ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS COLLEGES AFFILIATED ANNA UNIVERSITY
M.E.AEROSPACE TECHNOLOGY
REGULATIONS 2021
CHOICEBASEDCREDITSYSTEM

I TO IV SEMESTERS CURRICULA & SYLLABI

1. PROGRAMME EDUCATIONALOBJECTIVES (PEOs): (3)

I.	Graduates Hold positions of technical responsibility, as members or leaders of multi-disciplinary teams engaged in aerospace engineering problem solving, systems analysis, design, development, testing or research.
II.	Understanding of multicultural and global perspectives and work effectively with engineers and customers from around the world, while providing for issues such as public safety, energy efficient and product design.
III.	Have enhanced and continue to enhance their professional skills by pursuing / completing a graduate degree or other post-graduate training.

2. PROGRAMME OUTCOMES (POs):

PO#	Programme Outcomes
1	An ability to independently carry out research/investigation and development work to solve practical problems
2	An ability to write and present a substantial technical report/document
3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
4	Students should know how to analyse complex engineering assets in the aerospace and aviation environment, and develop engineering, scientific and technological solutions to ensure problem-free operations.
5	An ability to develop systematic problem-solving and engineering/technological systems design methodologies operating in the industry.
6	An understanding of professional and ethical responsibility and also capable of doing doctoral studies in multidisciplinary areas.

Note: Program may add up to three additional Pos.

4. PEO/PO Mapping:

PEO	PO					
	1	2	3	4	5	6
I.	2	-	3	3	2	-
II.	-	2	-	1	2	3
III.	2	2	-	-	3	3
IV.						
V.						

Every programme objectives must be mapped with 1,2,3,-, scale against the correlation PO's

MAPPING–PG-AEROSPACE TECHNOLOGY

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Advanced Mathematical Methods				✓	✓	
		Space Propulsion Systems			✓	✓	✓	✓
		Aerospace Structural Analysis			✓	✓	✓	✓
		Space Vehicle Aerodynamics			✓	✓	✓	✓
		Research Methodology and IPR	✓	✓				✓
		Professional Elective-I						
		Audit course-I*						
		Launch Vehicle Aerodynamics Laboratory	✓		✓	✓	✓	
		Space Propulsion Laboratory	✓		✓	✓	✓	
	SEMESTER II	Hypersonic Aerodynamics			✓	✓		
		Orbital Mechanics			✓	✓	✓	
		Computational Modeling And Data Analysis In Aerospace Engineering	✓		✓	✓	✓	✓
		Analysis of composite structures			✓	✓		
		Professional Elective-II						
		Professional Elective-III						
		Audit course-II*						
		AerospaceStructures Laboratory	✓	✓	✓	✓		
		Computational Laboratory	✓	✓	✓	✓		
		Mini Project with Seminar	✓		✓			✓
YEAR II	SEMESTER III	Project Work I						
		Professional Elective-IV						
		Professional Elective-V						
		Open Elective						
	SEMESTER IV	Project Work II						

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I TO IV SEMESTERS CURRICULA AND SYLLABUS

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4153	Advanced Mathematical Methods	FC	4	0	0	4	4
2.	AS4101	Space Propulsion Systems	PCC	4	0	0	4	4
3.	AS4102	Aerospace Structural Analysis	PCC	3	1	0	4	4
4.	AS4103	Space Vehicle Aerodynamics	PCC	3	0	0	3	3
5.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Professional Elective-I	PEC	3	0	0	3	3
7.		Audit course-I*	AC	2	0	0	2	0
PRACTICAL								
8.	AS4111	Launch Vehicle Aerodynamics Laboratory	PCC	0	0	4	4	2
9.	AS4112	Space Propulsion Laboratory	PCC	0	0	4	4	2
			TOTAL	**21**	**1**	**8**	**30**	**24**

* Audit Course is optional.

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AS4251	Hypersonic Aerodynamics	PCC	3	0	0	3	3
2.	AS4201	Orbital Mechanics	PCC	3	0	0	3	3
3.	AS4202	Computational Modeling and Data Analysis in Aerospace Engineering	PCC	3	0	0	3	3
4.	AO4251	Analysis of Composite Structures	PCC	3	0	0	3	3
5.		Professional Elective - II	PEC	3	0	0	3	3
6.		Professional Elective - III	PEC	3	0	0	3	3
7.		Audit course-II*	AC	2	0	0	2	0
PRACTICAL								
8.	AS4211	Aerospace Structures Laboratory	PCC	0	0	4	4	2
9.	AS4212	Mini Project with Seminar	EEC	0	0	4	4	2
10.	AS4213	Computation Laboratory	PCC	0	0	4	4	2
			TOTAL	**20**	**0**	**12**	**32**	**24**

* Audit Course is optional.

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective -IV	PEC	3	0	0	3	3
2.		Professional Elective -V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICAL								
4.	AS4311	Project Work I	EEC	0	0	12	12	6
			TOTAL	**9**	**0**	**12**	**21**	**15**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICAL								
1.	AS4411	Project Work II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

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

PROFESSIONAL ELECTIVE COURSES

SEMESTER I, ELECTIVE – I

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4001	Elements of Satellite Technology	PEC	3	0	0	3	3
2.	AS4002	Cryogenic Technology	PEC	3	0	0	3	3
3.	AS4003	Introduction to Aeronautics and space Technology	PEC	3	0	0	3	3
4.	AS4004	Fundamentals of Combustion	PEC	3	0	0	3	3
5.	AS4072	Computational Heat Transfer	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE – II

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4005	Missile Aerodynamics	PEC	3	0	0	3	3
2.	AS4006	Spacecraft Attitude Dynamics and Control	PEC	3	0	0	3	3
3.	AS4007	Chemical Rocket Technology	PEC	3	0	0	3	3
4.	AS4071	Aerospace Materials	PEC	3	0	0	3	3
5.	AS4008	Space Vehicle Design	PEC	3	0	0	3	3
6.	AS4009	Theory of Plates and Shells	PEC	3	0	0	3	3

SEMESTER II, ELECTIVE – III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4010	Missile Guidance and Control	PEC	3	0	0	3	3
2.	AO4076	Theory of Boundary Layers	PEC	3	0	0	3	3
3.	AO4252	Finite Element Analysis	PEC	3	0	0	3	3
4.	AO4072	Fatigue and Fracture Mechanics	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE – IV

SL. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AO4078	Vibration Isolation and Control	PEC	3	0	0	3	3
2.	AO4074	Non-Destructive Evaluation	PEC	3	0	0	3	3
3.	AS4011	Plasma Engineering	PEC	3	0	0	3	3
4.	AS4012	Rocket and Missile Systems	PEC	3	0	0	3	3
5.	AS4013	Electric Propulsion Systems	PEC	3	0	0	3	3
6.	AO4077	Theory of Vibrations	PEC	3	0	0	3	3

SEMESTER III, ELECTIVE – V

SL. NO.	COURSE CODE	COURSETITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AS4014	Manned Space Missions	PEC	3	0	0	3	3
2.	AS4015	High Temperature Gas Dynamics	PEC	3	0	0	3	3
3.	AO4073	High Speed Jet Flows	PEC	3	0	0	3	3
4.	AO4075	Smart Materials and Structural Health Monitoring	PEC	3	0	0	3	3
5.	AS4016	Unmanned Aerial Systems	PEC	3	0	0	3	3
6.	AS4017	Reliability and Quality	PEC	3	0	0	3	3

AUDIT COURSES (AC)
Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	AX4091	English for Research Paper Writing	2	0	0	0
2.	AX4092	Disaster Management	2	0	0	0
3.	AX4093	Constitution of India	2	0	0	0
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AS4212	Mini Project with Seminar	0	0	4	2	2
2.	AS4311	Project Work - I	0	0	12	6	3
3.	AS4411	Project Work-II	0	0	24	12	4
						TOTAL CREDITS	**18**

Summary

	Name of the Programme					
	Subject Area	**Credits per Semester**				**Total credits**
		I	**II**	**III**	**IV**	
1.	FC	4				4
2.	PCC	13	6			19
3.	PEC	3	9	6		18
4.	RMC	2				2
5.	OEC			2		2
6.	EEC					
7.	Non Credit/Audit Courses					

MA4153 ADVANCED MATHEMATICAL METHODS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

- To attain the knowledge of solving Partial Differential Equations using Laplace transform.
- To apply Fourier Transform to solve boundary value problems.
- To achieve maxima and minima of a functional.
- To acquire knowledge on using conformal mapping to fluid flow and heat flow problems.
- To understand the tensor analysis as a tool to solve problems arising in engineering disciplines.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform : Definitions – Properties – Transform error function – Bessel's function - Dirac delta function – Unit step functions – Convolution theorem – Inverse Laplace transform : Complex inversion formula – Solutions to partial differential equations : Heat equation – Wave equation.

UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

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

UNIT III CALCULUS OF VARIATIONS 12

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

UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12

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

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

COURSE OUTCOMES :

After completing this course, students should demonstrate competency in the following skills:

- Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundary value problems in Partial Differential Equations.
- Maximizing and minimizing the functional that occur in various branches of Engineering Disciplines.
- Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid flow and heat flow problems.
- Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors.
- Competently use tensor analysis as a tool in the field of applied sciences and related fields.

REFERENCES :

1. Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007.
3. Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics and Engineering", 6^{th} Edition, Jones and Bartlett Publishers, 2012.
4. Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition, 2014.
5. Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005.
6. Saff, E.B and Snider, A.D, "Fundamentals of Complex Analysis with Applications in Engineering, Science and Mathematics", 3^{rd} Edition, Pearson Education, New Delhi, 2014.
7. Sankara Rao, K., "Introduction to Partial Differential Equations", 3^{rd} Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2010.
8. Spiegel, M.R., "Theory and Problems of Complex Variables and its Applications", Schaum's Outline Series, McGraw Hill Book Co., 2009.
9. Ramaniah. G. "Tensor Analysis", S. Viswanathan Pvt. Ltd., 1990.

AS4101	SPACE PROPULSION SYSTEMS	L	T	P	C
		4	0	0	4

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 PROPULSIONSYSTEMS 12

Historical outline, Scramjet Propulsion-Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-Tripropellants; Metalized Propellants; Free Radical Propulsion, Electric Propulsion, Micropropulsion-Micropropulsion Requirements, MEMS and MEMS- Hybrid Propulsion Systems.

UNIT II BASIC CONCEPTS OF IONIZED GASES 12

Electromagnetic theory: electric charges and fields, currents, and magnetic fields, and applications to ionized gases. Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas – Electrical conductivity of an ionized gas - Kinetic Theory, Introduction to plasma physics- Electrode phenomena.

UNIT III NUCLEAR ROCKET PROPULSION 12

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.

UNIT IV RADIOISOTOPE PROPULSION 12

Alternative Approaches, Direct Recoil Method, Thermal Heating Method, Basic Thruster Configurations, Propulsion System and Upper Stage, Relative Mission Capabilities, Primary Propulsion, Auxiliary Propulsion, Thruster Technology, Design Criteria, Performance, Safety, Heat Source Development, Radioisotope Fuel, Capsule Technology, General Considerations, Thermal Design, Fabrication and Non-Destructive Testing Techniques, Pressure Containment, Heat Source Simulation, Oxidation and Corrosion of Encapsulating Materials, Nozzle Performance.

UNIT V ADVANCED SPACE PROPULSION CONCEPTS 12

Introduction, General Consideration for Propulsion in Space, Power Supply, Propellant Storage and Handling Facilities, Electrostatic and Electromagnetic Thrusters, 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

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Have knowledge on the basics and classification of space propulsion.

CO2: Comprehend the physics of ionized gases, their theories and particle collisions.

CO3: Demonstrate the working, types and performance of nuclear rockets with their design considerations.

CO4: Learn the basics of radioisotope propulsion with their performance studies.

CO5: Have knowledge on advanced methods of space propulsion systems with new thrust generation mechanisms.

REFERENCES:

1. Czysz, Paul A., Bruno, Claudio, Chudoba, Bernd “Future Spacecraft Propulsion Systems and Integration”, Springer, Praxis Publishing Ltd, 2018.
2. George W. Sutton, “Engineering Magneto hydrodynamics”, Dover Publications Inc., New York, 2006.
3. George P. Sutton & Oscar Biblarz, “Rocket Propulsion Elements, John Wiley & Sons Inc., NewYork, 9th Edition, 2016.
4. Martin Tajmar, “Advanced Space Propulsion Systems” Springer Verlag GmbH, 2003.
5. Robert G. Jahn, “Physics of Electric Propulsion”, McGraw-Hill Series, New York, 1968.
6. William J. Emrich, “Principles of Nuclear Rocket Propulsion” Elsevier Science, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	2	-	-
CO2	2	1	1	2	-	-
CO3	2	1	2	2	2	-
CO4	2	1	2	2	2	-
CO5	2	1	2	2	2	-

AS4102 **AEROSPACE STRUCTURAL ANALYSIS**

L	T	P	C
3	1	0	4

COURSE OBJECTIVES:

This course will enable students

1. To learn the important technical aspects on theory of bending.
2. To find the shear flow distribution and to locate the shear centre for open and closed sections.
3. To analyse the stability problems involved in aircraft structural components under various modes of loadings.
4. To impart knowledge on how to analyze aircraft structural components under various forms of loading.
5. To gain knowledge on the spacecraft structures and materials used.

UNIT I BENDING OF BEAMS 9+3

Elementary theory of pure bending – Stresses in beams of symmetrical and unsymmetrical sections - Box beams – Generalized theory of bending – Methods of bending stress determination – Principal axes method – Neutral axis method – 'k' method – Deflection of unsymmetrical beams – Stresses in Composite Beams – Deflection of Sandwich Beams – Design Principles.

UNIT II SHEAR FLOW ANALYSIS 9+3

Concept of shear flow in thin walled open & closed sections – Determination of the shear centre in symmetrical and unsymmetrical cross-sections – Flexural shear flow in multi-flange box beams – Shear flow due to combined bending & torsion in closed sections – Torsion of thin-walled open section members – Stress analysis of aerospace components – Tapered wing spar.

UNIT III DESIGN OF COMPRESSION MEMBERS 9+3

Analysis of solid columns – Governing Equations – Critical Loads & Buckled Modes – Thin-walled Compressions Members – Stability Analysis – Design Criterion – Buckling of sheets under compression – Plate buckling coefficient – Inelastic buckling of plates – Sheet-stiffener panels – Effective width – Failure stress in plates and stiffened panels – Local Buckling – Crippling Load Estimation.

UNIT IV ANALYSIS OF AEROSPACE STRUCTURAL COMPONENTS 9+3

Loads on an aircraft – Aerodynamic loads – Manoeuvre loads – Load factor determination – The flight envelope – Shear force, bending moment and torque distribution along the span of the wing and fuselage – Structural parts of wing and fuselage and their functions – Introduction to aeroelasticity – Sources of launch vehicles loads – Launch vehicle categories – Load and acceleration time-line profile.

UNIT V REQUIREMENTS OF SPACECRAFT STRUCTURES 9+3

Introduction & General Aspects – The Satellite Primary Structure – Load Classification – Typical Requirements – Strength – Failure Theories – Buckling – Sources of Vibration – Frequency Limits – Stiffness, Damping & Mass Distribution – Satellite Vibration Analysis – Response Spectrum – Design Requirements – Materials Used for Construction – Mechanical Interfaces.

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

COURSE OUTCOMES:

Upon completion of the course, students will be able to

CO1: Apply the concept of normal stress variation on unsymmetrical sections subjected to bending moments on practical problems.

CO2: Find the shear flow variation in thin walled open sections with skin effective and ineffective in bending.

CO3: Evaluate the shear flow variation in single cell and multi-cell tubes subjected to shear and torque loads.

CO4: Analyse the behaviour of buckling of simply supported plates and also to know the effective width of sheet stringers combination.

CO5: Analyse and design structural members subject to compression.

REFERENCES:

1. Bruce.K.Donaldson, "Analysis of Aircraft Structures: An Introduction", Cambridge University Press, 2nd edition, 2008.
2. Bruhn. EF, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co, 1980.
3. Megson, TMG, "Aircraft Structures for Engineering Students", Elsevier Aerospace Engineering Series, 5th Edition, 2012.
4. Peery, DJ and Azar, JJ, "Aircraft Structures", 2nd Edition, McGraw-Hill, New York, 1993.
5. Rivello, RM, "Theory and Analysis of Flight Structures", McGraw-Hill, N.Y., 1993.
6. Sun. CT, "Mechanics of Aircraft Structures", Wiley publishers, 3rd edition, 2021.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	3	-	-
CO2	2	1	1	3	-	-
CO3	2	1	1	3	2	-
CO4	2	1	1	3	2	-
CO5	2	1	1	3	2	-

AS4103 SPACE VEHICLE AERODYNAMICS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enable students to

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 INCOMPRESSIBLE FLOW 9

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 – Kutta Joukowski theorem– Kutta Joukowski Transformations and its applications.

UNIT II COMPRESSIBLE FLOWS 9

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

UNIT III BOUNDARY LAYER THEORY 9

Laminar boundary layer - Turbulent boundary layer – Prandtle mixing length theory, Velocity distribution loss - Skin friction drag estimation - Shock wave-boundary layer interactions – Thermal Boundary Layer – Exact and Approximate solutions to thermal Boundary Layer flows.

UNIT IV AERODYNAMIC CHARACTERISTICS OF MISSILES 9

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

UNIT V AERODYNAMIC HEATING 9

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: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will

CO1: Have through knowledge on the concepts of incompressible aerodynamics.

CO2: Be able to analyse practical problems involving Fanno and Rayleigh flow and also flow affecting phenomena.

CO3: Have knowledge on the concepts of laminar and turbulent boundary layer flows and their interaction with shock waves and thermal effects.

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. Anderson, JD, "Fundamentals of Aerodynamics", McGraw-Hill Book Co, 6th edition 2017.
2. Chin SS, "Missile Configuration Design", Mc GrawHill, 1961.
3. Hermann Schlichting, "Boundary Layer Theory", Springer, 9th edition, 2017.
4. Michael Mendenhall, "Tactical Missile Aerodynamics: Prediction Methodology, Progress in Astronautics and Aeronautics", 1992.
5. Nielson, JackN, Stever, Gutford, "Missile Aerodynamics", McGraw Hill, 1960.
6. Anderson, JD, "Modern Compressible Flows", McGraw-Hill Book Co, 2010

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2	-	-
CO2	2	1	2	2	-	-
CO3	3	1	2	3	2	-
CO4	3	1	2	3	2	-
CO5	3	1	2	2	-	-

RM4151 RESEARCH METHODOLOGY AND IPR

L	T	P	C
2	0	0	2

UNIT I RESEARCH DESIGN 6

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS 6

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL : 30 PERIODS

REFERENCES:

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

AS4111	LAUNCH VEHICLE AERODYNAMICS LABORATORY	L T P C
		0 0 4 2

COURSE OBJECTIVES:

This laboratory course will enables students

1. To get exposure with a practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
2. To have a practical exposure on Aerodynamic measurement techniques.
3. To do testing of sub systems and components of aircraft at low speed.
4. To measure force and moments on missile models.
5. To calibrate subsonic and supersonic wind tunnels.

LIST OF EXPERIMENTS:

1. Calibration of subsonic wind tunnel
2. Pressure distribution on a swept wing model
3. Pressure distribution on nose cone model at subsonic speeds
4. Pressure distribution on a sphere model
5. Force and moment measurements on D model using wind tunnel balance
6. Base drag measurements on missile model
7. Pressure distribution on backward step model
8. Thermal boundary layer measurements over a flat plate
9. Calibration of supersonic wind tunnel
10. Wall pressure measurements over a circular cone in a Supersonic flow
11. Wall pressure measurements on a semi wedge in a supersonic flow
12. Flow visualization of a bow shock in front of a bluff body
13. Flow visualization of shock boundary layer interaction
14. Wall pressure measurements in single expansion ramp nozzle

TOTAL: 60 PERIODS

Any 10 Experiments will be conducted.

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To operate and calibrate subsonic and supersonic wind tunnel

CO2: To comprehend the pressure distribution over the streamlined and bluff bodies.

CO3: To measure force and moments on aircraft models

CO4: To measure boundary layer thickness for various models

CO5: To carry out flow visualization at subsonic speeds.

LABORATORY EQUIPMENTS REQUIREMENTS

1. Subsonic wind tunnel
2. Supersonic wind tunnel
3. Wind tunnel balance
4. Schlieren system
5. Pressure Transducers/ pressure scanner
6. Models for testing cone, wedge, bluff body, swept wind, missile, D model and SERN.

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

AS4112 SPACE PROPULSION LABORATORY **L T P C**
0 0 4 2

COURSE OBJECTIVES:

This course will enable students to

1. Visualize the shock pattern in supersonic flows
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. Develop ability to analyze and interpret the experimental data using software.
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. Wall pressure measurements in a supersonic diffuser
5. Total pressure measurements in the radial direction of a supersonic circular jet
6. Total pressure measurements along the jet axis of a circular supersonic jet
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:

At the end of the course, student will be able

- **CO1:** To perform wall pressure distribution on subsonic and supersonic nozzles
- **CO2:** To acquire knowledge on fundamental concepts of low speed and high speed jets and experimental techniques pertains to measurements.
- **CO3:** To gain adequate knowledge on pressure distribution on cavity models
- **CO4:** To have exposure on wake survey methods.
- **CO5:** To carry out flow visualization at supersonic speeds.

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 least 2-D)
6. Pressure Transducers/ pressure scanner
7. Cascade model for compressor blades
8. Multitube manometers

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

AS4251 HYPERSONIC AERODYNAMICS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enables 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 AERODYNAMICS9

Peculiarities of Hypersonic flows - Thin shock layers – entropy layers – 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 8

Local surface inclination methods – modified Newtonian Law – 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 10

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 10

Peculiarities of hypersonic boundary layers - boundary layer equations r – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux and skin friction estimation.

UNIT V VISCOUS INTERACTIONS AND TRANSITION 8

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:

Upon completion of the course, students will

CO1: Be able to arrive at the solution for problems involving inviscid and viscous hypersonic flows.
CO2: Have thorough knowledge on high temperature effects in hypersonic aerodynamics.
CO3: Be able to arrive at various solution methods to overcome aerodynamic heating problem on hypersonic vehicles.
CO4: To gain ideas on the design issues associated with hypersonic vehicles.
CO5: Able to realize the importance and use of the relevant equations for viscous hypersonic flows.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓		

REFERENCES:

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

AS4201 ORBITAL MECHANICS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To have a basic knowledge on the peculiarities of space environment and to realize the importance of manned space missions.
2. To get introduced with the characteristics of various orbits and the importance of orbital elements.
3. To get familiarize with the basic aspects of satellite injection and the types of satellite perturbations.
4. To compute trajectory for interplanetary travel and flight of ballistic missiles based on the fundamental concepts of orbital mechanics.
5. To provide basic knowledge on the ballistic missile trajectories.

UNIT I SPACE ENVIRONMENT9

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

UNIT II CHARACTERISTICS OF VARIOUS ORBITS9

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.

UNIT III SATELLITE INJECTION AND SATELLITE PERTURBATIONS9

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 TRAJECTORIES9

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 TRAJECTORIES9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To acquire knowledge on the peculiarities of space environment and its effect on spacecraft materials.

CO2: To estimate the time and position of an object in various orbits.

CO3: To acquire knowledge on the basic concepts of satellite injection and satellite perturbations.

CO4: To calculate orbital parameters and to perform conceptual trajectory designs for geocentric or interplanetary missions.

CO5: To estimate the time of flight and the position of impact point of ballistic missiles.

REFERENCES:

1. Cornelisse, JW, Schoyer, HFR &Wakker, KF, "Rocket Propulsion and Space Dynamics", Pitman Publishing, 1979.
2. Howard D.Curtis, "Orbital Mechanics for Engineering Students", 3rd Edition, Butterworth-Heinemann, 2013.
3. Parker, ER, "Materials for Missiles and Spacecraft", Mc.Graw Hill Book Co. Inc., 1982.
4. Suresh. BN & Sivan. K, "Integrated Design for Space Transportation System", Springer India, 2015.
5. Sutton, G.P. "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓	✓		

AS4202 COMPUTATIONAL MODELING AND DATA ANALYSIS IN AEROSPACE ENGINEERING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will make the students

1. To get familiarize with the procedure to obtain numerical solution to fluid dynamic problems.
2. To gain knowledge on the important aspects of grid generation for practical problems.
3. To get exposure on time dependant and panel methods.
4. To understand the use of computation to understand real world phenomena.
5. To learn the data analysis techniques and its applications to space science.

UNIT I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS 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 - Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations-Panel methods.

UNIT II GRID GENERATION 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 for geometries like aerofoil and CD nozzle.Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries – Overlapping grids – Grids around multi bodies.

UNIT III TIME DEPENDENT METHODS 9

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

UNIT IV INTRODUCTION TO DATA ANALYSIS 9

An introduction to probability theory-the modeling and analysis of probabilistic systems and elements of statistical inference - Probabilistic models - conditional probability. Discrete and continuous random variables

UNIT V DATA ANALYSIS IN AEROSPACE APLICATIONS 9

Expectation and conditional expectation, and random variables - Limit Theorems - Bayesian estimation and hypothesis testing - Elements of classical statistical inference - Bernoulli and Poisson processes - Markov chains.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able

CO1: To arrive at the numerical solutions to boundary layer equations.

CO2: To perform numerical grid generation and have knowledge about the mapping techniques.

CO3: To familiarise himself/herself with high performance computing for CFD applications.

CO4: To implement the explicit time dependent methods and their factorization schemes.

CO5: To do the stability analysis and linearization of the implicit methods.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓	✓	
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

REFERENCES:

1. Bose. TK, “Numerical Fluid Dynamics”,Narosa Publishing House, 2001.
2. Chung. TJ, “Computational Fluid Dynamics”, Cambridge University Press, 2010.
3. Hirsch,AA, “Introduction to Computational Fluid Dynamics”, McGraw-Hill, 1989.
4. John D. Anderson, “Computational Fluid Dynamics”, McGraw Hill Education, 2017.
5. Anil Maheshwari, Data Analytics, McGraw Hill Education; First edition, 2017
6. Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AO4251 ANALYSIS OF COMPOSITE STRUCTURES

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will make students

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

UNIT I FIBERS, MATRICES, AND FABRICATION METHODS 9

Production & Properties of Glass, Carbon and Aramid Fibers – Thermosetting and Thermoplastic Polymers – Polymer Properties of Importance to the Composite, Summary of Fabrication Processes – Scope of Composite Materials for Various Aerospace Application.

UNIT II MICROMECHANICS OF A UNIDIRECTIONAL COMPOSITE 9

Volume and Weight Fractions in a Composite Specimen – Longitudinal Behaviour of Unidirectional Composites – Load Sharing – Failure Mechanism and Strength – Factors Influencing Longitudinal Strength and Stiffness – Transverse Stiffness· and Strength – Prediction of Elastic Properties Using Micromechanics –Typical Unidirectional Fiber Composite Properties – Minimum and Critical Fiber Volume Fractions.

UNIT III MACROMECHANICS APPROACH 9

Stress Analysis of an Orthotropic Lamina-Hooke's Law-Stiffness and Compliance Matrices - Specially Orthotropic Material-Transversely Isotropic Material & Specially Orthotropic Material under Plane Stress-Determination of E_x, E_y, G_{xy}-Stress & Strain Transformations-Transformation of Stiffness and Compliance Matrices-Strengths of an Orthotropic Lamina Using Different Failure Theories.

UNIT IV ANALYSIS OF LAMINATED COMPOSITES 10

Laminate Strains - Variation of Stresses in a Laminate - Resultant Forces and Moments - Synthesis of Stiffness Matrix - Laminate Description System - Construction and Properties of Special Laminates - Symmetric Laminates – Balanced Laminate - Cross-Ply, and Angle-Ply Laminates - Quasi-isotropic Laminates - Determination of Laminae Stresses and Strains – Determination of Hygrothermal Stresses - Analysis of Laminates after Initial Failure.

UNIT V ANALYSIS OF LAMINATED PLATES AND BEAMS 8

Governing Equations For Laminated Composite Plates -- Governing Equations for Laminated Beams -Application of Theory – Bending, Buckling and Vibration of Laminated Beams and Plates repair-Analysis of sandwich construction-AE technique.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To calculate the elastic and strength properties of unidirectional laminates using micromechanics theory.

CO2: To analyze a composite laminate using the different failure theories.

CO3: To select the most appropriate manufacturing process for fabricating composite components.

CO4: To demonstrate understanding of the different materials (fibres, resins, cores) used in composites.

CO5: To gain knowledge on non-destructive inspection (NDI) and structural health monitoring of composites.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1	2		2		3	1
CO2	2		2		3	1
CO3			2		2	1
CO4			2		2	1
CO5			2		1	1
	0.8	0	2	0	2.2	1

REFERENCES:

1. Agarwal, BD and Broutman, LJ, “Analysis and Performance of Fibre Composites”, John Wiley & Sons, 3rd edition, 2006.
2. Allen Baker, “Composite Materials for Aircraft Structures”, AIAA Series, 2nd Edition, 2004.
3. Autar K Kaw, “Mechanics of Composite Materials”, CRC Press, 2nd edition, 2005.
4. Calcote, LR, “The Analysis of laminated Composite Structures”, Von – Nostrand Reinhold Company, New York, 1998.
5. Isaac M. Daniel &OriIshai ,“Mechanics of Composite Materials”, OUP USA publishers, 2nd edition, 2005.
6. Lubing, “Handbook on Advanced Plastics and Fibre Glass”, Von Nostran Reinhold Co., New York, 1989.

AS4211 **AEROSPACE STRUCTURES LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

This laboratory course will make students

1. To impart practical knowledge on calibration of photoelastic materials.
2. To determinethe elastic constant for composite lamina,
3. To find the symmetrical and unsymmetrical bending of beams.
4. To determine the shear centre locations for closed and open sections.
5. To find the buckling of columns with different end conditions.

LIST OF EXPERIMENTS:

1. Symmetrical & Unsymmetrical Bending of Beams
2. Buckling of Columns with Different End Conditions
3. Shear Centre Location of Thin-Walled Beams
4. Influence Coefficients & Flexibility Matrix Determination
5. Stresses Due to Combined Loading
6. Calibration of Photo Elastic Materials / Experiments in Photoelasticity
7. Experimental Modal Analysis / Free Vibration Tests
8. Resonance Testing of Structural Parts
9. Fabrication of Composite Laminates
10. Mechanical Testing & Characterization of Composite Material
11. Non-Destructive Characterization of Materials
12. Non-Destructive Evaluation of Flaws using Acoustic Emission / Ultrasonics
13. Modelling and Static Analysis of an Aircraft Component using FE software
14. Fatigue Testing and Inspection of Failure Surface

NOTE: Any TEN experiments will be conducted out of 14.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, a student will be able

CO1: To conduct tests on beams and columns.

CO2: To design an experimental evaluation technique for a given application.

CO3: To carry out non-destructive testing.

CO4: To fabricate a composite laminate and characterize it.

To carry out structural analysis using finite element software.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓										
CO3	✓	✓										
CO4	✓	✓										
CO5	✓	✓										

LABORATORY EQUIPMENTS REQUIREMENTS

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

AS4212 **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.

TOTAL : 60 PERIODS

AS4213 **COMPUTATION LABORATORY** **L T P C**
(Consists of FEM & CFD experiments) **0 0 4 2**

COURSE OBJECTIVES:

1. This course is intended to make students familiar with different types of structural analysis using finite element software
2. This course helps students to correctly interpret the results of simulation.
3. To equip with the knowledge base essential for application of computational fluid dynamics to engineering flow problems.
4. To provide the essential numerical background for solving the partial differential equations governing the fluid flow.
5. To develop students' skills of using a commercial software package

EXPERIMENTS IN FEM

LIST OF EXPERIMENTS:

1. Static analysis of a uniform bar subject to different loads -1-D element
2. Thermal stresses in a uniform and tapered member - 1-D element
3. Static analysis of trusses / frames under different loads
4. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads
5. Static analysis of a beam with additional spring support
6. Stress concentration in an infinite plate with a small hole
7. Bending of a plate with different support conditions
8. Stability analysis of a plate under in-plane loads
9. Buckling of solid and thin-walled columns under different end conditions
10. Free vibration analysis of a bar / beam
11. Forced response of a bar / beam under harmonic excitation
12. Heat transfer analysis using 1-D & 2-D elements - conduction and convection
13. Modelling and analysis of a laminated plate
14. Impact analysis of a laminated plate

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
7. 3-D numerical simulation of flow development of a subsonic and supersonic jets
8. Numerical simulation of boundary layer development
9. Numerical simulation of subsonic combustion in a ramjet combustor
10. Numerical simulation of transonic flow over airfoils

(note) Experiments 6-10 can be done by using CFD Software tools

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be
CO1: Able to get solution of aerodynamic flows.
CO2: Able to perform stability analysis of structural components.
CO3: To define and setup flow problem properly within CFD context, performing solid modelling using CAD package and producing grids via meshing tool.
CO4: Able to comprehend both flow physics and mathematical properties of governing Navier-Stokes equations and define proper boundary conditions for solution.
CO5: Able to use CFD software to model relevant engineering flow problems.

CO	PO1 1	PO2 2	PO3 3	PO4 4	PO5 5	PO6 6
CO1	3		2			1
CO2	3		2			1
CO3	3	2	3			1
CO4	3	2	3			1
CO5	3		2			1
	3	0.8	2.4	0	0	1

LABORATORY EQUIPMENTS REQUIREMENTS
1. Desktop computers
2. MS visual C++
3. CFD software

AS4311 **PROJECT WORK I** **L T P C**
0 0 12 6

OBJECTIVE:

To develop the ability to solve a specific problem partially right from its identification and literature review till the successful solution of the same.

The individual student must identify a project Advisor in the third semester. The student, in consultation with their Advisor, will form a Thesis Committee that includes head of the department and domain expert. The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 180 PERIODS

AS4411 **PROJECT WORK II** **L T P C**
0 24 12

OBJECTIVE:
To complete the process of solving a specific problem right from project phase-I to complete the entire solution.

To independently carry out research/investigation and development work to solve practical problems

To write and present a substantial technical report/document.

The progress of the project is evaluated based on a minimum of three reviews. The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The project work is evaluated based on oral presentation and the project report jointly by external and internal examiners constituted by the Head of the Department.

TOTAL: 360 PERIODS

AS4001 **ELEMENTS OF SATELLITE TECHNOLOGY** **L T P C**
3 0 0 3

COURSE OBJECTIVES:
This course will make students
1. To learn the satellite mission and configurations,
2. To have an basic idea on power system of satellites
3. To learn the attitude and orbit control systems of satellites.
4. To gain knowledge on basic of propulsion systems, structures, and thermal controls involved in satellites.
5. To learn the basic aspects of telemetry systems.

UNIT I SATELLITE MISSIONAND CONFIGURATION 9
Mission Overview – Requirements for different missions – Space Environment, Spacecraft configuration-Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions and Trade-offs–Spacecraft configuration process– Broad design of Spacecraft Bus–Subsystem layout–Types of Satellites–Constellations– Applications.

UNIT II POWER SYSTEM 8
Power sources–Energy storage–Solar panels–Deployable solar panels–Spacecraft Power management –Power distribution–Deep Space Probes.

UNIT III ATTITUDE AND ORBIT CONTROLSYSTEM (AOCS) 9
Coordinate system –AOCS requirements–Environment effects – Attitude stabilization – Attitude sensors –Actuators–Design of control algorithms.

UNIT IV PROPULSION SYSTEMS, STRUCTURES AND THERMAL CONTROL 10
Systems Trade-off–Mono-propellant systems –Thermal consideration–System integration design factors – Pre-flight test requirements–System reliability Configuration design of Spacecraft structure– Structural elements–Material selection–Environmental Loads-Vibrations– Structural fabrication– Orbital environments -Average temperature in Space–Transient temperature evaluation– Thermal control techniques– Temperature calculation for a spacecraft– Thermal design and analysis program structure –Thermal design verification–Active thermal control techniques.

UNIT V TELEMETRY SYSTEMS 9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will

CO1: 1 Be able to describe the main components of a satellite and its importance.

CO2: 2 Compare the merits and demerits of various power systems used.

CO3: 3 Be able to learn the dynamics of the satellite.

CO4: 4 Be able to study the design of propulsion systems, structures needed for satellites.

CO5: 5 Acquire knowledge on satellite orbit control and telemetry systems.

REFERENCES:

1. James R.Wertz,"Spacecraft Attitude Determination and Control", Kluwer Academic Publisher, Re edition 2012.
2. James R Wertz & Wiley J. Larsen, "Space Mission Analysis and Design", (Space Technology Library, Vol. 8, Microcosm Publisher, 1999.
3. Marcel J.Sidi, "Spacecraft Dynamics and Control-A Practical Engineering Approach", Cambridge University press, 2000.
4. Lecture notes on"Satellite Architecture", ISRO Satellite Centre Bangalore–560017.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-			
CO2	1	-	-	2	2	2
CO3	1	-	-	2	2	
CO4	-	-	-		2	2
CO5	-	-	-			

AS4002 CRYOGENIC TECHNOLOGY L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To learn various thermodynamic cycles for cryogenic plants.
2. To analyse the problems associated with a cryopropellants.
3. To calculate the efficiencies of cryogenic systems.
4. To gain knowledge on the various cycles of cryogenic plants.
5. To compare the performance of cryogenic engines with non-cryogenic engines.

UNIT I FUNDAMENTALS OF CRYOGENICS 10

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

UNIT II CRYOGENIC SYSTEMS EFFICIENCY 8

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

UNIT III THERMODYNAMIC CYCLES FOR CRYOGENIC PLANTS 8
Classification of cryogenic cycles - The structure of cycles Throttle expansion cycles - Expander cycles - Mixed throttle expansion and expander cycles - Thermodynamic analysis - Numerical problems.

UNIT IV PROBLEMS ASSOCIATED WITH CRYOPROPELLANTS 10
Storage problems of cryogenic propellants - zero gravity problems associated with cryopropellants - phenomenon of tank collapse - geysering effect - material strength considerations.

UNIT V CRYOGENIC ROCKET ENGINES 9
Peculiar design difficulties associated with the design of feed system, injector and thrust chamber of cryogenic rocket engines - Relative performance of cryogenic engines when compared to non-cryo engines.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, Students will be able

- **CO1:** To acquire knowledge on the fundamental requirements that are peculiar to cryogenic rocket engines.
- **CO2:** To determine the thermodynamic efficiency of cryogenic systems.
- **CO3:** To carry out thermodynamic analysis for cryogenic plants.
- **CO4:** To demonstrate the peculiar problems associated with cryopropellants.
- **CO5:** To acquire knowledge oncryogenic propulsion systems

REFERENCES:

1. Barron.RF, “Cryogenic systems”, Oxford University, 1985.
2. Dieter K. Huzel& David H. Huang, “Modern Engineering for Design of Liquid-Propellant Rocket Engines", AIAA Series, 1992.
3. Haseldom.G, “Cryogenic Fundamentals”, Academic press, 2001.
4. Sarner.S.F, “Propellant Chemistry”, Reinhold Publishing Corporation New York, 1966.
5. Sutton, G.P. “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th edition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	-	-	-
CO2	1	-	2	-	-	-
CO3	1	-	2	-	-	-
CO4	1	-	2	-	-	-
CO5	1	-	2	-	-	-

AS4003 INTRODUCTION TO AERONAUTICS AND SPACE TECHNOLOGY

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

- Students acquire knowledge about the present space technology.
- Students can focus on various orbits, re-entry paths, and also understand the future scenario.
- To provide an exposure with attitude requirements and design limitations.

UNIT - I FUNDAMENTALS OF ROCKET PROPULSION 12

Space Mission-Types based on Space Environment, vehicle selection. Rocket propulsion-Types, Rocket equation, chemical rocket propulsion, solid propellant rocket motor, liquid propellant rocket engine, Two-dimensional trajectories of rockets and missiles-Multi-stage rockets-Vehicle sizing-Two stage Multi-stage Rockets-Trade-off Ratios-Single Stage to Orbit-Sounding Rocket-Aerospace Plane-Gravity Turn Trajectories-Impact point calculation-injection conditions-Flight dispersions.

UNIT - II ATMOSPHERIC REENTRY 8

Introduction-Steep Ballistic Re-entry-Ballistic Orbital Re-entry-Skip Re-entry- "Double-Dip" Re-entry - Aero-braking - Lifting Body Re-entry.

UNIT - III FUNDAMENTALS OF ORBIT MECHANICS, ORBIT MANEUVERS 9

Two-body motion-Circular, elliptic, hyperbolic, and parabolic orbits-Basic Orbital Elements-Ground trace In-Plane Orbit changes-Hohmann Transfer Bi-elliptical Transfer-Plane Changes - Combined Maneuvers - Propulsion for Maneuvers.

UNIT - IV SATELLITE ATTITUDE DYNAMICS 8

Torque free axi-symmetric rigid body-Attitude Control for Spinning Spacecraft - Attitude Control for Non-spinning Spacecraft - The Yo-Yo Mechanism - Gravity - Gradient Satellite-Dual Spin Spacecraft- Attitude Determination.

UNIT – V SPACE MISSION OPERATIONS 8

Supporting Ground Systems Architecture and Team interfaces - Mission phases and Core operations - Team Responsibilities - Mission Diversity - Standard Operations Practices.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

CO1: Understanding of rocket propulsion, types equation, their stages as well as trajectories
CO2: Ability to understand about Atmospheric Re-entry
CO3: Analysis of orbit Mechanics and their manoeuvres
CO4: Knowledge of Attitude determination of spacecraft/satellites
CO5: Analysis the space mission operations

REFERENCES:

1. "Spaceflight Dynamics", W.E. Wiesel, McGraw Hill, 3rd edition 2012
2. "Rocket Propulsion and Space flight dynamics", Cornelisse, Schoyer HFR and Wakker KF, Pitman, 1984
3. Vincent L. Pisacane, "Fundamentals of Space Systems", Oxford University Press, 2005.
4. Elements of Space Technology for aerospace Engineers", Meyer Rudolph X, Academic Press, 199

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

AS4004 FUNDAMENTALS OF COMBUSTION

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

This course will enable students

1. To impart knowledge to students on basic fuel and oxidizer characteristics.
2. To impart the concept of various governing equation and role of chemical kinetic in combustion process.
3. To make the students to understand various kinds flame and factors affecting flame.
4. The concept of diffusion flames.
5. Application of calculation in the field of Aerospace engineering.

UNIT I THERMODYNAMICS OF COMBUSTION 9

Combustion, types of fuels and oxidizers, calorific value measurements, flash point, fire point, smoke point, specific gravity, auto ignition temperature, Proximate analysis, ultimate analysis, Ideal gas law, gas mixture, sensible enthalpy, stoichiometry, equivalence ratio, heat of reaction, heat of combustion, heat of formation, adiabatic flame temperature, determination of equilibrium composition.

UNIT II TRANSPORT PHENOMENA AND CHEMICAL KINETIC OF COMBUSTION 9

Mass Transfer Rate Laws, Species Conservation, Some Applications of Mass Transfer, Global Versus Elementary Reactions, Rates of Reaction for Multistep Mechanisms, Net Production Rates, Compact Notation, Relation Between Rate Coefficients and Equilibrium Constants, Steady-State Approximation, The Mechanism for unimolecular Reactions, Chain and Chain-Branching Reactions, Chemical Time Scales, Partial Equilibrium, Reduced Mechanisms.

UNIT III PREMIXED FLAMES 10

Physical Description, detonation and deflagration, Hugoniot curve, Determination of CJ points, Governing Equations, Boundary Conditions, Structure of CH_4–Air Flame, Factors Influencing Flame Velocity and Thickness, Flame Speed Correlations, Quenching, Flammability, and Ignition, Quenching by a Cold Wall Flammability Limits Ignition, Flame Stabilization.

UNIT IV LAMINAR DIFFUSION FLAMES 9

Non-reacting Constant-Density Laminar Jet, Physical Description, Conservation Laws, Boundary Conditions, Solution, Jet Flame Physical Description, Simplified Theoretical Descriptions, Flame Lengths for Circular-Port and Slot Burners, Roper's Correlations ,Flow rate and Geometry Effects, Factors Affecting Stoichiometry, Soot Formation and Destruction Counter flow.

UNIT V DROPLET EVAPORATION AND BURNING 8

Simple Model of Droplet Evaporation, Gas-Phase Analysis, Droplet, Simple Model of Droplet Burning, Burning Rate Constant and Droplet, Lifetimes, Extension to Convective Environments, Additional Factors, One-Dimensional Vaporization-Controlled Combustion.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be

CO1: Exposed to different kinds of fuel and oxidizer characteristics.
CO2: Able to realize basic chemical kinetics and mechanisms behind exothermic reactions.
CO3: Exposed to the significance of premixed flames.
CO4: To acquire knowledge on characteristics of diffusion flames, soot formations etc.
CO5: To familiarize in the field of droplet and evaporation theory.

REFERENCES:

1. Kenneth K.Kuo, "Principles of combustion", John Wiley & sons Inc, 2ndedition, 2012.
2. Mishra, DP, "Fundamentals of Combustion",PHI publishers, 2008.
3. Mukunda,HS, "Understanding combustion", Orient Blackswan, 2nd edition, 2009.
4. Stephen Turns , "An Introduction to Combustion: Concepts and Applications", McGrawHill, 4thedition, 2020.
5. VasudevanRaghavan, "Combustion Technology: essentials of flames and burners", Ane Books Pvt.Ltd, 1stedition, 2016.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	-	-
CO2	2	-	2	1	-	-
CO3	2	-	2	1	-	-
CO4	2	-	2	1	-	-
CO5	2	-	2	1	-	-

AS4072 COMPUTATIONAL HEAT TRANSFER **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

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

UNIT I INTRODUCTION 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 CONDUCTIVE HEAT TRANSFER 9

General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One –dimensional steady state heat conduction –with Heat generation-without Heat generation- 2D-heat conduction problem with different boundary conditions-Numerical treatment for extended surfaces- Numerical treatment for 3D- Heat conduction-Numerical treatment to 1D-steady heat conduction using FEM.

UNIT III TRANSIENT HEAT CONDUCTION 9

Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes Computation(FDM) of One– dimensional un-steady heat conduction –with heat Generation-without Heat generation – 2D-transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes-Importance of Courant number- Analysis for I-D,2-D transient heat Conduction problems.

UNIT IV CONVECTIVE HEAT TRANSFER 9

Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection-diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme-Stream function-vorticity approach-Creeping flow.

UNIT V RADIATIVE HEAT TRANSFER 9

Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method – Montacalro method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will

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

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

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

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

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

REFERENCES:

1. Chung,TJ, "Computational Fluid Dynamics", Cambridge University Press, 2002.
2. Holman,JP, "Heat Transfer", McGraw-Hill Book Co, Inc., McGraw-Hill College; 10^{th}edition, 2017.
3. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017.
4. John H. Lienhard, "A Heat Transfer", Text Book, Dover Publications, 5th edition, 2020.
5. Richard H. Pletcher, John C. Tannehill & Dale Anderson, "Computational Fluid Mechanics and Heat Transfer", 4^{th} edition, CRC Press, 2021
6. Sachdeva,SC, "Fundamentals of Engineering Heat & Mass Transfer", New age publisher, 4^{th} edition Internationals, 2017.

CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
	1	**2**	**3**	**4**	**5**	**6**
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	3	-	2	3	3	-
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

AS4005 MISSILE AERODYNAMICS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To impart knowledge on the basic aspects on the classification of missiles and its aerodynamics characteristics.
2. To provide idea about the missile configurations and preliminary drag estimation.
3. To analyse the aerodynamic characteristics of slender and blunt bodies.
4. To get insight into the basic aspects of launching phase of missiles.
5. To demonstrate the stability aspects of missile configuration and various control methods of missiles.

UNIT I BASICS ASPECTS OF MISSILE AERODYNAMICS 9

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

UNIT II MISSILE CONFIGURATIONS AND DRAG ESTIMATION 9

Various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation – Various types of drag and their origin – methods of minimize the drag types.

UNIT III AERODYNAMICS OF SLENDER AND BLUNT BODIES 9

Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

UNIT IV AERODYNAMIC ASPECTS OF LAUNCHING PHASE 9

Booster separation-cross wind effects-specific considerations in missile launching-missile integration and separation-methods of evaluation and determination- Wind tunnel tests – Comparison with CFD Analysis.

UNIT V STABILITY AND CONTROL OF MISSILES 9

Forces and moments acting on missiles-Lateral, rolling and longitudinal moments-missile dispersion-stability aspects of missile configuration-Aerodynamic control methods-Jet control methods-Stability derivatives.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, Students will be able

CO1: To apply the concepts of high speed aerodynamics on missiles.

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.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓		
CO4	✓	✓	✓	✓	✓	
CO5	✓	✓	✓	✓		

REFERENCES:

1. Anderson, JD, “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd edition, 2006.
2. Anderson JD, “Modern compressible flow: with Historical Perspective”, McGraw Hill Education, 3rd edition, 2017.
3. Chin SS, “Missile Configuration Design”, McGrawHill, NewYork, 1961.
4. Jack Nielson, “Missile Aerodynamics”,AIAA; 1st edition, 1988.

AS4006 SPACECRAFT ATTITUDE DYNAMICS AND CONTROL

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will enable students

1. To get introducedwiththe basics of attitude sensors and its types.
2. To gain knowledge on the basic principles of operation of thrusters.
3. To learn rigid body dynamics and various disturbing forces in space.
4. To gain in-depth knowledge on attitude stabilization schemes & orbit maneuvers.
5. To be familiar with the concepts of operating principles and design of guidance laws.

UNIT I ATTITUDE SENSORS8

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

UNIT II CONTROL ACTUATORS9

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

UNIT III ATTITUDE DYNAMICS, ATTITUDE AND ORBITAL DISTURBANCES9

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 MANEUVERS10

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

UNIT V MISSILE AND LAUNCH VEHICLE GUIDANCE9

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able to

CO1: Get basic idea on the working principles of attitude sensors and its 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 manoeuvres of satellites and rocket vehicle guidance.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓								
CO4	✓	✓	✓	✓	✓							
CO5	✓	✓	✓									

REFERENCES:

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

AS4007 CHEMICAL ROCKET TECHNOLOGY L T P C
3 0 0 3

COURSEOBJECTIVES:
This course will make 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 analyse 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.

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 10
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 8
Standard and reverse hybrid rocket – Application – Limitation - Advance fuel – Combustion mechanism of hybrid rocket – Regression rate measurement – Methods for improving regression rate.

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 the 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: Analyse propellants properties and associated physical and chemical processes.
CO5: Describe and classify liquid propellant rocket motors, its components and various associated systems.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓			
CO2	✓	✓	✓		✓	
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	✓
CO5	✓	✓	✓		✓	✓

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.

AS4071 AEROSPACE MATERIALS

L TP C
3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To get insights into the basic aspects of material science.
2. To provide basic idea on the mechanical behaviour of materials.
3. To impart knowledge on the macro mechanics of composite materials,
4. To gain knowledge on the analysis and manufacturing methods of composite materials.
5. To learn about the sandwich construction.

UNIT I MATERIAL SCIENCE 9

Crystallography of metals & metallic alloys – Imperfections – Dislocations in Different Crystal Systems – Effect on plasticity – Strengthening Mechanisms Due to Interaction of Dislocations with Interfaces – Other Strengthening Methods – Dislocation Generation Mechanisms

UNIT II MECHANICAL BEHAVIOUR 9

Stress-strain curve and mechanical behaviour of materials – linear elasticity and plasticity – failure of ductile and brittle materials – use of failure theories – maximum normal stress and maximum shear stress failure theories – importance of the octahedral stress failure theory – failure theories based on strain energy – cyclic loading and fatigue of materials – the S-N curve

UNIT III METALLIC ALLOYS 9

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

UNIT IV HIGH TEMPERATURE MATERIALS 9

Carbon-Carbon Composites and Ceramic Materials For High Temperature Aerospace Application – Manufacturing Technologies & Controlling Parameters – Mechanical and Thermal Properties of These Material Systems – Thermal Protection Material System for a Re-Entry Vehicle – Use of Superalloys – Metal Matrix Composites &Cermets – Properties and Applications – Mechanical and Thermal Fatigue

UNIT V SMART MATERIALS 9

Introduction to smart materials-shape memory effects-shape memory alloys-shape memory polymers-electro-rheological fluids-energy harvesting materials-self healing polymers.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will

CO1: Be able to investigate the physical and mechanical behaviour of different materials.
CO2: Have exposure on dislocation theories and their importance.
CO3: Have general knowledge of the properties of different aerospace materials
CO4: Be able to apply failure theories appropriately.
CO5: Be able to select good materials for a specific aerospace application.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓		✓			
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓	✓	✓		✓	
CO5	✓		✓			✓

REFERENCES

1. Adrian Mouritz, “Introduction to Aerospace Materials”, Woodhead Publishing, 1st edition, 2012.
2. Jones. R M, “Mechanics of Composite Materials”, 2nd Edition, CRC Press, Taylor & Francis Group, 1998.
3. Prasad, N. Eswara, Wanhill, RJH, “Aerospace Materials and Material TechnologiesVolume 1: Aerospace Materials”, Springer Singapore, 2017.
4. Sam Zhang &Dongliang Zhao, “Aerospace Materials Handbook”, CRC Press, Taylor & Francis Group, 2012.
5. Brain culshaw, smart structures and materials, Artech house, 2000.

AS4008 SPACE VEHICLE DESIGN L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make 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 SPACE 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 – Flyback 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:

Upon the completion of this course, students will be

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 vehicles.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓		✓							
CO2	✓	✓	✓	✓		✓						
CO3	✓	✓	✓	✓	✓	✓						
CO4	✓	✓				✓						
CO5	✓	✓		✓	✓	✓						

REFERENCES:

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

AS4009 **THEORY OF PLATES AND SHELLS** **L T P C**
3 0 0 3

COURSE OBJECTIVE

To get fundamental understanding of the classical theory of elastic plates and shells, address limitations and differences, nomenclature, analytical and numerical solution techniques.

To enable students to apply the theory of plates to problems, involving various geometries and boundary conditions, to diverse problems in aerospace engineering.

UNIT I THEORY OF PLATE BENDING 9

Plate-Bending Theory - Classical Solution Methods-Rectangular Plates, Circular Plates - Plates on Elastic Foundations

UNIT II ENERGY METHODS 9

Analysis of Membranes-Bending & Stretching- Ritz Method- Galerkin's method- Finite Difference method- Large Deflection - Stability: Fundamentals, Applications

UNIT III VIBRATIONS AND STABILITY OF PLATES 9

Stability and Free Vibration Analysis of Rectangular Plates with various end conditions.- nonlinear geometric effects- Free Vibration and Stability Analysis.

UNIT IV SHELLS 9

Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells - the general theory of elastic shells and axisymmetric shells - Introduction to the nonlinear analysis of shells.

UNIT V BUCKLING OF SHELLS 9

buckling, crushing and bending strength of cylindrical shells - Energy absorption and crashworthiness of prismatic tubes - Applications: Pipes, Tanks, Pressure Vessels

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1: To get knowledge on the behavior of plates with different geometry under various types of loads
CO2: To analyses the plates by approximation methods and its applications
CO3: Have exposure on failure of plates under vibrations.
CO4: To get knowledge on the behavior of shells under various types of loads.
CO1: Able to get attentiveness on shells for aerospace applications.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓				
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓	✓			
CO4	✓	✓	✓	✓		
CO5	✓	✓	✓		✓	

REFERENCES:
1. Timoshenko, Stephen P., and S. Woinowsky-Krieger. *Theory of Plates and Shells*. 2nd ed. New York, NY: McGraw-Hill Companies, 1959.
2. A. C. Ugural, “Stresses in Beams, Plates, and Shells,” 3 rd edition,” CRC Press, 2009.
3. Reddy, J. N., “Theory and Analysis of Elastic Plates and Shells,” CRC, 2nd edition, December 2006.
4. S. Timoshenko, and S. Woinowsky-Krieger “Theory of Plates and Shells,” McGraw-Hill, 1959.

AS4010	MISSILE GUIDANCE AND CONTROL	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course will make students

1. To provide basic introduction to missiles systems
2. To impart knowledge to students on basic missile configurations and preliminary drag estimation.
3. To introduce slender body aerodynamics, aerodynamic aspects during launching phase and stability and control aspects of missile.
4. To provide knowledge on strategic missiles.
5. To get insight into the basic aspects of weapon delivery systems.

UNIT I MISSILE SYSTEMS INTRODUCTION 8

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

UNIT II MISSILE AIRFRAMES, AUTOPILOTS AND CONTROL 9

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

UNIT III MISSILE GUIDANCE LAWS 10

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

UNIT IV STRATEGIC MISSILES 10

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

UNIT V WEAPON DELIVERY SYSTEMS 8

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

- **CO1:** Have through knowledge with the advanced concepts of missile guidance and control to the engineers.
- **CO2:** Provide the necessary mathematical knowledge that is needed in understanding the physical processes.
- **CO3:** Derive fundamental guidance equations and to compare guidance system performance.
- **CO4:** Explain the importance of strategic missiles and tracking equation of motions.
- **CO5:** Provide concepts on weapon delivery systems and also the factors influences weapon delivery system.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓									
CO2	✓	✓	✓	✓	✓							
CO3	✓	✓	✓	✓	✓							
CO4	✓	✓	✓	✓	✓	✓						
CO5	✓	✓	✓	✓	✓	✓						

REFERENCES:

1. Blakelock, JH,"Automatic Control of Aircraft and Missiles", 2nd edition, John Wiley & Sons, 1991.
2. Fleeman, Eugene L, "Tactical Missile Design", 2nd edition, AIAA Education series, 2006.
3. Garnell, P, "Guided Weapon Control Systems", 2nd Edition, Pergamon Press, 1980.
4. Joseph Ben Asher and Isaac Yaesh, "Advances in Missile Guidance Theory" AIAA Education series, 1998.
5. Paul Zarchan, "Tactical and Strategic Missile Guidance", AIAA Education series,6th edition, 2013.
6. Siouris, GM,"Missile Guidance and control systems", Springer, 2004.

O4076 THEORY OF BOUNDARY LAYERS **L T P C**

3 0 0 3

COURSE OBJECTIVES:

1. This course imparts knowledge to students on growth of boundary layer and its effect on the aerodynamic design of airframe of flight vehicles.
2. This course will introduce them the solution methods for boundary layer problems.
3. This course enables the students to understand the importance of viscosity and boundary layer in fluidflow.
4. This course also introduces the theory behind laminar and turbulent boundary layers.
5. This course will make students to learn the concepts of boundary layer transition and separation.

UNIT I THEORY OF VISCOUS FLOW 8

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

UNIT II INCOMPRESSIBLE VISCOUS FLOWS AND BOUNDARY LAYER 10

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

UNIT III LAMINAR BOUNDARY LAYER THEORY 10

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

UNIT IV THEORY OF TURBULENT BOUNDARY LAYER 9

Turbulence-physical and mathematical description, Two-dimensional turbulent boundary layer equations –– Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient, Eddy Viscosity, mixing length , Turbulence modelling.

UNIT V BOUNDARY LAYER TRANSITION AND SEPARATION 8

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

1. To apply proper governing equations for various types of viscous flows in engineering applications.
2. To obtain solutions for various viscous flow problems in engineering.
3. To estimate skin friction over solid surfaces, over which laminar boundary layer persists.
4. To arrive at the solutions for turbulent boundary layer and the resulting drag.
5. To gain insights on the techniques for boundary layer control.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1			2	2	3	1
CO2			2	3	3	1
CO3			2	3	3	1
CO4			2	2	3	1
CO5			2	1	3	1

REFERENCES:

1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York, 2008.
2. Schlicting, H., Boundary Layer Theory, McGraw-Hill, New York, 1979.
3. Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.

AO4252 FINITE ELEMENT ANALYSIS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable the students

1. To learn the concepts of finite element methods and the various solution schemes available.
2. To impart knowledge to solve plane stress and plane strain problems.
3. To solve heat transfer and fluid mechanics problems using Finite element methods.
4. To formulate mass and stiffness element matrices for vibration problems.
5. To be familiar in obtaining solutions to fluid flow problems.

UNIT I INTRODUCTION 9

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods – Problem Formulation – Application to Structural Elements & Practical Problems – Derivation ofStiffness and Flexibility Matrices – Spring Systems – Role of Energy Principles – Basic Concepts of Finite Element Method – Interpolation, Nodes, Degrees of Freedom – Solution Schemes.

UNIT II DISCRETE ELEMENTS 9

Finite Element Structural Analysis Involving 1-D Bar and Beam Elements – Tapered Bar – Temperature Effects – Static Loading – Formulation of the Load Vector for 1-D Elements – Methods of Stiffness Matrix Formulation – Interpolation & Shape Functions – Boundary Conditions – Determination of Displacements & Reactions – Constitutive Relations – Determination of Nodal Loads & Stresses.

UNIT III CONTINUUM ELEMENTS 9

Plane Stress & Plane strain Loading – CST Element – LST Element – Element Characteristics – Problem Formulation & Solution Using Finite Elements – Axisymmetric Bodies & Axisymmetric Loading – Consistent and Lumped Load Vectors – Use of Local, Area and Volume Co-ordinates – Isoparametric Formulation – Shape Functions – Role of Numerical Integration – Load Consideration – Complete FE Solution.

UNIT IV VIBRATION & BUCKLING 9

Formulation of the Mass and Stiffness Element Matrices for Vibration Problems – Bar and Beam Elements – Derivation of the Governing Equation – Natural Frequencies and Modes – Damping Considerations –Harmonic Response – Response Calculation Using Numerical Integration – Buckling of Columns – Problem Formulation – Solution – Determination of Buckling Loads and Modes.

UNIT V HEAT TRANSFER & FLUID MECHANICS PROBLEMS 9

One Dimensional Heat Transfer Analysis – Formulation of the Governing Equations in Finite Element Form – Equivalent Load Vector – Solution & Temperature Distribution – Finite Element Formulation & Solution for Sample Problems Involving Fluid Mechanics .

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will have

CO1: An ability to frame governing equations involving different type of finite elements.
CO2: Knowledge onthe general finite element methodology for a variety of practical problems.
CO3: An ability to solve simple 1-D and 2-D problems using the finite element method.
CO4: Knowledge on how to apply numerical integration techniques effectively in finite elements solutions.
CO5: An ability to frame and solve heat transfer and fluid mechanics problems using the FE method.

REFERENCES:

1. Bathe, KJ &Wilson,EL, Numerical Methods in Finite Elements Analysis, Prentice Hall of India Ltd., 1983.
2. Dhanaraj, R &K.PrabhakaranNair,K, Finite Element Method, Oxford university press, India, 2015.
3. Krishnamurthy,CS, Finite Elements Analysis, Tata McGraw – Hill, 1987.
4. Rao,SS Finite Element Method in Engineering, Butterworth, Heinemann Publishing, 3rd Edition, 1998.
5. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, Concepts and Applications of Finite Element Analysis, John Wiley & Sons, 4th Edition, 2002.
6. Segerlind,LJ, Applied Finite Element Analysis, , John Wiley and Sons Inc., New York, 2nd Edition,1984.
7. Tirupathi R. Chandrupatla& Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1	1		3		2	1
CO2	1		2		2	1
CO3	2		3		3	1
CO4	1		3		3	1
CO5	2		3		3	1
	1.4	0	2.8	0	2.6	1

AO4072 FATIGUE AND FRACTURE MECHANICS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To learn the fundamentals aspects of fatigue & fracture mechanics.
2. To gain knowledge on the statistical aspects of fatigue behaviour of materials.
3. To get insights into the physical aspects of fatigue.
4. To evaluate the strength of the cracked bodies.
5. To provide knowledge on fatigue design and testing of aerospace structures.

UNIT I BASIC CONCEPTS & OVERVIEW 9

Historical Perspective – Case Studies – Review of Material Behaviour – Linear & Non-Linear Response – Temperature and Strain Rate Effect – Strain Hardening – Different Mechanisms of Failure – Typical Defects & Elements of Dislocation Theories – Atomic View of Fracture – Fractographic Examination of Failure Surfaces of Different Materials – Overview of Design Approach – Safe Life Design.

UNIT II FATIGUE OF STRUCTURES 9

S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Stress concentration factors – Notched S-N curves – Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Load History Analysis – Cycle counting techniques – Cumulative damage theory

UNIT III PHYSICAL ASPECTS OF FATIGUE 9

Fracture mechanism in metals - Phase in fatigue life – Crack source – Cleavage initiation – Crack growth – Ductile-brittle transition – Final fracture – Dislocations – Fatigue fracture surface of inter and intra-granular fracture – Environmental effects – Terminology and classification – Corrosion principles – Stress corrosion cracking – Hydrogen embrittlement – Influencing parameters on crack behaviour

UNIT IV LINEAR ELASTIC FRACTURE MECHANICS 9

Stress analysis and strength of a cracked body – Stress concentration – potential energy and surface energy – Energy release rate – Griffith's theory – Irwin extension of Griffith's theory to ductile materials – Plastic zone shape – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries – Instability of the R-curve – K-controlled fracture – Plane strain fracture toughness – Mixed mode – Interaction of cracks – Limitations of the linear elastic fracture theory

UNIT V FRACTURE TOUGHNESS TESTING 9

General considerations for metallic specimens – Specimen configuration – Stress intensity factors – Pre-cracking – Grooving – ASTM E-399 and similar standards – K-R curve – J-testing on metals – Determination of crack parameters – CTOD testing – Testing of metals in the ductile-brittle transition region – Quantitative toughness tests – Charpy&Izod tests –- Mathematical modelling concepts

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To identify and describe the basic fracture and fatigue mechanisms and apply that knowledge to failure analysis.

CO2: To correctly apply linear elastic fracture to predict material failure.

CO3: To predict lifetimes for fatigue and environmentally assisted cracking.

CO4: To demonstrate fatigue design and testing of structures.

CO5: To realise the importance of composite materials in Aerospace structures.

REFERENCES:

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

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1
	2	1.8	1	2	2	1

AO4078 VIBRATION ISOLATION AND CONTROL L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of vibration theory.
2. To get in-depth knowledge on different types of isolators and its effectiveness.
3. To provide the basic knowledge on dynamic vibration absorber.
4. To realize the importance of materials selection for appropriate applications.
5. To get knowledge on the principles of active vibration control.

UNIT I BASIC VIBRATION THEORY 9

Free Vibration Theory – Determination of Natural Frequency of a Single Degree Of Freedom – System– Response of a Damped Single Degree of Freedom System – Role of Damping – Forced Vibrations of Discrete Systems – Continuous Systems – Vibrations of Beams and Shafts – Idealization of a Real System Into a Discrete Model – Resonance – An Overview of the Different Methods of Vibration Control

UNIT II VIBRATION ISOLATION 9

Transmissibility – Numerical Examples – Necessity of Vibration Isolation – Vibration Reduction at Source – System Redesign – Different Types of Isolators & Their Effectiveness – Pneumatic Suspension – Excitation Reduction at Source and Factors Affecting Vibration Level – Source Classification – Control of Flow Induced & Self-Excited Systems

UNIT III DYNAMIC VIBRATION ABSORBER 9

Dynamic Vibration Neutralizers – Self-tuned Pendulum Neutralizer - Optimum Design of Damped Absorbers – Absorber with ideal spring and viscous dashpot – Gyroscopic vibration absorbers – Impact Absorbers – Absorbers attached to continuous systems – Field Balancing of Rotors – Resonance: Detuning and Decoupling – Remedial Measures

UNIT IV SELECTION OF MATERIALS 9

Dynamic Properties of Viscoelastic Material – Selection of Materials – Damping-Stress Relationship – Selection Criteria for Linear Hysteretic Material – Design for enhanced material damping – Linear Viscoelastic Model – Constrained Layer Damping – Relaxation – Frequency and Temperature Dependence of the Complex Modulus – Overview and Role of Smart Materials

UNIT V PRINCIPLES OF ACTIVE VIBRATION CONTROL 9

Conceptual Understanding – Shape Memory Actuators for Vibration Control – Shape Memory Materials – Tuned Vibration Absorbers using SMA – Basics of Electro-and Magneto-Rheological Fluids – Active Vibration Isolation using ERF and MRF – Methods of Active Vibration Control Using Piezoelectric Materials – Derivation of Governing Equations – Response of the Structure

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will beable

CO1: To realise the importance of vibration theory & its practical applications

CO2: To work out response calculations

CO3: To analyse and compare the different methods of vibration control

CO4: To exposure on vibration control using smart materials

CO5: To design a vibration control unit.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1	2	2	2	2	2	1
CO2	2	2	2	2	2	1
CO3	3	3	3	3	3	1
CO4	1	1	1	1	1	1
CO5	3	3	3	3	3	3
	2.2	2.2	2.2	2.2	2.2	1.4

REFERENCES:

1. Malcolm J. Crocker, “Handbook of Noise and Vibration Control”, Wiley; 1st edition, 2007.
2. Mallik, AK, “Principles of Vibration Control”,Affiliated East-West Press, India, 1990.
3. Mead,DJ, “Passive Vibration Control”, Wiley, 1st edition, 1999.
4. Preumont,A“Vibration Control of Active Structures”, Springer Netherlands, 3rd edition, 2011.

AO4074 **NON-DESTRUCTIVE EVALUATION** **L T P C**
3 0 0 3

COURSE OBJECTIVES:
This course will make students

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

UNIT I INTRODUCTION 9
Need for non-destructive evaluation (NDT) – Applications – Structural inspection – Structural deterioration due to corrosion and fatigue – Crack growth – Fabrication defects – Overloading – Detailed visual inspection – Aircraft wing and fuselage inspection using various NDT techniques – Overview and relative comparison of NDT methods – Jet engine inspection – Critical locations

UNIT II ELECTRON MICROSCOPY 9
Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM

UNIT III ACOUSTIC EMISSION AND ULTRASONICS 9
Sources of acoustic emission – Physical principals involving acoustic emission and ultrasonics – Configuration of ultrasonic sensors – Phased array ultrasonics – Instrument parts and features for acoustic emission and ultrasonics – Defect characterization – Inspection of cracks and other flaws in metals and composites – Interpretation of data – Image processing – Concepts and application

UNIT IV AIRCRAFT INSPECTION 9
Inspection Levels – General Visual Inspection – During pre, or post flight – Detailed Visual Inspection (DET) – Periodic inspection – Special Detailed Inspection (SDET) – Uses of NDT Methods – Jet Engine Inspection – Engine overhaul – Fluorescent penetrate inspection – Airframe Loading – Fuselage Inspection – Critical Locations – Comparison of different methods of NDT – Visual – Radiography – Eddy Current Testing – Liquid Penetrant Testing – Remote Testing - Landing Gear Inspection

UNIT V STRUCTURAL HEALTH MONITORING 9
An Overview of Structural Health Monitoring – Structural Health Monitoring and Role of Smart Materials – Structural Health Monitoring versus Non-Destructive Evaluation – A Broad Overview of Smart Materials Applications – Notable Applications of SHM in Aerospace Engineering – Structural health monitoring of composites – Repair investigation using SHM – Current limits and future trends.

TOTAL: 45 PERIODS

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

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

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1	1	1	1	2	1	1
CO2	1	1	1	2	1	1
CO3	2	1	2	2	2	1
CO4	1	1	1	2	1	1
CO5	1	1	1	2	1	1
	1.2	1	1.2	2	1.2	1

REFERENCES:

1. Cullity, BD & Stock, SR, "Elements of X-ray diffraction", Prentice Hall, Inc. USA, 2001.
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. Douglas B. Murphy, "Fundamentals of light microscopy and electronic imaging", Wiley-Liss, Inc. USA, 2001.
5. Richard Brundle. C, Charles A. Evans, Jr., Shaun Wilson, "Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films", Butterworth-Heinemann, Boston, USA, 1992.
6. Williams, DB & Barry Carter,C, "Transmission electron microscopy, vol. 4", Springer, USA, 1996.
7. Non-destructive Testing Handbook – ASNT Series – Volume 1 – 6.

AS4011 PLASMA ENGINEERING L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To impart knowledge to students on basic plasma and its application in aerospace engineering.
2. To learn about the motion of charged particles.
3. To get inference about the collision of charged particles and energy Equilibrium.
4. To learn about the MHD plasma and its stability.
5. To get information about electromagnetic waves, kinetic of plasma and some of the damping mechanism.

UNIT I INTRODUCTION TO PLASMA 8

Plasma, An Ionized Gas, Plasmas are Quasi-Neutral, Plasma Shielding, Elementary Derivation of the Boltzmann Distribution, Plasma Density in Electrostatic Potential, Debye Shielding, Plasma-Solid Boundaries (Elementary), Thickness of the Sheath, the 'Plasma Parameter', Occurrence of Plasmas, Different Descriptions of Plasma, Equations of Plasma Physics.

UNIT II MOTION OF CHARGED PARTICLES IN FIELDS 9

Uniform B field, E = 0, Uniform B and Non-zero E, Drift Due to Gravity or Other Forces, Non-uniform B Field, Curvature Drift, Interlude: Toroidal Confinement of Single Particles, The Mirror Effect of Parallel Field Gradients: E = 0, ∇B ||B, Time Varying B Field (E Inductive), Time Varying E-field (E, B Uniform), Direct Derivation of [(dE)/dt] Effect: 'Polarization Drift', Non Uniform E (Finite Larmor Radius)

UNIT III COLLISIONS IN PLASMAS 9

Binary Collisions between Charged Particles, Scattering Angle, Differential Cross-Section for Scattering by Angle, Relaxation Processes, ,Energy Loss, Cut-offs Estimate, Momentum Loss, Thermal Distribution Collisions, Thermal Collision Frequencies, Applications of Collision Analysis, Energy Equilibration

UNIT IV FLUID DESCRIPTION OF PLASMA 9

Particle Conservation (In 2-d Space),Fluid Motion, Lagrangian& Eulerian Viewpoints, Two-fluid Equilibrium: Diamagnetic Current, Reduction of Fluid Approach to the Single Fluid Equations, Single Fluid Equations: M.H.D, Heuristic Derivation/Explanation, Maxwell's Equations for MHD Us, MHD Equilibria, General Properties of MHD Equilibria, Low β equilibria: Force-Free Plasmas, Toroidal Equilibrium, MHD Stability, General Principles Governing Instabilities.

UNIT V ELECTROMAGNETIC WAVES IN PLASMAS 10

Linear Waves in Anisotropic Medium, Isotropic Medium, High Frequency Plasma Conductivity, Cold Plasma Waves, Thermal Effects on Plasma Waves, Electrostatic Approximation Waves, Simple Example of MHD Dynamics: Alfven Waves, Non-uniform Plasmas and Wave Propagation, Two Stream Instability, Kinetic Theory of Plasma Waves, Vlasov Equation, Linearized Wave Solution of Vlasov Equation, Landau's Original Approach, Solution of Dispersion Relation, Direct Calculation of Collisionless Particle Heating, Damping Mechanisms, Ion Acoustic Waves and Landau Damping, Alternative Expressions of Dielectric Tensor Elements, Electromagnetic Waves in UnmagnetizedVlasov Plasma Experimental Verification of Landau Damping

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To acquire knowledge on the use of plasma and its application in field of Aerospace vehicles.

CO2: To realize the basic motion of charged particles and flow physics.

CO3: To get exposure on the significance of particle collision.

CO4: To acquire knowledge about the motion of MHD and its stability in the flow field.

CO5: To get through knowledge in the field of plasma wave kinetics.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓		✓	✓						
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓	✓	✓	✓						
CO4	✓	✓	✓		✓	✓						
CO5	✓	✓	✓	✓		✓						

REFERENCES:

1. Dan M. Goebel, Ira Katz, “Fundamentals of Electric Propulsion: Ion and Hall Thrusters”, Wiley publication, 1st edition,2008.
2. George P. Sutton& Oscar Biblarz, “Rocket Propulsion Elements”, Wiley publication, 9th Edition, 2016.
3. Prof. Hutchinson, “Introduction to Plasma Physics I”, lecture notes, MIT open courseware.
4. Luis Conde, “An Introduction to Plasma Physics and its Space Applications, Volume 1”,Morgan & Claypool Publishers as part of IOP Publishing- 2018.

AS4012 ROCKET AND MISSILE SYSTEMS

L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of rockets and missile subsystems.
2. To impart knowledge on igniters system, injection system, thermal protection system.
3. To get knowledge on stage separation system and vehicle optimization.
4. To provide knowledge on thrust vector control methods.
5. To get in-depth knowledge on thermal protection system and high temperature materials for aerospace applications.

UNIT I ROCKET AND MISSILE SUBSYTEM 9

Various subsystem of thrust chamber – igniters for solid propellants and liquid propellants – Pyrogen igniter - Pyrodyne igniter- Pelleted Pyrotechnic- Insulation system – Liner system – Injector system- Damping system for propellant slosh - Propellant hammer– Thermal insulating for cryogenic propellants – Cooling system.

UNIT II STAGE SEPARATION SYSTEM 9

Need of multi staging – Clustering – Staging method - stage separation techniques in atmosphere - Stage separation techniques in vacuum - Vehicle Optimization.

UNIT III THRUST VECTOR CONTROL 9

Thrust vector control – TVC mechanism in single nozzle – Gimbal – movable nozzle – jet vanes- jet tabs- jetavator – secondary injection of liquid and hot gas injection – small auxiliary thrust chamber – TVC with multiple thrust chamber – TVC testing

UNIT IV THERMAL PROTECTION SYSTEM 9

Principle of high temperature design – thermal environment – aerodynamic heating –solar heating – principles of thermal protection – thermal protection systems – systems based on heat dissipation – systems based on heat absorption- capabilities of thermal protection systems.

UNIT V HIGH TEMPERATURE MATERIAL FOR AEROSPACE APPLICATIONS 9

Component system analysis – re-entry component analysis – composite material systems- Ceramics reinforced with refractory metal fibres – high temperature material fabrication – Fracture of pressure vessels – temperature control of spacecrafts – ablation materials.

TOTAL:45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be

CO2: Able to learn the principles of operation and design of various rocket systems.
CO3: Able to explore the design of multi-stage launch vehicles.
CO4: Able to acquire knowledge on the application and working of thrust vector control in rocket and missiles.
CO5: Aware of thermal protecting requirements and preventive measurements for aerodynamics heating.
CO6: Able to get attentiveness on high temperature material components analysis for aerospace applications.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	✓	✓	✓	✓		
CO2	✓	✓	✓		✓	
CO3	✓	✓	✓	✓	✓	
CO4	✓	✓	✓		✓	
CO5	✓	✓	✓	✓	✓	

REFERENCES:

1. Cornelisse, JW, Schoyer, HFR &Wakker, F, "Rocket Propulsion and Space Dynamics", Pitman Publishing, 1979.
2. Earl R. Parker, "Materials for Missiles and Spacecraft", McGraw –Hill Book company, Inc.1982.
3. Howard D.Curtis, "Orbital Mechanics for Engineering Students", 3rd Edition, Butterworth-Heinemann, 2013.
4. Sutton, G.P, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2016.

AS4013 ELECTRIC PROPULSION SYSTEMS **L T P C**
3 0 0 3

COURSE OBJECTIVES:

This course will enables 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 IONIZED GASE **8**

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.

UNIT II INTRODUCTION TO THE BASIC PHYSICS OF ELECTRIC PROPULSION SYSTEMS **9**

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

UNIT III ELECTRO-THERMAL PROPULSION **9**

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

UNIT IV ELECTROSTATIC PROPULSION **9**

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

UNIT V ELECTROMAGNETIC PROPULSION **10**

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the course, students will be

- **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.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓	✓								
CO2	✓	✓	✓									
CO3	✓	✓	✓	✓		✓						
CO4	✓	✓	✓	✓		✓						
CO5	✓	✓	✓	✓		✓						

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.

AO4077 **THEORY OF VIBRATIONS**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

This course will enables students

1. To get insight into the basic aspects of vibration theory.
2. This course presents the principles of dynamics and energy methods pertaining to structures.
3. This course provides a platform for better understanding of the approximate methods for aerospace structures.
4. To get insight into the dynamic responses of the large systems.
5. To get insight into the basic aspects of aero-elasticity.

UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 9

Simple harmonic motion, definition of terminologies, Newton’s Laws, D’Alembert’s principle, Energy methods.Free and forced vibrations with and without damping, base excitation, and vibration measuring instruments.

UNIT II MULTI-DEGREES OF FREEDOM SYSTEMS 9

Two degrees of freedom systems, Static and dynamic couplings, eigen values, eigen vectors and orthogonality conditions of eigen vectors, Vibration absorber, Principal coordinates, Principal modes. Hamilton’s Principle, Lagrange’s equation and its applications.

UNIT III VIBRATION OF ELASTIC BODIES 9

Transverse vibrations of strings, Longitudinal, Lateral and Torsional vibrations. Approximate methods for calculating natural frequencies.

UNIT IV EIGEN VALUE PROBLEMS & DYNAMIC RESPONSE OF LARGE SYSTEMS 9

Eigen value extraction methods – Subspace hydration method, Lanczos method – Eigen value reduction method – Dynamic response of large systems – Implicit and explicit methods.

UNIT V ELEMENTS OF AEROELASTICITY 9

Aeroelastic problems – Collar's triangle of forces – Wing divergence – Aileron control reversal – Flutter.

TOTAL: 45 PERIODS

REFERENCES

1. Timoshenko, S. "Vibration Problems in Engineering", John Wiley & Sons, Inc., 2018.
2. Meirovitch, L. "Elements of Vibration Analysis", New Delhi, McGraw-Hill Education, 2014.
3. Thomson W.T, Marie Dillon Dahleh, "Theory of Vibrations with Applications", Harlow, Essex Pearson 2014
4. F.S. Tse., I.F. Morse and R.T. Hinkle, "Mechanical Vibrations", Prentice-Hall of India, 1985.
5. Rao.J.S. and Gupta.K. "Theory and Practice of Mechanical Vibrations", New Delhi, New Age International, 1999.
6. Fung, Y.C., "An Introduction to the Theory of Aeroelasticity", Dover Publications.,Mineola, N.Y., 2008.

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

AS4014 MANNED SPACE MISSIONS L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will make students

1. To get insights into the basic aspects of manned and unmanned missions.
2. To provide with the basic knowledge on the structure of atmosphere and the space environment.
3. To learn the complexities involved in sending human being into space missions.
4. To learn how the unmanned missions with respect to mission logistics and planning are different from manned missions.

UNIT I INTRODUCTION 8

The physics of space - Current missions: space station, Moon mission and Mars missions - Engineering challenges on Manned vs. unmanned missions - Scientific and technological gains from space programs - Salient features of Apollo and Space station missions – space shuttle mission

UNIT II SPACE VS EARTH ENVIRONMENT 10

Atmosphere: Structure and Composition - - Atmosphere: Air Pressure, Temperature, and Density - Atmosphere: Meteoroid, Orbital Debris & Radiation Protection - Human Factors of Crewed Spaceflight, . Safety of Crewed Spaceflight - Magnetosphere - Radiation Environment: Galactic Cosmic Radiation (GCR) , Solar Particle Events (SPE) - Radiation and the Human Body – Impact of microgravity and g forces on humans – space adaptation syndrome

UNIT III LIFE SUPPORT SYSTEMS AND COUNTERMEASURES 8

Life Support Systems and Space Survival Overview - - Environment Controlled Life Support Systems (ECLSS) - Human / Machine Interaction - - Human Factors in Control Design - Crew Accommodations

UNIT IV MISSION LOGISTICS AND PLANNING 10

Group Dynamics: Ground Communication and Support - Space Resources and Mission Planning - Space Mission Design: Rockets and Launch Vehicles - Orbital Selection and Astrodynamics , Entry, Descent, Landing, and Ascent, Designing and Sizing Space elements, Transfer, Entry, Landing, and Ascent Vehicles, Designing, Sizing, and Integrating a Surface Base, Planetary Surface Vehicles

UNIT V ALLIED TOPICS 9

Spacecraft Subsystems: Space Operations - Space Architecture, Attitude Determination and Control - Designing Power Systems - Extravehicular Activity (EVA) Systems - Space Robotics - Mission Operations for Crewed Spaceflight - Command, Control, and Communications Architecture.

TOTAL:45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To get updated with technical status on current knowledge manned and unmanned missions.

CO2: To apply space element architectures, design and sizing principles and processes for on-orbit, ascent and re-entry operations. Apply sizing principles to estimate mass and power for a given set of requirements.

CO3: To apply basic principles of orbital mechanics and how they apply to human missions.

CO4: To familiarize with human spaceflight mission design principles, limitations and processes and apply them to develop goals, objectives as well as top level requirements

CO5: To characterize the scope, functions and physical architecture options for human spaceflight support systems such as Environmental Control and Life Support, Thermal Control, EVA Systems, and others.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓	✓									
CO2	✓	✓	✓	✓								
CO3	✓	✓	✓									
CO4	✓	✓	✓	✓								
CO5	✓	✓	✓									

REFERENCES:

1. Connors, MM, Harrison, AA, and Akins, FR,."Living Aloft: Human Requirements for Extended Spaceflight", University Press of the Pacific, Honolulu, 2005.
2. Eckart, P, "Spaceflight Life Support and Biospherics", Springer publishers, 1stt edition, 2010.
3. Larson, WJ and Pranke, LK, "Human Spaceflight: Mission Analysis andDesign", McGraw-Hill Higher Education, Washington, DC, 1999.
4. McNamara, Bernard, "Into the Final Frontier: The Human Exploration of Space", Brooks Cole Publishing, 1st edition, 2000.

AS4015 HIGH TEMPERATURE GAS DYNAMICS L T P C

3 0 0 3

COURSE OBJECTIVES:

This course will enable students

1. To realize the importance and influence of non-equilibrium real-gas effects in high temperature flows.
2. To know the physical mechanisms causing aerodynamic heating of high speed vehicles.
3. To study the parameters that influences the design of hypersonic vehicles.
4. To know the computational methods appropriate to high temperature flows.
5. To realize the effects of friction and heat addition to gasdynamic flow, typical in aerospace engines.

UNIT I INTRODUCTION 8

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

UNIT II STATISTICAL THERMODYNAMICS 8

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

UNIT III KINETIC THEORY AND HYPERSONIC FLOWS 9

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

UNIT IV INVISCID HIGH TEMPERATURE FLOWS 10

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

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 10

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be

CO1: Able to identify the critical physical phenomena in high temperature flows.

CO2: Realize the importanceof kinetic theory of gases.

CO3: Having knowledge about the features and importance of high - enthalpy flows.

CO4: In a position to demonstrate the transport properties in High-Temperature gases.

CO5: Having knowledge on some of the basic phenomena in rarefied flows.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓										
CO2	✓	✓		✓								
CO3	✓	✓		✓								
CO4	✓	✓		✓								
CO5	✓	✓										

REFERENCES:

1. Anderson, JD, “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series, 2nd edition, 2006.
2. Anderson J D,“Modern compressible flow: with Historical Perspective”, McGraw Hill Education, 3rd edition, 2017.
3. Bose,TK, “High Temperature Gas Dynamics”,Springer-Verlag Berlin Heidelberg, 1st edition, 2004.
4. John T. Bertin, “Hypersonic Aerothermodynamics”, AIAA Education Series, 1993.
5. William H. Heiser&David T. Pratt, “Hypersonic Air Breathing propulsion”, AIAA Education Series, 1994.

AO4073	**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 9

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 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 & Entrainment, Mathematical treatment of jet profiles- Semi-empirical Theories. Mixing Layers- Computational and Experimental Techniques for Studying the Jets.

UNIT III ACTIVE JETCONTROL METHODS 9

Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS, Synthetic Jets, Controls and Sensors, Applications.

UNIT IV PASSIVE JET CONTROL METHODS 9

Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches & wires, vortex generators.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 – applications

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 havethrough 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.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	2	3	4	5	6
CO1			2		3	1
CO2	3		2	2	3	1
CO3			2	1	3	1
CO4			2		3	1
CO5	2		2	3	3	1
	1	0	2	1.2	3	1

REFERENCES:

1. EthirajanRathakrishnan, “Applied Gas Dynamics”, John Wiley, New York, 2010.
2. Liepmann and Roshko, “Elements of Gas Dynamics”, Dover Publishers, 2017.
3. Rathakrishnan E., “Gas Dynamics”, Prentice Hall of India, New Delhi, 5th edition, 2014.
4. Shapiro, AH, “Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I & II”, Ronald Press, New York, 1953.

AO4075 SMART MATERIALS AND STRUCTURAL HEALTH MONITORING L T P C
3 0 0 3

COURSE OBJECTIVES:

This course will enables students

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 STRUCTURAL HEALTH MONITORING 8

An Overview of Structural Health Monitoring, Structural Health Monitoring and Smart Materials, Structural Health Monitoring versus Non Destructive Evaluation A broad Overview of Smart Materials Overview of 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 10

Introduction to Smart Materials, 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 10

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 , Vibration Control using SHM –introduction to FE formulation Constitutive Relationship - Element Stiffness Matrix for High Precision Finite Element -Element Mass Matrix for High Precision Finite Element - Developing Actuator and Sensor Influence Matrix .Delamination Sensing using Piezo Sensory Layer.

UNIT IV INTELLIGENT SYSTEMS AND NEURAL NETWORKS 9

Operational evaluation -.Data acquisition- 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.

UNIT V ADVANCES IN SMART STRUCTURES &MATERIALS 8

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, students will be able

CO1: To familiarize with the fundamentals of history of SHM.
CO2: To provide a systematic approach to SHM process.
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.

CO	PO1	PO2	PO3	PO4	PO5	PO6
	1	**2**	**3**	**4**	**5**	**6**
CO1	3		3		1	1
CO2			2		1	1
CO3			2		1	1
CO4	3		3		1	1
CO5			2		2	1

REFERENCES:

1. Brian Culshaw, "Smart Structures,and Materials", Artech House, 2000.
2. DanielBalageas, 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. LaureneFausett**, "**Fundamentals Of Neural Networks",Pearson publishers, 1994
6. Victor Giurglutiu, "Structural Health Monitoring with Wafer Active Sensors", Academic Press Inc, 2007.

AS4016 **UNMANNED AERIAL SYSTEMS** **L T P C**

3 0 0 3

COURSE OBJECTIVES:

This course will enables 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 UNMANNED AERIAL 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 PATH PLANNING 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

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.

	PO1	PO2	PO3	PO4	PO5	PO6						
CO1	✓	✓				✓						
CO2	✓	✓			✓	✓						
CO3	✓	✓			✓	✓						
CO4	✓					✓						
CO5	✓				✓	✓						

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.

AS4017 RELIABILITY AND QUALITY **L T P C**
3 0 0 3

OBJECTIVES:

- Provide basic knowledge of quality and reliability in engineering
- Introduce analyses of quality concepts
- Develop skills to analyse quality culture in companies.

UNIT I FUNDEMENTALS OF RELIABILITY 9

Reliability engineering fundamentals- Failure data analysis, Failure rate, mortality curve, Concept of burn in period - Useful life and wear out phase of a system - Mean time to failure (MTTF) - Mean time between failure, (MTBF) and mean time to repair (MTTR) - Reliability in terms of Hazard rate and failure density, Conditional probability and multiplication rules.

UNIT II RELIABILITY OF SIMPLE SYSTEMS AND MAINTAINABILITY 9

Series and parallel configurations – Reliability improvement – redundancy – combined series and parallel systems – High level and low level redundancy – k-out of n system – standby redundancy. Maintainability – Factors affecting maintainability of systems – Design for maintainability – MTTR – Maintenance – spare provisioning.

UNIT III MODERN QUALITY MANAGEMENT 9

Definitions and Principles of Operation - Tools and Techniques - Quality Circles, 5 S Practice, Total Quality Control (TQC), Total Employee Involvement (TEI), Problem Solving Process, Quality Function Deployment (QFD), Failure Mode and Effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools.

UNIT IV CONTEMPORARY TRENDS 9

Concurrent Engineering - Lean Manufacturing, Agile Manufacturing - World Class Manufacturing - Cost of Quality (COQ) system - Bench Marking, Business Process Re-engineering, Six Sigma - Basic Concept, Principle, Methodology, Implementation, Scope, Advantages and Limitation.

UNIT V CONTROL CHARTS 9

Control charts for individual measurements - Exponentially Weighted Moving Average (EWMA) and Deviation (EWMD) charts - Control charts for variables - X-bar and R charts, X-bar and S charts - SPC - Variables Control charts- SPC - Attributer Control charts.

TOTAL: 45 PERIODS

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

- Apply continuous improvement techniques and basic quality concepts in analysis
- Analyse a manufacturing process using appropriate control charts
- The student can identify different areas of Quality and Reliability Engineering.
- Can find the applications of all the areas in industry.
- Use software for SPC analysis

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

REFERENCES:

1. Reliability Engineering by Srinath L. S., Affiliated East West Press.
2. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India.
3. Montgomery D. C. – ‘Introduction to Statistical Quality Control’ – John Wiley – 2010
4. Ebeling C. – ‘An Introduction to Reliability and Maintainability Engineering’ – Tata McGraw Hill Publishing Company Ltd. – 2004.

AUDIT COURSES

AX4091 ENGLISH FOR RESEARCH PAPER WRITING **L T P C**
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING 6
Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6
Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6
Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6
Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS **6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability

CO2 – Learn about what to write in each section

CO3 – Understand the skills needed when writing a Title

CO4 – Understand the skills needed when writing the Conclusion

CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

AX4092 DISASTER MANAGEMENT

L	T	P	C
2	0	0	0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster

CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.

CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies",Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall OfIndia, New Delhi,2001.

AX4093 CONSTITUTION OF INDIA

L	T	P	C
2	0	0	0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

- The Constitution of India,1950(Bare Act),Government Publication.
- Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution, 1st Edition, 2015.
- M.P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis,2014.
- D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

AX4094	நற்றமிழ் இலக்கியம்	L T P C 2 0 0 0

UNIT I சங்க இலக்கியம் **6**

1. தமிழின் துவக்க நூல் தொல்காப்பியம்

– எழுத்து, சொல், பொருள்

2. அகநானூறு (82)

- இயற்கை இன்னிசை அரங்கம்

3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி
4. புறநானூறு (95,195)

- போரை நிறுத்திய ஔவையார்

UNIT II அறநெறித் தமிழ் **6**

1. அறநெறி வகுத்த திருவள்ளுவர்
   - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்
2. பிற அறநூல்கள் - இலக்கிய மருந்து

– ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)

UNIT III **இரட்டைக் காப்பியங்கள்** **6**

1. கண்ணகியின் புரட்சி
   - சிலப்பதிகார வழக்குரை காதை
2. சமூகசேவை இலக்கியம் மணிமேகலை
   - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை

UNIT IV **அருள்நெறித் தமிழ்** **6**

1. சிறுபாணாற்றுப்படை
   - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வைகொடுத்தது, அதியமான் ஔவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்
2. நற்றிணை
   - அன்னைக்குரிய புன்னை சிறப்பு
3. திருமந்திரம் (617, 618)
   - இயமம் நியமம் விதிகள்
4. தர்மச்சாலையை நிறுவிய வள்ளலார்
5. புறநானூறு
   - சிறுவனே வள்ளலானான்
6. அகநானூறு (4) - வண்டு
   நற்றிணை (11) - நண்டு
   கலித்தொகை (11) - யானை, புறா
   ஐ ஐந்திணை 50 (27) - மான்
   ஆகியவை பற்றிய செய்திகள்

UNIT V **நவீன தமிழ் இலக்கியம்** **6**

1. உரைநடைத் தமிழ்,
   - தமிழின் முதல் புதினம்,
   - தமிழின் முதல் சிறுகதை,
   - கட்டுரை இலக்கியம்,
   - பயண இலக்கியம்,
   - நாடகம்,
2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,
3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,
4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,
5. அறிவியல் தமிழ்,
6. இணையத்தில் தமிழ்,
7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.

TOTAL: 30 PERIODS

தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University)
- www.tamilvu.org
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia)
-https://ta.wikipedia.org
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம்
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம்
- தமிழ் வளர்ச்சித்துறை (thamilvalarchithurai.com)
6. அறிவியல் களஞ்சியம்
- தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்