sutton, “Engineering Magnetohydrodynamics”, Dover Publications Inc., New York, 2005
3. George P. Sutton & Oscar Biblarz, “Rocket Propulsion Elements, John Wiley & Sons Inc., New York,8TH Edition, 2010.

AS7009 SPACECRAFT ATTITUDE DYNAMICS AND CONTROL **L T P C**
3 0 0 3

OBJECTIVES:

- To introduce the students the basics of attitude sensors, control actuators and factors which disturb satellite orbit.
- To make the students familiarize with orbit maneuvers of satellites and rocket vehicle guidance.

UNIT I ATTITUDE SENSORS 8

Relative Attitude sensors – Gyroscopes, Motion reference Units, Absolute Attitude sensors – Horizon sensor, Orbital Gyrocompass, Earth sensors, sun sensors (Digital and analog), star sensor- Magnetometer

UNIT II CONTROL ACTUATORS 9

Fundamental principles of operation of Thrusters- Momentum Wheel-Control Moment Gyros-Reaction wheel- Magnetic Torques- Reaction Jets- Ion Propulsion- Electric propulsion- solar sails

UNIT III ATTITUDE DYNAMICS, ATTITUDE AND ORBITAL DISTURBANCES 9

Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics- disturbing forces due to Drag, Solar radiation Pressure and forces - Disturbances due to Celestial bodies

UNIT IV ATTITUDE STABILIZATION SCHEMES & ORBIT MANEUVERS 10

Spin, Dual spin - Gravity gradient - Zero momentum system - Momentum Biased system - Reaction control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer-Station Keeping and fuel Budgeting

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE 9

Operating principles and design of guidance laws - homing guidance laws- short range - Medium range and BVR missiles - Launch Vehicle- Introduction - Mission requirements- Implicit guidance schemes - Explicit guidance - Q guidance schemes

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course the students will be able to understand the working principles of attitude sensors, control actuators used for satellite applications. Students will be able to comprehend the application of rocket vehicle guidance laws, satellite orbit stabilization schemes and methods of satellite orbit transfer.

REFERENCES:

1. Marcel J. Sidi, "Spacecraft Dynamics and control, A Practical Engineering Approach", Cambridge University Press.2000
2. Kaplan M, "Modern Spacecraft Dynamics and control", Wiley Press, 1979
3. James R Wertz, Spacecraft Attitude Determination and control, Reidel Publications.2001.
4. Vladimir A Chobotov, "Spacecraft Attitude Dynamics and Control (Orbit)", Krieger Publishing Company Publishers,1991.
5. Blake Lock, J.H 'Automatic control of Aircraft and missiles ', John Wiley Sons, New York, 1990.
6. Meyer Rudolph X, Elements of Space Technology for Aerospace Engineers", Academic Press, 1999

AS7010 VIBRATIONS AND AEROELASTICITY

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AS7010	**VIBRATIONS AND AEROELASTICITY**	**3**	**0**	**0**	**3**

OBJECTIVE:

- To study the effect of time dependent forces on mechanical systems and to get the natural characteristics of system with more degree of freedom systems.
- To study the aeroelastic effects of aircraft wing.

UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 10

Introduction to simple harmonic motion, D'Alembert's Principle, Free vibrations – Damped vibrations – Forced Vibrations, with and without damping – support excitation – Transmissibility - Vibration measuring instruments.

UNIT II MULTI DEGREES OF FREEDOM SYSTEMS 10

Two degrees of freedom systems - Static and Dynamic couplings - vibration absorber- Principal co-ordinates - Principal modes and orthogonal conditions - Eigen value problems - Hamilton's principle - Lagrangean equations and application.

UNIT III CONTINUOUS SYSTEMS 8

Vibration of elastic bodies - Vibration of strings – Longitudinal, Lateral and Torsional vibrations

UNIT IV APPROXIMATE METHODS 9

Approximate methods - Rayleigh's method - Dunkerlay's method – Rayleigh-Ritz method, Matrix Iteration method.

UNIT V ELEMENTS OF AEROELASTICITY 8

Coupled flexural–Torsional oscillation of beam- Aeroelastic problems - Collars triangle - Wing Divergence - Aileron Control reversal – Flutter – Buffeting. – Elements of servo elasticity

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the vibrational and aeroelastic problems associated with the aircraft wings.

TEXT BOOKS:

1. Leonard Meirovitch, 'Elements of Vibration Analysis' – McGraw Hill International Edition,2007
2. G.K.Grover, "Mechanical Vibrations", 7th Edition, Nem Chand Brothers, Roorkee, India, 2003
3. Thomson W T, 'Theory of Vibration with Application' - CBS Publishers, 1990.

REFERENCES:

1. William Weaver, Stephen P. Timoshenko, Donovan H. Yound, Donovan H. Young. 'Vibration Problems in Engineering' – John Wiley and Sons, New York, 2001
2. Bisplinghoff R.L., Ashely H and Hogman R.L., Aeroelasticity – Addision Wesley Publication, New Tork, 1983.
3. William W Seto, 'Mechanical Vibrations' – McGraw Hill, Schaum Series.
4. TSE. F.S., Morse, I.F., Hinkle, R.T., 'Mechanical Vibrations' – Prentice Hall, New York, 1984.
5. Den Hartog, 'Mechanical Vibrations' Crastre Press, 2008.