ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM

M.E. AEROSPACE TECHNOLOGY (FT)

THE VISION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

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

THE MISSION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

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

PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

PO	Graduate Attribute	Programme outcomes
1.	Engineering knowledge	Postgraduate will be able to use the Engineering knowledge acquired from the basic courses offered in the programme to pursue either doctoral studies or a career as an academician scientist or engineer.

2.	Conduct investigations of complex problems	Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the Aerospace industry and R&D organizations related to Aeronautical engineering and other professional fields.
3.	The Engineer and society	Postgraduate will be capable of doing research in inter and multidisciplinary areas which will result in more efficient and cheaper products that are beneficial to society.
4.	Environment and sustainability	Postgraduate will exhibit awareness of contemporary issues on environment focusing on the necessity to develop new materials, design and testing methods for the solution of environmental problems related to Aerospace industry.
5.	Individual and team work	Postgraduate will exhibit capability towards design and development of airframes from system integration point of view that requires team work.
6.	Report writing skill	Postgraduate will have the ability to write and present a Comprehensive technical report and research article.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

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

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

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

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

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

PROGRAMME SPECIFIC OUTCOMES

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

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

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

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

Mapping of PEOs with POs

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

			PO 1	PO2	PO3	PO4	PO5	PO6	PSO 1	PSO 2	PSO 3	PSO 4
YEAR 1	**Sem. 1**	Advanced Mathematical Methods	3	3	3		2.33					
		Research Methodology and IPR	3	3	2	-	-	-				
		Aerospace Structures	3	2		3		2				3
		Space Vehicle Aerodynamics	3	1	2	1			2	2		1
		Space Propulsion	3	3	3	1.67			1.6	2	1	2
		Professional Elective - I										
		Launch Vehicle Aerodynamics Laboratory	3	2.2	1.5	1	3		2	2	3	2
		Space Propulsion Laboratory	3	2	1		3		2	2	2	
	Sem.2	Hypersonic Aerodynamics	3	3					3			2
		Orbital Mechanics	3	2.67	2.83		2.33	1.67	3	2.83	2.6	2.8
		Computational Heat Transfer	3	2	2	1.8	2		3	2		1
		Professional Elective - II										
		Professional Elective - III										
		Aerospace Structures Laboratory	2	1.6	2.2	1	2	1.2	1.4	2	2.2	
		Mini Project with Seminar							3	2.6		3
YEAR 2	**Sem. 3**	Professional Elective - IV										
		Professional Elective - V										
		Project Work - I										
	Sem. 4	Project Work - II										

		PO 1	PO2	PO3	PO4	PO5	PO6	PSO	PSC	PSO3	PSO 4
PROGRAM CORE COURSES (PCC)	Space Propulsion	3	3	3	1.67			1.6	2	1	2
	Aerospace Structures	3	2		3		2				3
	Space Vehicle Aerodynamics	3	1	2	1			2	2		1
	Launch Vehicle Aerodynamics Laboratory	3	2.2	1.5	1	3		2	2	3	2
	Space Propulsion Laboratory	3	2	1		3		2	2	2	
	Hypersonic Aerodynamics	3	3					3			2
	Orbital Mechanics	3	2.67	2.83		2.33	1.67	3	2.83	2.6	2.8
	Computational Heat Transfer	3	2	2	1.8	2		3	2		1
	Aerospace Structures Laboratory	2	1.6	2.2	1	2	1.2	1.4	2	2.2	
PROGRAM ELECTIVE COURSES (PEC)											
	Elements of Satellite Technology	3	2	1				2	1	1	
	Aerospace Materials	3	2		3						
	Spacecraft sensors and Instrumentation	3	2.2	2			1	3	2	2	1
	Launch Vehicle Design	3	3	2	2	1.67		3	2	2	1
	Applications of CFD	3	3	3	2.57			3	3	2	**2**
	Spacecraft Attitude Dynamics and Control	3	2.2	2			1				
	Missile and Launch Vehicle Aerodynamics	2.8	2.6	1	2	1.67		3	2	2	2.8
	Navigation, Guidance and Control for Space Vehicles	3	2.8	2.4		2	2	3	3	2	3
	Mechanics of Composite Materials and Structures	3	3				2.4	3	3	2	2
	Nuclear Propulsion	3	2	1.75	2.5	2		2.2	2	2	2
	Rocketry and Space Mechanics	3	3	2	2		1	3	3		3
	Chemical Rocket Technology	3	2	1	1			2	2		2
	Spacecraft Systems Engineering	3	3	1.3	1	1.3	2	3		3	
	Manned Space Missions	3	3	2	3	1		3	3	2	2
	High Speed Jet Flows	3	2					3	2		1
	Electric Propulsion Systems	1.8	3	1.5	2	2		3	1	3	1.8
	Multifunctional Materials and Their Applications	3	2.67	3	3	3		3	2	1	
	Unmanned Aerial Systems	3	2	2.6	1	2.25	2	2	1.2		2
	High Temperature Gas Dynamics	3	3	2	2.67			3	3	2	2
	Finite Element Analysis	2.8	2.8	2							
	Analysis of Composite materials and structures	3	2		3						
	Hypersonic Propulsion	3	1.75	3	1.25	3		2.2	2.2	3	2
	Geospatial Drone Data Processing	1	0.4	1.2	0	0.2	0	1.4	1.6	0.2	1.2
	Space Exploration	3	2	2.6	1	2.25		3	3		3
	Combustion in Jet and Rocket Engines	1.4	2		2.6	1	2.6	1.8	0.8	0.8	1
	Vibration and Structural Dynamics	3	2.2	2			2.6	3	3	2	2
	Drone Propulsion for Aerospace Applications	3	2.6	1.6	1		2.4	3	3	2	2
	Spacecraft Navigation Guidance and Control	3	2.2	2.4	2.8	3	2	2.2	2	3	2.5

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

REGULATIONS - 2023

CHOICE BASED CREDIT SYSTEMS

M.E. AEROSPACE TECHNOLOGY (FULL – TIME)

CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
3.	AO3101	Aerospace Structures	PCC	3	1	0	4	4
4.	AO3102	Space Vehicle Aerodynamics	PCC	4	0	0	4	4
5.	AO3103	Space Propulsion	PCC	3	0	0	3	3
6.		Professional Elective I	PEC	3	0	0	3	3
PRACTICALS								
7.	AO3111	Launch Vehicle Aerodynamics Laboratory	PCC	0	0	4	4	2
8.	AO3112	Space Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**19**	**2**	**8**	**29**	**25**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AO3251	Hypersonic Aerodynamics	PCC	3	0	0	3	3
2.	AO3201	Orbital Mechanics	PCC	4	0	0	4	4
3.	AO3202	Computational Heat Transfer	PCC	3	0	2	5	4
4.		Professional Elective	PEC	3	0	0	3	3
5.		Professional Elective	PEC	3	0	0	3	3
PRACTICALS								
6.	AO3211	Aerospace Structures Laboratory	PCC	0	0	4	4	2
7.	AO3212	Mini Project with Seminar	EEC	0	0	4	4	2
			TOTAL	**16**	**0**	**10**	**26**	**21**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective	PEC	3	0	0	3	3
2.		Professional Elective	PEC	3	0	0	3	3
PRACTICALS								
4.	AS3311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**6**	**0**	**12**	**18**	**12**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	AS3411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS: 70

FOUNDATION COURSES (FC)

Sl. No.	Course Code	Course Title	Periods per week			Credits	Semester
			L	T	P		
1.	MA3153	Advanced Mathematical Methods	4	0	0	4	1

PROGRAM CORE COURSES (PCC)

Sl. No.	Course Code	Course Title	Periods per week			Credits	Semester
			L	T	P		
1.	AO3103	Space Propulsion	4	0	0	4	1
2.	AO3101	Aerospace Structures	3	1	0	4	1
3.	AO3102	Space Vehicle Aerodynamics	4	0	0	4	1
4.	AO3111	Launch Vehicle Aerodynamics Laboratory	0	0	4	2	1
5.	AO3112	Space Propulsion Laboratory	0	0	4	2	1
6.	AO3251	Hypersonic Aerodynamics	3	0	0	3	2
7.	AO3201	Orbital Mechanics	4	0	0	4	2
8.	AO3211	Aerospace Structures Laboratory	0	0	4	2	2
9.	AO3202	Computational Heat Transfer	3	0	2	4	2

PROFESSIONAL ELECTIVE COURSES (PEC)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AO3051	Elements of Satellite Technology	PEC	3	0	0	3	3
2.	AO3001	Aerospace Materials	PEC	3	0	0	3	3
3.	AO3002	Spacecraft Sensors and Instrumentation	PEC	3	0	0	3	3
4.	AO3003	Launch Vehicle Design	PEC	3	0	0	3	3
5.	AO3004	Applications of CFD	PEC	3	0	0	3	3
6.	AO3005	Spacecraft Attitude Dynamics and Control	PEC	3	0	0	3	3
7.	AO3052	Missile and Launch Vehicle Aerodynamics	PEC	3	0	0	3	3
8.	AO3053	Navigation, Guidance and Control for Space Vehicles	PEC	3	0	0	3	3
9.	AO3015	Mechanics of Composite Materials and Structures	PEC	3	0	0	3	3
10.	AO3006	Nuclear Propulsion	PEC	3	0	0	3	3
11.	AO3054	Rocketry and Space Mechanics	PEC	3	0	0	3	3
12.	AO3007	Chemical Rocket Technology	PEC	3	0	0	3	3
13.	AO3008	Spacecraft Systems Engineering	PEC	3	0	0	3	3
14.	AO3009	Manned Space Missions	PEC	3	0	0	3	3
15.	AL3054	High Speed Jet Flows	PEC	3	0	0	3	3
16.	AO3055	Electric Propulsion Systems	PEC	3	0	0	3	3
17.	AL3053	Multifunctional Materials and their Applications	PEC	3	0	0	3	3
18.	AO3010	Unmanned Aerial Systems	PEC	3	0	0	3	3
19.	AO3011	High Temperature Gas Dynamics	PEC	3	0	0	3	3
20.	AO3012	Finite Element Analysis	PEC	3	0	0	3	3
21.	AL3052	Analysis of Composite Structures	PEC	3	0	0	3	3
22.	AO3056	Hypersonic Propulsion	PEC	3	0	0	3	3
23.	AO3013	Geospatial Drone Data Processing	PEC	3	0	0	3	3
24.	AO3014	Space Exploration	PEC	3	0	0	3	3
25.	AO3057	Combustion in Jet and Rocket Engines	PEC	3	0	0	3	3
26.	AL3055	Vibration and Structural Dynamics	PEC	3	0	0	3	3
27.	AO3017	Drone Propulsion for Aerospace Applications	PEC	3	0	0	3	3
28.	AO3018	Spacecraft Navigation Guidance and Control	PEC	3	0	0	3	3

MA3153 ADVANCED MATHEMATICAL METHODS

L	T	P	C
4	0	0	4

OBJECTIVES:

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

UNIT I ALGEBRAIC EQUATIONS 12

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

UNIT II LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT III FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT I CALCULUS OF VARIATIONS 12

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

UNIT V TENSOR ANALYSIS 12

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

TOTAL: 60 PERIODS

OUTCOMES:

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

REFERENCES:

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

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

CO-PO Mapping:

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

RM3151 RESEARCH METHODOLOGY AND IPR

	L	T	P	C
	2	1	0	3

OBJECTIVES:

To impart knowledge on

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

UNIT I RESEARCH PROBLEM FORMULATION 9

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

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

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

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

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

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

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

UNIT V PATENTS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

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

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

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

CO4: Explain about Intellectual property rights, types and procedures

CO5: Execute patent filing and licensing

REFERENCES:

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

AO3101 **AEROSPACE STRUCTURES**

L	T	P	C
3	1	0	4

COURSE OBJECTIVES: This course will enable students

1. Analysis of loads acting on aircraft and spacecraft components
2. Comprehension of design requirements of aircraft and spacecraft
3. Knowledge of the generalized theory of pure bending and an understanding of beam behavior in symmetrical and unsymmetrical bending
4. Ability to carry out shear flow calculations involving aircraft components
5. Exposure to shear flow analysis and design of compression members

UNIT I LOADS ACTING ON AIRCRAFT AND SPACECRAFT 12

Loads Acting on an Aircraft – Balancing Tail Loads – Determination of the Load Factor during Symmetric Manuevers – Inertia Loads – Aircraft V-n Diagram – Satellite Primary and Secondary Structure – Satellite Loads – Satellite Vibration Analysis – Stiffness, Damping & Mass Distribution – Materials Used for Aircraft and Spacecraft Construction

UNIT II DESIGN REQUIREMENTS 12

Structural Components of an Aircraft & Their Functions – Structural Design Principles – Application Different Theories of Failure – Failure Envelopes – Safe Life vs Fail Safe Design – Certification Standards – Airworthiness Requirements – Principles of Damage Tolerance – Fatigue Strength Prediction – Elements of Fatigue and Fracture Mechanics

UNIT III ANALYSIS OF BEAMS 12

Bending Moment and Shear Force Diagrams – Generalized Theory of Pure Bending – Normal Stress Distribution in Unsymmetrical Bending – Neutral Axis Determination – Thin-Walled Beams – Shear Centre – Deflection Analysis – Sandwich Beam Theory – Stress Distribution in Sandwich Beams – Exact Theory – Approximate Theory – Sandwich Beam Design

UNIT IV SHEAR FLOW ANALYSIS 12

Flexural Shear Flow in Thin-Walled Beams – Equilibrium Equations and Strain-Displacement Relations – Determination of the Shear Centre Position in Open and Closed Sections – Structural Idealization of Wing and Fuselage – Shear Flow due to Combined Bending and Torsion – Torsion of Thin-Walled Sections – Shear Flow in a Thin-Webbed Tapered Beam

UNIT V COMPRESSION MEMBERS 12

Buckling Analysis of Slender Columns – Critical Loads and Buckled Mode Shapes – Design Criterion – Column Curves – Thin-Walled Column Design – Stability Analysis and Failure Modes – Local Buckling – Crippling – Elastic Buckling of Thin Plates – Plate Buckling Coefficient – Inelastic Buckling – Concept of Effective Sheet Width – Needham Method

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

CO1 Ability to analyze and calculate static and dynamic loads acting on the structural components of aircraft and spacecraft

CO2 Appreciation and understanding of airworthiness requirements and design procedures

CO3 Skill in carrying out stress and deflection calculations in bending of beams

CO4 Ability to carry out shear flow calculations involving aircraft components

CO5 Knowledge and confidence in designing a compression member for aerospace application

REFERENCES:

1. Howard D Curtis, “Fundamentals of Aircraft Structural Analysis”, WCB-McGraw Hill, 1997.
2. Rivello, R.M, “Theory and Analysis of Flight Structures”, 4th Edition, McGraw Hill, 2007.
3.Bruce. K. Donaldson, “Analysis of Aircraft Structures: An Introduction”, Cambridge University Press, 2nd edition, 2008.
4. Bruhn. E.H, “Analysis and Design of Flight Vehicles Structures”, Tri-state off-set company, USA, 1985.
5. Peery, D.J and Azar, J.J, “Aircraft Structures”, McGraw - Hill, N.Y, 2012
6. Spacecraft Structures and Mechanisms - Edited by: Sarafin& LarsonDate: 1995 / Springer

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

AO3102 SPACE VEHICLE AERODYNAMICS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES: This course will enable students

1. Gain knowledge on the basics of low-speed aerodynamics
2. Learn the physics involved in compressible flows.
3. Provide enough knowledge on boundary layers and their interactions.
4. Impart knowledge on the aerodynamic characteristics of missile components.
5. Gain an idea about aerodynamic heating phenomena.

UNIT-I BASICS OF INCOMPRESSIBLEFLOW 12

Aerodynamic forces and moments - Centre of pressure - Aerodynamic centre - Continuity equation - Momentum equation - Stream function - Potential function - Elementary flows - Flow over cylinder, sphere and cones.

UNIT II COMPRESSIBLE FLOWS 12

Compressibility - Speed of sound - Normal shock - Oblique shock - Expansion fan - Variable area ducts - Unsteady shock waves - Fanno flow - Rayleigh flow - Wave drag- Crocco's Theorem - Method of characteristics.

UNIT III BOUNDARY LAYERTHEORY 12

Boundary layer thickness - Displacement thickness - Momentum thickness - Laminar boundary layer - turbulent boundary layer - Blasius solution - Skin friction drag estimation - Shock wave- boundary layer interactions.

UNIT IV AERODYNAMIC CHARACTERISTICSOFMISSILES 12

Airframe components of missiles - Forebody shapes - Prediction of component characteristics - Wing planform for missiles Delta wing - Vortex break down - Compressibility effect on deltawing- Wing-body interference effects - Transonic and Supersonic drag reduction methods – Findrag- Bodydrag.

UNIT V AERODYNAMIC HEATING 12

Heat transfer process - Basic parameters in aerodynamic heating - Reference temperature method - Aerodynamic heating on conical surfaces - Variable entropy effects - Heat transfer across junctures - Non isothermal wall effects - Swept shock interactions - Application of methodology in practical missile design.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1 Have through knowledge on the concepts of incompressible aerodynamics.
CO2 Be able to analyse practical problems involving Fanno and Rayleigh flow.
CO3 Have knowledge on the concepts of laminar and turbulent boundary layer flows and their interaction with shock waves.
CO4 Able to demonstrate and analyse different configurations of missiles and their characteristics.
CO5 Be able to design efficient re-entry vehicles by solving the problem of aerodynamic heating.

REFERENCES:

1. Hermann Schlichting, “Boundary Layer Theory”, Springer, 8th edition,2000.
2. Michael Mendenhall, “Tactical Missile Aerodynamics: Prediction Methodology, Progress in Astronautics and Aeronautics”, 1992.
3. Nielson, Jack N, Stever, Gutford, “Missile Aerodynamics”, McGraw Hill,1960.
4. Anderson, JD, “Fundamentals of Aerodynamics”, McGraw-Hill Book Co,2010.
5. Chin SS, “Missile Configuration Design”, Mc GrawHill,1961.

COs	POs	PSOs

	1	2	3	4	5	6	10	1	2	3	4
1	3						1	2	2		1
2	3	1	2					2	2		1
3	3		2					2	2		1
4	3	1	2	1				2	2		1
5	3		2	1				2	2		1

AO3103 SPACE PROPULSION L T P C

3 0 0 3

COURSE OBJECTIVES: This course will enable students

1. To impart knowledge on the basic concepts of space propulsion.
2. To learn about the physics of ionized gases.
3. To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
4. To study about the radioisotope propulsion.
5. To realise the importance of advanced space propulsion concepts.

UNIT I INTRODUCTION TO SPACE PROPULSION 9

Background and Fundamentals of Space propulsion - Classification of Propulsion Systems, Scramjet Propulsion - Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-Tripropellants; Metalized Propellants; Free Radical Propulsion, Nuclear Propulsion, Electric Propulsion, Micropropulsion, MEMS and MEMS- Hybrid Propulsion Systems.

UNIT II ELECTRIC PROPULSION 9

Electric propulsion working principle- Classification of electric propulsion systems- Electrothermal, Electrostatic and Electromagnetic, Resistojet and arcjet concept, Electrostatic – concepts of Ion Thruster, Hall Thruster, Field Emission Thruster, Colloid Thruster, Low power neutralizers concept with diagram, Laser Accelerated Plasma Propulsion, Electromagnetic thrusters types – MPD, PPT, VASIMAR

UNIT III NUCLEAR ROCKET PROPULSION 9

Nuclear Rocket Engine Design and Performance, Types of Nuclear Rockets, Overall Engine Design, Nuclear Rocket Performance, Component Design, Nuclear Rocket Reactors, General Design Considerations, Reactor Core Materials, Thermal Design, Mechanical Design, Nuclear Design, Shielding, Nuclear Rocket Nozzles, General Design Considerations, Heat-Transfer Analysis, Over-all Problem, Hot-Gas Boundary, Cold-Gas Boundary, Fusion Propulsion, Radioisotope Propulsion.

UNIT IV MICROPROPULSION 9

Introduction to Micropropulsion - types of Micropropulsion -Micropropulsion Requirements - Mechanism ofSolid Microthrusters, Micro Mono and bi-propellant Thrusters, Cold Gas Thruster - Microchip laser thruster concept - Comparison between Micro Ion Thruster, Low Power Hall Thruster, Micro PPT Thruster, MEMS FEEP/Colloid Thruster and Microchip Laser Thruster

UNIT V ADVANCED SPACE PROPULSION CONCEPTS 9

Introduction, General Consideration for Propulsion in Space, Power Supply, Propellant Storage and Handling Facilities, Advanced Electric Propulsion Systems for Space Vehicles, Sputtering, A Thrust Generation Mechanism, Sputtering Phenomena, Possible Performance of Sputtering Thrusters, Energy Efficiency of the Sputtering Process, Analyses of an Elementary Mission with Different Electric Thrusters, General Consideration, Performance Formula for Electric Thrusters, Optimization with Electric Thrusters, Propellantless Propulsion

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Know about different types of Space propulsion
CO2 Have understanding on the classification and working principle of Electric propulsion
CO3 Acquire the knowledge on types of nuclear rockets with their design considerations.
CO4 Learn the basics of micropropulsion and the different types of that with the working concept.
CO5 Know more about the advancements in the space propulsion and their diverse fields of new studies.

REFERENCES:

1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons; 8th Edition 2010.
2. Bruno Claudio and Paul A. Czysz, “Future Spacecraft Propulsion Systems”, Springer, Praxis Publishing Ltd, 2006.
3. Robert G. Jahn, “Physics of Electric Propulsion”, McGraw-Hill Series, New York, 1968.
4. William J. Emrich, “Principles of Nuclear Rocket Propulsion” Elsevier Science, 2016.
5. George P. Sutton & Oscar Biblarz, “Rocket Propulsion Elements, John Wiley & Sons Inc.,NewYork, 9^{th} Edition, 2016.
6. Martin Tajmar, “Advanced Space Propulsion Systems” Springer Verlag GmbH, 2003.
7. George W. Sutton, “Engineering Magnetohydrodynamics”, Dover Publications Inc., New York, 2005.

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

AO3111	**LAUNCH VEHICLE AERODYNAMICS LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

COURSE OBJECTIVES:

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

LIST OF EXPERIMENTS:

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

Any 10 experiments may be conducted.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

CO1 Able to operate and calibrate subsonic and supersonic wind tunnel
CO2 Able to analyse the pressure distribution over the streamlined and bluff bodies
CO3 Able to carry out measurement of force and moments on aircraft models
CO4 Capable of measuring boundary layer thickness over various models.
CO5 Able to carry out flow visualization at subsonic speeds.

LABORATORY EQUIPMENTS REQUIRED

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

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

AO3112 SPACE PROPULSION LABORATORY L T P C

0 0 4 2

COURSE OBJECTIVES:

1. To practically determine flow behaviour of jets
2. Provides an idea of wall pressure distribution on subsonic and supersonic inlets and nozzles.
3. Perform testing on compressor blades and basic knowledge on cold flow studies.
4. Visualize the shock pattern in supersonic flows
5. Perform experiments on cavity models.

LIST OF EXPERIMENTS

1.Flow visualization of a secondary injection in a supersonic flow
2. Flow visualization of shock system in front of a supersonic inlet
3. Wall pressure measurements in a supersonic nozzle
4. Total pressure measurements along the jet axis of a circular supersonic jet
5. Total pressure measurements in the radial direction of a supersonic circular jet
6. Wall pressure measurements in a supersonic diffuser
7. Cold flow studies of a wake region behind flame holders
8. Wall pressure measurements of a noncircular combustor
9. Wall pressure measurements of a subsonic diffuser
10. Cascade testing of compressor blades.
11. Pressure distribution on cavity model with injections.

TOTAL : 60 PERIODS

COURSE OUTCOMES:

CO1 To apply the basic fundamentals into practical problem in propulsive systems.

CO2 To get practical exposures to internal flow characteristics of compressor and turbine blade passage.

CO3 To demonstrate the fundamental concepts of low speed and high speed jets and experimental investigation through the pressure data.

CO4 To get practical exposures on flow visualization techniques pertaining to supersonic flows.

CO5 To demonstrate the working of supersonic combustor and its flow characteristics.

LABORATORY EQUIPMENTS REQUIREMENTS

1. Supersonic nozzle and supersonic diffuser
2. Total pressure probes
3. Symmetrical Cambered aerofoil
4. Models of flame holders and non circular combustor
5. Traversing mechanism (at least2-D)
6. Pressure Transducers/ pressure scanner
7. Cascade model for compressor blades
8. Multitube manometers

COs	POs	PSOs

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

AO3251	HYPERSONIC AERODYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION TO HYPERSONIC AERODYNAMICS 9

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

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9

Local surface inclination methods – modified Newtonian Law – Newtonian theory – centrifugal force corrections to Newtonian theory - tangent wedge tangent cone and shock expansion methods – Calculation of surface flow properties – practical application of surface inclination methods – hypersonic independence principle.

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 9

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

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 9

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

UNIT V VISCOUS INTERACTIONS AND TRANSITION 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

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

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

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

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

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

REFERENCES:

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

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

AO3201	**ORBITAL MECHANICS**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

COURSE OBJECTIVES: This course will enable students

1. To introduce special needs for manned space missions and pre calculation of space environment to students.
2. To impart the knowledge on basis concepts of space mechanics like Newton's law of gravitation and its applications, reference co-ordinate systems and position vs time relationships of celestial bodies.
3. To acquaint students on the methodologies for computation of satellite orbit perturbations
4. To elucidate the concepts of space of influence and its purpose in computing interplanetary trajectories to students.
5. Toimpartknowledgeofvariousphasesofballistictrajectoriesandspecialfeaturesofre-entryphase to students also to calculate simple orbital rendezvous and phasing maneuvers.

UNIT I SPACE ENVIRONMENT 12

Peculiarities of space environment and its description– International Standard Atmosphere - radiation and magnetic fields - effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time. The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – Newton's universal law of gravitation

UNIT II CHARACTERISTICS OF VARIOUS ORBITS 12

Two Body Motion: equations of motion – Kepler laws – solution to two-body problem - Properties of elliptic, Parabolic and hyperbolic properties in terms of orbital elements – relations between position and time – Barker's theorem – Whittaker's theory – Sphere of influence - Kepler equation – orbital elements – orbit determination -the many bodies problem - Lagrange-Jacobiidentity – the circular restricted three body problem – libration points – the general N-body problem.

UNIT III SATELLITE INJECTION AND SATELLITE PERTURBATIONS 12

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

UNIT IV INTERPLANETARY TRAJECTORIES 12

Orbital Maneuvers in earth satellite and deep space missions-Hohmann transfer – inclination change maneuvers, combined maneuvers, bi-elliptic maneuvers - Hoelker and Silber Transfers- 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 12

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: 60 PERIODS

COURSE OUTCOMES:

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

CO1 be able to apply the basic knowledge in the calculation of space orbits and the purpose & applications of space missions and identify suitable orbit for a particular mission

CO2 be able to analyze the motion of space objects with time with the choice of using modern computer software tools that would pave the way for igniting the desire to contribute to society

CO3 be able to apply orbit control methods and determine injection errors of satellites by analyzing the orbit and trajectory data using the relevant computer software tools as a member of satellite monitoring team and to create methods and procedures for cost effective and economical approaches to increase the satellite life time which would contribute to the benefit of the society

CO4 be able to perform calculations and analyze the suitability pertaining to trajectories for interplanetary missions with a good grasp in basics of mathematical and physical sciences with the use of modern computer simulation tools

CO5 be able to design and analyse various orbit maneuvers for planetary and interplanetary missions that would inculcate a life-long interest in the subject of space mechanics and help design methods for cost effective solutions

be able to evaluate trajectories required for various defence missions that use missiles by way of identifying and formulating the requirements followed by design and analysis using modern tools for computation as a mission team member

REFERENCES:

1. Wiesel, W. E., Spaceflight Dynamics , 2 nd ed., McGraw-Hill (1996).
2. Brown, C. D., Spacecraft Mission Design , 2 nd ed., AIAA Edu. Series (1998).
3. Escobal, P. R., Methods of Orbit Determination , 2 nd ed., Krieger Pub. Co. (1976).
4. Tewari, A., Atmospheric and Space Flight Dynamics: Modeling and Simulation with MAT-LAB and Simulink ,Birkhuser (2007).
5. Curtis, H. D., Orbital Mechanics for Engineering Students, 2 nd ed., Elsevier (2009).
6. Chobotov, V. A., Orbital Mechanics, 3 rd ed., AIAA Edu. Series (2002).
7. Craig A Kluever , Space Flight Dynamics, Aerospace series (2018)

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

AO3202 COMPUTATIONAL HEAT TRANSFER

L	T	P	C
3	0	2	4

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION 9

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

UNIT II GOVERNING EQUATIONS FOR FLUIS FLOW AND HEAT TRANSFER 9

Governing Equations in fluid flows-Continuity, momentum and energy equation-turbulence model, governing equations in conductive heat transfer-Cartesian, cylindrical and spherical co-ordinate, Governing equations convective- Force and free convection and radioactive heat transfer.

UNIT III FINITE DIFFERENCE FORMULATION FOR CONDUCTIVE HEATTRANSFER 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. 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 FINITE DIFFERENCE FORMULATION FOR CONVECTIVE AND RADIATIVE 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. Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method - Montecarlo method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

UNIT V NUMERICAL APPROACH FOR RADIATIVEHEATTRANSFER 9

Introduction, Addition and Subtraction of Two Matrices, Program for Solving M × N Matrix, 5 Jacobi's Iterative Method for Solving Matrix, Coding for One-Dimensional Heat Condition in a Slab with Temperature Specified Boundary Condition, Coding for Transient Heat Condition in a Slab with Temperature Specified Boundary Condition using any one of the programming languages namely C, c++,MATLAB and Python.

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

NOTE: Any five experiments will be conducted

TOTAL : 45 PERIODS+30 Periods

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Have an Idea about discretization methodologies for solving heat transfer problems.
CO2 Be able to solve 2-D conduction and convection problems.
CO3 Have an ability to develop solutions for transient heat conduction in simple geometries.
CO4 Be capable of arriving at numerical solutions for conduction and radiation heat transfer problems.
CO5 Have knowledge on developing numerical codes for practical engineering heat transfer problems.

REFERENCES:

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

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

AO3211 AEROSPACE STRUCTURES LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

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

LIST OF EXPERIMENTS:

1. Study of Symmetrical Bending of Beams
2. Un symmetrical Bending of Beams
3. Performance of an Electrical Resistance Strain Gauge and Strain Measurement Using Electrical Resistance Strain Gauges
4. Experimental Determination of the Shear Center Position for a Thin-Walled Beam
5. Transmission and Reflection Polariscope Experimental Set-up & Working Principle
6. Fabrication and Calibration of a Photoelastic Specimens
7. Static analysis of a uniform bar subject to different loads -1-D element
8. Thermal stresses in a uniform and tapered member – 1-D element
9. Static analysis of trusses / frames under different loads
10. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads
11. Static analysis of a beam with additional spring support
12. Stress concentration in an infinite plate with a small hole
13. Bending of a plate with different support conditions
14. Buckling of solid and thin-walled columns under different end conditions
15. Free vibration analysis of a bar / beam

Any 12 experiments will be conducted from above15 experiments

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be

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

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

AO3212	MINI PROJECT WITH SEMINAR	L	T	P	C
		0	0	4	2

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

AO3051	ELEMENTS OF SATELLITE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will enable students

1. To learn the satellite mission and configurations,
2. To learn an Electrical power sub system of satellites
3. To learn the attitude and orbit control systems of satellites.
4. To gain knowledge on basics of propulsion systems, structures, and thermal controls of Satellites.
5. To learn the satellite telemetry and telecommand systems.

UNIT I SATELLITE MISSION AND CONFIGURATION 9

Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration-Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions and Trade-offs–Spacecraft configuration process– Subsystem layout–Types of Satellites–Types of Orbits-Applications.

UNIT II POWER SYSTEM 9

Power sources–Energy storage–Solar panels–Deployable solar panels–Spacecraft Power management –Power distribution–Power regulation and control-Deep Space Probes.

UNIT III ATTITUDE AND ORBIT CONTROL SYSTEM 9

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

UNIT IV PROPULSION SYSTEMS, STRUCTURES AND THERMAL CONTROL 9

Propulsion systems–Thermodynamic- Electrodynamic propellant systems –Design of Spacecraft structure– Structural elements–Material selection–Environmental Loads-guiding factors– Structural fabrication– Thermal control techniques– Active –Passive thermal control techniques-Heat balance equation.

UNIT V TELEMETRY SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Understand the importance of Spacecraft missions and configurations
CO2 Explain Spacecraft power system functions and importance
CO3 Explain spacecraft Attitude and orbital control system design
CO4 Understand satellite propulsion, thermal control and structure subsystems
CO5 Analyse satellite telemetry and telecommand systems

REFERENCES:

1. Marcel J.Sidi “Spacecraft Dynamics and Control”, Cambridge University press, 1997.
2. Lecture notes on “Satellite Architecture”, ISRO Satellite Centre Bangalore – 560 017
3. Space Mission Analysis and Design (Third Edition) by James R.Wertz and Wiley J.Larson – 1999.
4. James R.Wertz “Spacecraft Attitude Determination and Control”, Kluwer Academic Publisher, 1988.

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

AO3001 AEROSPACE MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. Applied understanding of material science and significance of material defects
2. Knowledge of how different materials behave in tension, compression and shear
3. Understand the behavior of high-performance alloys for aerospace application
4. Exposure to various types of high temperature materials and their properties
5. Study of different ways in which material failure can take place

UNIT I MATERIAL SCIENCE 9

Functional Classification of Materials – Application and Material Selection – Atomic Structure – Bonding – Relation Between Atomic Structure & Material Properties – Analysis of Crystalline Structure – Crystallography – Imperfections – Defects – Interstitial Sites – Dislocations – Effect of Imperfections – Atom and Ion Movements – Diffusion – Engineering Applications

UNIT II MECHANICAL BEHAVIOUR 9

Behaviour in Tension, Compression and Shear – Analysis of Stress-strain Curves of Different Types of Materials – Effect of Strain Rate and Temperature – Creep Behaviour – Impact Testing – Impact Behaviour – Study of Strengthening Mechanisms in Metals and Alloys – Deformation Response of Engineering Plastics – Viscoelastic Behaviour – Strengthening of Polymers

UNIT III METALLIC ALLOYS 9

High Performance Alloys For Aerospace Application – Alloys of Aluminium, Magnesium, and Titanium – Comparison of Properties – Steel Quality and Carbon Content – Effect of Alloying – Study of Various Heat Treatments – Environmental Effects – Stress Corrosion Cracking – Corrosion Resistance Materials – Effect of Alloying Elements & Ideal Percentage Composition

UNIT IV HIGH TEMPERATURE MATERIALS 9

Aerospace Applications – High Temperature Alloys – Mechanical and Thermal Properties of Carbon-Carbon Composites, Ceramic Materials and Metal Matrix Composites – Use of Cermets – Design of a Thermal Protection System for a Re-Entry Vehicle – High Temperature Material Characterization – Various Manufacturing Technologies & Controlling Parameters

UNIT V MATERIAL FAILURE 9

Theoretical Strength of a Material – Failure of Materials in Tension, Compression and Shear – Microstructural Features of Fracture in Metals, Ceramics and Composites – External Variables Affecting Fracture – Statistical Failure Strength Analysis – Fatigue of Materials – Fatigue Testing – S-N Curve – Creep Behaviour and Fracture – Elements of Fracture Mechanics

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Knowledge of material science and ability to perform theoretical calculations
CO2 Good understanding about the mechanical behavior of metals and other materials
CO3 Ability to correctly choose a suitable metallic alloy for a specific application
CO4 Understanding and appreciation of high temperature materials and their properties
CO5 Knowledge about how material failure can take place and exposure to fracture mechanics

REFERENCES:

01. Martin, J.W., ' Engineering Materials, Their properties and Applications', Wykedham Publications (London) Ltd., 1987
02. Prasad, N. Eswara, Wanhill, R. J. H., 'Aerospace Materials and Material Technologies' Indian Institute of Metals Series, 2017
03. Sam Zhang, 'Aerospace Materials Handbook (Advances in Materials Science and Engineering) 1^{st} Edition, 2016
04. Adrian Mouritz,'AIAA Education Series – Introduction to Aerospace Materials', 2012.
05. Titterton.G., 'Aircraft Materials and Processes', V Edition, Pitman Publishing Co.,1995.
06. Donald R Askeland, Pradeep P Fulay, 'The Science and Engineering of Materials', Cengage Learning, 2010
07. Prasad, N. Eswara, Wanhill, R J H, 'Aerospace Materials and Material Technologies, Volume 1: Aerospace Materials, Springer Singapore, 2017
08. Raghavan.V., 'Materials Science and Engineering', Prentice Hall of India, New Delhi, 5^{th} edition, 2004

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

AO3002 SPACECRAFT SENSORS AND INSTRUMENTATION **L T P C**
3 0 0 3

COURSE OBJECTIVES: This course will enable students

1. Ability to categorise and characterize a conventional sensor.
2. To study accelerometer instruments, frame conversion and its measurements.
3. To study the gyroscope and its types and its application.
4. To study magnetic compass types and GPS systems.
5. To study various power plant measurements related to satellite systems.

UNIT I ATTITUDE SENSORS 9

Spacecraft sensors – Types, -Analog to Digital and Digital to Analog, Resistive, Capacitive, Inductive, Piezoelectric, Magnetostrictive and Hall effect sensors - Static and Dynamic Characteristics of Transducers, Electro optic sensors-Horizon sensor, Earth sensors, sun sensors, star sensor.

UNIT II ACCELEROMETER AND ITS MEASUREMENTS 9

Accelerometer and its properties, Analog accelerometer, Digital Accelerometer, MEMS, Inertial frame to body frame conversion, Body to inertial frame conversion, Fundamentals of attitude estimation.

UNIT III GYROSCOPE AND ITS MEASUREMENTS 9

Gyroscope and its properties, gyro system, Gyro horizon, Erection systems for Gyro Horizons-Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, Turn coordinator, Digita gyroscopes, MEMS, Ring Laser Gyro (RLG) and Fiber Optic Gyroscope (FOG).

UNIT IV COMPASS SYSTEMS AND GPS MEASUREMENTS 9

Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator, IRNSS and GPS.

UNIT V POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING 9

Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments, exhaust gas temperature, Engine fuel Indicators, engine vibration, monitoring and Flight Data Recording.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Ability to understand various types of spacecraft sensors.
CO2 Ability to understand the working principle of various accelerometers and their applications.
CO3 Ability to determine and analyze the working of various types of Gyroscope instruments
CO4 Familiarize with the compass system used for satellite applications.
CO5 Ability to understand the working principle of fuel measurement and engine measurement system.

REFERENCES:

1. Pallet, E.H.J. —Aircraft Instruments & Integrated systems, Longman Scientific and Technical, McGraw-Hill, 1992.
2. NagabhushanaS.andSudha L.K. — Aircraft Instrumentation and Systems, I.K. International publishing house PVT Ltd, 2010.
3. Murthy, D.V.S., —Transducers and Measurements‖, McGraw-Hill, 1995
4. Doeblin. E. O, —Measurement Systems Application and Design‖, McGraw-Hill, New York, 1999.
5. Harry L. Stilz, —Aerospace Telemetry‖, Vol I to IV, Prentice-Hall Space Technology Series.
6. Myron Kyton, Walfred Fried, 'Avionics Navigation Systems', John Wiley & Sons, 2nd edition, 1997.
7. Collinson R.P.G, 'Introduction to Avionics', Chapman and Hall, India, 1996.

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

AO3003 LAUNCH VEHICLE DESIGN

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. To provide knowledge on the basic aspects of space vehicle operation environment.
2. To give an idea about the structural loads acting on space vehicles
3. To introduce the space vehicle design aspects, its complex issues requiring expertise from many different areas of Aerospace Engineering.
4. To impart knowledge on various parameters that influences the design of space vehicles including their mission, orbital mechanics and the space environment.
5. To get insight into the basic aspects of re-entry motion.

UNIT I LAUNCH VEHICLE BASICS 9

Earth environment - Launch environment – Atmospheric environment – Rocket performance and staging – Selection criteria of space vehicles - Expendable launch vehicles- Advanced mission concepts.

UNIT II STRUCTURAL DESIGN 9

Design drivers – Mission goals – Payload and instrument requirements – factors in structural concept selection - Deployable Structures – Vehicle mass – Vehicle centre of mass – Moment of inertia – Sources of structural loads – Analysis of structural loads – Load alleviation – Stress levels and safety factors – Structural materials.

UNIT III CONFIGURATION ASPECTS 9

Propulsion system aspects – Vehicle configuration – Number of stages/boosters – Vehicle layout – Recovery system selection – Launch sites – Guidance strategy - Ascent guidance – Fly back guidance systems – Attitude controller.

UNIT IV POWER SYSTEM DESIGN 9

Power system functions – Power system design drivers – Power system elements – Solar array design – Fuel cells – Power conditioning and control – Future concepts in space propulsion.

UNIT V RE-ENTRY MOTION 9

Re-entry Motion - Trade-offs for Re-entry Design - Significant Forces on a Re-entry vehicle - Ballistic Coefficient - Re-entry Motion Analysis - Trajectory and Deceleration - Trajectory and Heating - Trajectory and the Re-entry Corridor - Vehicle Shape design.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Familiar with the selection criteria of space launch vehicles
CO2 Able to design space vehicles considering the various structural loads
CO3 In a position to wisely select suitable configuration of space launch vehicle for given Requirements
CO4 Able to perform the design of power system for space vehicles.
CO5 Able to analyze re-entry motion of space vehicles.

REFERENCES:

1. Pasquale M Sforza, “Manned Spacecraft Design Principles”, Butterworth-Heinemann, 2015.
2. Peter Fortescue, John Stark and Graham Swinerd, “Spacecraft Systems Engineering”, Wiley, 3rd Edition, 2003.
3. Alan C. Tribble, “The Space Environment: Implications for Spacecraft Design”, 2nd edition, Princeton University Press, 2003.
4. Michael D. Griffin, James R. French, “Space Vehicle Design”, AIAA Education Series, Second edition, 1991.
5. Mukund R. Patel, “Spacecraft Power Systems”, CRC Press, 2005.

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

AO3004	APPLICATIONS OF CFD	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I GOVERNING EQUATIONS OF FLUID FLOW AND NUMERICAL SOLUTIONS 9

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

UNIT II GRID GENERATION AND ASSESSMENT OF GRID QUALITY 9

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

UNIT III TIME DEPENDENT METHODS AND THEIR APPLICATIONS 9

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

UNIT IV FINITE VOLUME METHOD AND ITS APPLICATIONS 9

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

UNIT V INDUSTRIAL APPLICATIONS OF CFD 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 To understand the significance of both conservative and non-conservative forms of governing equations for fluid flows

CO2 To apply with diligence the proper boundary conditions for obtaining the solutions for fluid flow solutions

CO3 To analyse the grid quality and assess its suitability for using it for obtaining CFD solutions

CO4 To evaluate the grid generation techniques and grid control methods for obtaining CFD solutions

CO5 To apply suitable time dependent methods with proper numerical schemes for finding solutions either by steady or unsteady approach for aeronautical and aerospace problems

CO6 To evaluate and identify the required flux evaluation schemes while using finite volume methods for numerical solutions

CO7 To understand the importance of parallelization of computer codes and high performance computing for solving large scale aeronautical and aerospace problems

REFERENCES:

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

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3		2			3	3	2	2
2	3	3		2			3	3	2	2
3	3	3		2			3	3	2	2
4	3	3		3			3	3	2	2
5	3	3	3	3			3	3	2	2
6	3	3	3	3			3	3	2	2
7	3	3	3	3			3	3	2	2

		L	T	P	C
AO3005	**SPACECRAFT ATTITUDE DYNAMICS AND CONTROL**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES: This course will enable students

1. To learn the concept of measurement, error estimation and various sensors used in space applications.
2. To study the different actuators and their application in spacecraft
3. To study the attitude dynamics and orbital disturbances experienced by the spacecraft.
4. To study various satellite stabilization and orbit maneuvers.
5. To study various types of missiles, launch vehicle and their guidance.

UNIT I ATTITUDE SENSORS 8

Relative Attitude sensors – Gyroscopes, Frame conversion, Fundamental of attitude estimation 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, Actuator Bandwidth, First order system, second order system.- 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 Control, Dual spin Control - Gravity gradient technique - Zero momentum system - Momentum Biased system – Reaction wheel control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer, Bielliptical 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 - Trajectory/ Mission planning -Optimal staging, Pitch program optimization, Disturbances in stages separation region, Disturbances in High dynamic pressure region , Launch Vehicle- Introduction - Mission requirements- Implicit guidance schemes - Explicit guidance - Q guidance schemes

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1 Get a basic idea of the working principles of attitude sensors and their applications.
CO2 Familiarize with control actuators used for satellite applications.
CO3 Comprehend the application of rocket vehicle guidance laws.
CO4 Demonstrate satellite orbit stabilization schemes and methods of satellite orbit transfer.
CO5 Familiarize with orbit maneuvers of satellites and rocket vehicle guidance.

REFERENCES:

1. Kaplan M, Modern Spacecraft Dynamics and control, Wiley Press, 1979.
2. Marcel J. Sidi, Spacecraft Dynamics and control, A Practical Engineering Approach, Cambridge University Press.2000.
3. Meyer Rudolph X, Elements of Space Technology for Aerospace Engineers, Academic Press, 1999.
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. N.V.Kadam, Practical Design of Flight control systems for launch vehicles and Missiles, Allied Publishers,2009.
7. James R Wertz, Spacecraft Attitude Determination and control, Reidel Publications.2001.

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

AO3052 MISSILE AND LAUNCH VEHILE AERODYNAMICS

	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

COURSE OBJECTIVES:

This course will enable students

1. To impart knowledge to students on basic launch vehicle configurations and preliminary drag estimation
2. To introduce slender and blunt body aerodynamics, aerodynamic aspects of launching phase.
3. To analyse the aerodynamic characteristics of slender and blunt bodies.
4. To provide idea about the missile configurations and preliminary drag estimation.
5. To demonstrate the stability aspects of missile configuration and various control methods of missiles.

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 LAUNCH VEHICLE 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 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

UNIT IV 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 aeroelastic effects.

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

COURSE OUTCOMES:

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

CO1 To apply the concepts of high speed aerodynamics on missiles and launch vehicles
CO2 To acquire knowledge on aerodynamics characteristics of missiles of various types
CO3 To estimate drag for various missile configurations and methods to reduce it.
CO4 To estimate the forces and moments acting on missiles.
CO5 To apply slender body aerodynamics knowledge during launching phase and stability and control aspects of missiles.

REFERENCES:

1.Chin SS, Missile Configuration Design, Mc Graw Hill, New York, 1961.
2.Elements of Space Technology for Aerospace Engineers", Meyer Rudolph X, Academic Press, 1999
3.Nielson, Jack N, Stever, Gutford, "Missile Aerodynamics", Mc Graw Hill, New York, 1960.
4.Anderson Jr., D., – "Modern compressible flows", McGraw-Hill Book Co., New York 1999.
5.Anderson, J.D., "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985.
6.Anderson, 3.J.D., "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series.
7.Charles D.Brown, "Spacecraft Mission Design", AIAA Education Series, Published by AIAA, 1998

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

AO3053	NAVIGATION, GUIDANCE AND CONTROL FOR SPACE VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I INTRODUCTION 9

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

UNIT II ATTITUDE SENSORS AND CONTROL ACTUATORS 9

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

UNIT III INERTIAL NAVIGATION SYSTEMS AND GPS 9

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

UNIT IV RELATIVE NAVIGATION SYSTEMS 9

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

UNIT V ATTITUDE DYNAMICS AND STABILIZATION SCHEMES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

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

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

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

CO4 Understand Relative Navigation system and Rendezvous & Docking concepts

CO5 Explain the Attitude dynamics and Stabilization and FBW Control system

REFERENCES:

1.Slater, J.M. Donnel, C.F.O and others, “Inertial Navigation Analysis and Design”, McGraw-Hill Book Company, New York, 1964.
2.Albert D. Helfrick, ‘Modern Aviation Electronics’, Second Edition, Prentice Hall Career & Technology,1994
3.George M Siouris, ‘Aerospace Avionics System; A Modern Synthesis’, Academic Press Inc., 1993
4. Maxwell Noton, ”Spacecraft navigation and guidance”, Springer (London, New York), 1998
5.Myron Kyton, Walfred Fried, ‘Avionics Navigation Systems’, John Wiley & Sons, 1997
6.Collinson R.P.G, ‘Introduction to Avionics’, Chapman and Hall, India, 1996.

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

AO3015	MECHANICS OF COMPOSITE MATERIALS AND STRUCTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. An understanding of the importance of composite materials in aerospace application
2. Knowledge of the behaviour of unidirectional composites under longitudinal and transverse loading
3. Understanding about the micromechanics and macromechanics aspects of unidirectional composite materials
4. Familiarization with the classical lamination theory
5. Student would understand different fabrication processes involving composite materials

UNIT I COMPOSITE MATERIALS IN AEROSPACE APPLICATION 9

Classification of Composite Materials – Aircraft and Aerospace Application – Properties of Reinforcements and Matrices – Production of Glass, Carbon & Aramid Fibres – Basic Terminology – Constituent Material Forms – Fabrication Processes – Autoclave Production – Filament Winding – Resin Transfer Molding – Compression Molding – Pultrusion

UNIT II BEHAVIOUR OF UNI-DIRECTIONAL COMPOSITES 9

Micromechanics – Mechanics of Materials Approach – Assumptions – Prediction of Elastic Constants of a Uni-directional Lamina – Longitudinal Behaviour & Strength – Minimum & Critical Fibre Volume Fractions – Factors Influencing Strength & Stiffness – Transverse Strength & Stiffness – Failure Modes – Introduction to the Behaviour of Short Fibre Composites

UNIT III MACROMECHANICS APPROACH 9

Elastic Properties – Hooke's Law for Different Types of Materials – Compliance & Stiffness Matrices – Analysis of an Orthotropic Lamina – Transformation Equations for Stress and Strain – Plane Stress Analysis – Determination of Engineering Constants – Strengths of an Orthotropic Lamina – Bi-axial Failure Criteria – Experimental Determination of Elastic Constants

UNIT IV CLASSICAL LAMINATION THEORY 9

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

UNIT V COMPOSITE BEAMS 9

Laminated Beam Analysis – Basic Assumptions – Bending of a Laminated Beam – Eigenvalue Problem – Beam Vibration – Sandwich Type Construction – Bending of Sandwich Beams – Stress Distribution – Exact Theory – Approximate Theory – Failure Modes of Sandwich Beams and Plates – Outline of Design Procedure for Composite Beams

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Knowledge of the properties and advantages of composite materials for aerospace application

CO2 Solve problems related to micromechanics and macro mechanics aspects of composite materials

CO3 Ability to carry out lamina stress analysis and apply different failure theories

CO4 Understand classical lamination theory and ability to design a laminate

CO5 Awareness of the different production methods involving composite parts

REFERENCES:

1. Robert M. Jones, “Mechanics of Composite Materials”, CRC Press, 2nd Edition, 2006.
2. Alan Baker, “Composite Materials for Aircraft Structures”, AIAA Series, 3rd Edition, 2016.
3. Calcote, L R. “The Analysis of laminated Composite Structures”, Von – Nostrand Reinhold Company, New York 2008.
4. MadhujitMukhopadhyay, “Mechanics of Composite Materials and Structures”, Universities Press, 2005
5. Agarwal, B.D. and Broutman, L.J., "Analysis and Performance of Fibre Composites, "John Wiley & Sons, 4thedition, 2017.
6. Autar K Kaw, “Mechanics of Composite Materials”, CRC Press, 2nd Edition, 2006.

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

AO3006 **NUCLEAR PROPULSION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. Understand the fundamental principles of nuclear physics and their application to aerospace propulsion systems.
2. Develop a comprehensive understanding of nuclear reactor theory and its relevance to aerospace engineering.
3. Explore the design, performance, and safety considerations of nuclear propulsion technologies.
4. Understand the principles of radiation shielding, containment, and safety regulations in nuclear propulsion.
5. Gain insights into the future prospects and challenges of nuclear propulsion in aerospace.

UNIT I INTRODUCTION TO NUCLEAR PROPULSION 9

Historical overview of nuclear propulsion in aerospace - Basic principles of nuclear physics - Fundamentals of nuclear reactions and radioactivity - Overview of nuclear propulsion concepts and their advantages

UNIT II NUCLEAR REACTOR THEORY 9

Principles of nuclear fission and fusion reactions - Neutron physics and reactor kinetics - Types of nuclear reactors and their characteristics - Nuclear fuel cycle and management

UNIT III NUCLEAR PROPULSION TECHNOLOGIES 9

Nuclear thermal rockets (NTR) - Nuclear electric propulsion (NEP) - Project Orion and other advanced concepts - Comparison of different nuclear propulsion technologies

UNIT IV SAFETY AND ENVIRONMENTAL CONSIDERATIONS 9

Radiation shielding and containment - Nuclear safety principles and regulations - Environmental impact assessment - Waste management and disposal strategies

UNIT V FUTURE PROSPECTS AND CHALLENGES 9

Current research and development in nuclear propulsion - Challenges and limitations of nuclear propulsion - Policy and regulatory considerations - Future trends and potential applications

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 To explain the historical significance and evolution of nuclear propulsion in aerospace engineering and to demonstrate a solid understanding of the fundamental principles of nuclear physics and their relevance to propulsion systems.

CO2 To describe the principles of nuclear fission and fusion reactions and their role in nuclear reactors and to apply neutron physics and reactor kinetics principles to analyze and evaluate reactor performance.

CO3 To compare and contrast different nuclear propulsion technologies based on their performance and efficiency.

CO4 To assess and implement radiation shielding and containment strategies in the design of nuclear propulsion systems and to evaluate the environmental impact of nuclear propulsion systems and propose appropriate mitigation measures.

CO5 To analyze the current research and development activities in nuclear propulsion and to identify the challenges and limitations associated with the practical implementation of nuclear propulsion technologies.

REFERENCES:

1.John R. Lamarsh and Anthony J. Baratta, "Introduction to Nuclear Engineering", 3rd Edition, 2021. Pearson

2.Joseph A. Angelo and David Buden, "Space Nuclear power", 1st Edition, 1985. Krieger Pub Co.

3.William J. Emrich, Jr., "Principles of Nuclear Rocket Propulsion", 2nd Edition, 2023. Butterworth-Heinemann

4.Elmer E. Lewis, "Fundamentals of Nuclear reactor physics", 1st Edition, 2008. Academic Press

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

AO3054 ROCKETRY AND SPACE MECHANICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

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

UNIT I ORBITAL MECHANICS 9

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

UNIT II SATELLITE DYNAMICS 9

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

UNIT III ROCKET MOTION 9

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

UNIT IV ROCKET AERODYNAMICS 9

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

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

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

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

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

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

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

REFERENCES:

1. Parker,ER, “Materials for Missiles and Spacecraft”, McGraw-Hill Book Co., Inc., 1982.
2. Suresh. B N & Sivan. K, “Integrated Design for Space Transportation System”, Springer India, 2015.
3. Sutton,GP, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8 th Edition, 2010.
4. Van de Kamp, “Elements of Astromechanics”, Pitman Publishing Co., Ltd., London, 1980.
5. Cornelisse,JW, “Rocket Propulsion and Space Dynamics”, J.W. Freeman & Co., Ltd., London, 1982.
6. Howard D. Curtis, “Orbital Mechanics for Engineering Students (with MATLAB examples)”, Butterworth-Heinemann Publishing, 4th edition, 2019.

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

AO3007	CHEMICAL ROCKET TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

1.	To classify the rockets and can develop the thrust equation.
2.	To impart knowledge to the students on solid, liquid and hybrid rocket propulsion.
3.	To provide knowledge on the types of igniters and injectors used in solid and liquid rocket systems.
4.	To conduct various rocket testing and to analyze various modes of combustion instabilities.
5.	To describe and understand types of rocket testing, safety and environmental concerns

UNIT I — ROCKET PERFORMANCE — 9

Classification of Rockets - Propellants classification -Thrust equation, specific impulses, total impulse, characteristic velocity – Thrust coefficient – Efficiency: Real and ideal nozzle characteristic, Adiabatic flame temperature and its calculation, Criterion for Choice of propellants- flight performance of a rocket vehicle- flight trajectory of a single stage rocket vehicle

UNIT II — SOLID ROCKET MOTORS — 9

Viscous subsystems of solid rocket motor and their function – Igniters - Type of igniters – Internal ballistics properties– Burning rate - Factor affecting burning rate - Equilibrium Chamber pressure– Propellant grain geometry design, Erosive burning – Pressure vs Time curve- thrust vs time curve – Special problems of solid rocket nozzle – Combustion mechanism of solid propellants – Solid rocket motor design.

UNIT III — LIQUID ROCKET ENGINES — 9

Classification of liquid rocket engine –– Injectors and its types - various of types of feeding system - performance and choice of feed system cycle – Propellants tank and propellant slosh - Gas requirement for propellant draining - Thrust chamber – Thrust chamber cooling – Cryogenic propellants – Problems peculiar to cryogenic engine -– Turbo pumps – Ignition system - Combustion of liquid rocket – Thrust chamber design.

UNIT IV — HYBRID PROPULSION SYSTEM — 9

Standard and reverse hybrid rocket – Application – Limitation - Advanced fuel – Combustion mechanism of hybrid rocket – Regression rate measurement – Methods for improving regression rate - composite propulsion

UNIT V — ROCKET TESTING AND COMBUSTION INSTABILITIES — 9

Burning rate measurement techniques - Rocket testing – Static testing of rockets – Instrumentation and safety procedures – Ignition delay testing – Combustion instability - L* instability – different modes of combustion instability – Bulk and wave mode of combustion instability in solid and liquid rockets – Pogo instability.

TOTAL : 45 PERIODS

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

CO1	To identify the rocket propulsion system and its applications.
CO2	Analyze the performance of thrust chambers.
CO3	Describe and classify solid propellant rocket motors and its components.
CO4	Analyze propellants properties and associated physical and chemical processes
CO5	Describe and classify liquid propellant rocket motors, its components and various associated systems.

REFERENCES:

1.Martin J. Chiaverini& Kenneth K. Kuo, “Fundamentals of Hybrid Rocket Combustion and Propulsion”, Progress in Astronautics and Aeronautics (book218), 1st edition, 2007.
2.Ramamurthi,K, “Rocket Propulsion”, Laxmi Publications Private Limited, 1st edition, 2016.
3.Sutton,GP “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2016.

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

AO3008	SPACECRAFT SYSTEMS ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To acquaint students with the need for systems engineering and the different process involved in systems engineering
2. To impart knowledge on different phases of development process and design drivers in different phases.
3. To impart knowledge on evolution of avionics architecture and systems integration in spacecraft.
4. To familiarise students with varying system configurations and their compatibility with system evolution.
5. To impart knowledge on system reliability by analysing fault and failure of spacecraft systems and types of maintenance.

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING 9

Overview-Systems Definition and Concepts-Conceptual System Design- System Engineering Process- Everyday examples of systems-Spacecraft systems.

UNIT II DESIGN AND DEVELOPMENT PROCESS 9

Product Life Cycle –Concept Phase-Definition Phase-Design Phase-Build, Test, Operate and Disposal Phase-Whole Life Cycle Tasks-Systems Analysis- Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems.

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION 9

Systems Architectures - Modeling and Trade-Offs- Evolution of Avionics Architectures – Redundancy - Systems Integration Definition- Examples of Systems Integration-Integration Skills - Management of Systems Integration.

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL 9

Stake holders-Communications-Criticism- Configuration Control Process - Risk Management - Varying Systems Configurations- Compatibility-Factors Affecting Compatibility – Systems Evolution Considerations and Integration of Spacecraft Systems.

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY 9

Systems and Components-Analysis-Influence, Economics, Design for Reliability- Availability - Fault and Failure Analysis, FTA, FMEA - Case Study-Maintenance Types-Program-Planning and Design.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 Explain the importance of systems engineering and different process involved in systems engineering

CO2 Explain the different phases of development process and discuss on different factors affecting development process.

CO3 Select a suitable avionics architecture for system integration based on design requirements.

CO4 Design a compatible system by analysing the different factors affecting the compatibility.

CO5 Explain the importance of reliability and different methods of analysing fault and failures to provide system maintenance.

REFERENCES:

1. Andrew P. Sage, James E., Jr. Armstrong, "Introduction to Systems Engineering (Wiley Series in Systems Engineering and Management)", 2000.
2. Aslaksen, Erik and Rod Belcher, “Systems Engineering”, Prentice Hall, 1992.
3. Peter.Sydenham , “Systems Approach to Engineering”, Artech house, Inc, London, 2004.
4. INCOSE, “Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities”, Fifth Edition, Wiley, 2023.

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

AO3009 **MANNED SPACE MISSIONS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. To make student familiarize with various types of space missions and their challenges
2. To make students understand the peculiarities of space environment which satellites and astronauts have to encounter for various space missions
3. To expose the students the challenges posed by manned space missions and how to meet them
4. To make students familiarize with planning procedures for successful space missions
5. To expose the students the command, control and communication architecture and the unique nature of technologies required for space missions

UNIT I INTRODUCTION TO MANNED SPACE MISSIONS 9

Manned vs. unmanned missions – Objectives of manned space missions - Peculiarities and engineering challenges for manned space missions – Space capsules and Space station - Moon and Mars missions - Scientific and technological gains from manned space programs –Reusable space vehicles for manned space missions – Additional requirements for manned space missions – space medicine- microgravity

UNIT II EFFECT OF SPACE ENVIRONMENT ON MANNED SPACE MISSIONS 9

Description of space environment - Meteoroid, Orbital Debris &Space Radiation – Space dust - Magnetosphere - Radiation Environment: Galactic Cosmic Radiation (GCR), Solar Particle Events (SPE) - Human Factors of Crewed Spaceflight . Safety of Crewed Spaceflight - Radiation and the Human Body – Impact of microgravity and g forces on humans – space adaptation syndrome

UNIT III SUPPORT SYSTEMS FOR MANNED SPACE MISSIONS 9

Design considerations for Life Support Systems- Space Survival –Requirements and design of Environment Controlled Life Support Systems (ECLSS) - Facilitation of Human / Machine Interaction and features needed to support the interaction- - Human Factors in Control Design –Requirements for Crew Accommodations for short term and long term manned space missions

UNIT IV PLANNING AND LOGISTIC REQUIREMENTS 9

Planning requirements at various levels – Resources and mission requirements mapping - Ground Communication and Support –Design and planning of Space Mission in terms of Rockets and Launch Vehicles - Mission planning with Orbital Selection and Astrodynamics- Entry, Descent, Landing, and Ascent, Designing and Sizing Space elements – Logistics with respect to Transfer, Entry, Landing, and Ascent Vehicles – Surface Base Design, Sizing, and Integration –Logistic considerations in the operation of Planetary Surface Vehicles

UNIT V SUPPORT TECHNOLOGIES FOR MANNED SPACE MISSIONS 9

A brief introduction to additional technology requirements for manned space missions - Technology requirements for Mission Operations for Crewed Spaceflight– Role of Space Robotics in manned space missions – Recent developments in technical knowhow for AttitudeDetermination and Control for manned space platforms - Power Systems, command, control and communications for manned space platforms - Extravehicular Activity (EVA) Systems

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 To understand the detailed mission requirements for manned space missions and the challenges posed by such missions

CO2 To evaluate and understand the role of complex phenomena such as microgravity and the importance of space medicine for manned space missions

CO3 To analyse the unique nature of and various effects of cosmic radiation on space environment and apply this knowledge in the design and planning of manned space missions

CO4 To understand and evaluate the intricacies of challenges involved in manned space missions and the human factors such as space adaptation syndrome and the ways to meet them

CO5 To apply space mission planning principles and procedures and also the logistic considerations in the operation of planetary surface vehicles

CO6 To understand the required critical technologies involved in manned space missions and evaluate and apply them in designing human/machine interactions and space robotics

REFERENCES:

1.Connors, M.M., Harrison, A.A., and Akins, F.R. "Living Aloft: Human Requirements for Extended Spaceflight", Createspace Independent Pub, 2014.

2. Eckart, P. "Spaceflight Life Support and Biospherics:5", Space Technology Library, 2010

3. Larson, W. J. and Pranke, L. K., "Human Spaceflight: Mission Analysis and Design", McGraw- Hill College, 1st Edition, 1999.

4. McNamara, Bernard, "Into the Final Frontier: The Human Exploration of Space", Brooks/Cole Publishing, 2nd Edition, 2000.

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

AL3054 HIGH SPEED JET FLOWS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will make students

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

UNIT I INTRODUCTION 11

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

UNIT II TYPES OF JETS 9

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

UNIT III ACTIVE JET CONTROL METHODS 8

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

UNIT IV PASSIVE JET CONTROL METHODS 8

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

UNIT V JET ACOUSTICS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

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

REFERENCES:

1. Ethirajan Rathakrishnan, “Applied Gas Dynamics”, John Wiley, New York, 2010.
2. Liepmann and Roshko, “Elements of Gas Dynamics”, Dover Publishers, 2017.
3. Genrikh Abramovich,”The Theory of Turbulent Jets” MIT Press, 1963
4. Shapiro, AH, “Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I & II”, Ronald Press, New York, 1953.
5. H. Schlichting, K. Gersten, “Boundary Layer Theory” Springer 2017
6. Ginevsky A .S. “Acoustic Control of Turbulent Jets” Springer; Softcover reprint of hardcover 1st ed. 2004 edition (8 December 2010)

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

AO3055	ELECTRIC PROPULSION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

1.	To get familiarize with the basic the operating principles of the various electrical thrusters.
2.	To learn the concept of plasma kinetic theory
3.	To gain idea on the elements of gas kinetics.
4.	To impart knowledge on the classes of MPD thrusters.
5.	To study the importance of electric propulsion for space applications.

UNIT I PHYSICS OF IONIZEDGASE 9

Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas Electrical conductivity of an ionized gas - Kinetic Theory – Application of ionized gas flows.
Particle collision in ionized gas-Electron Atom collision, Electron ion collision, Electron –Electron and ion-Ion collision, Atom-Atom collision and ion atom collision.

UNIT II BASIC PHYSICS OF ELECTRIC PROPULSION 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.

UNIT III ELECTRO-THERMAL ACCELERATION 9

One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency – Resistojets - Electrical discharges - Arc jets - Operation and Analysis - Materials - advantages and Disadvantages

UNIT IV ELECTROSTATIC ACCELERATION 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

UNIT V ELECTROMAGNETIC ACCELERATION 9

The Lorentz force – Magneto gas dynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self-induced fields - Sources of the conducting gas - The magneto plasma dynamic arc - Magneto- plasma dynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Travelling wave acceleration, Circuit analysis of pulsed acceleration, coaxial guns and punched acceleration.

TOTAL : 45 PERIODS

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

CO1	Able to classify and describe the electric thrusters for space applications.
CO2	Able to perform the preliminary sizing of a test facility for electric propulsion.
CO3	Able to perform calculations of first approximation on plasmas of electric propulsion.
CO4	Able to set theory models for the study of electric propulsion systems.
CO5	Able to acquire knowledge on the basics of rarefied gas dynamics and plasma physics.

REFERENCES:

1.George W. Sutton, “Engineering Magnetohydrodynamics”, Dover Publications Inc., New York,2006.
2.Robert G. Jahn, “Physics of Electric Propulsion”, Dover Publications,2012.
3.Sutton,GP “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition, 2016.

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

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

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION OF STRUCTURAL HEALTH MONITORING 9

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

UNIT II OVERVIEW OF SMART MATERIALS 9

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

UNIT III SMART COMPOSITES 9

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

UNIT IV INTELLIGENT SYSTEMS AND NEURAL NETWORKS 9

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

UNIT V ADVANCES IN SMART STRUCTURES &MATERIALS 9

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design of Chemical and Biochemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems and Distributed measurement .

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

REFERENCES:

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

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

AO3010 UNMANNED AERIAL SYSTEMS

L	**T**	**P**	**C**
3	**0**	**0**	**3**

COURSE OBJECTIVES: This course will enable students

1. To impart knowledge on the basic aspects of UAV and its types.
2. To realize the importance of airframe designs and types of propulsions in unmanned aerial vehicle
3. Gain knowledge on various subsystems and testing procedure of an unmanned aerial vehicle.
4. To enhance the knowledge in the field of real time applications
5. To get familiarize with the ground control procedures and operations.

UNIT I INTRODUCTION TO UAV 9

History of UAV –classification –basic terminology-models and prototypes –applications

UNIT II BASICS OF AIRFRAME 9

Airframe–dynamics–modeling- structures –wing design- engines and its types-equipment, maintenance and management-control surfaces-specifications.

UNIT III DEVELOPMENT OF UAS SYSTEM 9

System Development- Ground Testing-UAV component testing-Uav Sub-assembly and Sub- System Testing- Testing Complete UAV, Environmental testing – Testing Complete UAV- Control Station testing-Catapult Launch systems -System In flight Testing- Test sites-Test Crew training-Onsite preparation - System Certification.

UNIT IV DEPLOYMENT OF UNMANNEDAERIAL SYSTEM 9

Operational trails-network centric operations-Radar confusion-Missile Decoy-radio relay- Electronic Intelligence-Covert Reconnaissance and surveillance Target designation by laser, NBC contamination Monitoring-Long Range reconnaissance and strike- Aerial photography- Information services- communication relay- landmine detection and Destruction-other applications

UNIT V COMMUNICATION PAYLOADS AND PATHPLANNING 9

Payloads-Telemetry-tracking-Aerial photography, Frequency range – Commands- Control, FPV videos - Flight computer sensor-displays, RF modems, Simulation and ground testing, Trouble shooting, waypoints navigation and ground control software.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 To classify UAVs based on different parameters
CO2 To demonstrate ability to design an efficient structure for an UAV of specific application.
CO3 To perform ground testing of UAVs.
CO4 To apply the knowledge gained on electronic intelligence and target designation for successful development of UAS.
CO5 To understand the basic concepts in the different types of navigation schemes for UAS.

REFERENCES:

1. Armand J. Chaput, “Design of Unmanned Air Vehicle Systems”, Lockheed Martin Aeronautics Company,2001.
2. Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy”, Springer,2007.
3. Paul G Fahlstrom, Thomas J Gleason, “Introduction to UAV Systems”, UAV Systems, Inc, 1998.
4. Reg Austin, “Unmanned Aircraft systems-UAVs Design, Development and Deployment”, WILEY Publication,2010.
5. Robert C. Nelson, “Flight Stability and Automatic Control”, McGraw-Hill, Inc,1998.
6. Swatton , PJ, “Ground studies for pilots’ flight planning”, 6th edition,2008.

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

AO3011 **HIGH TEMPERATURE GAS DYNAMICS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. To make students understand the fundamental physics behind the high temperature gas dynamics

2. To introduce students the fundamentals of statistical thermodynamics and its role in understanding the nature of high temperature flows

3. To expose the students the chemical kinetic theory behind the high temperature effects and the nature of chemical equilibrium in high temperature air

4. To introduce the governing equations for equilibrium and non equilibriuminviscid high temperature flows

5. To explain to the students the role of transport properties in controlling the phenomena such as radiation and diffusion in high temperature gases

UNIT I INTRODUCTION TO HIGH TEMPERATURE FLOWS 9

Basics of high temperature flows – Important phenomena associated with high temperature flows - Chemical effects in high temperature air – Real and perfect gases – Concept of Gibb's free energy-entropy changes in chemical and non chemical equilibria – Chemically reacting mixtures – presence of chemically reacting boundary layers

UNIT II ROLE OF STATISTICAL THERMODYNAMICS 9

Introduction to statistical thermodynamics – Relevance of high temperature effects in hypersonic flow –Role of statistical thermodynamics in understanding the effects of high temperature in hypersonic flows – Applications of statistical thermodynamics - Microscopic description of gases – Boltzman distribution – Cartesian function.

UNIT III CHEMICAL KINETIC ASPECTS IN HIGH TEMPERATURE FLOWS 9

Description of Chemical equilibrium in high temperature air and gases –Procedure for calculation of equilibrium composition of high temperature air – Determination of equilibrium properties of high temperature air – Concepts of collision frequency and mean free path – Role of velocity and speed distribution functions

UNIT IV PHENOMENA IN INVISCID HIGH TEMPERATURE FLOWS 9

Nature of Equilibrium and non equilibrium flows – Governing equations and solution methods for inviscid high temperature equilibrium flows – Properties of equilibrium normal and oblique shock wave flows – Outcome of results on the approximation of frozen and equilibrium flows – Salient features of equilibrium conical and blunt body flows – Governing equations for non equilibrium in viscid high temperature flows

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 9

Transport coefficients and nature of their variation with temperature– mechanisms of diffusion – Concept of total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting – equations for absorbing gases

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 To understand the basic physics behind the high temperature flows and will apply the knowledge to account for real gas effects in high temperature flows in aerospace applications

CO2 To analyse the differences between perfect gas flows and real gas flows under high temperature effects

CO3 To understand the relevance of statistical thermodynamics in high temperature flows and also the need for applying the principles of high temperature gas effects in hypersonic flows

CO4 To apply principles of statistical thermodynamics and understand the microscopic description of gases

CO5 To evaluate the equilibrium properties of high temperature air and apply the principles of chemical kinetic theory for calculation of chemical equilibrium composition of gases at high temperature

CO6 To evaluate and analyze the results from equilibrium and frozen flows of inviscid high temperature air flows

CO7 To understand the importance of radiative transport gases and apply the knowledge in the analysis of high temperature gas flows

REFERENCES:

1.John D. Anderson, Jr., “Modern Compressible Flow with Historical perspective”, Mc-Graw Hill Series, 4th Edition, 2021.

2.Tarit K. Bose, “High Temperature Gas Dynamics: An Introduction for Physicists and Engineers”, Springer, 2014.

3 John D. Anderson, Jr., “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd Edition, 2006.

COs	POs						PSOs			
	1	2	3	4	5	6	1	2	3	4
1	3	3					3	3	2	2
2	3	3					3	3	2	2
3	3	3					3	3	2	2
4	3	3					3	3	2	2
5	3	3	2	3			3	3	2	2
6	3	3		2			3	3	2	2
7	3	3	2	3			3	3	2	2

AO3012 FINITE ELEMENT ANALYSIS

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. Basic understanding of different methods of analysis for the solution of static structural problems
2. Knowledge of how finite element equations are formulated
3. An understanding of how characteristic matrices are generated
4. Exposure to different finite elements and awareness of element capability
5. Learning the assembly of finite element equations and solving for unknowns

UNIT I BASIC PROCEDURE 12

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

UNIT II 1-D STRUCTURAL ANALYSIS 12

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

UNIT III FLEXURE ELEMENTS 12

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

UNIT IV TWO DIMENSIONAL PROBLEMS 12

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

UNIT V FIELD PROBLEMS 12

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

TOTAL : 60 PERIODS

COURSE OUTCOMES:

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

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

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

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

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

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

REFERENCES:

1.Bathe K.J. and Wilson, E.L, "Numerical Methods in Finite Elements Analysis",Prentice Hall of India, 2016.
2.Krishnamurthy, C.S, "Finite Element Analysis", Tata McGraw Hill, 2nd edition, 2001.
3.Rao. S.S, "The Finite Element Methods in Engineering", Butterworth and Heinemann, 5th edition, 2010.
4.Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", 4th edition, John Wiley and Sons, 2003
5.Segerlind L J, "Applied Finite Element Analysis", John Wiley and Sons Inc., New York, 2nd Edition,1984
6.Tirupathi.R. Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 4th Edition, 2012.
7.Dhanaraj. R and K.Prabhakaran Nair, "Finite Element Method", Oxford university press, India, 2015

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

AL3052 ANALYSIS OF COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I BEHAVIOUR OF A UNI-DIRECTIONAL LAMINA 9

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

UNIT II CLASSICAL LAMINATION THEORY 9

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

UNIT III ANALYSIS OF LAMINATED BEAMS AND PLATES 9

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

UNIT IV DESIGN OF COMPOSITE STRUCTURES 9

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

UNIT V CHARACTERIZATION AND NON-DESTRUCTIVE EVALUATION 9

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

TOTAL : 45 Periods

COURSE OUTCOMES:

CO1 Ability to perform theoretical calculations in the micromechanics and macromechanics aspects of a composite lamina
CO2 Sound understanding of the applications of the classical lamination theory
CO3 Ability to design a composite laminate including special laminates
CO4 Good understanding of the possible failure modes of composite beams plates
CO5 Skill in carrying out characterization and non-destructive evaluation studies involving composite materials

REFERENCES:

1. Calcote, L R. “The Analysis of laminated Composite Structures”, Von – Nostrand Reinhold Company, New York 2008
2. Alan Baker, “Composite Materials for Aircraft Structures”, AIAA Series, 3rd Edition, 2016
3. Michael W, Hyer, “Stress analysis of fiber Reinforced Composite Materials”, Mc-Graw Hill International, 2009
4. J. N. Reddy, "Mechanics of Laminated Composite Plates and Shells: Theory and Analysis", CRC Press
5. Ever J. Barbero, "Introduction to Composite Materials Design", CRC Pres
6. Madhujit Mukhopadhyay, “Mechanics of Composite Materials and Structures”, Universities Press, 2005
7. Agarwal, B.D. and Broutman, L.J., "Analysis and Performance of Fibre Composites, "John Wiley & Sons, 4thedition, 2017.
8. Robert M. Jones, “Mechanics of Composite Materials”, CRC Press, 2nd Edition, 2006.

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

AO3056 **HYPERSONIC PROPULSION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

UNIT I INTRODUCTION TO HYPERSONIC FLOWS AND PROPULSION 9

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

UNIT II RAMJET PROPULSION 9

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

UNIT III SCRAMJET PROPULSION 9

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

UNIT IV ROCKET-BASED HYPERSONIC PROPULSION 9

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

UNIT V HYPERSONIC VEHICLE DESIGN AND TESTING 9

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

TOTAL : 45 Periods

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

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

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

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

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

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

REFERENCES:

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

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

AO3013	GEOSPATIAL DRONE DATA PROCESSING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. To make students familiarize about Remote sensing Technology
2. To impart knowledge on UAV in Survey and Mapping applications
3. To gain knowledge of the Geospatial Data Base Creation
4. To introduce the basic concepts of Drone Data Analysis
5. To impart knowledge on Drone in Mapping applications

UNIT I REMOTE SENSING TECHNOLOGY 9

Principles of Observation, Remote Sensing Types & Resolution, Earth Observation sensors, Spectral Signature, Image/Video Interpretation, Definition of GIS, Application of GIS and Remote Sensing.

UNIT II DRONE SURVEY AND MAPPING 9

Principles of Data acquisition, Comparison of Tradition survey with Advanced Survey Techniques, Challenges in Data Capturing, Data Capturing Methodology, DGPS – GCP Importance, GCS Overviews, Flight Plan, Auto Mission, Advantages and limitation of Drones in Mapping.

UNIT III GEOSPATIAL DATA BASE CREATION 9

Introduction to Photogrammetry, Challenges in Drone Photogrammetry, Drone Data Processing Methodology, Cluster computing Process, Data Products Generation - Point Cloud, - DSM, - DEM, - DTM, - Orthomosaic, Secondary Product Generation.

UNIT IV GEOSPATIAL DATA ANALYSIS 9

Introduction of Analysis Software, Input spatial data into GIS, Conversion of Data, Accuracy Assessment, Analysis of 2D and 3D Data Products, Importance of Data Analysis, Data Management, Case Study on Drone Data Analysis, WebGIS.

UNIT V CASE STUDIES 9

Drones in Disaster, Agriculture, Mining, Urban Planning, Construction and Infrastructure, Environmental Mapping, Archaeological, Rehabilitation and reconstruction - Drones in Future Mapping Applications.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Explain the Remote Sensing Technology.
CO2 Execute Drone flight plan, data capturing and its challenges
CO3 Explain the Advanced Drone data processing
CO4 Describe the Drone Data Interpretation
CO5 Develop Drone based Applications and Impacts

TEXT BOOKS:

1.Lillesand, T.M. and Kiefer, R.W.,“Remote sensing and Image Interpretation”, John Wiley, 1987.
2.Frazier, A., & Singh, K. (Eds.) “Fundamentals of Capturing and Processing Drone Imagery and Data (1st ed.)”, CRC Press, 2021.
3.Daniel Tal, John Altschuld “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, John Wiley & Sons, Inc, 2021
4.“Drone Technology: Future Trends and Practical Applications”, Scrivener Publishing LLC, 2023
5.Jean Doumit, “From drones to geospatial analysis”, Scientific edition polygraph Center Kuban State University, 2018.

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

AO3014 **SPACE EXPLORATION**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES: This course will enable students

1. To familiarize students with the historical context, current agencies, and key concepts related to space exploration.
2. To provide students with an understanding of the essential systems and technologies used in space exploration missions.
3. To explore the history, challenges, and future prospects of human space exploration.
4. To introduce students to the world of unmanned missions and robotic exploration of celestial bodies.
5. To explore the various challenges and future possibilities in the field of space exploration.

UNIT I INTRODUCTION TO SPACE EXPLORATION 9

History of Space Exploration: From ancient observations to the Space Age- Overview of Current Space Agencies and their Missions- The Space Environment: Celestial bodies, gravity, and vacuum-Motivations for Space Exploration: Scientific, technological, and societal perspectives- Spacecraft and Mission Architectures: Design considerations and mission planning

UNIT II SPACECRAFT SYSTEMS AND TECHNOLOGIES 9

Rocket Propulsion Systems: Principles and types- Spacecraft Subsystems: Power, communication, thermal control, and attitude control- Life Support Systems: Providing sustenance for human space missions- Remote Sensing Instruments: Capturing data from space- Orbital Mechanics: Understanding satellite motion and orbital transfer

UNIT III HUMAN SPACEFLIGHT 9

Human Factors in Space: Physiological and psychological challenges- Manned Missions: Mercury, Gemini, Apollo, and the International Space Station-Space Suits and Extravehicular Activities (EVAs)-Space Medicine: Health considerations for astronauts-Future of Human Spaceflight: Lunar and Mars exploration programs

UNIT IV ROBOTIC EXPLORATION 9

Unmanned Missions: Lunar probes, Mars rovers, and beyond- Planetary Science: Studying other celestial bodies- Remote Sensing and Imaging: Gathering data from distant objects-Sample Return Missions: Challenges and scientific importance-Future Trends in Robotic Space Exploration

UNIT V SPACE EXPLORATION CHALLENGES AND FUTURE PROSPECTS 9

Space Debris and Environmental Concerns- Interplanetary Travel: Advanced propulsion concepts-Space Tourism: Opportunities and challenges-Colonizing Other Worlds: Habitats and sustainability-Future Space Missions and Exploration Initiatives

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

CO1 Demonstrate an understanding of the history and motivations behind space exploration.
CO2 Explain the fundamental principles of rocket propulsion and spacecraft subsystems.
CO3 Analyze the challenges and advancements in human space exploration.
CO4 Evaluate the significance and challenges of robotic exploration in space
CO5 Discuss the major challenges and future prospects in the field of space exploration.

REFERENCES:

1. F. Landis Markley, John L. Crassidis “Fundamentals of Spacecraft Attitude Determination and Control” Springer, 31-May-2014
2. Peter Fortescue, Graham Swinerd, John Stark “Spacecraft Systems Engineering” John Wiley & Sons, Ltd. 2011.
3. James Miller “Planetary Spacecraft Navigation” Springer International Publishing, 10-Jan-2019

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

AO3057 COMBUSTION IN JET AND ROCKET ENGINES

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

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

UNIT I THERMODYNAMICS OF COMBUSTION 9

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

UNIT II PHYSICS AND CHEMISTRY OF COMBUSTION 9

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

UNIT III PREMIXED AND DIFFUSED FLAMES 9

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

UNIT IV COMBUSTION IN GAS TURBINE , RAMJET AND SCRAMJET 9

Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlled by decision mixing and heat convection.

UNIT V COMBUSTION IN CHEMICAL ROCKET 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

REFERENCES:

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

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

AL3055 VIBRATION AND STRUCTURAL DYNAMICS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

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

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

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

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

UNIT III TWO DEGREE OF FREEDOM SYSTEMS 9

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

UNIT IV MULTI DEGREE OF FREEDOM SYSTEMS 9

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

UNIT V VIBRATION OF CONTINUOUS SYSTEMS 9

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

TOTAL : 45 PERIODS

COURSE OUTCOMES:

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

REFERENCES:

1. LeonardMeirovitch,“ ElementsofVibrationAnalysis”–McGrawHillInternational Edition,2007.
2. Morse and Hinkle, “Mechanical Vibrations Theory and Applications”, Allyn and Bacon, 2nd Edition, 2004.
3. William Weaver, Stephen P. Timoshenko, Donovan H.Young,“Vibration Problems in Engineering”, John Wiley and Sons, New York, 2007.
4. Den Hartog, “Mechanical Vibrations”, Crastre Press, 3rd Edition 2011.

5. S S Rao, “Mechanical Vibrations”, 6th Edition, Pearson, India, 2018
6. William T. Thomson & Marie Dillon Dahleh, “Theory of Vibration with Application”, Prentice Hall publishers, 5th edition, 2008.
7. Grover, G.K. “Mechanical Vibrations”, 8th Edition, Nem Chand Brothers, Roorkee, India, 2009.

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

AO3017	DRONE PROPULSION FOR AEROSPACE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:
Of this course are
1 To make students familiarize about Drones
2 Learn about the various components of drone design.
3 To gain knowledge about the Drone subsystems
4 To impart knowledge on Drone propulsion
5 To introduce the basic concepts and types of Drone propulsion

UNIT V DRONE INTRODUCTION 9

Definition and history of drones, Types of drones, Importance of Drone Rules and Regulation,- Indian Drone Rules History & Evolution, - Indian Drone Rules 2021, - Drone Quality Certification Scheme related to propulsion

UNIT V DRONE DESIGN AND ASSEMBLY 9
Design considerations for drone airframe and propulsion systems, Selecting and assembling drone components such as motors, batteries, Electronic Speed controllers, Flight controllers, and cameras, Basic wiring and component layout.

UNIT V DRONE MOTOR 9
Working, Types: Brushed and Brushless Motors, motor sizing and identification, mounting patterns and thread size, Thrust to Weight ratio, KV ratings, advanced motor selection, BLDC Motor -Speed control methods -PWM techniques- Embedded processor based BDLC motor speed control. life cycle test.

UNIT V PROPULSION SYSTEM 9

Introduction to Propulsion,- Types of propellers , Types of Propulsion system, - hybrid fuel-electric, solar , - Types of drone engines, - Two-stroke, - Turbofan, - Turboprop, - Piston engine.

UNIT V TESTING OF DRONE PROPULSION 9

Drone maintenance and quality testing, Diagnostic test, Safety test, Environmental test, Component endurance test, Vibration test, Lifecycle test, Performance test, Stability test, Validation certificate and standards - EMI, EMC, IP rating, Case studies.

TOTAL :45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Acquire knowledge on the Drones
CO2 Gain Insights on Drone components, design, design standards and System selection
CO3 Acquire knowledge on Drone motor, Battery and ESC
CO4 Gain Insights on Drone propulsion system
CO5 Acquire Knowledge on Drone subsystem testing and Data Interpretation and its challenges.

REFERENCES:

1. Reg Austin "unmanned aircraft systems UAV design, development and deployment", Wiley,2010.
2. D. McLeod, Getting Started with Drone: How to Build, Fly, and Program Your own Drone, Apress, 2019.
3. Daniel Tal, John Altschuld "Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation", John Wiley & Sons, Inc, 2021.
4. Drone Technology: Future Trends and Practical Applications", Scrivener Publishing LLC, 2023

5. M. LaFay, Building Drones for Dummies, John Wiley & Sons, Inc., n.d.
6. E. Tooley, Practical Drones: Building, Programming, and Applications, Apress, 2021.
7. K. Venkata Raman ,Special Electrical Machines, Universities Press, 2014, 1st Edition.
8. S. K. Kopparthy, Drone Technology: Theory and Practice, Springer, 2020.
9. K. Sundar and R. V. Rajakumar, Multicopters: Principles and Applications, Springer, 2021.

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

AO3018 SPACECRAFT NAVIGATION GUIDANCE AND CONTROL

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

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

UNIT I NAVIGATION CONCEPTS 9

Fundamentals of spacecraft navigation systems and Position Fixing – Geometric concepts of Navigation - 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 - Mechanization INS system - Rate Corrections - Block diagram – Acceleration errors – -Coriolis effect - Schuler Tuning - Cross coupling - Gimbal lock – Alignment

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 9

Relative Navigation – fundamentals – Equations of Relative Motion for circular orbits (Clohessy_Wiltshire Equations) - Sensors for Rendezvous Navigation - RF Sensors -Relative Satellite Navigation - Differential GSP - Relative GPS- Optical rendezvous sensors (Laser type and Camera type) -Formation Flying - Figure of Merit (FOM)

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Students will be able to:

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

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

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

CO4 Understand Relative Navigation system and Rendezvous & Docking concepts

CO5 Explain the Attitude dynamics and Stabilization and FBW Control system

REFERENCES:

1. Slater, J.M. Donnel, C.F.O and others, “Inertial Navigation Analysis and Design”, McGraw-Hill Book Company, New York, 1964.
2. Albert D. Helfrick, ‘Modern Aviation Electronics’, Second Edition, Prentice Hall Career & Technology, 1994
3. Collinson R.P.G, ‘Introduction to Avionics’, Chapman and Hall, India, 1996
4. Maxwell Noton, ”Spacecraft navigation and guidance”, Springer (London, New York), 1998
5. George M Siouris, ‘Aerospace Avionics System; A Modern Synthesis’, Academic Press Inc., 1993
6. Myron Kyton, Walfred Fried, ‘Navigation Systems’, John Wiley & Sons, 1997

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