Sanjay Ghodawat University

Kolhapur

School of Engineering and Technology

Department of Aerospace Engineering

M. Tech. Aerospace Engineering

Structure and Syllabus (R25)

(Programme Structure and Course Contents)

Semester I & II

Programme Structure for M. Tech. Aerospace Engineering First Year
Semester I: Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		Th	Pr	Tu	Th	Pr	Tu	Total credits
PASPC101	Finite Element Method	3	-	-	3	-	-	3
PASPC102	Rocket Propulsion	3	-	-	3	-	-	3
PASPC103	Flight Performance	3	-	-	3	-	-	3
PASPE1XX	Program Specific Elective I	3	-	-	3	-	-	3
PSTRM101	Research Methodology	2	-	-	2	-	-	2
PXXOE1XX	Open/Multidisciplinary Elective I	2	-	-	2	-	-	2
PASVS101	Software proficiency I	-	4	-	-	2	-	2
PASPC104	Flight Performance Lab	-	4	-	-	2	-	2
	Total	**16**	**08**	**-**	**16**	**4**	**-**	**20**

Th: Theory, Pr: Practical, Tu: Tutorial

Programme Structure for M. Tech. Aerospace Engineering First Year
Semester I: Evaluation Scheme

Course Code	Course Name	*Theory Marks*					*Practical Marks*		Total
		Internal Assessment				SEE	Term work	Practical Oral/POE	
		T1	T2	FET	Total				
PASPC101	Finite Element Method	10	10	5	25	50	-	-	75
PASPC102	Rocket Propulsion	10	10	5	25	50	-	-	75
PASPC103	Flight Performance	10	10	5	25	50	-	-	75
PASPE1XX	Program Specific Elective I	10	10	5	25	50	-	-	75
PSTRM101	Research Methodology	-	10	5	15	35	-	-	50
PXXOE1XX	Open/Multidisciplinary Elective I	-	10	5	15	35	-	-	50
PASVS101	Software proficiency I	-	-	-	-	-	50	-	50
PASPC104	Flight Performance Lab	-	-	-	-	-	25	25	50

FET – Faculty evaluation for Theory, T1, T2, Continuous Assessment Test, SEE - Semester End Examination

Program Specific Elective		
I	PASPE101	Advanced Aerodynamics
	PASPE102	Satellite Communications

Programme Structure for M. Tech. Aerospace Engineering First Year

Semester II: Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		Th	Pr	Tu	Th	Pr	Tu	Total credits
PASPC201	Computational Fluid Dynamics	3	-	-	3	-	-	3
PASPC202	Hypersonic Aerodynamics	3	-	-	3	-	-	3
PASPC203	Aerospace Structure	3	-	-	3	-	-	3
PASPE2XX	Program Specific Elective II	3	-	-	3	-	-	3
PSTRM201	Research Publications and Ethics	2	-	-	2	-	-	2
PXXOE2XX	Open/Multidisciplinary Elective II	2	-	-	2	-	-	2
PASVS201	Software proficiency II	-	4	-	-	2	-	2
PASPC204	Hypersonic Aerodynamic Lab	-	4	-	-	2	-	2
	Total	**16**	**08**	**-**	**16**	**4**	**-**	**20**

Th: Theory, Pr: Practical, Tu: Tutorial

Programme Structure for M. Tech. Aerospace Engineering First Year
Semester II: Evaluation Scheme

Course Code	Course Name	*Theory Marks*					*Practical Marks*		Total
		Internal Assessment				SEE	Term work	Practical Oral/POE	
		T1	T2	FET	Total				
PASPC201	Computational Fluid Dynamics	10	10	5	25	50	-	-	75
PASPC202	Hypersonic Aerodynamics	10	10	5	25	50	-	-	75
PASPC203	Aerospace Structure	10	10	5	25	50	-	-	75
PASPE2XX	Program Specific Elective II	10	10	5	25	50	-	-	75
P01RM201	Research Publications and Ethics	-	10	5	15	35	-	-	50
PXXOE2XX	Open/Multidisciplinary Elective II	-	10	5	15	35	-	-	50
PASVS201	Software proficiency II	-	-	-	-	-	50	-	50
PASPC204	Hypersonic Aerodynamic Lab	-	-	-	-	-	25	25	50

FET – Faculty evaluation for Theory, T1, T2, Continuous Assessment Test, Term, SEE - Semester End Examination

Exit Option: Students who exit at the end of first year shall be awarded a PG Diploma after successful completion of first year with additional 4 credits earned through industry internship/field work/ vocational training/generic course/(s).

Program Specific Elective		
II	PASPE201	Propellant Technology
	PASPE202	Boundary Layer Theory

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC101	Finite Elements Method	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC101	Finite Elements Method	10	10	5	25	40%	50	40%	75

Course Description

This course is at first semester of first year Aeronautical Engineering. The Finite Elements Method course introduces the fundamental principles of finite element analysis (FEA) for solving engineering problems. It covers the formulation of finite element models, application to structural analysis, heat transfer, and fluid dynamics, emphasizing practical implementation using software tools. Ideal for engineering students and professionals seeking analytical skills.

Pre-requisites: B. Tech Mechanical/Aeronautical

Course Objectives

This course will enable the students

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

Course Outcomes: The students will be able to,

- **CO1** **Explain[2]** governing equations involving different type of finite elements.
- **CO2** **Formulate[3]** the general finite element methodology for a variety of practical problems.
- **CO3** **Analyze[4]** simple 1-D and 2-D problems using the finite element method.
- **CO4** **Evaluate[5]** Knowledge on how to apply numerical integration techniques effectively in finite elements solutions.
- **CO5** **Analyze[4]** to frame and solve heat transfer and fluid mechanics problems using the FE method.

Course Contents

Module	Unit	Description	Hours
1.0		**Introduction**	**9**
1	1.1	Need for sue of FEM – Advantages and Disadvantages of FEM Matrix algebra – Terminologies relating to matrices, methods of solution of linear algebraic equations.	
	1.2	Solution of Eigenvalue problems - Introduction to transient field problems	
2.0		**Discrete Elements**	**9**
2	2.1	Finite Element Structural Analysis Involving 1-D Bar and Beam Elements – Tapered Bar – Temperature Effects – Static Loading	
	2.2	Formulation of the Load Vector for 1-D Elements – Methods of Stiffness Matrix Formulation – Interpolation & Shape Functions	
	2.3	Boundary Conditions – Determination of Displacements & Reactions	
3.0		**Continuum Methods**	**9**
3	3.1	Plane Stress & Plane strain Loading – CST Element – LST Element – Element Characteristics – Problem Formulation & Solution	
	3.2	Using Finite Elements – Axisymmetric Bodies & Axisymmetric Loading – Consistent and Lumped Load Vectors	
	3.3	Isoparametric Formulation – Shape Functions – Role of Numerical Integration – Load Consideration – Complete FE Solution.	
4.0		**Vibration & Buckling**	**9**
4	4.1	Formulation of the Mass and Stiffness Element Matrices for Vibration Problems – Bar and Beam Elements – Derivation of the Governing Equation – Natural Frequencies and Modes	
	4.2	Damping Considerations –Harmonic Response – Buckling of Columns – Problem Formulation – Solution – Determination of Buckling Loads and Modes.	

5.0		**Heat Transfer & Fluid Mechanics Problems**	9
5	5.1	One Dimensional Heat Transfer Analysis – Formulation of the Governing Equations in Finite Element Form – Equivalent Load Vector – Solution & Temperature Distribution	
	5.2	Finite Element Formulation & Solution for Sample Problems Involving Fluid Mechanics.	

Text Books

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.

References

1. Rao,SS Finite Element Method in Engineering, Butterworth, Heinemann Publishing, 3rd Edition, 1998.
2. 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.
3. Segerlind,LJ, Applied Finite Element Analysis, , John Wiley and Sons Inc., New York, 2nd Edition,1984.

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC102	Rocket Propulsion	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC102	Rocket Propulsion	10	10	5	25	40%	50	40%	75

Course Description

This course is at second semester of first year Aerospace Engineering. It covers basics of rocket propulsion and thermodynamic relations. This course gives brief knowledge about different types of propulsion systems and propellants, also covers the advanced techniques in propulsion system.

Pre-requisites: B.Tech -Propulsion

Course Objectives

- To acquire the knowledge on the rocket propulsion system, nozzle theory and thermodynamic relations.
- To learn the Liquid propulsion systems and its functions.
- To know the concepts of solid propulsion and propellants and characteristics.
- To learn the hybrid propulsion systems.
- To learn the various types of advanced propulsion techniques.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Explain**[2] the fundamentals of rocket propulsion
- **CO2** **Apply**[3] t the nozzle theory and thermodynamic relations to solve rocket propulsion problems
- **CO3** **Explain**[2] liquid and hybrid propulsion systems used in rockets
- **CO4** **Apply**[3] concepts of propulsion to solve solid propellant problems
- **CO5** **Explain**[2] advanced rocket propulsion systems and techniques

Course Contents

Module	Unit	Description	Hours
1.0		**Fundamentals Of Rocket Propulsion, Nozzle Theory And Thermodynamic Relations**	**9**
1	1.1	Operating principle –Applications – Definitions and fundamental parameters: Thrust, Exhaust Velocity, Energy and Efficiencies, Typical Performance Values 6 2	
	1.2	Ideal rocket – Isentropic flow through nozzles – Nozzle Performance: nozzle area ratio, characteristic velocity, thrust coefficient – Nozzle configurations, Under-expansion and over-expansion.	
2.0		**Liquid Propulsion**	**9**
2	2.1	Classifications –Propulsion system components and its functions - Propellant feed systems and Turbo pump feed system.	
	2.2	Injectors and types - Thrust chamber and its cooling - Cryogenic propulsion system, special features of cryogenic systems	
3.0		**Solid Propulsion**	**9**
3	3.1	Application and Classification of Solid Propellant Rocket Motors - Propellants and Characteristics - Ingredients and Processing - Propellant Burning Rate - Propellant Grains and Grain Configurations - Grain Design.	
4.0		**Hybrid Propulsion**	**9**
4	4.1	Classification - System Arrangement and Components - Typical Fuels and Oxidizers - Advantages and Disadvantages - Application Areas - Performance and Limitations Performance Parameters of selected existing Hybrid Rocket Engines - System Integration - Manufacturing Methods for Low and High- thrust Engines.	
5.0		**Advanced Propulsion Techniques**	9
5	5.1	Electric rocket propulsion– types of electric propulsion techniques - Ion propulsion – Nuclear rocket – comparison of performance of these propulsion systems with chemical rocket propulsion systems – future applications of electric propulsion systems - Solar sail.	

Text Books

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edition, 1993.
2. Mathur, M.L., and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi, 1988. Anderson, J.D., Introduction to Flight, McGraw-Hill; 8th edition, 2015.

References

1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley and Sons Inc., New York, 8thEdn., 2012.
2. Hill, P.G. and Peterson, C.R. "Mechanics and Thermodynamics of Propulsion" Addison, Wesley Longman INC, 1999.
3. Cornelisse, J.W., Rocket Propulsion and Spaceflight Dynamics, Pitman Publishing, 1979.

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprised of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC103	Flight Performance	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC103	Flight Performance	10	10	5	25	40%	50	40%	75

Course Description

This course provides an in-depth study of flight mechanics, covering fundamental principles and advanced concepts. Topics include aircraft motion, forces and moments, stability and control, dynamic response, flight testing, and modern control systems. The course aims to equip students with the knowledge and skills necessary for careers in aerospace engineering.

Pre-requisites: 11th and 12th physics.

Course Objectives

- Understand the fundamental principles of flight mechanics, including equations of motion, forces, and moments.
- Analyze and evaluate aircraft stability and control, focusing on static and dynamic stability.
- Examine the dynamic response of aircraft to various inputs and disturbances, including modes of motion and transfer functions.
- Gain practical knowledge in flight testing procedures and data analysis to verify and validate aircraft performance.
- Explore modern and advanced flight control systems, including automatic control, stability augmentation, and hypersonic flight dynamics.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Apply^{3} the basic airplane performance parameters.**
- **CO2** **Differentiate^{3}** the aircraft performance in steady unaccelerated and accelerated flight.
- **CO3** **Explain^{2}** the aircraft maneuver performance.
- **CO4** **Explain^{2}** the aircraft take-off and landing performance.
- **CO5** **Differentiate^{3}** the aircraft pull up and pulldown maneuver

Course Contents

Module	Unit	Description	Hours
1.0		**The Equations Of Motion Steady Un-Accelerated Flight**	**9**
1	1.1	Introduction, four forces of flight, General equation of motion, Power available and power required curves. Thrust available and thrust required curves. Conditions for power required and thrust required minimum.	
	1.2	Thrust available and maximum velocity, Power available and maximum velocity, Altitude effects on power available and power required; thrust available and thrust required.	
2.0		**Steady Performance – Level Flight, Climb & Glide**	**9**
2	2.1	STEADY PERFORMANCE – LEVEL FLIGHT, CLIMB & GLIDE Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absolute ceiling, Service ceiling, Time to climb – graphical and analytical approach, climb performance graph (hodograph diagram);	
	2.2	climb performance graph (hodograph diagram); maximum climb angle and rate of climb Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.	
3.0		**Fundamental Airplane Performance Parameters**	**9**
3	3.1	The fundamental Parameters: Thrust – to – weight ratio, Wing loading, Drag polar, and lift-to – drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to- drag ratio.	
4.0		**Range And Endurance**	**9**
4	4.1	Propeller driven Airplane: Physical consideration, Quantitative formulation, Breguet equation for Range and Endurance, Conditions for maximum range and endurance.	

	4.2	Jet Airplane: Physical consideration, Quantitative formulation, Equation for Range and Endurance, Conditions for maximum range and endurance, Effect of head wind tail wind.	
5.0		**Maneuver Performance**	9
5	5.1	Turning performance: Level turn, load factor, Constraints on load factor, Minimum turn radius, Maximum turn rate.	
	5.2	Pull-up and Pull-down maneuvers: (Turning rate, turn radius). Limiting case for large load factor. The V-n diagram. Limitations of pull up and push over.	

Text Books

1. John D. Anderson, Aircraft Performance and Design, McGraw-Hill International, Aerospace Science/ Technology Editions, 1999
2. John D. Anderson,Introduction to flight, McGraw-Hill International, Aerospace Science/ Technology Editions, 2000

References

1. Perkins, C.D., and Hage, R.E , Airplane Performance stability and Control John Wiley Son Inc, New York 1988
2. Barnes W. McCormick , Aerodynamics, Aeronautics, and Flight Mechanics, John Wiley Son Inc, New York,1995

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPE101	Advanced Aerodynamics	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPE101	Advanced Aerodynamics	10	10	5	25	40%	50	40%	75

Course Description

This course introduces the principles of aerodynamics, covering the behaviour of hot air balloons, aircraft, and various airplane types. It explores both incompressible and compressible flow theories, viscous flow, and high-speed aerodynamics, with practical applications in design and performance analysis.

Course Objectives

- Understand basic aerodynamic principles, lift and drag, and fluid flow around bodies.
- Apply thin aerofoil theory, Kutta condition, and lifting line theory.
- Compressible Flow Theory: Explore compressible flows, shocks, expansion waves, and supersonic flow.
- High-Speed Aerodynamics: Analyze critical Mach numbers, shock stall, and supersonic aircraft design.
- Study boundary layers, flow visualization, and wind tunnel measurements.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Explain**[2] the fundamental knowledge of aerodynamics
- **CO2** **Explain**[2] incompressible flow and its applications
- **CO3** **Calculate**[3] the compressible flow properties over an flying vehicles
- **CO4** **Select**[4] the appropriate flow analysis method to study the component of flying vehicles
- **CO5** **Select**[4] the appropriate flow measurement devices

Course Contents

Module	Unit	Description	Hours
1.0		**Introduction To Aerodynamics**	**9**
1	1.1	Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient.	
	1.2	Continuity and Momentum equations, Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity distributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect.	
2.0		**Incompressible Flow Theory**	**9**
2	2.1	Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, lifting line theory.	
3.0		**Compressible Flow Theory**	**9**
3	3.1	Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics.	
4.0		**Viscous Flow And Flow Measurements**	**9**
4	4.1	Basics of viscous flow theory – Boundary Layer – Displacement, momentum an Energy Thickness – Laminar and Turbulent boundary layers	
	4.2	Boundary layer over flat plate – Blasius Solution - Types of wind tunnels – Flow visualization techniques– Measurement of force and moments in wind tunnels.	
5.0		**Airfoils, Wings And Airplane Configuration In High Speed Flows**	9
5	5.1	Critical Mach number, Drag divergence Mach number, Shock stall, supercritical airfoils,Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes.	

Text Books

1. J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 5th edition 2010
2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 5th edition, 2013.
3. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press,1982.

References

1. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd Edition 1999
2. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPE102	Satellite Communications	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPE102	Satellite Communications	10	10	5	25	40%	50	40%	75

Course Description

This course provides a comprehensive understanding of satellite communication systems, covering the fundamental principles, design considerations, and practical applications. Students will learn about the various components of satellite systems, including the space segment (satellites) and the ground segment (earth stations), and how these components interact to facilitate global communication.

Pre-requisites: Avionics Engineering

Course Objectives

- Understand the basic principles and concepts of satellite communication.
- Gain knowledge about satellite orbits and the mechanics of satellite movement.
- Learn about the design and functioning of satellite subsystems, including transponders, antennas, and power systems.
- Explore the different types of satellite communication services and applications.
- Study the protocols and standards used in satellite communication.
- Analyze the challenges and solutions related to satellite link design, including link budget analysis.
- Understand the regulatory and legal aspects of satellite communication

Course Outcomes: The students will be able to,

CO1 **Illustrate**[2] the basic concepts of satellite communication and different Frequency allocations for satellite services.

CO2 **Analyze**[3] the satellite orbits and link design for transmission & reception of signals

CO3 **Analyze**[3] various satellite subsystems and its functionality

CO4 **Choose**[3] appropriate multiple access technique for a given satellite communication application

Course Contents

Module	Unit	Description	Hours
1.0		**Introduction to Communication Satellite:**	**9**
1	1.1	Communication Satellite: Orbit and Description: A brief History of Satellite Communication, Satellite Frequency bands, Satellite Systems, Applications, Orbital Period and Velocity, Effects of Orbital inclination, Azimuth and Elevation, Coverage and Slant range, Eclipse, Orbital perturbations, Placement of a Satellite in a Geo-Stationary Orbit.	
2.0		**Satellite Sub-Systems and Satellite Link**	**9**
2	2.1	**Satellite Sub-Systems:** Altitude and orbit control system, TT&C Sub-System, Altitude control Sub-System, Power Systems, Communication Subsystems, Satellite antenna Equipment.	
	2.2	**Satellite Link:** Basic transmission theory, system noise temperature and G/T ratio, Basic Link Analysis, Interference Analysis, Design of satellite links for specified C/N, (with and without frequency Re-use), Link Budget.	
3.0		**Propagation effects and Multiple Access**	**9**
3	3.1	Propagation effects: Introduction, Atmospheric Absorption, Cloud Attenuation, Tropospheric and Ionospheric Scintillation and Low angle fading, Rain Induced attenuation, rain induced cross polarization interference.	
	3.2	Multiple Access: Frequency Division Multiple Access(FDMA), Intermodulation, Calculation of C/N. Time Division Multiple Access(TDMA), Frame structure, Burst structure, Satellite Switched TDMA Onboard processing, Demand Assignment Multiple Access (DAMA) – Types of Demand Assignment, Characteristics, CDMA Spread Spectrum Transmission and Reception	
4.0		**Earth Station Technology**	**9**
4	4.1	Transmitters, Receivers, Antennas, Tracking systems, Terrestrial Interface, Power Test methods, Lower Orbit Considerations.	

	4.2	Satellite Navigation & Global Positioning Systems: Radio and Satellite Navigation, GPS Position Location principles, GPS Receivers, GPS C/A code accuracy, Differential GPS.	
5.0		**Satellite Packet Communications**	9
5	5.1	Satellite Packet Communications: Message Transmission by FDMA: M/G/1 Queue, Message Transmission by TDMA, PURE ALOHA-Satellite Packet Switching, Slotted Aloha, Packet Reservation, Tree Algorithm.	

Text Books

1. Satellite Communications- Timothy Pratt, Charles Bostian and Jeremy Allnutt, WSE, Wiley Publications, 2nd Edition, 2003, John Wiley & Sons.
2. Satellite Communication Engineering- Wilbur L. Pritchand, Robert A Nelson and Henri G.Suyderhoud, 2nd Edition, Pearson Publications.
3. Digital Satellite Communications-Tri. T.Ha, 2nd Edition, 1990, Mc. Graw Hill.

References

1. Satellite Communications- Dennis Roddy, 2nd Edition, 1996, McGraw Hill.
2. Satellite Communications: Design Principles- M. Richharia, 2nd Edition,BS Publications, 2003.
3. Digital Satellite Communications-Tri. T. Ha,2nd Ed.,MGH,1990.
4. Fundamental of Satellite Communications- K. N Raja Rao, PHI, 2004

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
USTRM101	Research Methodology	02	-	-	02	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
USTRM101	Research Methodology	-	10	5	15	40%	35	40%	50

Course Description

This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches.

Pre-requisites:-

Course Objectives

- understand the types of research and their applications and research process arising in many engineering problems.
- practice the ethical standards in research
- understand Computation of Jacobian of functions of several variables and their applications.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** Explain the types of research and their applications and research process
- **CO2** Demonstrate the ethical standards in research
- **CO3** Identify and state the research problem clearly
- **CO4** Design carries out research literature review and identify gaps in literature pertaining to a particular research issue.

Course Contents

Module	Unit	Description	Hours
1.0		**Research Fundamentals and Types**	**6**
1	1.1	Definition and objectives of Research: Research method and research methodology, Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity and reliability of research. Objective of research. Types of Research: Pure and applied research. Descriptive and explanatory research. Qualitative and quantitative approaches Ethical Issues in research	
2.0		**Research Process and Research Modelling**	**6**
2	2.1	Steps in research process Formulating the Research Problem, Literature Review, Developing the objectives, Preparing the research design including sample Design Relevance, interest, available data, choice of data, Analysis of data, Generalization and interpretation,	
3.0		**Outcome of research**	**6**
3	3.1	Outcome of Research: Design of sample surveys Sampling design, measurement and scaling, data collection ,data preparation and data analysis using various techniques Research outcomes Research papers and Publications	
4.0		**Hypothesis Formulation and Testing**	**6**
4	4.1	Probability distributions. Type I and II error, testing of mean, proportion, tests for equality of mean and variances of two populations, confidence interval, Z test and χ^2 test for goodness of fit, ANOVA (one-way classification),	
		Non-parametric tests: sign test, U test. Correlation and Regression Analysis: Karl Pearson's and Rank Correlation coefficient, simple linear regression: least squares method	
5.0		**Interpretation and Report Writing:**	6
5	5.1	Meaning Of Interpretation, Why Interpretation?, Technique Of Interpretation, Precautions In Interpretation, Significance Of Report Writing, Different Steps In Writing Report, Layout Of The Research Report, Mechanics Of Writing A Research Report, Precautions For Writing Research Report	

Text Books

1. Kothari C R, Research Methodology (Methods and Techniques), 2004, New Age International Publishers, New Delhi.

References

1. Pannnerselvam, R Research Methodology, 2014, Phi Learning Private Limited, Delhi.
2. Saravanavel P, Research Methodology, 2011, Kitab Mahal, Allahabad.
3. Kumar R. Research Methodology, 2011, SAGE Publications Asia-Pacific Ptd Singapore.
4. Singh Yogesh Kumar, 2011, Fundamental of Research Methodology and Statitics, New Age International Publishers, New Delhi.
5. Michael V P 2000, Research Methodology in Management Himalaya Publishing House, Mumbai.

Internal Assessment (T1, T2 and FET)

1. T2 should be based on First to Fourth modules, for 10 marks.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 35 marks comprise of 5 questions, each carrying 7 marks
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC104	Flight Performance Lab	-	02	-	-	01	-

Evaluation Scheme

Course Code	Course Name	In Semester Evaluation		End Semester Exam (OE/POE)		
		Term work	Min pass	Marks	Min pass	Total (Marks)
PASPC104	Flight Performance LAB	25	40%	25	40%	50

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** Develop[2] MATLAB and Simulink models to simulate and analyse aircraft and airship motions, aerodynamic properties, and flight dynamics.
- **CO2** Utilize[3] MATLAB for wind analysis, flight instrument checks, and solving aerodynamic equations to find critical flight parameters such as maximum airspeed.

List of Experiments

All the experiments will be based on the course content of **Flight Performance Lab**

Ex.No	Experiment Name
1.	Create a .M file to compute the temperature, pressure, and density with respect to altitude less than 68 km and plot the respective graphs using MATLAB.
2.	Develop a MATLAB m-file using Cessna 172 data at sea level to plot a) CL vs AoA and b) CL vs CD.
3.	Solve a fourth-degree polynomial numerically using MATLAB to find the maximum airspeed for a jet engine aircraft.
4.	Create a Simulink model and an m-file to run a simulation of the motion of the aircraft. The result should include the state vector X, output vector Y, and the forces and moments as functions of time. Show the structure of your model in a few graphs.
5.	Create a Simulink model and an m-file to run a simulation of the motion of the airship. The result should include the state vector X and output vector Y as functions of time. Assume that the centre of mass is placed on the x-axis and the air density remains constant.
6.	Conduct wind analysis using MATLAB.

7.	Check flight instruments using MATLAB.
8.	Perform flight simulator interface using MATLAB.
9.	Analyze and control flight actuators using MATLAB.

References

1. Nelson, R.C. Flight Stability and Automatic Control, McGraw-Hill Book Co., 2004
2. McCornick. W., Aerodynamics, Aeronautics and Flight Mechanics, John Wiley, NY, 1979

Evaluation Scheme

1. TERM WORK assessment shall be based on the overall performance of the student with every assignment graded from time to time.
2. The grades will be converted to marks as per 'credit and grading system' manual and should be added and averaged.
3. Based on above scheme grading and TERM WORK assessment should be done.

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Programme Structure for M. Tech. Aerospace Engineering First Year
Semester II: Teaching Scheme

Course Code	Course Name	Teaching Scheme (Hrs/week)			Credits Assigned			
		Th	Pr	Tu	Th	Pr	Tu	Total credits
PASPC201	Computational Fluid Dynamics	3	-	-	3	-	-	3
PASPC202	Hypersonic Aerodynamics	3	-	-	3	-	-	3
PASPC203	Aerospace Structure	3	-	-	3	-	-	3
PASPE201	Program Specific Elective II	3	-	-	3	-	-	3
PSTRM201	Research Publications and Ethics	2	-	-	2	-	-	2
PXXOE2XX	Open/Multidisciplinary Elective II	2	-	-	2	-	-	2
PASVS201	Software proficiency II	-	4	-	-	2	-	2
PASPC204	Hypersonic Aerodynamic Lab	-	4	-	-	2	-	2
	Total	**16**	**08**	**-**	**16**	**4**	**-**	**20**

Th: Theory, Pr: Practical, Tu: Tutorial

Programme Structure for M. Tech. Aerospace Engineering First Year
Semester II: Evaluation Scheme

Course Code	Course Name	*Theory Marks*					*Practical Marks*		Total
		Internal Assessment				SEE	Term work	Practical Oral/POE	
		T1	T2	FET	Total				
PASPC201	Computational Fluid Dynamics	10	10	5	25	50	-	-	75
PASPC202	Hypersonic Aerodynamics	10	10	5	25	50	-	-	75
PASPC203	Aerospace Structure	10	10	5	25	50	-	-	75
PASPE201	Program Specific Elective II	10	10	5	25	50	-	-	75
PSTRM201	Research Publications and Ethics	-	10	5	15	35	-	-	50
PXXOE2XX	Open/Multidisciplinary Elective II	-	10	5	15	35	-	-	50
PASVS201	Software proficiency II	-	-	-	-	-	50	-	50
PASPC204	Hypersonic Aerodynamic Lab	-	-	-	-	-	25	25	50

FET – Faculty evaluation for Theory, T1, T2, Continuous Assessment Test, Term, SEE - Semester End Examination

Exit Option: Students who exit at the end of first year shall be awarded a PG Diploma after successful completion of first year with additional 4 credits earned through industry internship/field work/ vocational training/generic course/(s).

Program Specific Elective		
II	PASPE201	Propellant Technology
	PASPE202	Boundary Layer Theory

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC201	Computational Fluid Dynamics	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC201	Computational Fluid Dynamics	10	10	5	25	40%	50	40%	75

Course Description

This course is at second semester of first year Aeronautical Engineering. The Computational Fluid Dynamics (CFD) course explores numerical methods for analysing fluid flow and heat transfer. It covers governing equations, discretization techniques, and solution algorithms. Students learn to use CFD software to model real-world engineering problems, making it essential for those pursuing careers in aerospace engineering.

Pre-requisites: B. Tech Mechanical/Aeronautical

Course Objectives

This course will enable the students

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

Course Outcomes: The students will be able to,

CO1 **Explain**^{2} numerical solutions of CFD.

CO2 **Apply**^{3} various grid generation techniques.

CO3 **Create**^{4} numerical modeling and its role in the field of fluid flow and heat transfer

CO4 **Apply**^{3} various time dependent methods, panel methods in Computational fluid dynamic problems.

Course Contents

Module	Unit	Description	Hours
1.0		**Numerical Solutions Of Some Fluid Dynamical Problems**	**9**
1	1.1	Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, Stability analysis of linear system.	
	1.2	Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations,Numerical integration and shooting technique.	
	1.3	Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations.	
2.0		**Grid Generation**	**9**
2	2.1	Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions.	
	2.2	Boundary point control – orthogonality of grid lines at boundaries. Elliptic grid generation using -Laplaces equations for geometries like airfoil and CD nozzle.	
3.0		**Transonic Relaxation Techniques**	**9**
3	3.1	Small perturbation flows, Transonic small perturbation (TSP) equations, Central and backward difference schemes, conservation equations and shock point operator.	
	3.2	Line relaxation techniques, Acceleration of convergence rate, Jameson's rotated difference scheme -stretching of coordinates, shock fitting techniques Flow in body fitted coordinate system.	
4.0		**Time Dependent Methods**	**9**
4	4.1	Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Sometime dependent solutions of gas dynamic problems.	
	4.2	Numerical solution of unsteady 2-D heat conduction problems using SLOR methods	

5.0		**Panel Methods**	**9**
5	5.1	Elements of two- and three-dimensional panels, panel singularities. Application of panel methods to incompressible, compressible, subsonic and supersonic flows.	
	5.2	Numerical solution of flow over a cylinder using 2-D panel methods using both vertex and source panel methods for lifting and non- lifting cases respectively.	

Text Books

1. A.A. Hirsch, 'Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.
2. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.

References

1. H.J. Wirz and J.J. Smeldern "Numerical Methods in Fluid Dynamics", McGraw-Hill & Co., 1978.
2. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.
3. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
4. T.K.Bose, "Computation Fluid Dynamics" Wiley Eastern Ltd., 1988.

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC202	Hypersonic Aerodynamics	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC202	Hypersonic Aerodynamics	10	10	5	25	40%	50	40%	75

Course Description

This course delves into hypersonic aerodynamics, exploring thin shock layers, entropy layers, and the behavior of both low and high-density flows. It covers surface inclination methods, approximate inviscid flow theories, and viscous hypersonic flow theory, including boundary layers and aerodynamic heating. Emphasis is placed on the interactions between shock waves and boundary layers in hypersonic conditions

Course Objectives

- Understand thin shock layers, entropy layers, and the characteristics of low and high-density flows in hypersonic flight.
- Learn to apply local surface inclination methods and theories to calculate surface flow properties.
- Utilize approximate methods and theories to analyze inviscid hypersonic flow behavior and shock wave correlations.
- Examine the interactions between shock waves and boundary layers, and the role of similarity parameters in hypersonic viscous flow.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1 Explain**^{2} the fundamental knowledge of hypersonic flows
- **CO2 Explain**^{2} the surface inclination methods
- **CO3 Calculate**^{3} the characteristics of hypersonic flow by using approximate methods
- **CO4 Select**^{4} the appropriate hypersonic viscous flow analysis
- **CO5 Select**^{4} the experimental measurement devices for hypersonic flow

Course Contents

Module	Unit	Description	Hours
1.0		**Basics Of Hypersonic Aerodynamics**	**9**
1	1	Thin shock layers – entropy layers – low density and high density flows – hypersonic flight paths hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.	
2.0		**Surface Inclination Methods for Hypersonic Inviscid Flows**	**9**
2	2	Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties	
3.0		**Approximate Methods for Inviscid Hypersonic Flows**	**9**
3	3	Approximate methods hypersonic small disturbance equation and theory – thin shock layer theory – blast wave theory - entropy effects - rotational method of characteristics - hypersonic shock wave shapes and correlations.	
4.0		**Viscous Hypersonic Flow Theory**	**9**
4	4	Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux estimation.	
5.0		**Viscous Interactions in Hypersonic Flows**	9
5	5	Weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.	

Text Books

1. J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 5th edition 2010
2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 5th edition, 2013.
3. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.

References

1. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd Edition 1999
2. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC203	Aerospace Structure	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPC203	Aerospace Structure	10	10	5	25	40%	50	40%	75

Course Description

This course is a fundamental course dealing with analysis of thin-walled aircraft structures required for design of aerospace vehicles. The course primarily discusses analysis of thin-walled aircraft structures under torsion, shear and bending loads from the concepts of theory of elasticity.

Pre-requisites:

Course Objectives

- Understand the basic principles and theories related to aerospace structures.
- Identify and describe the different types of loads and stresses experienced by aerospace structures.
- Learn about the materials commonly used in aerospace structures, such as metals, composites, and alloys.
- Understand the mechanical properties of these materials and their impact on structural design.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Analyze**[4] various types of aircraft and spacecraft components based on its configurations.
- **CO2** **Analyze**[4] shear flow and shear centre in thin wall sections.
- **CO3** **Explain**[2] structural instability in thin plates.
- **CO4** **Calculate**[3] bending, shear and torsion of thin-walled beams.
- **CO5** **Describe**[2] smart materials and adaptive materials

Course Contents

Module	Unit	Description	Hours
1.0		**Analysis of Structural Components and Loads of Aircraft**	**9**
1	1.1	Loads on Structural components, Function of structural components, Fabrication of structural components, Connections; Airworthiness: Factors of Safety- flight envelope	
	1.2	Load factor determination, Airframe loads: Aircraft inertia loads, Symmetric maneuver loads, Normal accelerations associated with various types of maneuvers, Gust loads.	
2.0		**Shear Flow and Shear Centre in Open and Closed Thin Wall Sections**	**9**
2	2.1	Open Sections:Shear center and elastic axis, Concept of shear flow, Beams with one axis of symmetry;	
	2.2	Closed Sections: Bradt-Batho formula, Single and multi-cell closed box structures,	
	2.3	Semi monocoque and mono cocque structures,	
	2.4	Shear flow in single and multi cell monocoque and semi monocoque box beams subject to torsion	
3.0		**Structural Instability in Thin Plates**	**9**
3	3.1	Bending of thin plates having a small initial curvature, Energy method for bending of thin plates; Structural Instability in Thin Plates:	
	3.2	Buckling of thin plates, Inelastic buckling of plates, Experimental determination of critical loads for a flat plate, Local instability, Instability of stiffened panels.	
4.0		**Bending, Shear and Torsion of Thin-Walled Beams**	**9**
4	4.1	Calculation of section properties, Applicability of bending theory, Temperatur effects;	
	4.2	Shear of Beams: General stress, strain and displacement relationships for open and single cell closed section thin-walled beams.	
	4.3	Combined Open and Closed Section Beams: Bending, Shear, Torsion	

5.0		**Smart Materials**	9
5	5.1	Smart Materials Technologies and Control Applications: Control requirements,	
	5.2	Smart Materials-Piezoelectric elements, Electrostrictive elements, Magentostrictive transducers, Electrorheological fluids, Shape memory alloys.	

Text Books

1. Aircraft Structures for Engineering Students , Fourth Edition, T. H. G. Megson, Butterworth-Heinemann, Elsevier Ltd, 2007

References

1. Airplane Structural Analysis and Design, Earnest E. Sechler, Lois G. Dunn, Dover Publications, 1963
2. Theory and Analysis of Flight Structures, Robert M. Rivello, McGraw-Hill, 19AS
3. Mechanics of Aircraft Structures, Second Edition, C. T. Sun, John Wiley & Sons, 2006.

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPE201	Propellant Technology	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPE201	Propellant Technology	10	10	5	25	40%	50	40%	75

Course Description

This course is at second semester of first year Aeronautical Engineering. It covers about liquid fuels and different types of propellants such as cryogenic, liquid and solid propellants. It explains the propellant testing and its theory.

Pre-requisites: B.Tech – Propulsion/Rocket Propulsion.

Course Objectives

- To acquire the knowledge on the liquid fuels and solid propellants.
- To learn the cryogenic propellants.
- To know the concepts of liquid propellants
- To learn the concept of propellant testing.
- To learn the theory of propellants.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Explain**[2] various types of aircraft and spacecraft fuels.
- **CO2** **Explain**[2] various types of solid propellants.
- **CO3** **Describe**[2] properties of cryogenic propellants.
- **CO4** **Describe**[3] the studies of ignition of liquid propellants.
- **CO5** **Analyze**[4] thermo-gravimetric propellant testing.

Course Contents

Module	Unit	Description	Hours
1.0		**Liquid Fuels and Solid Propellants**	**9**
1	1.1	Properties and tests for petroleum products, Motor gasoline, Aviation gasoline, Aviation turbine fuels, Requirements of aviation fuels of kerosene type and high flash point type, Requirements for fuel oils.	
	1.2	Single base propellants, Double base propellants, Composite propellants, CMBD propellants, Metalized composite propellants. Introduction to different fuels and oxidizers of composite propellants. Brief introduction to composite theory of composite and double base propellants	
2.0		**Cryogenic Propellants**	**9**
2	2.1	Introduction to cryogenic propellants, Liquid hydrogen, liquid oxygen, liquid nitrogen and liquid nitrogen and liquid helium and their properties.	
3.0		**Liquid Propellants**	**9**
3	3.1	Various liquid propellants and their properties, Monopropellants and bipropellant system, concept of ullage, Ignition studies of liquid propellants. Propellant loading tolerances, inventory, Volume versus mass loading. Loading measurement and control, Outage control.	
4.0		**Propellant Testing**	**9**
4	4.1	Laboratory testing, Arc Image Furnace, Ignitability studies. Differential Thermal Analysis, Thermo-gravimetric analysis, Particle size measurement Micro-merograph Strand burner tests impulse bomb, Performance estimation.	
5.0		**Theory of Propellants**	9
5	5.1	Behind the production of low temperature, Expansion engine, Cascade process, Joule Thompson effect, Magnetic effect, Ortho and para H2, Helium 4 and Helium 3. Ideal cycles and efficiency of cryo systems, Storing of cryogenic propellants, Cryogenic loading problems.	

Text Books

1. Cornelissse J. W. (1980), Rocket Propulsion and Space Dynamics, Pitman Publishing, London.

References

1. Shutton, G. P. (2010), Rocket Propulsion Elements, John Wiley / BSP Books, USA.
2. Samir Sarkar (2009), Fuels and Combustion, 3rd edition, Universities Press /CRC Press, New York
3. Mathur M, Sharma R. P. (2010), Gas Turbine and Jet and Rocket Propulsion, Standard Publishers, New Delhi.

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPE202	Boundary Layer Theory	03	-	-	03	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
		T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
PASPE202	Boundary Layer Theory	10	10	5	25	40%	50	40%	75

Course Description

This course deals about the basics of laminar boundary layer theory. You will explore how to analyze and describe a tiny viscous region that surrounds the body, the boundary layer, and how to estimate the drag acting on the body. A course completion badge allows you to showcase your success.

Pre-requisites:

Course Objectives

- Grasp the fundamentals of fluid mechanics, including viscosity, laminar and turbulent flow, and the Navier-Stokes equations.
- Define and describe the boundary layer and its characteristics.
- Develop the ability to derive and solve the boundary layer equation.
- Apply similarity solutions and scaling laws to simplify and solve boundary layer problems.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Identify**[2] the relationship between different boundary layer transport phenomena.
- **CO2** **Evaluate**[3] separation of boundary layer and how it affects the form drag and total drag
- **CO3** **Solve**[3] the flat plate boundary layer equations by similarity and integral methods
- **CO4** **Evaluate**[3] exact and approximate solutions to thermal boundary layer flows relation
- **CO5** **Evaluate**[3] different options for boundary layer control of aerodynamic systems

Course Contents

Module	Unit	Description	Hours
1.0		**Introduction**	**9**
1	1.1	A general review of basic concepts, physics and mathematical descriptions of viscous flow; BL parameters; Prandtl Laminar BL equations	
2.0		**Navier-Stokes Equation and its Application**	**9**
2	2.1	Navier-Stokes equations and some of the exact solutions; Understand the boundary layer model and different analytic methods.	
3.0		**Solution To Boundary Layer**	**9**
3	3.1	Flat plate at zero angle of incidence, method of exact solution Blassius solution to boundary layer problems,	
	3.2	Approximate solutions - Vonkarman solution to boundary layer flows over the flat plate, flow with pressure gradient, flow over a cylinder, plane Couette flow, flow between parallel plates.	
4.0		**Thermal Boundary Layers**	**9**
4	4.1	Heat transfer from heated surface. Heat transfer from cold surface, thermal boundary layer growth over the hot and cold surface,	
	4.2	Flow over the flat plate with different flow conditions with heat transfer, exact and approximate solutions to thermal boundary layer flows relation between thermal and hydrodynamic boundary layer theories,	
	4.3	Reynolds analogy and Colburn analogy, non-dimensional numbers governing boundary layer flows.	
5.0		**Boundary Layer Control**	9
5	5.1	Need of boundary layer control, causes of boundary layer separation, flow over the cylinder and aerofoil for different flow conditions leads separation,	

	5.2	Advanced Boundary layer Theory, Similarity solutions to the BL equations (other than a flat plate); Similarity solutions to thermal BL; Energy Equation in thermal BL.	

Text Books

1. Schlichting, H. and Gersten, K., Boundary Layer Theory, 8th edition, 2000, springer.
2. Panton, R. L., Incompressible Flow, 3rd edition, 2006, Wiley

References

1. Bansal, R.K., ―Fluid Mechanics and Hydraulics Machines‖, (5th edition), Laxmi publications(P) Ltd., New Delhi, 1995.
2. White, F.M., ―Fluid Mechanics‖, Tata McGraw-Hill, 5th Edition, New Delhi, 2003.
3. Ramamirtham, S., ―Fluid Mechanics and Hydraulics and Fluid Machines‖, Dhanpat Rai and Sons, Delhi, 1991.
4. Som, S.K., and Biswas, G., ―Introduction to fluid mechanics and fluid machines‖, Tata McGraw Hill, 2nd edition, 2004

Internal Assessment (T1, T2 and FET)

1. T1 (Test 1) should be based on first two modules and T2 (Test 2) should be based on next two modules, for 10 marks each.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 50 marks comprise of 5 questions, each carrying 10 marks.
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all 5 questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

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Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
PSTRM201	Research Publications and Ethics	Theory	Practical	Tutorial	Theory	Practical	Tutorial
		02	-	-	02	-	-

Evaluation Scheme

Course Code	Course Name	Evaluation Scheme (In Semester)					End Semester Exam (ESE)		
PSTRM201	Research Publications and Ethics	T1	T2	FET	Total	Min pass	Marks	Min pass	Total (Marks)
		-	10	5	15	40%	35	40%	50

Course Description

This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches.

Course Objectives

- To know research ethics.
- To understand research approaches and their applications.

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** **Identify**[4] the ethical standards in research
- **CO2** **Analyse**[4] research literature review and identify gaps in literature pertaining to a particular research issue.
- **CO3** **Design**[5] and conduct research
- **CO4** **Describe**[6] the outcomes of research by preparing a paper for publication or patenting

Course Contents

Module	Unit	Description	Hours
1.0		**Publication ethics:**	**6**
1	1.1	definition, introduction, and importance - best practices / standards setting initiatives and guidelines: COPE, WAME, etc. - Conflicts of interest -	
	1.2	Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types - Violation of publication ethics, authorship, and contributor ship - Identification of publication misconduct, complaints, and appeals - Predatory publisher and journals.	
2.0		**Ethics with respect to science and research -**	**6**
2	2.1	Intellectual honesty and research integrity - Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP) - Redundant Publications: duplicate and overlapping publications,	
	2.2	salami slicing - Selective reporting and misrepresentation of data.	
3.0		**Open access publications and initiatives -**	**6**
3	3.1	SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finger / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggester, etc.	
4.0		**Databases:**	**6**
4	4.1	Indexing databases, Citation databases: Web of Science, Scopus, etc. Research Metrics: Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP,.	
	4.2	Cite Score - Metrics: h-index, g index, i10 Index, altmetrics	

Text Books

1. Gupta S. C. and Kapoor V. K, Fundamentals of Mathematical Statistics, Sultan Chand & Company New Delhi.
2. Creswell, J. W. Research design: Qualitative, quantitative, and mixed methods approach. 5th Ed. Thousand Oaks, CA: Sage, 2018.

References

1. Nicholas H. Steneck. Introduction to the Responsible Conduct of Research. Office of Research Integrity. 2007. Available at: https://ori.hhs.gov/sites/default/files/rcrintro.pdf
2. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
3. Gupta S. C. and Kapoor V. K, "Fundamentals of Mathematical Statistics", Sultan Chand & Company New Delhi.

Internal Assessment (T1, T2 and FET)

1. T2 should be based on First to Fourth modules, for 10 marks.
2. FET shall be assessed for 5 marks separately.

End Semester Examination

1. Question paper will be of 35 marks comprise of 5 questions, each carrying 7 marks
2. The duration of end semester examination shall be Two hours.
3. The students need to solve all questions.
4. Question No.1 will be compulsory and based on entire syllabus.
5. Remaining question (Q.2 to Q.5) will be selected from all the modules.

Course Code	Course Name	Teaching Scheme (Hr/week)			Credits Assigned		
		Theory	Practical	Tutorial	Theory	Practical	Tutorial
PASPC204	Hypersonic Aerodynamics Lab	-	04	-	-	02	-

Evaluation Scheme

Course Code	Course Name	In Semester Evaluation		End Semester Exam (OE/POE)		
		Term work	Min pass	Marks	Min pass	Total (Marks)
PASPC204	Hypersonic Aerodynamics Lab	25	40%	25	40%	50

Course Outcomes: After the successful completion of the course students will able to:

- **CO1** Understand and analyze the behavior of flow over various aerodynamic shapes and surfaces at hypersonic speeds, including flat plates, wedges, supersonic airfoils, pitot tubes, and re-entry bodies.
- **CO2** Evaluate and interpret the formation, interaction, and effects of shock waves and expansion waves in supersonic and hypersonic flow, including oblique shocks, attached and detached shocks, and shock wave reflections from solid boundaries.

List of Experiments

All the experiments will be based on the course content of **Hypersonic Aerodynamics Lab**

Ex.No	Experiment Name
1.	Introduction to Hypersonic Wind Tunnels
2.	Flow Over a Flat Plate at Mach 5
3.	Pressure Distribution on a Wedge Section
4.	Pressure Distribution on a Supersonic Airfoil Shape
5.	Flow Analysis on a Pitot Tube at Hypersonic Speeds
6.	Supersonic Flow Over a Corner: Oblique Shock Wave
7.	Supersonic Flow Over a Corner: Expansion Wave
8.	Analysis of Attached and Detached Shock Waves
9.	Reflection of a Shock Wave from a Solid Boundary

10. Flow Over a Re-entry Body

References

1. John D. Anderson, Jr, Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2. John.D.Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series

Evaluation Scheme

1. TERM WORK assessment shall be based on the overall performance of the student with every assignment graded from time to time.
2. The grades will be converted to marks as per 'credit and grading system' manual and should be added and averaged.
3. Based on above scheme grading and TERM WORK assessment should be done.