ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 4

(Syllabi for Aerospace Engineering Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Contents (Volume - 4)

Syllabi for Higher Semester (3 - 8) Aerospace Courses

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ASC201J	Course Name	ELEMENTS OF AEROSPACE ENGINERING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*recognize the art of flying*															
CLR-2:	*determine variation of pressure, temperature, density in the layers of atmosphere and their effect on the flying objects*															
CLR-3:	*discuss about the types of construction of aircraft and the aircraft stability*															
CLR-4:	*develop deep understanding on aircraft performance and working of powerplants*															
CLR-5:	*describe about the working of various types of satellites, spacecraft trajectories and orbital mechanics*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*discuss the evolution of aircraft and their types*	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*describe about the atmosphere and variation in properties, aircraft flight and different speed regimes*	3	1	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*explain the basics of aircraft structures, aerospace materials and airplane stability*	3	-	-	-	-	-	-	-	-	-	-	1	3	-	-
CO-4:	*describe the various performance parameters of aircraft and powerplants*	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*discuss about the basics of spacecraft trajectories, orbital mechanics and satellite operation*	3	-	-	-	-	-	-	-	-	-	-	1	3	-	-

Unit-1- Evolution of Aerospace Engineering	***12 Hour***
History of Aviation – Classification of Aircraft and Spacecraft - Anatomy of flight vehicles – Modern Developments in Aviation.	
Unit-2- Aerodynamics	***12 Hour***
International Standard Atmosphere – Pressure, Temperature and Density Altitude - Bernoulli's equation - Forces and Moments acting on aircraft–Lift generation - Aerofoil - NACA Nomenclature – Drag Polar – Manoeuvers - Classification of fluid flows.	
Unit-3- Aircraft Stability and Structural Theory	***12 Hour***
Degree of Freedom of aircraft motions – Stable, Unstable and Neutral Stability – Concept of Static Stability – Aircraft Construction – Types of Construction – Flight Envelope and V-n diagrams –Evolution of Aerospace Materials	
Unit-4- Performance and Propulsion	***12 Hour***
Takeoff and landing, cruising, climbing, gliding and turning flights - Range and Endurance, Ceiling - Types of Power Plants – Air-breathing engines - Relative merits of Piston engines and Gas Turbine engines - Comparison based on performance characteristics – Types of Rockets – Typical Applications – Case Study	
Unit-5- Space Applications	***12 Hour***
Spacecraft Trajectories and Basic Orbital Mechanics – Six orbital Elements – Kepler Law of Orbits – Newton's Law of Gravitation – Principles of Satellite Operation – Types and Applications – Space Debris – Case Study on Launch Vehicles.	

Practice:
1. Construction of Hunter Catapult Chuck Glider. *2. Construction of Hopper Chuck Glider.* *3. Training in flight Maneuvering through computer simulation* *4. Estimation of Centre of Gravity and Balancing of Fixed Wing UAV* *5. Estimation of Weight and Payload of Fixed Wing UAV.* *6. Propeller Balancing Procedure.* *7. Assembling Avionic components in Quadcopter Configuration.* *8. Calibration and Drone Flight Controller Programming* *9. Calibration and Estimation of Motor’s Thrust with Various Electronic Speed Controllers and Propellers.* *10. Image Transmission of a First-Person View System*

Learning Resources	*1. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd ed., McGraw-Hill (2009).* *2. John D. Anderson, Introduction to Flight, 8th Ed., McGraw-Hill Education, New York, 2015.* *3. Kermode, A.C., “Mechanics of Flight”, Himalayan Book, 1997.* *4. Szebehely, V. G. and Mark, H., Adventures in Celestial Mechanics, 2nd ed., Wiley (1998).*	*5. Turner, M. J. L., Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, 3rd ed., Springer (2009).* *6. Stephen. A. Brandt, "Introduction to Aeronautics: A design perspective" American Institute of Aeronautics & Astronautics, 1997.* *7. Laboratory Manual*

Learning Assessment							
		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom’s Level of Thinking	*Formative CLA-1 Average of unit test (45%)*		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*35%*	*-*	*-*	*35%*	*50%*	*-*
Level 2	*Understand*	*45%*	*-*	*-*	*40%*	*50%*	*-*
Level 3	*Apply*	*20%*	*-*	*-*	*20%*	*-*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Wg.Cdr retd. Manoharan, Continuing Airworthiness Manager, Blue Dart Aviation. manoharank@bluedart.com	*1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com*	*1. Dr. T. Selvakumaran, SRMIST*
2. Wg.Cdr R.Annamalai, Chief training co-ordinating officer, IAF,Tambaram. annamalai.ramasamy2@gmail.com	*2. Dr.S.Nadaraja Pillai, Department of Mechanical Engineering, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	*2. Mr. G. Mahendra Perumal, SRMIST*

Course Code	21ASC202T	**Course Name**	APPLIED SOLID MECHANICS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the concept of stress-strain behavior of a bar element subjected to different types of loading*
CLR-2:	*calculate the variation of shear force, bending moments and bending stress in various beams subjected to different loads*
CLR-3:	*calculate the slope and deflection of beams with double integration, Macaulay's and moment area method*
CLR-4:	*calculate the Torsional strength of solid and hollow shafts, different springs for different loads*
CLR-5:	*calculate the principal stresses for element subjected to loading on an oblique plane and stresses generated in thin and thick hollow type cylinders*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*determine the stress-strain behavior of a bar element subjected to different types of loading*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-	-
CO-2:	*sketch the SF & BM diagrams for cantilever and simply supported beams and also solve stresses using pure bending theory*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*	-	-
CO-3:	*determine the slope and deflection of beams using double integration, Macaulay's and moment area method*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-4:	*determine the Torsional strength of solid and hollow shafts, different springs for different loads*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*determine principal stresses for various loading and stresses generated in thin and thick hollow type cylinders*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-

Unit-1 - Concept of Stresses and Strains	***9 Hour***
Yield. Concept of stress, strain and volumetric strain, Hooke's law Tension, compression and shear; Poisson's ratio, elastic constants; Analysis of bar of uniform and varying sections.; Analysis of composite bars; Thermal stresses-concepts, support	
Unit-2- Analysis of Beams	***9 Hour***
Concept of Shear force and bending moment diagram and their sign conventions. Plot of SF & BMD for the simply supported beam, cantilever beam & over hanging beams for loads like point load, UDL, UVL and a couple; Concept of point of contra flexure.; introduction to bending stress, pure bending stress derivation. Concepts of section modulus and Moment of resistance. Concept of shear stress and its distribution for different symmetric and unsymmetrical beam sections.	
Unit-3- Deflection of Beams	***9 Hour***
Relationship between deflection, slope, the radius of curvature, shear force and bending moment.; finding slope and deflection of a cantilever beam, simple supported beam & Cantilever beam with a point load and UDL.; By Double integration method and Macaulay's method, By moment area method	
Unit-4 – Torsion of Circular Shafts and Springs	***9 Hour***
Theory of pure torsion, derivation of shear stress produced in a circular (solid & hollow) shaft subjected to torsion.; Expression for torque in terms of polar moment of inertia Strength, stiffness of the shaft and Torsional rigidity & power of solid and hollow shafts. Strain energy due to torsion - concepts, Shaft subjected to combined bending and torsion. Introduction to helical springs. Derivation of expression to find parameters for close-coiled helical springs	

Unit-5 – Biaxial Stresses and Thin & Thick Pressure Vessels	***9 Hour***

Principal plane, principal stress, Analytical & Mohr's circle method- direct stress in one plane, two mutually perpendicular directions and two mutually perpendicular directions accompanied by a simple shear; Thin cylindrical vessel subjected to an internal pressure; Change in dimensions due to internal pressure. Stresses in Thick cylinders –Lame's theory, Stresses in compound thick cylinder, Concept of shrink fit.

Learning Resources	1. *Beer, Ferdinand P.|Johnston Jr., E. Russell|DeWolf, John T.|Mazurek, David F.|Sanghi, Sanjeev,Mechanics of Materials, 8th Edition (in SI Units)., Tata McGraw-Hill Education, 2020* 2. *Egor P. Popov., Engineering Mechanics of Solids, 2nd ed., Prentice Hall of India, 20152*	3. *Barry J. Goodno, James M. Gere, Mechanics of Materials, 9th ed., Cl-Engineering, 2017* 4. *Shigley, J. E., Applied Mechanics of Materials, International Student Edition, McGraw Hill, 2000*

Learning Assessment							
		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*		*-*		*-*
Level 5	*Evaluate*	*-*	*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. T.Selvakumaran SRMIST*
2. *Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, NIT Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Mr. K.B.Ravicahndrakumar SRMIST*

Course Code	21ASC203T	Course Name	APPLIED FLUID MECHANICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*solve the flow properties of fluids at rest and fluids in motion*
CLR-2:	*use the suitable governing equations for solving fluid flow problems*
CLR-3:	*determine the exact solutions to various inviscid and viscous flow problems*
CLR-4:	*identify the suitable parameters involved in a fluid flow problem for planning experiments*
CLR-5:	*predict the flow nearer to the walls of an object and its effect on the aerodynamic drag*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the principles of fluid statics and fluid kinematics to fluid flows*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*model the fluid flow problems using Control volume and differential analysis*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*apply Navier-Stokes equations to obtain solutions to simplified flow configurations*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*solve potential flows around bodies*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*determine dimensionless numbers and characteristics of boundary layer around bodies*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Fluid Statics and Fluid Kinematics	***9 Hour***
Concept of Continuum, properties of Fluid, Fluid Statics, Manometry, Fluid Kinematics, Lagrangian and Eulerian Approach, Acceleration field, Types of Fluid flows, Streamlines Pathlines and Streaklines	
Unit-2- Control Volume and Differential Formulations	***9 Hour***
System and Control volume concepts, Reynolds Transport Theorem, Conservation of Mass, Momentum and Energy, Control Volume Analysis, Differential Formulation, Navier-Stokes Equations, Euler's equations, Bernoulli's equation and its applications	
Unit-3- Viscous Flows	***9 Hour***
Viscous flows – Simple Solutions to Navier-Stokes equations – Coutte flow and Poiseuille flow, Flow through pipes, Hagen Poiseuille equation, Darcy-Weisbach equation, Pipe friction, Moody's Chart	
Unit-4 – Potential Flows	***9 Hour***
Stream function and Velocity Potential, Basic Potential Flows – Uniform Flow, Source, Vortex and Doublet, Superposition of basic potential flows – Stationary and Rotating cylinder, Magnus effect	
Unit-5– Dimensional Analysis and Boundary Layer Theory	***9 Hour***
Dimensional Analysis – Buckingham-PI Theorem - Modelling and Similitude, Boundary layer theory - Boundary Layer Separation - Lift and Drag over immersed bodies	

Learning Resources	*1. Bruce R. Munson, Donald F. Young, Theodore H.Okiishi, Wade W. Huebsch, Fundamentals of Fluid Mechanics, 7th ed., John Wiley & Sons, Inc. 2016* *2. Yunus Cengel, and John Cimbala. Fluid Mechanics Fundamentals and Applications. 4th ed., McGraw Hill Education, 2018.*	*3. Frank M. White, Fluid mechanics. 8th ed McGraw Hill Education, 2016* *4. S K Som, Gautam Biswas, S Chakraborthy. Introduction to Fluid Mechanics and Fluid Machines, 3rd ed., McGraw Hill Education, 2017.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Exper**
1. Dr. Saurav Kumar Ghosh, CSIR-NAL, Bangalore skghosh@nal.res.in	*1. Dr. Lakshmana Dora C, IIT Hyderabad handrala@mae.iith.ac.in*	*1. Dr. S Senthilkumar, SRMIST*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. Arun Kumar Perumal, IIT Kanpur,akp@iitk.ac.in*	*2. Dr. K K Bharadwaj, SRMIST*

Course Code	21ASC204T	**Course Name**	INCOMPRESSIBLE AERODYNAMICS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	*0*	*0*	*3*

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*determine the aerodynamic forces and moments acting on different bodies*
CLR-2:	*determine thin airfoil flow properties*
CLR-3:	*predict the aircraft wing flow characteristics*
CLR-4:	*predict the aircraft propeller performance*
CLR-5:	*apply the methods for flow interference and separation control*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate the distribution of pressure and shear stress on various bodies*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*calculate the aerodynamic forces and moments of the thin airfoil*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*determine the aerodynamic properties of different aircraft wing*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*determine the aircraft propeller thrust and aerodynamic characteristics*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-5:	*examine flow interference effect, and flow separation control methods*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-

Unit-1 - Aerodynamic Forces and Moments	***9 Hour***
Introduction to Aerodynamics - Airfoil geometry and nomenclature - Experimental characteristics of airfoil - Wing geometrical parameters - Critical Mach numbers, drag divergence Mach number - Vortex types, vortex filament, vortex sheet – Starting vortex - Kutta condition and kelvin's circulation theorem - Helmholtz's theorem - Lift generation – Trailing vortices - Bound and horseshoe vortex - Kutta Joukowski theorem - Aerodynamic forces and moments - Types of drag	
Unit-2 - Airfoil Theory	***9 Hour***
Center of pressure - Aerodynamic center - Thin airfoil theory assumptions and limitations – Aerodynamic characteristics of thin symmetrical airfoil – Aerodynamic characteristics of thin unsymmetrical airfoil- High lift devices - Aerodynamic characteristics of thin Flapped airfoil	
Unit-3 - Wing Theory	***9 Hour***
The Biot-savart law and its Application - Downwash, induced drag and induced velocity – Lift distribution on wings - Prandtl's lifting line theory - Applications of Prandtl's lifting line theory - Elliptical lift Distribution - General lift Distribution - Lift slope relation - Influence of taper and twist applied to wings - Effect of sweep back and delta wings	
Unit-4 – Propeller Theory	***9 Hour***
Geometry of the propeller - Forces acting on Propeller - Types of Propellers - Propeller arrangements - Pressure and velocity distribution across the propeller and wind turbine - Axial momentum theory assumptions and limitations - Axial momentum theory - Blade-element theory - Combined blade element and momentum theories, and performance of propellers.	
Unit-5 – Computational Methods and Flow Control	***9 Hour***
Flow past non-lifting bodies - Introduction to panel method - Source panel method and its Application - Vortex panel method and its Application - Vortex lattice method and its application – Flow past bodies using computational tools - Interference drag of an airplane – Turbulent Boundary Layer - Flow separation and control methods - Introduction to CFD	

Learning Resources	1. *Houghton, E, L., Carruthers, N, B., Aerodynamics for Engineering Students, 6th ed., Edward Arnold Publishers Ltd., London, 2012* 2. *Anderson, J, D., Fundamentals of Aerodynamics,6th ed., McGraw Hill, 2016*	3. *Clancy, L, J., Aerodynamics, Sterling Book House, 2006* 4. *John J. Bertin, Russell M. Cummings, Aerodynamics for Engineers, Pearson, 2014* 5. *Sighard F. Hoerner, Fluid-dynamic Drag: Practical Information on Aerodynamic Drag and Hydrodynamic Resistance, Hoerner Fluid Dynamics, 1992*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr.Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in*	1. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	1. *Dr. Mohamed Arif R, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. Lakshmana Dora Chandrala, IIT Hyderabad, chandrala@mae.iith.ac.in*	2. *Dr. Bharadwaj K K, SRMIST*

Course Code	21ASC205T	Course Name	AERO ENGINEERING THERMODYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the engineering and practical applications of Heat, Energy and Work*
CLR-2:	*identify the applications of Thermodynamics on Engineering systems*
CLR-3:	*identify the significance of Thermodynamic Laws*
CLR-4:	*utilize the Thermodynamic concepts in physics for the broad understanding of Engineering and Technology*
CLR-5:	*analyze the working principle of Heat Energy driven systems*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand laws of Thermodynamics and its applications to Aerospace Engineering*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-2:	*comprehend the concept and applications of energy, entropy and exergy*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*understand various gas and vapor power cycles with applications*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*apply the Thermodynamic Principles to Aerospace Engineering Applications*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*understand the gas mixture behavior and chemical reactions*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - First Law of Thermodynamics ***9 Hour***

Basic Concepts: Microscopic & macroscopic point of view, Path and point functions. Intensive and extensive, total and specific quantities. System and their types. Zeroth law of thermodynamics, Thermodynamic equilibrium. First law of Thermodynamics: First law for a closed system undergoing a cycle, concept of Internal energy, change of state. Energy and Work Transfer in closed systems, P-V diagram, PMM1. First law for an Open system: Conservation of mass, energy, steady flow energy equation. Applications of SFEE to Nozzles, Diffusers. Types of turbines, compressor, boiler, pump. Heat exchanger and Throttling process

Unit-2 - Second Law of Thermodynamics ***9 Hour***

Limitations of the first law of Thermodynamics - Introduction to heat reservoirs, sources and sinks. Heat Engine, Refrigerator and Heat pump. Thermal efficiency of heat engines, COP - Second law of Thermodynamics - Kelvin-Planck statement, Clausius statement and their equivalence. Reversible and irreversible processes- causes of irreversibility. Carnot Theorem and corollary. Absolute Thermodynamic Temperature scale. Carnot cycle and its performance

Unit-3 - Third Law of Thermodynamics and Entropy ***9 Hour***

Limitations of Second Law of Thermodynamics. Explanation of the Concept of Entropy. Clausius inequality, T-s diagram. Entropy changes for different processes. Principle of increase of Entropy, p-v-t behavior and properties of ideal gas mixtures. Dalton's law of partial pressures, Avogadro's law. Gibbs-Dalton law, enthalpy and specific heat of a gas mixture. Maxwell relations, T-ds Equations, Difference and ratio of heat capacities. Energy equation, Joule Thomson Coefficient, Clausius-Clapeyron equation. Entropy changes of Ideal and Real gases. Isentropic efficiencies of steady flow devices. Exergy- High and low-grade energy. Available and unavailable energy of a source and finite body.

Unit-4 - Air Standard Cycles ***9 Hour***

Otto cycle, Diesel cycle, Dual cycle. Indicator diagram, Air standard efficiency, Mean effective pressure. Brayton cycle - Effect of Reheat, Regeneration and Intercooling. Isentropic efficiency of Turbine and Compressor. Equivalent Carnot cycles- Stirling and Ericsson cycle, Humphrey cycle.

Unit-5 - Basic Concepts, Heat Transfer and Combustion	***9 Hour***
Modes of heat transfer- conduction, convection and radiation. Governing equations for conduction. Newton's law of cooling, free and forced convective heat transfer, ablative heat transfer. Heat exchange due to radiation, Fundamentals of mass transfer, Fick's law of diffusion, Fundamentals of combustion and dissociation, Simulation of heat transfer and combustion processes	

Learning Resources	*1. Nag, P. K, "Engineering Thermodynamics", 6th Edition, Tata McGraw Hill, New Delhi, 2017.* *2. Yunus A. Cengel and Michael A. Boles, "Thermodynamics: an engineering approach", seventh edition, McGraw Hill Higher education, 2011.* *3. Rayner Joel, "Basic Engineering Thermodynamics", 5th Edition, Addison Wesley, New York, 2016.*	*4. Michael Moran, J., and Howard Shapiro, N., "Fundamentals of Engineering Thermodynamics", 4th Edition, John Wiley & Sons, New York, 2010.* *5. Holman, J. P., "Thermodynamics", 4th Edition Tata McGraw Hill, New Delhi, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in	*1. Dr S.R. Chakravarthy, I.I.T.Madras, src@ae.iitm.ac.in*	*1. Dr G Saravanan, SRMIST*
2. Dr Lakshmi VM, Scientist/Engineer 'SG', VSSC, ISRO, vm_lakshmi@vssc.gov.in	*2. Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	*2. Mr. Vinayak Malhotra, SRMIST*

Course Code	21ASC206T	**Course Name**	AIR BREATHING PROPULSION	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the working principles of gas turbine propulsion systems*
CLR-2:	*design of inlets, combustion chambers, nozzles used in Air breathing engines*
CLR-3:	*design of compressors in gas turbine propulsion systems*
CLR-4:	*understand the working principles of gas turbine propulsion systems*
CLR-5:	*understand the principle of operation of Pulse jet, RAMJET and SCRAMJET engines*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the performance and component efficiencies of gas turbine propulsion systems*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*analyze inlets, combustion chambers, nozzles used in Air breathing engines*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*analyze the compressors in gas turbine propulsion systems*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*analyze the turbines in gas turbine propulsion systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*analyze the performance of Pulse Jet, RAMJET and SCRAMJET engines*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - Basic Air Breathing Propulsion Engines	***9 Hour***
Introduction to Air breathing engines. Turbojet Engine. Numerical Problems on turbojet engines. High bypass turbofan Engine. Low bypass turbofan Engine. Numerical Problems on turbofan engines. Numerical Problems on turboprop engines. Typical engine performance. Methods of thrust augmentation. Ideal and actual Brayton cycle.	
Unit-2 - Inlets, Nozzles, Combustors	***9 Hour***
Inlets. Classification of Inlets. Subsonic Inlets. Supersonic Inlets. Modes of Inlet operation. Starting problems and Shock swallowing Methods. Numerical Problems on Inlets. Gas turbine combustion chamber. Types of combustion chamber. Fuel injector- Flame Tube cooling. Flame Stabilization-Flame holders. Nozzle. Classification of nozzles.	
Unit-3 - Compressor	***9 Hour***
Compressor and its Classification- Axial flow compressor. Work and compression ratio. Degree of reaction. Characteristic performance of a single stage axial compressor. Characteristic performance of a multistage axial compressor. Cascading of axial flow compressor and efficiency. Centrifugal compressor-Working Principle. Work and compression ratio. Inferences of Compressor types and utilization	
Unit-4 - Turbines	***9 Hour***
Classification of turbines. Axial flow turbine stage. Blade Element Theory-Velocity triangles and Power output, Free vortex theory. Limiting Factors of gas turbine design. Turbine performance. Turbine blade cooling methods. Turbine and compressor matching. Numerical modeling of Turbine processes.	
Unit-5 - Ramjet and Scramjet Engines	***9 Hour***
RAMJET Engine-Working principle. RAMJET with afterburner. Performance. SCRAMJET Engine-Working principle of SCRAMJET Engine. Challenges faced in supersonic combustion. Numerical on SCRAMJET. Pulse Jet Engine- Operating Principle, Prospects in Aerospace propulsion and combustion	

Learning Resources	1. *V. Ganesan.,' Gas Turbines', 3rd ed., Tata McGraw-Hill Education, 2010.* 2. *Hill, P. G., Peterson, C. R., 'Mechanics and Thermodynamics of Propulsion', 2nd ed., Addison-Wesley Publishing Company, 1992.*	3. *Flack. R. L, "Fundamentals of Jet Propulsion with Applications," Cambridge University Press, 2005.* 4. *Mattingly, J.D., Heiser, W.H., Pratt, D.T., 'Aircraft Engine Design', AIAA Education Series, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	25%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in*	1. *Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	1. *Dr. G. Saravanan, SRMIST*
2. *Dr Lakshmi VM, Scientist/Engineer 'SG', VSSC, ISRO, vm_lakshmi@vssc.gov.in*	2. *Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	2. *Mr. Vinayak Malhotra, SRMIST*

Course Code	21ASC207T	**Course Name**	AIRCRAFT MATERIALS AND PRODUCTION TECHNIQUES	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify materials and describe the mechanical behavior of materials*
CLR-2:	*classify heat treatment process and distinguish the existing heat treatment and coating techniques*
CLR-3:	*describe the different casting and welding techniques and identify their defects*
CLR-4:	*examine the applications of metal working process*
CLR-5:	*apply the experience of machining techniques for real-time applications*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify materials with suitable properties and describe the application of materials in different aircraft components*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*distinguish the various treatments to strengthen materials*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*identify different casting and welding techniques*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*differentiate the forming techniques*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*distinguish the machining techniques*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Aerospace Materials and Applications	***9 Hour***
Aerospace Materials and Mechanical properties - Classification of aircraft materials - Fixed-wing aircraft structures - Materials used for aircraft components and jet engines, Helicopter structures, Space shuttle structures - Lightweight material for MAV/UAV, Super alloys - Application of Composite materials - Introduction to smart materials - Shape memory alloys - Advanced structure ceramic, intermetallics, Ni and Ti aluminide - Introduction to FRP - Glass and Carbon Composites -Plastics and Rubber - Emerging trends in Aerospace materials	
Unit-2 - Heat Treatment Process	***9 Hour***
Heat Treatment - Purpose and Principles of Heat Treatment - Stages of Heat Treatment - Types of Heat Treatment - Procedures of Heat treatment of carbon steel - Procedures of Heat treatment of aluminum alloys, Procedures of Heat treatment of titanium alloys - Procedures of Heat treatment of Magnesium alloys - Case Hardening and their Procedures - Stress reliving Procedures - Protective Treatments	
Unit-3 - Casting and Welding	***9 Hour***
Introduction to Casting - Casting Procedure - Casting Nomenclature - Sand Casting - Making of Sand Casting, Gating and risering System - Special Casting Process - Expandable Mold Casting - Shell Mold Casting - Investment Casting - Permanent Mold Casting, Die Casting - Centrifugal Casting - Casting Defects - Introduction to Welding - Gas Welding, Arc Welding - Laser Beam Welding - Electron Beam Welding - Electric Resistance Welding - Welding Defects	
Unit-4 - Mechanical Working of Materials	***9 Hour***
Introduction to mechanical Working- Hot Working - Cold Working - Hot Working- Forging - Forging Types, Forging Defects - Rolling, Types of Rolling, Rolling Mills - Rolling Defects - Drawing - Drawing Types - Extrusion - Extrusion Types - Sheet Metal Operations - Types of Shearing Dies - Forming Operations - Forming Operations - Cutting Tools in sheet metal Process - Striking Tools in Sheet Metals	

Unit-5 - Machining Operations	***9 Hour***
Introduction to Machining process - Lathe Components, Tools, Working of Lathe, Operations in Lathe - Drilling Machine, Types of Drilling machine, Operations, Tools used in Drilling Machine - Shaper Machine - Operations - Quick return Mechanism - Slotter machine and its mechanisms, Grinding Machines - Cutting Tools in Grinding Machines - Operations in Grinding Machines - Types of Grinding Machines - Milling - Milling Operations, Types of Milling Machines, Basics concepts of CNC Machining	

Learning Resources	*1. Adrian P. Mouritz, Introduction to aerospace materials, Woodhead Publishing Limited, 2012* *2. Dieter, G. E., Mechanical Metallurgy, McGraw Hill, Singapore, 2001*	*3. Keshu S.C, Ganapathy K.K, Aircraft production technique, Interline Publishing House, Bangalore 1993* *4. Dr.P C Sharma, AText book of Production Technology, 8th ed. S.CHAND and company Pvt. Ltd. 2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	*1. Dr. V. Arumugam, MIT, Chennai, arumugam. mitaero@gmail.com*	*1. Mr. N Bharat, SRMIST*
2. Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com	*2. Dr. K. Vadivuchezhian, NIT, Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	*2. Dr. K. Saravanakumar, SRMIST*

Course Code	21ASC221L	Course Name	FLUID MECHANICS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards		*Nil*	

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the suitable flow measurement devices for practical use in design*
CLR-2:	*examine the principles of fluid flows by designing and performing experiments*
CLR-3:	*select the test-rigs for performing fluid flow experiments*
CLR-4:	*analyze the type of fluid flow using flow visualization techniques*
CLR-5:	*analyze the working of different air blowers and compressors*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*use various flow measurement instruments for measuring various fluid flow parameters like pressure, discharge, viscosity*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*illustrate the principles of Bernoulli's theorem and jet on vanes using experiments*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*calculate the losses in pipe systems*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*infer the nature of the flow and flow field using experiments*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*predict the performance of air blowers and air compressor*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-

Practice -	***30 Hour***
Practice: 1 Determination of the coefficient of discharge of a Venturimeter	
Practice: 2 Determination of the coefficient of discharge of an orifice meter	
Practice: 3 Verification of Bernoulli's theorem	
Practice: 4 Determination of the Impact force of water jet on a vane	
Practice: 5 Estimation of major loss due to friction in pipe flow	
Practice: 6 Estimation of Minor losses due to various pipe fittings in pipe flow	
Practice: 7 Determination of type of flow using Reynolds apparatus	
Practice: 8 Performance test on centrifugal air blowers	
Practice: 9 Determination of viscosity of oil using red wood viscometer	
Practice: 10 Performance test on reciprocating air compressor	
Practice: 11 Visualization of flow around objects using Hele-Shaw apparatus	

Learning Resources	1. *Laboratory manual* 2. *Yunus Cengel, and John Cimbala. Fluid Mechanics Fundamentals and Applications. 4th ed., McGraw Hill Education, 2018.*	3. *S K Som, Gautam Biswas, S Chakraborthy. Introduction to Fluid Mechanics and Fluid Machines, 3rd ed., McGraw Hill Education, 2017* 4. *https://fm-nitk.vlabs.ac.in/Introduction.html, https://me.iitp.ac.in/Virtual-Fluid-Laboratory/*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	20%	-	20%	-	20%	-	-
Level 2	*Understand*	-	20%	-	20%	-	20%	-	-
Level 3	*Apply*	-	40%	-	40%	-	40%	-	-
Level 4	*Analyze*	-	20%	-	20%	-	20%	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR-NAL, Bangalore skghosh@nal.res.in*	1. *Dr. Lakshmana Dora C, IIT Hyderabad , lchandrala@mae.iith.ac.in*	*1. Mr. S. Rajkumar, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	*2. Dr. K K Bharadwaj, SRMIST*

Course Code	21ASC222L	**Course Name**	APPLIED SOLID MECHANICS LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*use different types of hardness measuring instruments*
CLR-2:	*use different types of Toughness measuring techniques*
CLR-3:	*determine the rigidity modulus and fatigue strength of the material*
CLR-4:	*determine the deflection of beams*
CLR-5:	*illustrate the micro structure of the material*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*experiment different types of hardness measuring instruments*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*experiment different types of Toughness measuring techniques*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*calculate the rigidity modulus and fatigue strength of the material*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*calculate the deflection of beams*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*describe the micro structure of the material*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*1*	-	-

Practice -	***30 Hour***
Practice: 1 Test a specimen using Digital Rockwell Hardness Testing	
Practice: 2 Test a specimen using optical Brinell Hardness Testing	
Practice: 3 Test a specimen using vicker's Hardness test using Computerized semi- automatic micro-Hardness testing	
Practice: 4 Impact Performance comparison of heat-treated material with non-heat-treated material using an IZOD Impact test	
Practice: 5 Impact Performance comparison of heat-treated material with non-heat-treated material using an CHARPY Impact test	
Practice: 6 Test a specimen using Digital torsion testing machine	
Practice: 7 Perform fatigue strength of a specimen using fatigue – testing machine	
Practice: 8 Perform a Tensile test on a closed coil spring using Computerized Tensile testing machine	
Practice: 9 Perform a Compression test on an open coil spring using Computerized Tensile testing machine	
Practice: 10 Deflection of a simply supported beam	
Practice : 11 Deflection of a cantilever beam	
Practice : 12 Study of Magnified images obtained using an inverted metallurgical microscope on a specimen	

Learning Resources	1. *Laboratory manual*	2. *The user manual of respective instruments*

Learning Assessment

		Continuous Learning Assessment (CLA)						*Final Examination (0% weightage)*	
	Bloom's Level of Thinking	*CLA-1 Average of first cycle experiments (30%)*		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	20%	-	20%	-	20%	-	-
Level 2	*Understand*	-	20%	-	20%	-	20%	-	-
Level 3	*Apply*	-	60%	-	60%	-	60%	-	-
Level 4	*Analyze*	-	-	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1 *Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. T.Selvakumaran SRMIST*
2 *Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, NIT, Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Mr. K.B. Ravichandrakumar SRMIST*

Course Code	21ASC223L	Course Name	MANUFACTURING PROCESS LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*

Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*practice Various types of lathe operations*
CLR-2:	*examine the Production of flat surface and contour shapes on the given component*
CLR-3:	*practice basic Gear making processes*
CLR-4:	*experiment on the Surface finishing process*
CLR-5:	*practice on various machines like lathe, CNC Lathe, Shaper, Slotter, Milling, CNC MIlling, Gear hobbing and grinding*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*produce new components according to specified dimensions using different machines*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*prepare the flat surface and contour shapes on the given component*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*develop Gear using Milling and Hobbing machine*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*practice the Surface finishing process*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*prepare different components using lathe, CNC Lathe, Shaper, Slotter, Milling, CNC Milling, Gear hobbing and grinding machines*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-

Practice -	***30 Hour***
Practice: 1 Step Turning and Grooving in Lathe Machine	
Practice: 2 Drilling, Reaming, Tapping and Countersinking in Radial Drilling Machine	
Practice: 3 External keyway cutting in Shaper Machine	
Practice: 4 Taper turning in Lathe Machine	
Practice: 5 Surface Grinding operation in Surface Grinding Machine	
Practice: 6 Cylindrical grinding operation in Cylindrical Grinding Machine	
Practice: 7 Internal keyway cutting in Slotter Machine	
Practice: 8 Gear cutting in Gear Hobbing Machine	
Practice: 9 Spur gear cutting in Milling Machine	
Practice: 10 Thread cutting in Lathe Machine	
Practice: 11 Taper boring in Lathe Machine	

Learning Resources	1. Lab Manual, Manufacturing Process Laboratory, SRMIST	2. "Elements of workshop technologies" by Hajra Choudhary, Vol. 2, Media promoters and publishers, Pvt Ltd. 2008

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	30%	-	30%	-	30%	-	-
Level 2	Understand	-	30%	-	30%	-	30%	-	-
Level 3	Apply	-	40%	-	40%	-	40%	-	-
Level 4	Analyze	-	-	-	-	-	-	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100%		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	1. Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com	1. Mr. N. Bharat, SRMIST
2. Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com	2. Dr. K. Vadivuchezhian, NIT, Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in	2. Dr. K. Saravanakumar, SRMIST

Course Code	21ASC224L	**Course Name**	INCOMPRESSIBLE AERODYNAMICS LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the aerodynamic force generation on different bodies*
CLR-2:	*examine the wind tunnel and its instruments*
CLR-3:	*use the flow visualization techniques for the streamline patterns around the objects*
CLR-4:	*predict the pressure distribution over bluff and streamlined objects*
CLR-5:	*predict the forces and moments acting on bluff and streamlined objects*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the aerodynamic force generation and lift generating bodies*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*determine the calibration of wind tunnel and its instruments*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*examine the streamline patterns around the objects using flow visualization techniques*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*calculate the pressure distribution over bluff and streamlined objects*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*calculate the aerodynamic properties of bluff and streamlined objects*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-

Practice -	***30 Hour***
Practice: 1 Study of subsonic wind tunnels and its measurement techniques	
Practice: 2 Flow visualization over bluff & streamlined body.	
Practice: 3 Flow visualization over a finite wing with and without wingtip	
Practice: 4 Calibration of subsonic wind tunnel	
Practice: 5 Pressure distribution and Estimation of forces acting over a Smooth and Rough cylinder	
Practice: 6 Pressure distribution and Estimation of forces acting over a sphere model	
Practice: 7 Estimation of forces acting over a bluff / streamlined body using force balance method	
Practice: 8 Estimation of pressure distribution and forces acting over a symmetrical/ Unsymmetrical airfoil for different angle of attack	
Practice: 9 Estimation of pressure distribution and forces acting over a flapped airfoil for different angle of attack	
Practice: 10 Estimation of pressure and force distribution over a finite wing for different angle of attack	

Learning Resources	*1. Laboratory manual, User manual of respective instrument* *2. Ethirajan Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids,CRC Press, 2016*	*3. Houghton, E, L., Carruthers, N, B., Aerodynamics for Engineering Students, 6th ed., Edward Arnold Publishers Ltd., London, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*60%*	-	*40%*	-	*40%*	-	-
Level 4	*Analyze*	-	-	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100%*			

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in	*1. Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	*1. Dr. Mohamed Arif R, SRMIST*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	*2. Dr. Bharadwaj K K, SRMIST*

Course Code	21ASC225L	**Course Name**	AIRCRAFT COMPONENT DRAWING LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the techniques used for modelling, drafting and assembly*
CLR-2:	*demonstrate the Two-Dimensional designing of aircraft components*
CLR-3:	*demonstrate the Three-Dimensional Designing of aircraft solid & surface components*
CLR-4:	*use the assembly method for the designing of typical aircraft & its part*
CLR-5:	*use the drafting technique for the layout of typical aircraft & its parts*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the suitable techniques used for modelling, drafting and assembly*	*3*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*model 2-Dimensional Design of aircraft components*	*3*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*model 3-Dimensional Design of aircraft solid & surface components*	*3*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*demonstrate assembly of typical aircraft components*	*3*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*demonstrate drafting of typical aircraft & its components*	*3*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-

Practice -	***30 Hour***
Practice: 1 Introduction to CATIA and Mechanical design modules	
Practice: 2 2D layout of aircraft fuselage bulkhead and wing rib section	
Practice: 3 3D design of landing gear components	
Practice: 4 3D model of aircraft Wing Structure	
Practice: 5 3D model of aircraft fuselage Structure	
Practice: 6 3D model of aircraft Tail wing Structure	
Practice: 7 3D design of Propeller hub assembly	
Practice: 8 Assembly of Landing Gear components.	
Practice: 9 Assembly of Typical Aircraft.	
Practice: 10 Drafting of Typical Aircraft.	

Learning Resources	*1. Laboratory manual*	*2. User manual of respective software*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*60%*	-	*60%*	-	*60%*	-	-
Level 4	*Analyze*	-	-	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		*0%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in	*1. Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	*1. Dr.Mohamed Arif R, SRMIST*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	*2. Mr. K.B. Ravichandrakumar, SRMIST*

Course Code	21ASC301T	**Course Name**	AIRCRAFT STRUCTURES	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the physical meaning of symmetric bending and unsymmetrical bending*
CLR-2:	*explain the shear flow and shear center in open sections subjected to shear loads*
CLR-3:	*explain the shear flow and shear center in closed sections subjected to torque*
CLR-4:	*determine the buckling of thin plates*
CLR-5:	*analyze the aircraft structural components such as wings and fuselage*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts of unsymmetrical bending in various aircraft structural components*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*calculate the shear flow distribution due to shear load in different open sections*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-3:	*calculate the shear flow and twist in different closed sections due to shear load and torque*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-4:	*demonstrate the deformation of a thin plate supporting various loads on different end conditions*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-5:	*predict stress analysis in wing and fuselage design and evaluate the suitability of composite materials for specific aerospace applications*	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-

Unit-1 - Unsymmetrical Bending of Beams **9 Hour**

Symmetrical bending - Anticlastic bending - Unsymmetrical bending - Direct stress distribution and deflection due to unsymmetrical bending - Approximations for thin-walled sections - Bending of symmetric sections with symmetric loads and skew loads - Bending stress determination for symmetrical section with stringers - Bending of unsymmetric sections with skew loads and stringers - Determination of beam deflection shape of a beam using MATLAB - Bending moment distribution for wings and fuselages

Unit-2 - Shear Flow in Open Sections **9 Hour**

Shear of open section beams - Concept of shear flow and shear center - Shear flow expression for open sections - Shear flow distribution and shear center determination for thin-walled symmetrical and unsymmetrical open sections - Concept of structural idealization - Determination of boom areas - Shear flow distribution and shear center determination for open sections with walls effective and ineffective in bending - Shear flow distribution of an idealized channel section using MATLAB

Unit-3 - Shear Flow and Torsion in Closed Sections **9 Hour**

Shear of closed section beams - Shear flow expression for closed sections - Shear flow distribution and shear center determination for thin-walled symmetrical and unsymmetrical closed sections - Torsion of closed section beams - Concept of Bredt-Batho theory - Shear flow distribution for single-cell and multi-cell structures subjected to bending and torque with walls effective and ineffective in bending - Determination of shear flow distribution and rate of twist of a wing section using MATLAB - Shear flow distribution for tapered wings - Shear resistant web beams - Thin-webbed beams using Wagner's theory - Shear flow distribution for wings and fuselages

Unit-4 - Bending and Buckling of Plates **9 Hour**

Pure bending of thin plates - Anticlastic and synclastic surface - Plates subjected to bending, twisting and transverse loads - Combined bending and in-plane loading of a thin rectangular plate - Buckling of thin plates - Structural instability - Buckling of stiffened plates – Local buckling of composite shapes - Flexural–torsional buckling of thin-walled columns - Estimation of crippling stress using Needham's and Gerard's method - Stiffened panel / Sheet effective width concepts - Inter rivet and sheet wrinkling failures - Thin walled column strength - Torsional instability of thin walled columns - Shear lag concepts

Unit-5 - Stress Analysis and Introduction to Composite Structures	***9 Hour***
Shear distribution and bending distribution for wings and fuselage - Flight vehicle structures - Introduction to photoelasticity - Structural analysis using software packages - Case studies - Introduction to fiber reinforced polymers (FRP) - Analysis of orthotropic composite plies - Laminate theory - Analysis of composite laminates: Stiffness matrix - Stress and strain - Thermal expansion - Failure mechanisms and analysis - Failure criteria - Composite beams - Sandwich structures	

Learning Resources	*1. Megson T H G, "Aircraft Structures for Engineering Students", 7th edition, Elsevier, 2022* *2. Bruhn. E.F., "Analysis and Design of Flight Vehicles Structures", Tri-state offset company, USA 1985 Aircraft Structures Laboratory manual* *3. Peery, D.J., "Aircraft Structures", 2nd edition, McGraw-Hill, N.Y., 1999* *4. Rivello, R.M., "Theory and Analysis of Flight Structures", McGraw Hill, 1993.* *5. Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", WCB-McGraw Hill, 1997.*	*6. Timoshenko, S.P., and Young, D.H., "Elements of Strength of Materials Vol. I and Vol. II". T. Van Nostrand Co-Inc Princeton-N.J. 1990.* *7. B.K. Donaldson, "Analysis of Aircraft Structures - An Introduction", Second edition, Cambridge University Press, 2012.* *8. Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill Inc., New York, 1978* *9. Jones.R.M, “Mechanics of Composite Materials”, McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	*1. Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. S. Gurusideswar, SRMIST*
2. Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com	*2. Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	*2. Dr. K. Saravanakumar, SRMIST*

Course Code	21ASC302T	**Course Name**	AIRCRAFT SYSTEMS AND INSTRUMENTS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe about different type of control system and its components used in aircraft*
CLR-2:	*explain the principle of components and accessories of hydraulic & Pneumatic system*
CLR-3:	*summarize the type of electrical and lighting system operations in aircraft*
CLR-4:	*discuss the cabin environmental control system, oxygen system and other auxiliary system of an airplane*
CLR-5:	*describe about the various aircraft instruments and their functions*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the type of control system and its components used in aircraft*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*discuss the functional block diagram of hydraulic & Pneumatic system*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*explain the electrical and lighting system operations in aircraft engines*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*describe the cabin environmental control system, oxygen system and other auxiliary system of an airplane*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*summarize the various aircraft instruments and their functions*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Airplane Control Systems	***9 Hour***
Need for Control Systems, Conventional Flight Controls, Components of Conventional Flight Control System and their functions, Push Pull rod System, Cable Pulley System, Disadvantages of Mechanical Control System, Challenges in Power Assisted Flight Control System, Q – Feel System, Servo Tabs, Fully Powered Flight Control System for heavy aircraft, Fly by Wire System (FBW), Operation of FBW & its Advantages, Digital Fly by Wire System (DFBW), Operation of DFBW & its Advantages, Need for Automatic Flight Control Systems, Operation of Autopilot System, Auto Throttle System (ATS), Advantages of ATS- Demonstration of Aircraft Controls using Cessna 172R.	
Unit-2 - Aircraft Systems	***9 Hour***
Hydraulic Systems Applications & Advantages, Selection & Classification of Hydraulic Fluids, Open Centre & Closed Centre System, Components of Hydraulic System and its functions, Automatic Operating Control Valves, Study of Typical Hydraulic System for Modern Jet Airliner, Operation and its Advantages, Aircraft Brake System, Types and Applications. Pneumatic System - Applications & Advantages, Study of Typical Pneumatic System for Modern Airliner, Operation and its Advantages. Landing Gear System - Classification of Landing Gear System, Components of Landing Gear System and its Applications.	
Unit-3 - Basic Aircraft Electrical Systems	***9 Hour***
Basic aircraft electrical systems - Power generation, DC power generation, Typical aircraft DC System. AC power generation, Typical aircraft AC System. Power conversion and energy storage - Inverters, Transformer rectifier units, Auto-Transformers, Batteries - Lead-Acid and Nickel-Cadmium batteries. Emergency Power Generation - ETOPS, Ram Air Turbine (RAT), Backup power converters, Permanent Magnet Generators (PMGs). Aircraft lighting systems - Internal and external lighting systems - Demonstration of Cabin Lighting System using Airbus A300 Simulator.	
Unit-4 - Cabin Environmental Control Systems	***9 Hour***
Need for Aircraft Pressurization System, Principle of Air Cycle Cooling System, Operation & Advantages, Principle of Vapour Cycle Cooling System Operation& Advantages, Need for Cabin Heating System, Types & Operation, Need for Aircraft Oxygen System, Types & Advantages, Components of Oxygen System and its Operation, Fire Detection Systems, Requirements for Fire Detection System, Types, Principle and Operation, Need for Anti-Icing & De-Icing System, Types and Applications	

Unit-5 - Aircraft Instruments	***9 Hour***
Aircraft Flight Instruments types, Principle of Air Data Instruments, Operation of Altimeter, Operation of Air Speed Indicator, Operation of Vertical Speed Indicator, Principle of Gyroscopic Instruments, Operation of Attitude Indicator, Operation of Turn Coordinator, Operation of Heading Indicator, Principle & Operation of Engine Instruments – Tachometer & EGT, Principle & Operation of Electronic Instruments – EADI & EHSI, Principle & Operation of Electronic Systems Monitor Displays, Principle & Operation of EICAS, Need for Instrument Landing System (ILS), Components of ILS and their functions, Advantages - Demonstration of Aircraft Instruments using Airbus A300 Simulator.	

Learning Resources	*1. Ian Moir, Allan Seabridge, Aircraft Systems – Mechanical, Electrical and Avionics subsystems integration, 3rd ed., Professional Engineering Publishing Limited, 2008.* *2. E.H.J.Pallet, Aircraft Instruments, 2nded. Pearson Publishing Company, 2009.*	*3. Aviation Maintenance Technician Handbook – Airframe, Vol.2, U.S.Dept. of Transportation, Federal Aviation Administration, Flight Standards Service, 2012.* *4. Michael J. Kroes, William A. Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*50%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*50%*	-	*50%*	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Wg.Cdr retd. Manoharan, Continuing Airworthiness Manager,Blue Dart Aviation.manoharank@bluedart.com	*1. Dr. V.Arumugam, Madras Institute Of Technology Campus, Anna University, Chennai, arumugam.mitaero@gmail.com*	*1. Dr.S.Sivakumar, SRMIST*
2. Wg.cdr R.Annamalai,Chief training co-ordinating officer IAF, Tambaram, annamalai.ramasamy2@gmail.com	*2. Dr.S.Nadaraja Pillai, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	*2. Mr.G.Mahendra Perumal, SRMIST*

Course Code	21ASC303T	Course Name	COMPRESSIBLE AERODYNAMICS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*apply the isentropic relations for internal and external flows*
CLR-2:	*predict the change in properties across different shock waves*
CLR-3:	*examine the expansion fan flow properties and nozzles flow characteristics at different flow regime*
CLR-4:	*examine the duct flow with heat transfer and frictional effect*
CLR-5:	*predict the effect of compressibility on internal and external flow*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate the thermodynamic properties of isentropic flow*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*calculate the normal and oblique shock wave flow properties*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-3:	*determine the expansion fan and nozzles flow characteristics*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-4:	*calculate the change in flow properties across duct due to heat transfer and frictional effect*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*determine the compressibility effects and contour design of the supersonic nozzle*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Isentropic Relations	***9 Hour***
Introduction to compressible flow - Thermodynamic concepts and equations - Momentum and Energy equations for compressible fluid flow - Wave propagation at different flow speed regimes - Shock formation - Types of waves - Speed of sound derivation - Change in entropy relation - Isentropic relations - Characteristic Mach number	
Unit-2 - Shock Waves and their Application	***9 Hour***
Normal shock wave properties – Hugoniot equation – Rayleigh pitot formula – The propagating shock wave - shock tube - Oblique shock properties - Θ-β-M relation and graph - Supersonic flow over wedges, cones and blunt body - Shock polar - Shock reflections and interactions - Shock Boundary layer interaction - Multiple shock system	
Unit-3 - Expansion Waves and Nozzle Flows	***9 Hour***
Governing equation of Prandtl-meyer expansion waves - Shock Expansion theory: flat plate and Diamond airfoil - Shock Expansion theory using computational tools - Nozzle flow relations: Area-velocity, Area-Mach number, Maximum mass flow rate - Supersonic nozzle and diffuser - Variation of Pressure and Mach number along the C-D nozzle - Under expansion and over expansion nozzle	
Unit-4 - Rayleigh Flow and Fanno Flow	***9 Hour***
Rayleigh flow equations - Variation of flow properties for subsonic flow and supersonic flow - Critical reference states - Normal shock in Rayleigh flows - Rayleigh curve - Fanno flow equations - Variation of flow properties with duct length for subsonic flow and supersonic flow - Critical reference states - Normal shock in Fanno flows - Fanno curve	
Unit-5 - Linearized Theory and Method of Characteristics	***9 Hour***
Velocity potential equation for compressible flow - small perturbation theory - Linearized pressure coefficient - Prandtl-Glauert compressibility correction - Supersonic linearized theory - Application of Supersonic linearized theory - Method of characteristics and its Application - Transonic flow past airfoils - Similarity rules and Area rule	

Learning Resources	1. Rathakrishnan, E., *"Gas Dynamics", Prentice Hall India Learning Private Limited, 7th edition, Delhi, India, 2020.* 2. *Anderson J. D., Jr., "Modern Compressible Flow with Historical Perspective," McGraw Hill Publishing Co., 3rd edition, 2020* 3. *Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow (Vol I and Vol II)", Ronald Press, 1962.*	4. *Zucker, R. D., Biblarz, O., "Fundamentals of Gas Dynamics", Wiley-Blackwell; Third edition, 2019.* 5. *Yahya, S. M., "Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion", New Age International Publishers; Sixth edition, 2018.* 6. *S.M. Yahya, Gas Tables - For Compressible Flow Calculations, New Academic Science Limited, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in*	1. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	1. *Dr. R. Mohamed Arif, SRMIST.*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	2. *Dr. K. K. Bharadwaj, SRMIST.*

Course Code	21ASC304T	**Course Name**	SPACE MECHANICS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*examine the fundamental laws and governing equations of orbital dynamics*
CLR-2:	*show the importance of Keplerian orbital elements, Kepler's equation and different sources of orbital perturbations*
CLR-3:	*predict different types of orbital transfers for different scenarios, their energy and time requirements.*
CLR-4:	*determine the ballistic missile trajectory by using the fundamental equations of orbital dynamics*
CLR-5:	*examine different interplanetary trajectories and their applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*use the fundamental laws of orbital mechanics to derive governing equations of orbital motion*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-2:	*apply Kepler's equation in pin pointing the satellite in orbit*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*examine the energy and time requirements of different orbital transfers involving impulsive maneuvers*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply the governing equations of orbital motion for ballistic missile trajectory analysis*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-5:	*demonstrate different interplanetary trajectories and their practical importance*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Two-Body Orbital Mechanics	***9 Hour***
Fundamental / Basic laws – Newton's laws of motion, Newton's law of universal gravitation, Kepler's laws, Multi-body / N-body problem, Two-body problem - Equation of relative motion, Orbit / trajectory equation, Constants of motion, Conic sections – Geometrical properties, Relation between constants and orbit geometry, Elliptical orbit, Circular orbit, Parabolic and Hyperbolic trajectories	
Unit-2 - Orbits in Three Dimensions	***9 Hour***
Coordinate systems – Heliocentric, Geocentric, Right ascension-declination, Perifocal, Topocentric and Geographic coordinate systems, Time systems – Sidereal, Dynamic and Atomic times, Classical / Keplerian Orbital Elements, Kepler's Equation, Relation between eccentric and true anomalies, Orbital perturbations, Earth's oblateness and its effects – Regression of the line-of-nodes and Rotation of the line-of-apsides, Sun-synchronous and Molniya orbits	
Unit-3 - Orbital Maneuvers	***9 Hour***
Impulsive maneuvers, Single impulse maneuvers – Adjustment of heights, Simple rotation, Simple plane change, Combined change of Plane and height, Hohmann transfer, Bi-elliptic Hohmann transfer, One-tangent burn transfer, Phasing maneuvers	
Unit-4 - Ballistic Missile Trajectories	***9 Hour***
Ballistic missile Trajectory, Free-Flight Range Equation, Flight-Path Angle Equation, Maximum Range Trajectory, Time of Free-Flight, Effect of Earth Rotation – Compensating for movement of launch site and target, Effect of Launching Errors on Range – Down-range and cross-range errors	
Unit-5 - Interplanetary Trajectories	***9 Hour***
Interplanetary Hohmann transfers, Rendezvous opportunities, Sphere of influence, Method of patched conics, Planetary departure, Planetary rendezvous, Planetary flyby, non-Hohmann interplanetary trajectories, Mission analysis using open-source tools	

Learning Resources	1. *Howard D. Curtis, Orbital Mechanics for Engineering Students, 4th Edition, Butterworth-Heinemann, 2019.* 2. *William E. Wiesel, Spaceflight Dynamics, 3rd Edition, Create Space, 2010.* 3. *Roger R. Bate, Donald D. Mueller & Jerry E. White, Fundamentals of Astrodynamics,2nd Edition, Dover Publications, Inc., New York, 2020.*	4. *Ashish Tewari, Atmospheric and Space Flight Dynamics, Springer, 2007.* 5. *Cornelisse J.W., Schoyer H.F.R. & Wakker K.F., Rocket Propulsion and Spaceflight Dynamics, Pitman Publishing Ltd., 1979.* 6. *Martin J. L. Turner, Rocket and Spacecraft Propulsion, 3rd Edition, Springer, 2009.* 7. *Vladimir A. Chobotov, Orbital Mechanics, 3rd Edition, AIAA Education Series, AIAA, 2002.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Roshan Dinesh Kumar, GE Industry India Ltd., Bangalore, dineshforaero@gmail.com*	1. *Dr. K. Maruthupandiyan, Institute of Aeronautical Engineering, Hyderabad, k.maruthupandiyan@iare.ac.in*	1. *Dr. S. M. Aravindh Kumar, SRMIST*
2. *Dr. Saurav Kumar Ghosh, CSIR-NAL, Bangalore, skghosh@nal.res.in,*	2. *Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	2. *Dr. K. Allwyn, SRMIST.*

Course Code	21ASC305T	**Course Name**	ROCKET PROPULSION	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ASC206T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Gas Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the basic principles of rocket propulsion system*
CLR-2:	*explain the choice of propellants in chemical propulsion systems*
CLR-3:	*predict the basic performance parameters of chemical propellants*
CLR-4:	*examine the solid and liquid propellant rocket performance*
CLR-5:	*explain the working principle of advanced rocket propulsion techniques*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the working principles of rocket propulsion systems*	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*describe the propellant selection for chemical rocket system*	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*determine the performance parameters of chemical propellants*	-	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*solve the performance characteristics of solid and liquid rocket*	-	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-5:	*describe the various advanced rocket propulsion techniques*	-	3	-	-	-	-	-	-	-	-	-	2	2	-	-

Unit-1 - Basic Concepts	***9 Hour***
Rocket propulsion systems -working principle, Classification of rockets, Rocket equation, Rocket Nozzles and its classifications -Nozzle performance- equilibrium and frozen flow, Characteristic velocity and Thrust coefficient, Performance parameters and efficiencies of rocket, Staging and clustering of rocket	
Unit-2 - Chemical Propellants	***9 Hour***
Chemical propellants -Molecular mass, Specific heat capacities, Specific heat ratio, mixture ratio, Stoichiometric ratio and equivalence ratio, Energy release during combustion-Heat of formation and Heat of combustion-Combustion Instabilities-Criterion for choice of propellant, Solid Propellants-Composition and processing, Liquid Propellants-Classifications of liquid propellant, Storability of liquid propellant, Chemical Equilibrium	
Unit-3 - Solid Rocket Engine	***9 Hour***
Propulsion Elements for Solid Rocket Motors, Solid propellant combustion and Internal Ballistics of Motors -Mechanism of burning, Ignition System-Igniter types - Solid propellant grain design - Burn Rate-Factors influencing burn rates, burn rate index for stable operation, Action time and burn time, Design of Solid Propellant rocket, Simulation of solid rocket motor performance.	
Unit-4 - Liquid Rocket Engine	***9 Hour***
Liquid Propellant Rocket-Hardware components and its functions, Propellant feed systems –Gas pressure feed system, Turbo pump feed systems and engine cycles, Tank Pressurization - Types of injectors - Thrust chamber, Cooling of Thrust chamber - Cryogenic propulsion system and its special features, Simulation of Liquid rocket performance, Hybrid rockets- Review of solid-fuel regression rate behavior in classical and non-classical Hybrid Rocket Motors - Rocket engine design using software.	
Unit-5 - Non-conventional Propulsion Techniques	***9 Hour***
Non - conventional propulsion techniques -Electrical Rockets-Electro-thermal propulsion system-Arc-jet thruster, Resistojet Thruster-Electro-static thruster-Ion thruster, Bombardment Ionization, Hall Effect Thruster -Electro-magnetic propulsion system-Magneto plasma dynamic accelerator, Pulsed Plasma accelerator- Laser Propulsion -Nuclear powered rockets- Solar Propulsion system	

Learning Resources		
	1. George P. Sutton, Oscar Biblarz, *“Rocket propulsion elements”*, Wiley India Pvt Ltd. Ninth Edition, 2017 2. Ramamurthi.K, *“Rocket propulsion”*, Laxmi Publications, India, Second edition, 2019. 3. J D. Mattingly and K M. Boyer,”Elements of Propulsion: Gas Turbines and Rockets”, Second Edition,2016	4. Philip Hill and Carl Peterson, “Mechanics and thermodynamics of propulsion”, Pearson India, second edition, 2010. 5. Stephen R. Turns, “An Introduction to Combustion: Concepts”, McGraw-Hill Education; 4th edition , 2020 6. Yahya S M, "Gas Tables",8th Edition, 2018

Learning Assessment							
		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom’s Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. RS. Praveen, VSSC, ISRO, Thiruvananthapuram, rs_praveen@vssc.gov.in	*1. Dr.S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	*1. Dr.G. Saravanan, SRMIST*
2. Dr. Lakshmi VM, VSSC, ISRO, Thiruvananthapuram, vm_lakshmi@vssc.gov.in	*2. Dr. Rajesh Sadanandan, IIST, Thiruvananthapuram,rajeshsadanandan@iist.ac.in*	*2. Mr.Vinayak Malhotra, SRMIST*

Course Code	21ASC306T	Course Name	AIRCRAFT STABILITY AND CONTROL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ASC201J*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Gas Tables*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*calculate the degrees of static longitudinal, lateral and directional stabilities of an airplane*
CLR-2:	*determine the longitudinal, lateral and directional control effectiveness of a given airplane configuration*
CLR-3:	*generate the longitudinal and lateral stability and control matrices of a given airplane configuration*
CLR-4:	*examine the stability matrices to characterize the various dynamic responses of an airplane*
CLR-5:	*predict the neutral and maneuvering points of an airplane from flight test data.*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*predict the static stability of an airplane*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*examine the controllability of an airplane in all flight conditions*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*predict the dynamic stability of an airplane*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*demonstrate the recovery procedures for various instability modes of a given airplane for safer flight*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*determine the stability and maneuverability of a real airplane with real flight test data*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Longitudinal Stability and Control	***9 Hour***
Basic concepts of equilibrium, stability and control. Longitudinal equilibrium and static stability - Contributions of wing, tail, fuselage, powerplant to longitudinal static stability. Canard configuration. Stick fixed neutral point. Longitudinal control - factors affecting the design of control surface. Elevator effectiveness. Elevator angle to trim. Elevator hinge moment, stick free neutral point, static margin and neutral point. Stick forces and stick force gradients. Trim tabs	
Unit-2 - Lateral-Directional Stability and Control	***9 Hour***
Lateral static stability - contributions of various components to roll stability, dihedral effect. Roll control - aileron effectiveness. Directional static stability - contributions of various components. Directional control - requirements for directional control - rudder effectiveness. Aerodynamic balancing - set-back hinge, horn balance, Frise aileron, sealed nose balance, servo tab	
Unit-3 - Dynamic Equations	***9 Hour***
Coordinate systems. Equations of motion of rigid aircraft in body fixed axes. Position and orientation with respect to inertial system - body angular velocity and Euler angle rates. Linearised equations - small disturbance theory. Stability derivatives and stability coefficients - derivatives due to change in forward speed, pitching moment, time rate of change of angle of attack, rolling rate and yawing rate. Decoupling of longitudinal and lateral motion.	
Unit-4** - **Aircraft Motion Modes	***9 Hour***
Construction of stability of stability matrix - state variable representation, undamped natural frequency and damping ratio. Longitudinal dynamic stability - phugoid and short period oscillations. Lateral-directional dynamic stability - Directional divergence, Spiral divergence, Dutch roll. Wing stall - autorotation, spin and the recovery. Solving stability matrices using programming tools	
Unit-5 - Aeroelastic Effects and Flight Testing	***9 Hour***
Wing torsional divergence, control reversal, control surface flutter. Stick fixed and stick free neutral points by flight testing. Maneuvering stability. Stick fixed and stick free maneuvering points by flight testing.	

Learning Resources	1. *Nelson, R,C.,"Flight Stability and Automatic Control", McGraw Hill, Second Edition, 1998* 2. *Bernard Etkin "Dynamics of atmospheric flight", Courier Corporation, 2012*	3. *Perkins, C, D., and Hage, R, E., "Airplane Performance, Stability and Control," Wiley Toppan, 1974.* 4. *Babister, A, W.,"Aircraft Stability and Response", Elsevier Science, 2013.* 5. *L J Clancy "Aerodynamics", Sterling Book House, 2006.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	60%	-	60%	-	60%	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in*	1. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	1. *Dr. M. Vignesh Kumar, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. P. K Dash, Nitte Meenakshi Institute of Technology, Bangalore, drpdash@gmail.com*	2. *Dr. K. Allwyn, SRMIST*

Course Code	21ASC307T	**Course Name**	AIRCRAFT PERFORMANCE	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ASC201J*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Gas Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*determine the various components of drag on an airplane*
CLR-2:	*calculate the performance of different powerplants at different flight conditions*
CLR-3:	*determine maximum range, endurance and fuel efficiency from different performance parameters of an airplane*
CLR-4:	*determine maneuvering abilities of an airplane from different performance parameters of an airplane*
CLR-5:	*apply the various flight-testing procedures for finding the airplane drag at various flight conditions*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*predict the drag polar of a given aircraft configuration*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*show the optimal powerplant for an airplane with the desired performance*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*examine and optimize steady flight performance of an airplane*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*examine and optimize accelerated flight performance of an airplane*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*determine the drag polar of a real airplane with real flight testing*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Forces and Moments ***9 Hour***

Forces and moments acting on a vehicle in flight. Equations of motion of a rigid flight vehicle in steady flight. Various types of drag acting on an airplane - Methods to minimise them. Aerodynamic interference effects. Drag polar of vehicles from low speeds to hypersonic speeds.

Unit-2 - Engine Performance ***9 Hour***

Thrust and propulsive efficiency of air breathing engines and rocket - Trade-off between thrust and propulsive efficiency. Review of the variation of thrust/power and SFC with altitude and velocity, for various air breathing engines and rockets. Propeller performance - Role of advance ratio. Selection of Powerplant.

Unit-3 - Unaccelerated Flight ***9 Hour***

Variation of Thrust required and power required with velocity - Graphical and analytical approaches. Steady, level flight - Conditions for maximum and minimum velocity. Climbing Fight - Conditions for maximum rate of climb and maximum climb angle. Gliding flight - Conditions for minimum sink rate and minimum glide path angle. Range and endurance of jet driven and propeller driven aircraft - Conditions for maximising range and endurance - Flight velocity, range and endurance estimations using software/programming.

Unit-4 - ***Accelerated Flight*** ***9 Hour***

Accelerated level flight. Turning performance - Level turn equations of motion, conditions for minimum turn radius and maximum turn rate, constraints on load factor and velocity. Pull up and pull down performance. V-n diagram - Impact on structural design. Takeoff and landing performance - conditions for minimising takeoff and landing distances.

Unit-5 - Flight Testing ***9 Hour***

Altitude definitions, Speed definitions. Air speed, altitude, angle of attack and temperature measurements. Errors and calibration. Flight determination of drag polar - Speed power method, Incremental drag method, prop feathered sinks method, incremental power method.

Learning Resources	1. *Perkins, C. D., and Hage, R, E., "Airplane Performance, Stability and Control," Wiley Toppan, 1974* 2. *John D. Anderson, "Aircraft Performance and Design", McGraw-Hill Education (India) Pvt Limited, 2010*	3. *Nelson, R,C.,"Flight Stability and Automatic Control", McGraw Hill, Second Edition, 1998.* 4. *McCormik, B. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, 1995.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in*	1. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	1. *Dr. M. Vignesh Kumar, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. P. K Dash, Nitte Meenakshi Institute of Technology, Bangalore, drpdash@gmail.com*	2. *Dr. K. Allwyn, SRMIST*

Course Code	21ASC321L	Course Name	AIRCRAFT STRUCTURES LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*21ASC202T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the physical meaning of symmetric bending and unsymmetrical bending*
CLR-2:	*explain the shear flow and shear center in open sections subjected to shear loads*
CLR-3:	*explain the shear flow and shear center in closed sections subjected to torque*
CLR-4:	*determine the buckling of thin plates*
CLR-5:	*analyze the aircraft structural components such as wings and fuselage*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts of unsymmetrical bending in various aircraft structural components*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*calculate the shear flow distribution due to shear load in different open sections*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*calculate the shear flow and twist in different closed sections due to shear load and torque*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*demonstrate the deformation of a thin plate supporting various loads on different end conditions*	3	3	-	-	2	-	-	-	-	-	-	2	3	-	-
CO-5:	*predict stress analysis in wing and fuselage design and evaluate the suitability of composite materials for specific aerospace applications*	3	3	-	-	2	-	-	-	-	-	-	2	3	-	-

Practice -	***30 Hour***
Practice:1 Determination of principal centroidal axes of an unsymmetrical section	
Practice:2 Determination of shear center of an open section beam	
Practice:3 Determination of shear center of closed section beam	
Practice:4 Calculation of principal stresses of a hollow circular shaft subjected to combined bending and torsion loading	
Practice:5 Calculation of stress at various cross-sections for a constant strength cantilever beam	
Practice:6 Verification of Maxwell reciprocal theorem	
Practice:7 Verification of principle of superposition	
Practice:8 Determination of buckling load of a column	
Practice:9 Study of semi-tension field (Wagner) beam	
Practice:10 Determination of hoop and longitudinal stresses of a thin cylinder subjected to internal pressure	
Practice:11 Determination of forces and ratio of forces in a system of hinged bar suspended by two wires of different materials	
Practice:12 Deflection test on cantilever beam using flexibility matrix method	
Practice:13 Study of free and forced vibrations	
Practice:14 Fabrication of composite laminate using vacuum bagging kit	
Practice:15 Determination of fringe order using photoelasticity setup	

Learning Resources	1. *Laboratory manual* 2. *User manual of respective software*	3 *Megson T H G, "Aircraft Structures for Engineering Students", 7th edition, Elsevier, 2022* 4 *Timoshenko, S.P., and Young, D.H., "Elements of Strength of Materials Vol. I and Vol. II"., T. Van Nostrand Co-Inc Princeton-N.J. 1990.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 4	*Analyze*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. S. Gurusideswar, SRMIST*
2. *Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASC322P	**Course Name**	AIRCRAFT DESIGN PROJECT	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the aircraft design process, weight estimation and sizing of aircraft*
CLR-2:	*discuss the wing design parameters, forces and moments*
CLR-3:	*explain the engine selection and thrust requirements*
CLR-4:	*interpret the range and endurance and takeoff and landing performance*
CLR-5:	*describe the fuselage design, landing gear and material selection*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*evaluate weight for various components of the aircraft*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*determine the wing design parameters, forces and moments*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*estimate the thrust of an engine*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*explain the various performances of the aircraft*	*3*	*1*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-5:	*examine the fuselage design parameters and landing gear*	*3*	*1*	*1*	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Aircraft Design Process and Aerodynamics	***10 Hour***
Overview of design aircraft design, Aircraft sizing: Geometry, Control-surface sizing, Engine sizing. Weight estimation using any programming languages. Airfoil selection, Airfoil characteristics using any software, Wing geometry, Wing design parameters, Estimation of aerodynamic forces and moments	
Unit-2 - Aircraft Propulsion and Performance	***10 Hour***
Power plant selection, over view of engine components, Introduction to propeller and Electric drives, Fuel estimation, Thrust estimation. Estimation of Range and Endurance, Flaps selection, Wing-tip selection, Takeoff and Landing Analysis.	
Unit-3 - Aircraft Configurations	***10 Hour***
Fuselage design and selection, Overview of tail design, Landing gear arrangement, Material selection, Loads of aircraft components. Complete Layout of aircraft (2D/3D) using any CAD software	

Learning Resources	*1. Raymer, D. P., Aircraft Design: A Conceptual Approach, 6th Ed., Reston, Va.: AIAA, 2018* *2. Roskam, Jan. Airplane design. DARcorporation, 1985.* *3. Anderson, John David, and Mary L. Bowden. Introduction to flight. Vol. 582. New York: McGraw-Hill Higher Education, 2005.*	*4. Anderson, J. D., Aircraft Performance and Design, Boston: McGraw-Hill, 1999.* *5. Jenkinson, L.R., Simpkin, P., Rhodes, D., Jenkison, L.R. and Royce, R., 1999. Civil jet aircraft design (Vol. 338). London, UK: Arnold.*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	-	*10%*	-	*10%*	-	-
Level 2	*Understand*	*10%*	-	-	*10%*	-	*10%*	-	-
Level 3	*Apply*	*30%*	-	-	*30%*	-	*30%*	-	-
Level 4	*Analyze*	*30%*	-	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100%*		*100%*		*100%*		*0%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mrs. Smrutisudha Sahoo, DRDO, s.sahoo.pxe@gov.in	*1. Dr. Trushlyakov Valery, Omsk State Technical University, Russia, vatrushlyakov@yandex.ru*	*1. Dr Malaikannan G, SRMIST*
2. Mr. Dhanabal K, S & I Engineering Solutions Pv.t. Ltd., dhanabal@sandi.co.in	*2. Dr. Mohammed Ibrahim, IIT Kanpur, ibrahim@iitk.ac.in*	*2. **Dr.** Allwyn K, SRMIST*

Course Code	21ASC323L	**Course Name**	COMPRESSIBLE AERODYNAMICS LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*21ASC303T*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*explain the different types of supersonic wind tunnel and its measuring instruments*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*examine the supersonic wind tunnel and its instruments*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*predict the shock wave movement and shock reflection phenomenon*															
CLR-4:	*predict the shock wave pattern around different models*															
CLR-5:	*predict the supersonic jet flow properties*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*describe the working principle of supersonic wind tunnels and its measuring instruments*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*determine the calibration of supersonic wind tunnel and its instruments*	3	3	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-3:	*examine the shock wave formation and shock reflection phenomenon*	3	3	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-4:	*determine the shock wave pattern around the different aircraft and missile models*	3	3	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-5:	*calculate the flow properties of supersonic jet*	3	3	-	-	2	-	-	-	-	-	-	-	3	-	-

Practice -	***30 Hour***
Practice:1 Study of various types of Supersonic wind tunnel and Supersonic flow visualization techniques.	
Practice:2 Calibration of supersonic wind tunnel.	
Practice:3 Mach number distribution of various area ratio C-D nozzles	
Practice:4 Investigation of starting normal shock wave movement inside Convergent Divergent Nozzle.	
Practice:5 Visualization of shock wave pattern on wedge model using Schlieren flow visualization technique	
Practice:6 Verification of “Three-dimensional relieving effect”.	
Practice:7 Comparative study of shock reflection phenomenon using Schlieren flow visualization technique and computational tools	
Practice:8 Comparative study of shock wave pattern on Diamond Airfoil using Schlieren flow visualization technique and computational tools	
Practice:9 Investigation of supersonic flow over different aircraft/ missile models using Schlieren flow visualization technique	
Practice:10 Experimental investigation of supersonic jet characteristics	

Learning Resources	1. *Laboratory manual* 2. *User manual of respective software* 3. *Rathakrishnan, E., “Gas Dynamics”, Prentice Hall India Learning Private Limited, 7th edition, Delhi, India, 2020*	4 *S. M. Yahya, Gas Tables - For Compressible Flow Calculations,* 5 *Ethirajan Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, CRC Press, 2016.*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*60%*	-	*40%*	-	*40%*	-	-
Level 4	*Analyze*	-	-	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in	*1. Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	*1. Dr. Mohamed Arif R, SRMIST.*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	*2. Dr. S. M. Aravindh Kumar, SRMIST.*

Course Code	21ASC324L	**Course Name**	AEROSPACE COMPUTATIONAL ANALYSIS LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*21ASC225L*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*predict aerodynamic properties of Subsonic / supersonic flow over the objects*
CLR-2:	*predict aerodynamic properties of Subsonic /supersonic flow through ducts*
CLR-3:	*predict Structural characteristics of beams and aircraft structural components*
CLR-4:	*demonstrate the combustion simulation process*
CLR-5:	*demonstrate the heat transfer simulation process*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*solve subsonic internal and external flow problems*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-2:	*solve supersonic internal and external flow problems*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*solve Structural analysis of beams and aircraft structural components*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*use the simulation process for combustion*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*use the simulation process for heat transfer analysis*	*3*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-

Practice -	***30 Hour***
Practice: 1 Introduction to ANSYS modules & Grid independence study	
Practice: 2 2D analysis of subsonic flow through duct/ pipe	
Practice: 3 2D analysis of subsonic flow over bluff /streamlined body	
Practice: 4 2D analysis of supersonic flow through C-D Nozzle.	
Practice: 5 2D analysis of supersonic flow over bluff /streamlined body.	
Practice: 6 Structural analysis of Beam	
Practice: 7 Structural analysis of an aircraft Wing	
Practice: 8 Simulation of Premixed / Non-Premixed Combustion analysis	
Practice: 9 Conductive heat transfer analysis over a plate	
Practice: 10 Forced convective heat transfer analysis over a plate	

Learning Resources	*a. Laboratory manual* *b. User manual of respective software*	*6 S. M. Yahya, Gas Tables - For Compressible Flow Calculations,* *7 New Academic Science Limited, 2012*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 4	*Analyze*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		*0%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR NAL, skghosh@nal.res.in*	1. *Dr. Arun Kumar Perumal, IIT Kanpur, akp@iitk.ac.in*	1. *Dr. Mohamed Arif R, SRMIST.*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	2. *Mr. K. B. Ravichandrakumar, SRMIST.*

Course Code	21ASC325L	Course Name	AEROSPACE PROPULSION LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore practically the components of aircraft piston and gas turbine engines and their working principles*
CLR-2:	*carryout experiments in heat transfer*
CLR-3:	*explain the concepts of free jet and wall jet*
CLR-4:	*describe the performance of aircraft propeller and Ramjet engine*
CLR-5:	*explain the working and designing procedure of the solid and hybrid rocket motor*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*examine the basic concepts of aerodynamic and thermodynamic characteristics of major engine components/Identify components and information of piston and gas turbine engine*	2	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*predict the heat transfer mechanism over plates*	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*plot the characteristics of free jet and wall jet*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	2	-	-
CO-4:	*analyze the performance of the propeller and Ramjet engine*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	2	-	-
CO-5:	*examine the Solid and hybrid Propellant Rocket performance*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	2	-	-

Practice -	***30 Hour***
Practice: 1 Study of aircraft piston engine and it's components	
Practice: 2 Study of gas turbine engines, and it's components	
Practice: 3 Determination of convective heat transfer coefficient over a flat plate by natural convection	
Practice: 4 Determination of convective heat transfer coefficient over a flat plate by forced convection	
Practice: 5 Characteristic plots of a free jet through a non-circular orifice	
Practice: 6 Characteristic plots of a wall jet through a non-circular orifice	
Practice: 7 Performance test of an aircraft propeller	
Practice: 8 Performance test on RAMJET engine	
Practice: 9 Solid Rocket motor propellant preparation	
Practice: 10 Burning rate measurement of solid propellant using Window bomb setup	
Practice: 11 Hybrid Rocket motor fuel grain preparation	
Practice: 12 Regression rate measurement of hybrid rocket motor	

Learning Resources	1. George P. Sutton, Oscar Biblarz, “Rocket propulsion elements”, Wiley India Pvt Ltd. Eighth Edition, 2010.	2. Philip Hill and Carl Peterson, “Mechanics and thermodynamics of propulsion”, Pearson India, second edition ,2010 3. Lab manual

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	20%	-	20%	-	20%	-	-
Level 2	Understand	-	20%	-	20%	-	20%	-	-
Level 3	Apply	-	40%	-	40%	-	40%	-	-
Level 4	Analyze	-	20%	-	20%	-	20%	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100 %		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. RS Praveen, VSSC, ISRO, Thiruvananthapuram rs_praveen@vssc.gov.in	1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in	1. .Dr.G. Saravanan, SRMIST
2. Dr. Lakshmi VM, SVSSC, ISRO, Thiruvananthapuram vm_lakshmi@vssc.gov.in	2. Dr. Rajesh Sadanandan, IIST, Thiruvananthapuram, rajeshsadanandan@iist.ac.in	2. Mr.Vinayak Malhotra, SRMIST

Course Code	21ASC326L	**Course Name**	AIRCRAFT MAINTENANCE REPAIR LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	2	1

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify various types of rivets, riveting repair procedure and rigging of control system*
CLR-2:	*inspect the piston engine and jet engine components visually and pipe assembly*
CLR-3:	*check tracking of propeller and to check the aircraft symmetry of cessna*
CLR-4:	*detect cracks by penetrant and ultrasonic NDT method*
CLR-5:	*detect cracks by magnetic crack detection and eddy current testing method*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*practice repair by pneumatic riveting technique and control rigging check*	3	-	3	-	3	-	-	-	-	-	-	-	-	3	-
CO-2:	*inspect the Dimensional checks on piston engine and jet engine components and flaring of pipes*	3	-	3	-	3	-	-	-	-	-	-	-	-	3	-
CO-3:	*carry out symmetry check and propeller track check of Cessna aircraft*	3	-	3	-	3	-	-	-	-	-	-	-	-	3	-
CO-4:	*demonstrate liquid penetrant and ultrasonic crack detection method*	3	-	3	-	3	-	-	-	-	-	-	-	-	3	-
CO-5:	*practice on magnetic and eddy current crack detection method*	3	-	3	-	3	-	-	-	-	-	-	-	-	3	-

Practice -	***30 Hour***
Practice: 1 Identification of various rivets and use of any one riveting technique for repair	
Practice: 2 Rigging and operational check flight control systems	
Practice: 3 Pipe Flaring, bending and inspection of pipe assembly	
Practice: 4 Identification and dimensional inspection of various subassemblies of piston engines and jet engines components.	
Practice: 5 Propeller track check	
Practice: 6 Perform symmetry check of Cessna aircraft	
Practice: 7 Ultrasonic Thickness testing	
Practice: 8 Liquid Penetrant testing	
Practice: 9 Eddy current testing	
Practice: 10 Magnetic Particle testing	

Learning Resources	*1. Laboratory manual*	*2. Advisory Circular, Acceptable methods, techniques and practices-Aircraft Inspection and repair, AC 43.13-1B ,AC.43.13-2A.FAA,U.S.Department of transportation*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*40%*	-	*40%*	-	*40%*	-	-
Level 4	*Analyze*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Blue Dart Aviation, manoharank@bluedart.com*	1. *Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr.S. Sivakumar SRMIST.*
2. *Wg.cdr R. Annamalai,IAF, Tambaram annamalai.ramasamy2@gmail.com*	2. *Dr..S.Nadaraja pillai, SASTRA University Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr.G. Mahendra perumal, SRMIST.*

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ASE301T	**Course Name**	INDUSTRIAL AERODYNAMICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply principles of aerodynamics in fields other than Aerospace*
CLR-2:	*examine the role of atmosphere in industrial aerodynamics*
CLR-3:	*illustrate the importance of aerodynamics in Wind Turbine blade design*
CLR-4:	*determine the effect of wind flow on buildings and its impact*
CLR-5:	*use the aerodynamic principles in the design of automobiles and Sports*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*model the terrain and atmospheric boundary layer in a wind tunnel*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*apply aerodynamics in streamlining and Drag reduction in Automobiles*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*analyze the fluid-structure interactions and Aerodynamics in sports*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*use aerodynamics in the design of buildings and ventilation*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*apply aerodynamics in the design of wind turbines*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Atmosphere Aerodynamics	***9 Hour***
Aviation Aerodynamics vs Non-Aviation Aerodynamics, Industrial Aerodynamics and its need, Branches of Industrial Aerodynamics, Atmospheric layers, Atmospheric circulations, Local winds, Terrain types, Atmospheric Boundary Layer (ABL), Aerodynamic Roughness length, Mean velocity profiles, Power-law and Logarithmic law, Variation of wind velocity with height in ABL for different terrain types, Turbulence Intensity and its variation in ABL, Need for ABL simulation, Boundary layer tunnels, Simulation of ABL in a wind tunnel, Methods to produce ABL	
Unit-2 - Automotive Aerodynamics	***9 Hour***
-Rolling resistance Vs Air resistance, Need for automotive aerodynamics, History of Automotive Aerodynamics, Evolution of Automobile styling, Classification of cars, Pressure distribution over cars, Aerodynamic forces on Automobiles, Lift, Drag and Moments, Sources of vortices in automobiles, Flow separation and wake dynamics, Aerodynamic Improvements, Aerodynamics Vs Styling - Limitations, Aerodynamics of motor bikes, Aerodynamics of roofless vehicles, Aerodynamics of Trucks and Buses, Aerodynamics of Trains, Ahmed body – Generic automobile shape, Wind tunnel experiments and numerical simulations	
Unit-3 - Sports Aerodynamics and Fluid-Structure Interactions	***9 Hour***
Aerodynamics of race cars, Ground effects, Down force generation, Frontal and rear wings, Aerodynamic braking - Spoilers, Aerodynamics of wheels, Introduction to sports aerodynamics, Aerodynamics of Cricket ball, Swing and Spin, Effect of dimples on golf ball, Vortex shedding, Strouhal number, Flow induced vibrations, Fluid-structure interactions, Effect of Reynolds number on wake, Aerodynamic flutter, Wake galloping, Vortex shedding control methods	
Unit-4 - Building Aerodynamics	***9 Hour***
Need for Building aerodynamics, Environmental winds in city blocks, Low-rise buildings (LRB), Roof suction effects, High-rise buildings (HRB), Dynamic loads, Aerodynamic load mitigation techniques for LRB, Aerodynamic load mitigation techniques for HRB, Flow over a simplified building, Pressure distribution, Wind loads – TVL Formula, Funneling effect, Ventilation, HVAC, Architectural Aerodynamics, Wind catchers, Building codes, loads on launch vehicles subjected to winds	

Unit-5 - Wind Turbine Aerodynamics	***9 Hour***
Need for renewable energy sources, Wind energy and its importance, Wind turbine and its parts, Classification of wind turbines, Horizontal axis wind turbine (HAWT), Advantages and disadvantages of HAWT, Vertical axis wind turbine (VAWT), Advantages and disadvantages of VAWT, Wind power, Power coefficient, Tip speed ratio, Solidity ratio, 1-D Momentum theory, Betz limit, Power losses, Methods for power control, Blade sections - Airfoils, Wind turbine siting	

Learning Resources	1. *Tom Lawson, Building aerodynamics. Imperial College Press, 2001.* 2. *Joseph Katz, Automotive Aerodynamics, John Wiley & Sons, 2016.* 3. *Joseph Katz, Race Car Aerodynamics, Robert Bentley, 1995* 4. *Erich Hau, Wind turbines: fundamentals, technologies, application, economics. Springer Science & Business Media, 2013.*	5. *Martin OL Hansen, Aerodynamics of wind turbines. Routledge, 2015.* 6. *Robert D Blevins, Flow-induced vibration. Van Nostrand Reinhold Co., 1977.* 7. *Helge Nørstrud, Sport aerodynamics. Springer Science & Business Media, 2009.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*50%*	-	*60%*	-
Level 4	*Analyze*	-	-	*10%*	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR-NAL, Bangalore skghosh@nal.res.in*	1. *Dr. Lakshmana Dora C, IIT Hyderabad , lchandrala@mae.iith.ac.in*	1. *Dr. Kannan B T, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. Arun Kumar Perumal, IIT Kanpur,akp@iitk.ac.in*	2. *Dr. Bharadwaj K K, SRMIST*

Course Code	21ASE302T	Course Name	HELICOPTER AERODYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the concepts of helicopter configurations, characteristics and its rotor systems*
CLR-2:	*predict various aspects of helicopter aerodynamics in vertical flight*
CLR-3:	*examine the rotor’s mechanisms and aerodynamics in forward flight*
CLR-4:	*examine the performance of helicopter in hovering and climbing*
CLR-5:	*determine the trim, stability and control characteristics of helicopter*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*examine the configurations of helicopter, their characteristics and rotor systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*determine the various aspects of helicopter aerodynamics in vertical flight using momentum and blade element theories*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*interpret the rotor mechanism and rotor aerodynamics in forward flight*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*calculate the performance of helicopter in hovering and climbing*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*examine the trim, stability and control of helicopters*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Historical Background and Overview of Helicopter Aerodynamic Design	***9 Hour***
Historical Development, Helicopter configurations, Specifics of helicopters, Rotor systems, Aerodynamic design – Blade section design, Blade tip shapes, Parasite drag, Rear fuselage unsweep, Design process Articulated rotor system, Effect of cyclic pitch change, Swash plate, Rotor systems	
Unit-2 – Rotor in Vertical Flight	***9 Hour***
Momentum theory for hover, Figure of merit, Momentum theory for vertical climb, Vertical descent, Complete induced-velocity curve, Autorotation, Wake and its analysis methods, Ground effect, Blade element theory, Thrust approximations, Non-uniform flow, Ideal twist, Blade mean lift coefficient, Power approximations, Tip loss	
Unit-3 - Mechanisms and Aerodynamics of Rotor in Forward Flight	***9 Hour***
The edgewise rotor, Flapping motion, Rotor control, Equivalence of flapping and feathering, Momentum theory for forward flight, Wake analysis, Blade element theory – Factors involved, Thrust, Torque and power, Flapping coefficients	
Unit-4 – Performance	***9 Hour***
Hover and Vertical Flight, Forward level flight, Climb in forward flight, Optimum speeds, Maximum level speed, Rotor limits envelope, Accurate performance prediction	
Unit-5 - Trim, Stability and Control	***9 Hour***
Trim, Treatment of stability and control, Static stability – Incidence disturbance, Forward speed disturbance, Angular velocity disturbance, Sideslip disturbance, Yawing disturbance, Dynamic stability – Analytical process, Special case of hover, Hingeless rotor, Control, Auto stabilization	

Learning Resources		
	1. John Seddon, Simon Newman, Basic Helicopter Aerodynamics, 3rd Edition, John Wiley & Sons, Ltd., 2011. 2. Rathakrishnan E., Helicopter Aerodynamics, PHI Learning Private Limited, Delhi, 2019. 3. Nikolsky Alexander A., Helicopter Analysis, John Wiley & Sons Inc., New York, 1951	4. George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons Inc., New York, 1975. 5. Wayne Johnson, Helicopter Theory, Dover Publications, USA, 1994. 6. Gordon Leishman J., Principles of Helicopter Aerodynamics, Cambridge University Press, New York, 2000. 7. Alfred Gessow, Garry C. Myers Jr., Aerodynamics of the Helicopter, College Park Press, USA, 1999

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. A. Sakthivel, CEMILAC – DRDO, asakthironika@gmail.com*	1. *Dr. K. Maruthupandiyan, Institute of Aeronautical Engineering, k.maruthupandiyan@iare.ac.in*	1. *Dr. S. M. Aravindh Kumar, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. T. Chandrasekar, IIT Bombay, tchandra@aero.iitb.ac.in*	2. *Dr. K.K. Bharadwaj, SRMIST*

Course Code	21ASE303T	Course Name	APPLIED STRUCTURAL MECHANICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the statically determinate structures in an airplane*
CLR-2:	*explain the statically indeterminate structures in an airplane*
CLR-3:	*apply various energy methods in aerospace applications*
CLR-4:	*predict material failure and structural safe design from certain theories of failure*
CLR-5:	*discuss the importance of Finite Element Method in structural applications*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate linear analysis of determinate structures in various aircraft structural components*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*solve the reaction forces and illustrate the shear force and bending moment diagrams for indeterminate beams*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*calculate the reactions of structures using energy methods*	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-4:	*examine the structural failures using failure theories*	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-
CO-5:	*apply finite element method for structural analysis*	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-

Unit-1 - Statically Determinate Structures	***9 Hour***
Statically determinate and statically indeterminate structures - Analysis of plane truss - Method of joints - Method of sections - Analysis of space truss and plane frames - Principle of virtual work - Deflection of truss, frame and rings using unit load method	
Unit-2 - Statically Indeterminate Structures	***9 Hour***
Statically indeterminate beams - Analysis of continuous beam - Clapeyron's equation of three moments - Application of Clapeyron's equation of three moments to continuous beam with simply supported ends, fixed end supports, one end fixed and other one simply supported end and continuous over-hanging beam - Moment distribution method - Application of Moment distribution method to continuous beam with simply supported ends, fixed end supports, one end fixed and other one simply supported end and continuous over-hanging beam	
Unit-3 - Energy Methods	***9 Hour***
Strain energy and complimentary energy - Strain energy stored due to axial, bending, shear and torsional loads - Castigliano' s theorem - Application of Castigliano' s theorem to determine deflection of beams and trusses - Unit load method - Dummy load method - Case studies	
Unit-4 - Failure Analysis	***9 Hour***
Failure of ductile and brittle materials - Theories of failure - Maximum principal stress theory - Maximum shear stress theory - Maximum principal strain theory - Maximum strain energy theory - Distortion energy failure theory - Octahedral shear stress failure theory - Material fatigue - Introduction to fatigue failure and fracture - S-N curve - Case studies: Problems on thin and thick cylindrical shells	
Unit-5 - Finite Element Methods	***9 Hour***
Introduction - Formulation of FE equations - Overview of software packages - Approximate methods - Strong and weak forms - Shape function - Types of elements - Stiffness and flexibility matrix for simple cases - Vibration problem - Case studies	

Learning Resources	1. *Megson T H G, "Aircraft Structures for Engineering Students", 7th edition, Elsevier, 2022* 2. *Peery, D.J., "Aircraft Structures", 2nd edition, McGraw-Hill, N.Y., 1999.* 3. *Howard D Curtis, "Fundamentals of Aircraft Structural Analysis", WCB-McGraw Hill, 1997.* 4. *James M. Gere and Barry J Goodno, "Mechanics of Materials", 8th Edition, Cengage Learning Custom Publication. 2012*	5. *Timoshenko, S.P., and Young, D.H., "Elements of Strength of Materials Vol. I and Vol. II"., T. Van Nostrand Co-Inc Princeton-N.J. 1990* 6. *John Case, and Chilver, A.H., "Strength of Materials and structures", Edward Arnold Publishers Ltd., 2016* 7. *Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, 2002* 8. *Rao, S.S., "Finite Element Method in Engineering", Butterworth, Heinemann Publishing, 3rd Edition, 1998*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. S. Gurusideswar, SRMIST*
2. *Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE304T	Course Name	EXPERIMENTAL STRESS ANALYSIS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	discuss the various aspects of measurements and describe the physical principle of strain measuring instruments
CLR-2:	describe the working principle of resistance type strain gages and various circuits for strain measuring purpose
CLR-3:	explain the principles and materials in photoelastic concepts
CLR-4:	demonstrate the advance concepts in full-field strain technique
CLR-5:	illustrate various non-destructive testing methods

Course Outcomes (CO):	At the end of this course, learners will be able to:	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	list the measurement of strain and describe the mechanical, optical, pneumatic and electrical strain gauges for strain measurement	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	explain the physical principle and circuits used in resistance type strain gages and rosette analysis	3	3	-	-	-	-	-	-	-	-	-	2	3	-	-
CO-3:	illustrate the various photoelastic concepts of stress measurements and analyze fringe patterns	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-
CO-4:	apply advanced characterization techniques for stress analysis	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-
CO-5:	demonstrate the non-destructive methods of flaw detection	3	3	-	-	-	-	-	-	-	-	-	3	3	-	-

Unit-1 - Strain Gauge Systems **9 Hour**

Stress analysis - Analytical, Numerical and Experimental approaches - Principles of measurements - Accuracy - Precision - Tolerance - Range - Sensitivity -Threshold - Resolution - Hysteresis - Dead space - Error - Calibration - Strain gauge - Properties - Basic characteristics - Types - Mechanical - Electrical - Optical - Acoustical strain gauges - Laser displacement sensors

Unit-2 - Electrical Resistance Strain Gauges **9 Hour**

Principle of operation - Strain sensitivity of a conductor - Types - Materials - Strain sensitivity of a strain gauge - Transverse sensitivity factor - Gauge factor - Experimental determination of gauge factor - Temperature compensation - Strain gauge circuits - Rosette analysis - Stress gauges - Load sensors - Demonstration of strain measurement

Unit-3 - Photoelasticity **9 Hour**

Birefringence - Nature of light - Understanding polarization - Experiment of crossed polarizers - Stress-optic law - Polariscopes - Fringe patterns - Compensation techniques - Fringe separation methods - Photoelastic materials - Stress field in a circular disc under diametral compression

Unit-4 - Advanced Characterization Techniques **9 Hour**

Introduction to 3D photoelasticity - Digital photoelasticity – Photoelastic coatings - Brittle coating - Moire technique - Holography - Hologram and speckle interferometry - Shearography - Thermoelastic Stress Analysis (TSA) - Digital Image Correlation (DIC) - Caustics - Demonstration of caustic experiment

Unit-5 - Non-Destructive Testing **9 Hour**

Fundamentals of NDT - Fluorescent penetrant technique - Magnetic particle inspection - Eddy current testing - Radiography - Ultrasonic inspection - Thermography - Acoustic emission technique - Case study

Learning Resources	*1. Dally, J.W., and Riley, W.F., Experimental Stress Analysis, McGraw Hill Inc., New York, 1978* *2. Hetyenyi, M., Hand Book of Experimental Stress Analysis, John Wiley and Sons Inc., New York, 1972* *3. Srinath, L.S., Raghava, M.R., Lingaiah, K.Gargesha, G.Pant B., and Ramachandra, K., Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984*	*4. K. Ramesh, e-Book on Experimental Stress Analysis, IIT Madras, 2009. URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm* *5. K. Ramesh, Digital Photoelasticity – Advanced Techniques and Applications, Springer, 2000.* *6. W. N. Sharpe (Ed.), Springer Handbook of Experimental Solid Mechanics, Springer, 2008.* *7. Pollock, A.A., Acoustic Emission in Acoustics and Vibrations Progress, ed. By Stephens R.W.B., Chapman and Hall, 1983*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*		*-*		*-*
Level 5	*Evaluate*	*-*	*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	*1. Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. S. Gurusideswar, SRMIST*
2. Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com	*2. Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	*2. Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE305T	Course Name	COMPOSITE MATERIALS AND STRUCTURES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify Composite materials*
CLR-2:	*derive the governing equations of composite materials*
CLR-3:	*describe the mechanical behavior of composite materials*
CLR-4:	*analyze the stress, strain and various elastic modulus of composite materials*
CLR-5:	*explore various fabrication techniques of composite materials*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the types of composite materials and its properties*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*demonstrate application of composite materials in different aircraft components*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*identify different treatments to strengthen materials*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*describe various molding techniques*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*evaluate the stress strain relationships of composite Materials*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Basics of Composite Materials ***9 Hour***

Natural Composites-Basic Definitions-Basic Definitions-Introduction to Fibers-Types of Fibers - Matrices-Types of Matrices-Properties of Fibers-Properties of Matrices-Classification of Composite Materials-Block Diagram of Classification-Application of Composites-Application of Composites-Hooke's Law-Basics of Hooke's Law-Numericals solving

Unit-2 - Stress- Strain Relations ***9 Hour***

Generalized Hooke's law-Numericals-Hooke's law for Isotropic Materials-3Dimensional Orthotropic Materials- 2Dimensional Unidirectional lamina-Numericals-2Dimensional Angle Lamina-Numericals solving

Unit-3 - Micro and Macro Mechanics ***9 Hour***

Micro Mechanics-Micro Mechanics-Derivation of Volume Fraction, Mass Fraction-Density and Void Content-Numericals solving-Strength of Materials approach-Evaluation of four Elastic Modulii-Numericals Solving-Elasticity approach to determine Material Properties-Macro Mechanics-Macro Mechanics-Stress strain relationship with respect to neutral axis and arbitrary axis-Experimental characterization of Lamina

Unit-4 - Special Cases-Failure Predictions and Sandwich Structures ***9 Hour***

Governing differential equation of general laminate-Angle ply laminates-Cross ply laminates-Numericals Solving-Laminate Codes-Laminate Codes-Special cases of laminates-ABD Matrix representation-Maximum Stress failure theory-Maximum Strain failure theory-Tsai Hill failure theory-Tsai wu failure theory-Basic concept of sandwich construction-Materials used in sandwich construction-Failure modes of Sandwich panels

Unit-5 - Fabrication Techniques of Composite Materials ***9 Hour***

Manufacturing of Glass Fibers-Block diagram of Manufacturing-Manufacturing of Carbon Fibers-Block diagram of Manufacturing-Fabrication of Composite Materials-Molding Techniques-Hand Layup Process-Spray layup process-Compression Molding-Resin Transfer Molding-Vacuum Bag and Pressure bag Molding-Autoclave Processing-Filament winding process-Pultrusion Process-Types of resins-Properties and Applications-Netting Analysis

Learning Resources	1. *Autar K Kaw, "Mechanics of Composite Materials" CRC Press, Taylor and Francis Group 2005.* 2. *Jones.R.M, "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.*	3. *Agarwal.B.D, and Broutman.L.J, "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995* 4. *Lubin.G, "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*	*-*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, NAL, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Mr. N. Bharat, SRMIST*
2. *Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, NIT Karnataka, Surathkal,vadivuchezhian_k@yahoo.co.in*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE306T	**Course Name**	THEORY OF ELASTICITY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the concept of stress-strain to solve elasticity problems and equilibrium equations*
CLR-2:	*develop the stress-strain relations-strain-displacement relations and compatibility equations*
CLR-3:	*apply the solutions of polynomial to determine the stress- displacement for cantilever and simply supported beams*
CLR-4:	*develop the stress-strain & displacement relations in polar coordinate and predict the stress distribution in axisymmetric problems*
CLR-5:	*relate the concept of torsion for circular and non-circular members*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of stress-strain to derive equilibrium equations & compatibility conditions*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*solve the plane stress & plane strain problems*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-3:	*determine the polynomial solutions and solve simple two-dimensional problems in cartesian coordinate*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-4:	*solve the two-dimensional problem in polar coordinates*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-5:	*calculate the stresses induced due to torsion in non-circular cross-sections*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Basic Equation of Elasticity	***9 Hour***
Basic Concepts - Stress & Strain - Sign conventions - Notations for stress & strain - Sign conventions - Notations for stress & strain - Components of stress - Generalized Hooke's Law - Components of strain - Equations of equilibrium in 2D - Equations of equilibrium in 3D - Index notations for stress & strain - Stress - Strain relations - Lame's constant - Cubical dilatation - Lame's constant - cubical dilatation - Compressibility of materials - Bulk Modulus	
Unit-2 - Plane Stress and Plane Strain Problem	***9 Hour***
Plane stress and Plane strain - Stress at a point - Boundary Conditions - Strain at a point - Compatibility equations - Principal stresses and strain - Mohr's circle for plane stress - Mohr's circle for plane strain - Saint-Venant' Principle - Airy's stress function - Biharmonic equation equations	
Unit-3 - Applied Concepts	***9 Hour***
Solutions by polynomials of second degree - third degree - fourth degree - fifth degree - Bending of a cantilever beam and simply supported beam	
Unit-4 - Polar Coordinates	***9 Hour***
Equations of equilibrium in polar coordinates - Stress-strain relations - Strain components in polar coordinates - Strain-displacement relations - Equations of compatibility in polar coordinates - Stress distribution symmetrical about an axis - Stress distribution in pure bending of curved bars - Stress distribution in rotating disc	
Unit-5 - Torsion	***9 Hour***
Introduction to torsion of non-circular members - Saint-Venant's theory of torsion - General solutions of torsion problems - Boundary conditions - Conditions at the end of a twisted bar – Torsion of shafts with Elliptical cross-sections - Rectangular cross-sections - Equilateral cross-sections	

Learning Resources	1. *Timoshenko- S.P and Goodier J.N.- Theory of Elasticity- McGraw-Hill Education- Third Edition. - 2017* 2. *Enrico Voltorra and J.H.Caines- Advanced Strength of Materials- Prentice Hall- New Jersey- 1991.*	3. *Wang- C.T.- Applied Elasticity- Mc-Graw-Hill Co.- New York 1993* 4. *Sokolnkoff- IS. - Mathematical Theory of Elasticity- Mc-Graw-Hill Co.-New York 1978.* 5. *T.G.Sitharam- L. Govindaraju – Elasticity for Engineers – IK International Pvt. Ltd 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. L.R. Ganapathy Subramanian, SRMIST*
2. *Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, NIT, Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE307T	**Course Name**	FUNDAMENTALS OF COMBUSTION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the chemistry of combustion, the efficiency of burning processes and about pollutant emissions*
CLR-2:	*identify the significance of material identification for industrial applications, including burners and engines*
CLR-3:	*create insights to the combustion in engines and gas turbines, controlled experimentation and computational combustion*
CLR-4:	*analyze the principle of normal and microgravity flames for space activities and fire safety*
CLR-5:	*utilize the combustion concepts for the broad understanding of system testing, validation and designing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the combustion phenomenon and its applications to Aerospace Engineering*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-2:	*comprehend the concept and applications of the fundamental combustion parameters*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*examine combustion regimes: flame and detonation, premixed and diffusion combustion problems with applications*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*categorize the chemical kinetics, chain reactions and related processes*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*determine normal and microgravity flames and apply the knowledge to Aerospace Engineering Applications*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Basic Concepts, Heat Transfer and Combustion	***9 Hour***
Basic Concepts: Ideal gases, mass and mole concept, fuel and oxidizer, basics of thermodynamics. Various modes of combustion and their characteristics. Combustion and thermochemistry - Review of property relations. Laws of thermodynamics-Reactant and product mixtures. Solving Problems. Combustion Stoichiometry, Heat of Formation, Reaction, combustion. Lower Calorific Value (LCV) and Higher Calorific Value (HCV), Relationships between Calorific Values, Reaction Enthalpies and Formation Enthalpies. Thermochemical calculations: Enthalpies, Internal energy, Entropy. Chemical reaction and Stoichiometric coefficients, Air-Fuel ratio, Equivalence ratio. Calculation of Energy Release for Stoichiometric, oxidizer-rich and fuel rich Explosives. Adiabatic flame temperature calculations: Analysis and practical considerations. Chemical equilibrium, volumetric and gravimetric analysis. Dissociation process and related issues.	
Unit-2 - Combustible Materials and Flammability	***9 Hour***
Combustion regimes and classification of combustible materials. Flammability limits- Flame stabilization and material identification systems. Maxwell equation and parametric analysis of enthalpies and internal energy. Phase transformation, Combustion products, Flow analysis and approaches. Partial differential equations for combustion. Vectors and conservation equations for energy and momentum. Application of Mass Energy and species Conservation. Emission reduction and techniques in combustion instruments. Simulations and data analysis of combustion processes	
Unit-3 - Chemical Kinetics and Energy Transfer	***9 Hour***
Introduction to Chemical kinetics, Rate laws, order and molecularity, Forward and Reverse Reactions. Energy Release Rates in a Chemical Reaction, Concentration, Law of Mass Action, Arrhenius Law. Variations of Reaction Rate, Temperature and Concentration in a Chemical Reaction with Time. Rate of Reactions, Temperature dependence of rate coefficients, Pressure dependence of rate coefficients. Phase Rule for a System with Chemical Reactions. Thermodynamic Equilibrium Constant for a Gaseous Reaction. Chain Reactions and Methods of Solving Chemical Kinetic Rate Equations. Transport properties for gas mixtures.	
Unit-4 - Classification of Flames	***9 Hour***
Flame structures. Laminar flame speed, Factors affecting flame velocity--Methods of measuring flame velocity. Stability limits of laminar flames. Flame propagation through combustible mixtures. Introduction to diffusion flames; appearance, structure, theoretical considerations. Burning in convective atmospheres and Thermal spontaneous ignition. Image processing and combustion experimentation science. Introduction to computational combustion and relevance. Numerical modeling of flame spreading Phenomenon	

Unit-5 - Fire Propagation and Safety	***9 Hour***
Combustion in Normal and microgravity. Factors affecting heat transfer and flame propagation in normal and low gravity flames. Fire safety, Soot formation and related implications. Working of premixed gas burners and candle flames. Comparison of normal and microgravity experiments. Flame spread over thin fuels in actual and simulated microgravity conditions. Environmental combustion, heat transfer and emission in industrial applications. Fire safety aspects of combustion sciences	

Learning Resources	*1. Stephen R. Turns, “An Introduction to Combustion: Concepts and Applications”, 3rd Edition, McGraw-Hill Education, 2011.* *2. Kenneth K Kuo, “Principles of Combustion”, 2nd Edition, John Wiley and Sons, 2005.* *3. D. P. Mishra., “Fundamentals of Combustion”, Prentice Hall of India, New Delhi, 2008.*	*4. H.S. Mukunda., “Understanding Combustion”, Universities Press, Second edition 2009.* *5. Anil W. Date. “Analytic Combustion: With Thermodynamics, Chemical Kinetics and Mass Transfer”, Cambridge University Press, 2011.*

Learning Assessment							
	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in	*1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	*1. Mr. Vinayak Malhotra, SRMIST*
2. Dr Lakshmi VM, Scientist/Engineer ‘SG’, VSSC, ISRO, vm_lakshmi@vssc.gov.in	*2. Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	*2. Dr. T. Selvakumaran, SRMIST*

Course Code	21ASE308T	**Course Name**	HEAT TRANSFER	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*examine different modes of heat transfer*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*use the concept of conduction in plane wall and cylinders in heat transfer problems*															
CLR-3:	*solve the need of the Utilization of extended surface & Heat Generation*															
CLR-4:	*use the concept of convection mode and it various applications in heat transfer problems*															
CLR-5:	*use the concept of radiation mode and its various applications*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*solve conduction heat transfer problems in various coordinates systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*determine forced convection heat transfer rate for internal and external flow conditions*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*calculate free convection and phase change heat transfer problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*determine radiation heat transfer using electrical network analogy*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply heat transfer concepts in the design of fins and heat exchangers*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Conduction	***9 Hour***
Heat transfer - basic modes of heat transfer, conduction heat transfer, general heat conduction equations in Cartesian, cylindrical and spherical coordinates - initial and boundary conditions - one-dimensional steady state conduction with and without heat generation, temperature dependence of thermal conductivity, introduction to two-dimensional steady state conduction, Transient heat conduction in one dimension - lumped heat capacity system, semi-infinite solids	
Unit-2 - Forced Convection	***9 Hour***
Fundamentals of convection. Conservation of energy, thermal boundary layers, similarity and dimensionless parameters, momentum/heat/mass transfer analogies, Forced convection external flows: similarity parameters; laminar and turbulent boundary layers on flat surfaces; heat transfer to cylinders, spheres, tube banks, and packed beds; impinging jets, Forced convection internal flows: laminar and turbulent flow through circular and noncircular ducts, fully developed flow, hydrodynamically and thermally developing flows, empirical correlations	
Unit-3 - Free Convection and Phase Change Heat Transfer	***9 Hour***
Free convection boundary layer equations: laminar boundary layers on flat surfaces, turbulence, empirical Correlations, Condensation and boiling -film and drop wise condensation - film boiling and pool boiling, empirical relations for heat transfer with phase change	
Unit-4 - Thermal Radiation	***9 Hour***
Electromagnetic radiation spectrum, thermal radiation, black and gray surfaces, monochromatic and total emissive power, Planck's law, Stefan-Boltzmann law, Wein's Displacement law, surface properties, Kichhoff's identity, radiation exchange between black surfaces and between diffuse gray surfaces - shape factors for simple configurations- surface and shape resistances, radiation shields, electrical network analogy	
Unit-5 - Heat Transfer Applications	***9 Hour***
Applications of heat transfer like extended surfaces, critical insulation thickness, heat exchangers, heat pipes etc. Analysis of fins with constant area of cross section, Heat Exchangers- LMTD, correction factors, effectiveness-NTU method, Design of heat exchangers –Compact heat exchangers, introduction to Heat pipes and their applications. Ablative HT, Applications of radiative heat transfer, Multiple- mode heat transfer problems	

Learning Resources	1. *Yunus A. Cengel & Afshin J. Ghajar, "Heat & Mass Transfer", fifth Edition,McGraw-Hill, 2014* 2. *Theodore L. Bergman, Adrienne S. Lavine, Frank P. Incropera , David P. DeWitt, "Fundamentals of Heat and Mass Transfer", seventh Edition, John Wiley and Sons, New York, 2011*	3. *John H Lienhard, "A Heat Transfer Text Book", Dover publications inc, New York, 2011.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	60%	-	60%	-	60%	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. R. Krishnamurthy, DRDL- DRDO, Hyderabad, murthy_cfd@yahoo.com*	1. *Dr. B. Premachandran, IIT Delhi, prem@mech.iitd.ac.in*	1. *Dr. S. Senthilkumar, SRMIST*
2. *Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in*	2. *Dr. M. Arun, National Institute of Technology (NIT), Karnataka, m.arun1978@gmail.com*	2. *Mr. K. B. Ravichandrakumar, SRMIST*

Course Code	21ASE309T	Course Name	THEORY OF FIRE PROPAGATION AND SAFETY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
CLR-1:	*identify the fire dynamics, the burning processes and implications*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*identify the engineering applications of basic chemical combustion driven engineering systems*															
CLR-3:	*identify the significance of material identification for industrial applications, including burners and engines*															
CLR-4:	*create insights to the fires in engines, buildings, forests and compartments*															
CLR-5:	*utilize the fire safety principles for system testing, validation and designing*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the fire related hazards in practical, functional, engineering, industrial applications*	2	2	-	-	-	-	-	-	-	-	-	1	1	-	-
CO-2:	*explain fire phenomenon, its applications and safety*	2	2	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-3:	*comprehend the concept and applications of energy conservation in fires utilizations and apply the same for recent engineering advancement*	3	2	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-4:	*detail basic knowledge to the physical principles governing fire growth*	2	2	2	-	-	-	-	-	-	-	-	1	1	-	-
CO-5:	*apply the latest engineering capability in fire detection, prevention systems and life safety*	2	2	-	-	-	-	-	-	-	-	-	1	3	-	-

Unit-1 - Basic Concepts: Fire Phenomenon ***9 Hour***

Introduction to Fire Science, fire losses. Relevant material properties, and heat transfer. Chemistry and classification of fires-Composition of Combustion- (Flame, heat, fire gases, smoke). Review of Thermodynamics and Fluid Mechanics in fire behavior. Solving Problems. Heat and mass transfer. Relevance of fire classification and governing dynamics. Material Flammability principles, Thermal Ignition. Sources of ignition of combustible materials. Application of Mass Energy and species Conservation. Rate of burning. Heat transfer from Flames-Ignition temperature. Flash point, Fire point, Flash over. Components and objectives of a fire safety strategy. Fire dynamics process and related issues.

Unit-2 - Ignition and Fire Dynamics ***9 Hour***

Importance of fire dynamics on a fire strategy. Fundamentals of heat and mass transfer for fire, smoke production and transport. Fundamentals of ignition and flame propagation. Role of Material flammability in fire propagation. Parameters affecting ignition, flame spread. Heat release rate and flame extinction phenomenon. Explosions and fires, Egress– principles and calculations. Fire safety techniques in combustion instruments. Applications of fire dynamics.

Unit-3 - Fire Plumes ***9 Hour***

Development and behavior of fire propagation in free and confined atmosphere. Factors affecting fire growth. Buoyant Plumes, Combusting Plumes, Starting plume. Fireball, Transient Aspects of Fire Plumes. Fire spread over liquid and solid fuel surfaces. Enclosure fires, Incineration. Solving Problems. Forest fires Analysis of fire plumes. Fire safety aspects of plumes. Standardized material flammability testing. Solid, liquid and gaseous fuel combustion and its relation to fire safety.

Unit-4 - Fire Detection Characteristics ***9 Hour***

Identifying fire spread hazards and risks. Safety and financial implications, developing safe work systems. Introduction to Fires causes / Explosion hazards in Chemical, Electrical units. Finite Real Fire Effects. Fire hazards (health–flammability-reactivity (stability)). Air contaminants in fires-toxic effects of fire gases. Smoldering combustion science. Introduction to smoke formation, composition and movement, hazards. Essential conditions for explosion occurrence. Explosion characteristics and Prevention. Burning in convective atmospheres and Thermal spontaneous ignition.

Unit-5 - Fire Protection	***9 Hour***
Active and Passive Fire Protection Features. Fire prevention-handling and storing flammable and combustible liquids/fuels/propellants. Elimination of ignition sources. Fire protection in plants and factories, Fire walls, fire doors. Solving Problems. Fire prevention/suppression features, Microgravity fires control. Fire suppression. Fixed automatic sprinklers. Sprinkler system and design. Environmental fire propagation considerations. Role of combustion detectors (Fire detection, smoke detection, types of ionization-photoelectric-light intensity-scattered light detectors. Heat detectors. Flame detectors -infra red detector - ultraviolet flame detector). Portable fire Extinguishers-Types-extinguisher-location, Inspection–testing, principles and calculations. Incineration. Fire Safety Aspects.	

Learning Resources	*1. James G. Quintiere, "Fundamentals of Fire Phenomena", 2006 Wiley.* *2. Dougal Drysdale, "An Introduction to Fire Dynamics", 2011 Wiley.* *3. Akhil Kumar Das., "Principles of Fire Safety Engineering: Understanding Fire and Fire Protection", Prentice Hall of India, New Delhi, 2014.*	*4. R.S. Gupta., "A Hand Book of Fire Technology", Second edition, Modern press, 2005.* *5. V, K, Jain. "Fire safety in buildings", New age international publisher, 2006.* *6. Niamh Nic Daeid., "Fire Investigation", CRC Press, 2004.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	25%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in	*1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	*1. Mr. Vinayak Malhotra, SRMIST*
2. Dr Lakshmi VM, Scientist/Engineer 'SG', VSSC, ISRO, vm_lakshmi@vssc.gov.in	*2. Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	*2. Dr. T. Selvakumaran, SRMIST*

Course Code	21ASE310T	**Course Name**	AIRFRAME MAINTENANCE AND REPAIR	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the standard practices of airframe in fittings and repair process*
CLR-2:	*identify Plastics and Composite material repair in Aircraft Structures*
CLR-3:	*carryout inspection, assembly and testing of major and minor aircraft components*
CLR-4:	*explain the various documents of Inspection & Maintenance of major and auxiliary systems*
CLR-5:	*identify the various hazardous materials and storage practices*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain welding, riveting process and sheet metal repair operations and maintenance practices in aviation industry*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*describe maintenance and repair procedures on plastics and composite structures*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*demonstrate the Assembly & Rigging procedures and operation of Aircraft flight controls*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*describe the inspection and maintenance using the different types of manuals and check lists*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*explain Hazardous materials, safety, Inventory Procedures & Troubleshooting practices*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Structural Repair Practices	***9 Hour***
Identification of Fittings of aircraft hydraulic, fuel, oil, pneumatic and air system, Flexible hoses, Rigid pipes, Replacement and Installation of flexible hoses, Repair to fittings, Bending and belling/flaring aircraft pipes, Classification of Damage, Damage Investigation, Structural repair layout Techniques, Welding Repair Practices, Major welded repairs, Special welding repairs, Rivet repair design, Types and Nomenclature of Rivets, Equipments used for Riveting, Riveting repair Process in Aviation Industry	
Unit-2 - Plastics and Composites Repair	***9 Hour***
Applications & Advantages of Plastics used in Aircraft., Classification & Types of Plastics, Identification of Clear Plastics, Storage and Protection, Cutting, & Drilling of Plastics, Forming of Plastics. Cementing, Annealing & Cleaning of Plastics, Installation of Plastic Windows and Windshields, Inspection of Plastic Components, Repair of Cracks in Plastics, Repair of Holes in Plastics, Advantages of Composites over Metals in Aerospace Applications, Equipments used in Composite Fabrication, Wet Layup Process of Building Composite Parts. Prepreg Process of Building Composite.Parts, Repair of Composite Components, Special Precautions, NDT methods in Composite materials, Painting of composite parts	
Unit-3 - Airframe Assembly and Rigging	***9 Hour***
Inspection and testing of control cables, Aircraft Assembly and Rigging operations, Rigging Specifications, Aircraft Leveling Procedure, Assembly of Major Structural Components, Assembly of Movable Control Surfaces, Fixed Surface Alignment – Symmetry Check, Demonstration of Symmetry Check in Cessna Aircraft, Effects of Rigging on Flight, Checking & Adjusting Dihedral angle, Checking & Adjusting Incidence angle, Alignment Check of Empennage, Alignment Check of Wings, Alignment Check of Engines, Demonstration of various checks in Cessna.	
Unit-4 - Inspection Procedure	***9 Hour***
Inspection, Documentation and quality assurance, Routine, progressive, Annual inspection and procedure, Continuous and Special Inspection, Aircraft logs, Check lists, Publications. Manuals, Type certificate, illustrated parts catalogue, Airworthiness directives, Typical examples of inspection and checks of aircraft systems.	

Unit-5 - Hazardous Materials and Safety	*9 Hour*
Hazardous Materials, Types, Flammables - Handling, Storage & Emergency Procedure, Corrosives - Handling, Storage & Emergency Procedure, Toxins &Reactives - Handling, Storage & Emergency Procedure, Physical & Biological Hazards, Handling, Storage & Emergency Procedure, Osha's Hazardous Communication Standards, Material Safety Data Sheet, Inventory & Labeling, Introduction to Troubleshooting Theory, Types, Troubleshooting with Chart, Examples, Troubleshooting without chart, Examples, Troubleshooting ,intermittent discrepancies, Examples	

Learning Resources	1. *Michael J.Kroes, William A.Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013* 2. *Aviation Maintenance Technician Handbook – Airframe, Vol.1, 2, U.S.Dept of Transportation,Federal*	3. *Larry Reithmeir., Aircraft Repair Manual, Palamar Books, Marquette, 1992.* 4. *Aircarft Inspection Procedures Part I & II, CAA, English Book House, New Delhi 1986*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*50%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*50%*	-	*50%*	-
Level 3	*Apply*		-		-		-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Blue Dart Aviation.manoharank@bluedart.com*	1. *Dr. V.Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr.S. Sivakumar, SRMIST*
2. *Wg.cdr R.Annamalai,IAF, Tambaram annamalai.ramasamy2@gmail.com*	2. *Dr.S.Nadaraja pillai, SASTRA University. Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr.S. Rajkumar, SRMIST*

Course Code	21ASE311T	**Course Name**	AIRCRAFT ENGINE AND INSTRUMENT SYSTEMS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the type of Reciprocating engine fuel metering system and its components used in aircraft*
CLR-2:	*describe the components and accessories of gas turbine engine fuel system*
CLR-3:	*differentiate the type of induction and exhaust system used in the aircraft engines*
CLR-4:	*define the engine ignition and lubrication systems used in the aircraft engines*
CLR-5:	*explain the various aircraft engine instruments and their functions*

		Program Outcomes (PO)												**Program Specific outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the operation of Reciprocating engine fuel metering system and its components used in aircraft*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-2:	*explain the components and accessories of gas turbine engine fuel system*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-3:	*discuss the working of induction and exhaust system used in various aircraft engines*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-4:	*recite the need and functions of aircraft ignition and lubrication systems used in the aircraft engines*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	2	-	-
CO-5:	*interpret the principle and operation of various aircraft engine instruments*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	2	-	-

Unit-1 - Reciprocating Engine Fuel Systems ***9 Hour***

Reciprocating engine modular concept. Fuels and their characteristics for IC engines, Gravity feed fuel system, Fuel system- Basic fuel system, Fuel system requirements, Fuel metering systems- Fuel metering devices for reciprocating engines. Carburetor systems- Main metering, Idling, Accelerating and Economizer systems, Carburetor types - Float-type carburetor, Pressure injection carburetor. Automatic Mixture Control (AMC), Fuel-Injection systems - Bendix/Precision fuel-injection system.

Unit-2 - Gas Turbine Engine Fuel Systems ***9 Hour***

Gas turbine engine modular concept. Fuels and their characteristics for gas turbine engines, Pressure feed fuel system, Turbine engine fuel system - General requirements, Hydro mechanical fuel control, Hydro mechanical / Electronic fuel control. FADEC systems – FADEC system for an auxiliary power unit, FADEC fuel control propulsion engine. Engine fuel system components - Main fuel pumps, Fuel heater, Fuel filters, Flow divider, Fuel spray nozzles and Fuel manifolds

Unit-3 - Induction and Exhaust System ***9 Hour***

Reciprocating engine induction systems - Basic carburetor induction system, Induction system icing, induction system filtering, Supercharged induction systems. Reciprocating engines exhaust systems, Exhaust systems with turbocharger. Turbine engine inlet systems – Turboprop, Turboshaft Turbojet, and Turbofan engine inlet sections. Turbine engine exhaust nozzles - Thrust reversers, Afterburning / Thrust augmentation, Thrust vectoring, Engine noise suppression, Turbine engine emissions.

Unit-4 - Engine Ignition and Lubrication Systems ***9 Hour***

Reciprocating Engine Ignition Systems - Magneto-Ignition system operating principles, High-Tension magneto system theory of operation, Low-Tension magneto system. Turbine engine ignition systems -Capacitor-type ignition system, Capacitor discharge exciter unit, Igniter plugs. Principles of engine lubrication, Lubrication system components Reciprocating engine lubrication systems - Combination splash and pressure lubrication, Dry sump and Wet-sump lubrication Systems operation. Turbine Engine Lubrication Systems - Typical Dry-sump variable pressure lubrication system, Wet-Sump Lubrication System.

Unit-5 - Engine Instruments	***9 Hour***
Reciprocating engine instruments - Oil pressure, Oil temperature, Cylinder head temperature (CHT), Manifold pressure, Carburetor temperature, Fuel quantity, Fuel pressure, and Tachometer indicators. Turbine engine instruments - Oil pressure, Exhaust gas temperature (EGT), Turbine inlet temperature (TIT) or turbine gas temperature (TGT), Engine pressure ratio (EPR), Fuel quantity, Fuel pressure, Fuel flow, Tachometer (percent calibrated) N1 and N2 compressor speeds, and Torque meter (on turboprop and turboshaft engines) indicators.	

Learning Resources	*1. Aviation Maintenance Technician Handbook - Airframe, Vol.2, U.S. Dept. of Transportation, Federal Aviation Administration, Flight Standards Service, 2012.* *2. Aviation Maintenance Technician Handbook - Power plant, Vol.1, 2, U.S. Dept. of Transportation, Federal Aviation Administration, Flight Standards Service, 2012.*	*3. E.H.J. Pallet, Aircraft Instruments, 2nd edition, Pearson Publishing Company, 2009.* *4. Michael J. Kroes, William A. Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*50%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*50%*	-	*50%*	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Wg.Cdr retd.Manoharan, Blue Dart Aviation, Chennai manoharank@bluedart.com.	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2. Wg.cdr R.Annamalai, IAF, Tambaram,annamalai.ramasamy2@gmail.com	*2. Dr.S.Nadaraja pillai, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	*2. Mr. S. Rajkumar, SRMIST*

Course Code	21ASE312T	**Course Name**	HELICOPTER MAINTENANCE	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the types of rotor, helicopter controls ,gears, bearings and ground handling*
CLR-2:	*layout the main rotor system components and its maintenance*
CLR-3:	*demonstrate the engine power transmission to rotors*
CLR-4:	*identify the power plant modification , installation and maintenance*
CLR-5:	*identify the various airframe construction and related systems*

		Program Outcomes (PO)												**Program Specific Outcomes**		
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain helicopter fundamentals , main components and procedure of ground handling*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*describe the operation of main rotor components and its maintenance*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*describe the transmission system components and working of helicopter transmission system*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*identify the helicopter engine system components and maintenance of helicopter engines*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*explain helicopter fuselage construction ,Special equipments*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Flight Controls and Ground Handling	***9 Hour***
Helicopter Flight Controls ,Helicopter Rotor Arrangements, Folded Blades And Pylons, Inspection In Control Rigging , Maintenance In Control Rigging ,Towing, Towing Precautions, Helicopter Protection, Protection Equipments, Bearing And It's Types, Bearing Installation, Bearing Maintenance, Elastomeric Bearings, Gear, Types, Gear Pattern	
Unit-2 - Blade Tracking and Rotor Vibrations	***9 Hour***
Mast, Mast Stabilizer, Mast Dampeners, Swash plate flight control systems ,Rotor alignment; Main and tail rotor tracking methods; Static and dynamic balancing , Span wise dynamic balance , Blade sweeping,, Electronic balancing,, Dampener maintenance, Counter weight adjustments, Auto rotation adjustments, Dynamic model of the rotor, Vibration types, Vibration absorbers, Measurement of vibration in flight, Vibration indicating systems, vibration reduction methods; Ground resonance	
Unit-3 - Ransmissions	***9 Hour***
Transmission layout, Gear boxes, Transmission couplings, Drive shaft, Clutches, Free wheel units and Rotor brake. Tail rotor drive shafts, flexible couplings, bearings, vibration dampers and bearing hangers,, Rotor brake maintenance of roller unit, Rotor brake maintenance of torque meter, Vibrations in transmission systems, Mounting systems ,Transmission oil system	
Unit-4 - Power Plants	***9 Hour***
Fixed wing power plant modifications, Installation of typical Euro copter engine, cooling system, correlation system. Oil system, fuel system, Different types of power plant, Power plant maintenance, Maintenance of typical Euro copter Engine.	
Unit-5 - Airframe and Related Systems	***9 Hour***
Rotary wing fuselage structural construction, Tubular, sheet metal construction, Bonded construction, Bell-206, Euro copter BO-105, Fuselage, Fuselage maintenance, Airframe systems, Stress and loads on airframe, Wheel, Skid gear, Visibility, Structural components and materials- Body structure, Bottom structure, Cabin section, Rear section, Tail Boom, Vertical fin, Horizontal stabilizer, Skid gear, Anti vibration device, Special purpose equipments, High skid gear, Floats, Resque hoists, Cargo Hooks, Litter Installations, Light Installations, Spray equipment, Stabilization devices	

Learning Resources	*1. JoeSchafer,,HelicopterMaintenance,Jeppessen publications,Jan1,1980* *2. Gupta. L Helicopter Engineering, Himalayan Books 1996*	*3. "Bramwell A.R.S, Helicopter Dynamics, Edward Arnold Publications London 1976".* *4. 4. Johnson W Helicopter theory, Princeton University pres 1980.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	50%	-	50%	-	50%	-
Level 2	*Understand*	50%	-	50%	-	50%	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. 'Wg.Cdr retd.Manoharan, Blue Dart Aviation. manoharank@bluedart.com	*1. .Dr. V.Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	*1. .Dr..S. Sivakumar, SRMIST*
2. .Wg.cdr R.Annamalai, IAF, Tambaram annamalai.ramasamy2@gmail.com	*2. .Dr.S.Nadaraja pillai, SASTRA University ,Thanjavur, nadarajapillai@mech.sastra.edu*	*2. .Mr.S. Rajkumar, SRMIST*

Course Code	21ASE313T	Course Name	SPACE MISSION DESIGN AND ANALYSIS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the space mission profiles and types of space missions, space environments, and space mission profile*
CLR-2:	*explain the complete set of space systems and various modules of space system and spacecraft*
CLR-3:	*interpret the basics of spacecraft motions and the governing equations of spacecraft motions and orbit determination techniques*
CLR-4:	*describe the satellite attitude dynamics and reentry vehicle dynamics*
CLR-5:	*interpret the interplanetary mission trajectories and associated concepts*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the space mission and the classifications of space mission, space environments,and space mission profile*	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	*demonstrate the importance of the spacecraft systems and instrumentation*	2	-	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*explain the necessity orbit determination techniques*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*demonstrate the key features reentry flight physics and injection of spacecraft's*	3	-	-	1	-	-	-	-	-	-	-	1	-	2	-
CO-5:	*evaluate the interplanetary mission profile*	3	-	3	-	-	-	-	-	-	-	-	1	-	2	-

Unit-1 - Space Missions and Space Environment ***9 Hour***

Space mission: classification, objectives, life cycle, mission needs, requirements and constrains. Mission characterization, evaluation. Orbit and constellation design, Space environment and its effects on orbiting spacecraft. Case Study: Space mission (Chandrayaan)/ Mangalyaan (ISRO)/ Curiosity (NASA)/ Mars Express (ESA)/Conceptual space mission.

Unit-2 - Spacecraft Subsystem ***9 Hour***

Spacecraft design and sizing, Attitude Determination and Control Subsystem, Telemetry tracking command subsystem, command and data handling subsystem, Electrical power subsystem, Thermal control subsystem, Guidance and Navigation subsystem, Propulsion subsystem Structures and Mechanism subsystems.

Unit-3 - General N-body Problem ***9 Hour***

Relative motion in the N-body problem, Restricted three body problem, Lagrange points, Jacobi constant, orbit determination technique: Gibbs method, orbit determination using true anomaly iteration, determination of orbital elements using any programming languages.

Unit-4 - Satellite Injection and Reentry Flight Dynamics ***9 Hour***

Launching of a satellite, General aspects of satellite injections, launch vehicle ascent trajectories, injection parameters and orbital elements, orbit deviation due to injection errors, Reentry mechanics and Aerodynamic heating, Elementary aspects of thermal protection system.

Unit-5 - Interplanetary Trajectories ***9 Hour***

Hyperbolic trajectory, Interplanetary Hohmann Transfer, Planetary departure, Planetary rendezvous, Planetary arrival, Sphere of Influence, Lunar Trajectories. Space mission design and analysis using open-source tool (GMAT-NASA)

Learning Resources	*1. Larson, Wiley J., and James Richard Wertz. Space mission analysis and design. No. DOE/NE/32145-T1. Torrance, CA (United States); Microcosm, Inc., 1992.* *2. Curtis, Howard D. Orbital mechanics for engineering students. Butterworth- Heinemann, 2013.*	*3. Cornelisse, Jacobus W., H. F. R. Schoyer, and Karel F. Wakker. "Rocket propulsion and spaceflight dynamics."London: Pitman, 1979.* *4. Griffin, Michael Douglas. Space vehicle design. AIAA, 2004.* *5. Fortescue, Peter, Graham Swinerd, and John Stark, eds.Spacecraft systems engineering. John Wiley & Sons, 2011.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*		*-*		*-*		*-*
Level 5	*Evaluate*	*-*	*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mrs. Smrutisudha Sahoo, s.sahoo.pxe@gov.in	*1. Dr. Trushlyakov Valery,Omsk State Technical University, Russia. vatrushlyakov@yandex.ru*	*1. Dr. Malaikannan G, SRMIST*
2. Mr. Dhanabal K, S & I Engineering Solutions Pv.t. Ltd. dhanabal@sandi.co.in	*2. Dr.R.V Ramanan, Indian Institute of Space Science and Technology, Thiruvananthapuram,rvramanan@iist.ac.in*	*2. Dr. Aravindh Kumar S. M., SRMIST*

Course Code	21ASE314T	Course Name	AERO ENGINE MAINTENANCE AND REPAIR	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Aerospace Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the inspection, maintenance and troubleshooting procedure of aircraft piston engines*
CLR-2:	*identify the piston engine overhaul procedure and engine testing procedure*
CLR-3:	*differentiate and familiarize with the jet engines components inspection and its special maintenance procedures*
CLR-4:	*describe the overhaul procedure of aircraft jet engines*
CLR-5:	*explain the engine airworthiness inspection criteria*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss the inspections and maintenance checks on aircraft piston engines*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-2:	*describe the piston engine overhaul procedure*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-3:	*recite the types and function of each component in gas turbine engines*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-4:	*identify the overhaul procedures and balancing of gas turbine components*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-5:	*interpret the engine airworthiness inspection criteria*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-

Unit-1 - Inspection of Piston Engines	***9 Hour***
Details of starting the engines, Inspection, maintenance and troubleshooting – Inspection of all engine components – Daily and routine checks – Overhaul procedures – Compression testing of cylinders – Special inspection schedules – Engine fuel, control and exhaust systems – Engine mount and super charger – Checks and inspection procedures.	
Unit-2 - Overhaul Procedures of Piston Engines	***9 Hour***
Symptoms of failure – Fault diagnostics – Case studies of different engine systems –Tools and equipment requirements for various checks and alignment during overhauling – Tools for inspection- destructive testing techniques on engines – Equipment for replacement of part and their repair. Engine testing: Engine testing procedures and schedule preparation –Online maintenance.	
Unit-3 - Inspection of Jet Engine Components	***9 Hour***
Details of starting and operating procedures – Gas turbine engine inspection & checks – Use of instruments for online maintenance – Special inspection procedures: Foreign Object Damage – Blade damage – etc. Maintenance procedures of gas turbine engines – Trouble shooting and rectification procedures – Component maintenance procedures – Systems maintenance procedures. Gas turbine testing procedures – test schedule preparation – Storage of Engines – Preservation and de-preservation procedures.	
Unit-4 - Overhaul Procedures of Jet Engines	***9 Hour***
Engine Overhaul procedures – Inspections and cleaning of components – Repairs schedules for overhaul – Balancing of Gas turbine components. Trouble Shooting - Procedures for rectification – Condition monitoring of the engine on ground and at altitude – engine health monitoring and corrective methods	
Unit-5 - Engine Airworthiness Inspection Criteria	***9 Hour***
Inspection and maintenance documents, Type certificate data sheets, Aircraft specifications, Supplemental type certificates, Airworthiness directives, Advisory circulars, Maintenance and service manuals, overhaul manual, illustrated parts catalog, Service information, Types of airworthiness inspections - Annual inspection, 100-hour inspection, Progressive inspection. Large and turbine-powered multi-engine aircraft inspections.	

Learning Resources	1. KROES & WILD, "Aircraft Power plants", 8th Edition - McGraw Hill, New York, 2014. Aviation Maintenance Technician Handbook–Power plant (Vol 1 & Vol 2) – FAA, 2012. 2. TURBOMECA, "Gas Turbine Engines", the English Book Store, New Delhi, 1993.	3. UNITED TECHNOLOGIES PRATT & WHITNEY, "The Aircraft Gas Turbine Engine and its Operation", (latest edition) The English Book Store, New Delhi. 4. Michael J. Kroes, William A. Watkins ad Frank Delp, Aircraft Maintenance and Repair, 7th ed., Tata McGraw Hill, 2013.

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	50%	-	50%	-	50%	-
Level 2	*Understand*	50%	-	50%	-	50%	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd.Manoharan, Blue Dart Aviation, Chennai,manoharank@bluedart.com.*	1. *Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. S. Sivakumar, SRMIST*
2. *Wg.cdr R.Annamalai, IAF, Tambaram,annamalai.ramasamy2@gmail.com*	2. *Dr.S.Nadaraja pillai, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr. S. Rajkumar, SRMIST*

Course Code	21ASE315T	Course Name	EXPERIMENTAL METHODS IN STRUCTURAL MECHANICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*list the various aspects of measurements*
CLR-2:	*discuss the various sensors and data acquisition systems*
CLR-3:	*summarize the various techniques for material characterization*
CLR-4:	*describe the techniques involved in impact mechanics*
CLR-5:	*demonstrate structural health monitoring system*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the principles of measurement and calibration*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explain the working principle of various instruments for structural experimentation*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-3:	*demonstrate the various characterization techniques for understanding the behavior of materials*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-
CO-4:	*examine the experimental impact mechanics of materials*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-
CO-5:	*illustrate the basics of structural dynamics and its experimentation*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-

Unit-1 - Principles of Measurements	***9 Hour***
Functional elements of an instrument – Static and dynamic characteristics - Errors in measurement - Statistical evaluation of measurement data - Standards and calibration - Description of measuring instruments - Performance characteristics of instruments	
Unit-2 - Instrumentation and Data Acquisition System	***9 Hour***
Mechanical, electrical, electronic system and their calibration - Various types of sensors for displacement, velocity, acceleration, pressure, loads, strains, full-field measurements - Analog systems, digital systems using personal computers - Dynamic measurement, numerical and graphical data processing and archiving.	
Unit-3 - Experimental Techniques for Material Characterization	***9 Hour***
Application of various experimental techniques to stress analysis problems - Comparison of experimental and analytical methods - Theory of electrical resistance strain gages - Brittle lacquer coatings and their photoelasticity - To illustrate buckling of structural members; load-deformation behavior of beams, columns, joints, and frames under various loads - Determination of Young's \modulus for aluminum cantilever beam – Determination of Poisson's ratio - Determination of flexural modulus	
Unit-4 - Experimental Methods in Impact Mechanics	***9 Hour***
Quasi-static material test - Pendulum impact test - Drop weight impact test - Split-Hopkinson's bar test - Taylor cylinder test	
Unit-5 - Experimental Methods in Structural Dynamics	***9 Hour***
Natural frequency - Mode shapes - Damping factors from free and forced vibrations- Shake table tests - Experimental modal parameter evaluation - Experimental modal methods - Structural health monitoring and damage detection	

Learning Resources	1. *Jérôme Molimard, "Experimental Mechanics of Solids and Structures", Wiley, 2016.* 2. *C. Lakshmana Rao, V. Narayanamurthy, K. R. Y. Simha, "Applied Impact Mechanics", Wiley, 2016* 3. *W.J. Stronge, "Impact Mechanics", Cambridge University Press, 2010*	4. *Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw Hill Inc., New York, 1978* 5. *S. P. Timoshenko and D.H. Young, "Elements of strength materials Vol. I and Vol. II"., T. Van Nostrand Co-Inc Princeton-N.J. 1990* 6. *S. Timoshenko., "Vibration Problems in Engineering"- John Wiley and Sons, New York, 1993*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*		*-*		*-*
Level 5	*Evaluate*	*-*	*-*		*-*	*-*	*-*
Level 6	*Create*	*-*	*-*		*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. S. Gurusideswar, SRMIST*
2. *Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE316T	**Course Name**	AVIATION LEGISLATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the International and national standards and recommended practices*
CLR-2:	*explain the Role of air operators regarding continuing airworthiness and maintenance*
CLR-3:	*process the various certification requirements to fly the aircraft*
CLR-4:	*identify the civil aviation requirements applicable to aircraft maintenance*
CLR-5:	*identify the various aircraft operations and safety maintenance programme*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain International and National organization various standards, rules ,practices applicable*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*describe operator responsibilities related to commercial aircraft operations*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*describe the various certification requirements and documents for flying the aircraft*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*identify the various types of maintenance check lists*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*explain the different operations related to continuing airworthiness and safety concepts*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Aircraft Rules and Regulations ***9 Hour***

Role of International Civil Aviation Organization, Chicago Convention, 1944; ICAO Convention, Standards and Recommended Practices; The Aircraft Act, 1934; The Aircraft Rules, 1937, Role of the DGCA; Detailed understanding of CAR-21, CAR-M, CAR-145, CAR-66, CAR 147; Aeronautical Information Circulars (Applicable to Aircraft Maintenance and Release); CAR - Sections 1 and 2

Unit-2 - Aircraft Operations ***9 Hour***

Commercial Air Transport/Commercial Operations; Air Operators Certificates; Operators Responsibilities, in particular regarding continuing airworthiness and maintenance; Documents to be carried on board; Aircraft Placarding (Markings)

Unit-3 - Aircraft Certification ***9 Hour***

General - Certification rules: such as FAA & EACS 23/25/27/29; Type Certification Supplemental Type Certification; Type Approval; CAR-21 Sub-Part F, G, H, I, M, P & Q , permit to fly requirements , Documents - Certificate of Airworthiness; Certificate of Registration; Noise Certificate; Weight Schedule; Radio Station Licence and Approval

Unit-4 - Applicable Aviation Requirements ***9 Hour***

Introduction to FAR, EASA Regulations - Aircraft Maintenance and certification , Maintenance Programme, Maintenance checks and inspections; Master Minimum Equipment Lists, Minimum Equipment List; Dispatch Deviation Lists; Airworthiness Directives; Service Bulletins, manufacturers service information; Modifications and repairs; Maintenance documentation: maintenance manuals, structural repair manual, illustrated parts catalogue

Unit-5 - Continuing Airworthiness ***9 Hour***

Test flights; ETOPS /EDTO, maintenance and dispatch requirements; RVSM, maintenance and dispatch requirements; RNP, MNPS Operations, All Weather Operations; Category 2/3 operations and minimum equipment, maintenance, training and certification requirements, Safety Management System, Basic Safety Concepts; Hazards & Safety Risks; Safety Assurance

Learning Resources	1. *The Aircraft Act, 1934* 2. *The Aircraft Rules, 1937 VOL 1* 3. *The Aircraft Rules, 1937 VOL 3* 4. *Aeronautical Information Circular*	5. *CAR - Section - 1, 2, & 8 SMS* 6. *CAR - 21, M, 145, 66 & 147* 7. *Special Federal Aviation Regulations (SFARs) - 14 CFR, SFAR 88 & JAA TGL 47* 8. *Airworthiness Procedure Manual*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	50%	-	50%	-	50%	-
Level 2	*Understand*	50%	-	50%	-	50%	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Blue Dart Aviation manoharank@bluedart.com*	1. *Dr. V.Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	1. *Dr.S. Sivakumar, SRMIST*
2. *Wg.cdr R. Annamalai, IAF, Tambaram annamalai.ramasamy2@gmail.com*	2. *Dr.S.Nadarajapillai, SASTRA University Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr.S. Rajkumar, SRMIST*

Course Code	21ASE317T	Course Name	OPTICAL METHODS IN FLUID AND SOLID MECHANICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*discuss the concept of light and light sources*
CLR-2:	*summarize the various types of cameras*
CLR-3:	*explain the materials for optical methods*
CLR-4:	*illustrate the various optical methods in fluid mechanics*
CLR-5:	*demonstrate the various optical methods in solid mechanics*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the theory of light and the basics of optics*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explain the various tools for imaging and processing*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-3:	*summarize various materials for optical experimentation*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-4:	*model the experimental methods for flow visualization*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-
CO-5:	*examine the full-field techniques using optical methods*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-

Unit-1 - Light and Optics	***9 Hour***
Light Theory - Light Spectrum – Reflection and Refraction – Optical Interference - Light Sources - Halogen, LED, UV - Flickering - Diffusers – Basics of Optics – Lenses, Mirrors and their Types	
Unit-2 - Cameras, Accessories, and Imaging	***9 Hour***
Imaging requirements - Factors influencing Image Quality - Photographic Triangle - Camera - SLR - CCD, CMOS, High-Speed Cameras - Triggers - Synchronizer - Image Acquisition and Processing - Positioning Lights - Positioning, Synchronization and Calibration of Cameras	
Unit-3 - Materials for Experimentation	***9 Hour***
Tracers – Natural Dyes and Fluorescent Dyes - Hollow Glass Spheres - Alumina Particles – Materials for Smoke Generation - Materials for Speckle Pattern - Spray Paint - Toner - Lithography - Printing - Stencils - Ink - Grids – Projecting - Titanium Powder - Metal-Film Coating - Electron-Lithographic Technique.	
Unit-4 - Applications in Fluid Mechanics	***9 Hour***
Dye and Smoke Visualization - Optical Methods for Flow Visualization - Schlieren, Shadowgraph, and Interferometry - Laser Doppler Anemometry - Particle Tracking Velocimetry - Particle Imaging Velocimetry (PIV) - Tomographic PIV.	
Unit-5 - Applications in Solid Mechanics	***9 Hour***
Solid deformation visualization - Photoelasticity - Stress-optic law - Polariscope - Fringe Patterns - Optical metrology - Strain field visualization using Digital Image Correlation (DIC) - Fundamentals of DIC - Steps – DIC Post-processing Tools - Volumetric imaging using tomography.	

Learning Resources	1. *K. Iizuka, "Engineering Optics", 3rd Edition, Springer. 2009* 2. *K. J. Gasvik, "Optical Metrology", 3rd Edition, John Wiley & Sons, Ltd, 2007* 3. *G. Cloud, "Optical Methods of Engineering Analysis", Cambridge University Press, 1998* 4. *Raffel, Willter, Wereley and Kompenhans "Particle Image Velocimetry – A Practical Guide", Springer, 1998*	5. *Dally, J.W., and Riley, W.F., "Experimental Stress Analysis", McGraw Hill Inc., New York, 1978 S. Kobayashi, "Handbook of Experimental Mechanics", Prentice Hall, 1987* 6. *Pramod K. Rastogi, Erwin Hack, "Optical Methods for Solid Mechanics: A Full-Field Approach", Wiley, 2012* 7. *Optical Methods in Fluid and Solid Mechanics by Aloke Kumar and Koushik Viswanathan, NPTEL*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*60%*	*-*	*60%*	*-*	*60%*	*-*
Level 4	*Analyze*	*-*	*-*	*-*	*-*		*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in*	1. *Dr. N. Srinivasan, Indian Institute of Technology Jammu, srinivasan.n@iitjammu.ac.in*	1. *Dr. B. T. Kannan, SRMIST*
2. *Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com*	2. *Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	2. *Dr. S. Gurusideswar, SRMIST*

Course Code	21ASE318T	**Course Name**	COMBUSTION AND FLOW DIAGNOSTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply Knowledge on the application of Tracers and Scattering*
CLR-2:	*identify effect of various velocity measurement techniques*
CLR-3:	*illustrate the concepts of Flow Diagnostics*
CLR-4:	*describe about Spray Characterization*
CLR-5:	*apply knowledge on Flame Analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify different dyes and spectrum*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	3	-	-
CO-2:	*acquire knowledge on Imaging*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	3	-	-
CO-3:	*describe the working principles of velocimetry*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	3	-	-
CO-4:	*illustrate the usefulness of Patternation and droplet sizing*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	3	-	-
CO-5:	*apply knowledge on Fluorescence and Time series analysis*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	3	-	-

Unit-1 - Light Spectrum, Scattering and Tracers	***9 Hour***
Light, Spectrum, Mie Scattering, Rayleigh Scattering, Raman Scattering, Tracing elements, Dyes, and its Characteristics.	
Unit-2 - Imaging Equipment and Techniques	***9 Hour***
Light Source – Halogen Bulb, LED, Flash and Strobe, Camera – SLR, DSLR, Digital and High-Speed, Lens- Prime, Wide angle and Tele-zoom, Direct Imaging with various illumination techniques, High-Speed Imaging and its intricacies.	
Unit-3 - Flow Diagnostics	***9 Hour***
Lasers and Laser Safety; Principle and application of Particle Image Velocimetry (PIV), PIV Types - 2D, Tomo-PIV, Laser Doppler Velocimetry (LDV), and Visualization Techniques.	
Unit-4 - Spray Diagnostics	***9 Hour***
Backlit Shadowgraphy, Digital Background oriented Schlieren (D-BoS), Optical Patternator for Spray Diagnostics, Phase Doppler Particle Analyzer (PDPA), and Sauter Mean Diameter (SMD).	
Unit-5 - Flame Diagnostics	***9 Hour***
Fundamentals of spectroscopy, Planar Laser-Induced Fluorescence, and their application in species concentration and temperature measurements, Radicals - OH and CH, Direct Imaging of Flames, Fundamentals of Digital Image Processing, and Time Series Analysis.	

Learning Resources	*1. E Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, CRC Press, Taylor and Francis Group, 2016*	*2. Markus Raffel, Particle Image Velocimetry: A practical Guide, Springer, 2018* *3. A V Lefebvre Atomization and Sprays, CRC Press, 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in	*1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	*1. Dr. Kannan B T, SRMIST*
2. Dr Lakshmi VM, Scientist/Engineer 'SG', VSSC, ISRO, vm_lakshmi@vssc.gov.in	*2. Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	*2. Dr. Selvakumaran T, SRMIST*

Course Code	21ASE319T	Course Name	DESIGN OF GAS TURBINE ENGINE COMPONENTS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*illustrate basic design concepts of jet engine and estimation of required thrust to students*
CLR-2:	*explain the design parameter and off design calculations*
CLR-3:	*determine design procedure to the rotating components of engine such as compressor and turbine along with staging*
CLR-4:	*demonstrate aspects of combustion processes, flame stabilization issue, igniters design and NOx controls*
CLR-5:	*examine the concept of design inlet and nozzle for various on - off design conditions*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate preliminary weight and fuel estimation for an aircraft mission*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-2:	*identify variation in parametric analysis of ON and OFF design calculations*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-3:	*explain the principle design of compressor and turbine and selection of suitable materials*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-4:	*estimate the total pressure losses and able to predict ignition delay*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*determine the basic design factors affects ON and OFF design operation of inlets and nozzle on engine performance*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-

Unit-1 - Gas Turbine Engine Design Fundamentals ***9 Hour***

Design Process- compressible flow relationship; Constraint Analysis - Concept-Design tools-preliminary estimates; Mission analysis - Aircraft weight and fuel consumption data-Example problems on Constraint analysis, Mission analysis.

Unit-2 - On Design and Off-Design Parametric Analysis ***9 Hour***

Total and static properties-corrected mass flow rate-Engine Cycle Design- One-Dimensional Through flow Area-Flow path force on components- aircraft constraint analysis, aircraft mission analysis, engine parametric (design point) analysis, engine performance (off-design) analysis, engine installation drag and sizing.

Unit-3 - Design of Rotating Components ***9 Hour***

Fan and Compressor Aerodynamics-Diffusion factor - Aerofoil geometry -Flow path dimension- Radial variation -Turbine Aerodynamics- Constant axial velocity-adiabatic-selected Mach number -Mean line stage Design-stage pressure ratio-Airfoil geometry-radial variation-turbine cooling-range of turbine parameters-Engine life -Design Example –for fan-compressor-turbine.

Unit-4 - Combustion Chamber Design ***9 Hour***

Design: Combustion system components- Combustion- Chemical reactor theory. Combustor Stability map-Stirring and mixing-Total pressure loss-Fuels-Ignition-Combustion Systems of Main Burner Design: Air partitioning- Main burner component Design: Diffuser-types of burner-inner and outer casing design-Fuel nozzle-Dome and liner-Primary zone- swirler-Secondary holes-Dilution holes-Transition duct-Design of Afterburners-Design parameters-Diffuser-Fuel injection-Ignition-Flame stabilization – Flame spread and after burner length – Examples design calculation.

Unit-5 - Inlet and Nozzle Design	***9 Hour***
Inlets and Exhaust Nozzles Design: Elements of a Successful Inlet-Engine Integration Program-Definition of Subsonic Inlet-Engine Operational Requirements- Definition of Supersonic Inlet-Engine Operational Requirements- Engine Impact on Inlet Design- Inlet Impact on Engine Design-Validation of Inlet-Engine System-Exhaust nozzle design-Nozzle types and their design -Jet control methods for reduction of infrared signature.	

Learning Resources	1. *Mattingly J.D., Heiser, W.H. and Pratt D.T, 'Aircraft Engine Design', 2nd Edition, AIAA Education Series, AIAA, 2002* 2. *Oates G.C.,' Aircraft Propulsion Systems Technology and Design', 1989, AIAA Education Series.*	3. *Saravanamuttoo H.I.H and Rogers, G.F.C. “Gas Turbine Technology”, Pearson Education Canada; 6th edition, 2008.* 4. *Cumpsty N., “Jet Propulsion: A Simple Guide to the Aerodynamics and Thermodynamics Design and Performance of Jet Engines” , Cambridge University Press; 2nd edition, 2003*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in*	1. *Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	1. *Mr. Vinayak Malhotra, SRMIST*
2. *Dr Lakshmi VM, Scientist/Engineer ‘SG’, VSSC, ISRO, vm_lakshmi@vssc.gov.in*	2. *Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	2. *Mr. G. Mahendra Perumal, SRMIST*

Course Code	21ASE320T	**Course Name**	EXPERIMENTAL METHODS IN GAS DYNAMICS AND PROPULSION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply knowledge on the facilities for testing compressible flow*
CLR-2:	*identify test rigs for propulsive systems*
CLR-3:	*explain the concepts of visualization*
CLR-4:	*appreciate how sensors and instruments function*
CLR-5:	*apply knowledge about measurements*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify different flow testing facilities and its parts*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*acquire knowledge on various thrusters*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*explain the working principles of cameras and visualization methods*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*appreciate the usefulness of sensing equipment*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*apply knowledge on measurements and data analysis*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - Wind Tunnels and High Enthalpy Facilities	***9 Hour***
High-Speed Wind Tunnels - Blowdown-Type, Induction-Type, Continuous Type, Losses in Tunnels, Hypersonic Tunnels, Hypervelocity Facilities - Hotshot Tunnels, Plasma Arc Tunnels, Shock Tubes, Shock Tunnels, Gun Tunnels, Jet Facility	
Unit-2 - Thrusters, Chambers and Testing Facilities	***9 Hour***
Thrusters – Static and Dynamic, Solid propellant and Hybrid Propellant Thrusters, Window Bomb Setup, Liquid Rocket Testing Facility	
Unit-3 - Flame and Flow Visualization	***9 Hour***
Imaging Sensors – CCD and CMOS, Camera Types – SLR and High-Speed, Direct and IR Imaging, Schlieren – Inline and Z-type, Background Oriented Schlieren, Shadowgraph – Inline and backlit, Interferometry, Image Processing	
Unit-4 - Instruments, Sensors and Devices	***9 Hour***
Probes and Sensors - Pressure, Force, Temperature, Flow Rate, Data Acquisition Systems (DAQ), Calibrators, Signal Analyzer, Filters, Display and Storage Devices, Workstations	
Unit-5 - Measurements	***9 Hour***
Measurements of Flow and Thermal Properties, Burn Rate, Ignition Delay and Burning Velocity, Measurement Environment and Procedures, Traverse Systems, Steady and Transient Measurements, Sampling Frequency, Nyquist Criterion, Data Analysis, Signal Processing, Error/Uncertainty Analysis	

Learning Resources	1. *E Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, Second Edition, CRC Press, Taylor and Francis Group, 2017.* 2. *Experimental Aero/Gas Dynamics by Prof. Job Kurian, NPTEL*	3. *E Rathakrishnan, High Enthalpy Gas Dynamics, Wiley, 2015.* 4. *Applied Gas Dynamics, Second Edition, Wiley, 2019.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, Deputy Project Director, VSSC, ISRO, rs_praveen@vssc.gov.in	*1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in*	*1. Dr. Kannan B T, SRMIST*
2. Dr Lakshmi VM, Scientist/Engineer 'SG', VSSC, ISRO, vm_lakshmi@vssc.gov.in	*2. Dr. Rajiv Kumar, BIT Mesra, rajiv@bitmesra.ac.in*	*2. Dr. Aravindh Kumar S M, SRMIST*

Course Code	21ASE401T	Course Name	ROCKET AERODYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*examine the boundary layer theory and its importance*
CLR-2:	*use Newtonian theory for hypersonic flow and examine the qualitative aspects of hypersonic flow*
CLR-3:	*illustrate different missile configurations and their significance*
CLR-4:	*examine the aerodynamics of slender and blunt bodies, their merits and demerits*
CLR-5:	*apply the aerodynamic aspects, special considerations and wind effects for rocket launching*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of boundary layer theory, distinguish between characteristics of incompressible and compressible boundary layers*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-2:	*examine the salient features of hypersonic flow and their impact on the vehicle aerodynamic characteristics*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-3:	*Predict the various configurations of the rockets, especially from the aerodynamic stand point*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*use the concepts of slender and blunt body aerodynamics in aerospace vehicles*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*determine the various aerodynamic aspects, special considerations and wind effects of rocket launching for successful mission*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Boundary Layer Theory	***9 Hour***
Prandtl's concept of boundary layer, Boundary layer characteristics, Boundary layer thicknesses – Displacement thickness, Momentum thickness, Energy thickness, Blassius boundary layer solution, Compressible boundary layer, Boundary layer separation, Shock wave boundary layer interaction	
Unit-2 - Hypersonic Aerodynamics	***9 Hour***
Qualitative aspects of hypersonic flow – Thin shock layer, Viscous interaction, High temperature shock layer, Entropy layer, Low-density flow, High temperature effects, Hypersonic flight paths – Velocity- altitude map, Newtonian theory, Newton's sine-squared law, Modified Newtonian law, Mach number independence, Shock wave and expansion wave relations, Hypersonic similarity parameter, Aerodynamic heating of re-entry bodies	
Unit-3 - Rocket Configurations and Drag Estimation	***9 Hour***
Classes of rockets / missiles, External aerodynamic configurations – Types of design and control, Bodies of revolution, Forces acting on missile during atmospheric flight, Missile sections, Missile forebodies, Boat-tail, Types of missiles drags, Drag estimation methods	
Unit-4 - Aerodynamics of Slender and Blunt Bodies	***9 Hour***
Slender and blunt body characteristics, Missiles at small angles of attack, Cross-flow analysis, Total lift on a missile body, Total lift on a slender wing, Total lift on a wing-body combination, Missile wing-body interference, Flow separation at low and high angles of attack, Vortex shedding and its effects, Air loads	
Unit-5 - Aerodynamic Launching Problems	***9 Hour***
Safety of parent aircraft - Air launch, Launch boundaries – Air launch, Parent aircraft performance, Ground launch, Range safety, Ship board and underwater launches, Rocket separation – Separation mechanisms, Impulse devices	

Learning Resources	1. *John D. Anderson Jr., Fundamentals of Aerodynamics, 6th Edition, McGraw-Hill Education, 2016.* 2. *John D. Anderson., Modern Compressible Flows, 4th Edition, McGraw-Hill Education, 2021.* 3. *Rathakrishnan E., High Enthalpy Gas Dynamics, John Wiley & Sons Singapore Pteltd., 2015.*	4. *John D. Anderson Jr., Hypersonic and High-Temperature Gas Dynamics, 3rd Edition, AIAA Education Series, AIAA, 2019.* 5. *Chin S. S., Missile Configuration Design, McGraw-Hill Book Company Inc., New York, 1961.* 6. *Jack N. Nielsen, Missile Aerodynamics, McGraw-Hill Book Company Inc., New York, 1960.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Saurav Kumar Ghosh, CSIR-NAL, Bangalore, skghosh@nal.res.in*	1. *Dr. K. Maruthupandiyan, Institute of Aeronautical Engineering, Hyderabad, k.maruthupandiyan@iare.ac.in*	1. *Dr. S. M. Aravindh Kumar, SRMIST*
2. *Dr. Roshan Dinesh Kumar, GE Industry India Ltd., Bangalore, dineshforaero@gmail.com*	2. *Dr. Lakshmana Dora Chandrala, IIT Hyderabad, lchandrala@mae.iith.ac.in*	2. *Dr. K. K. Bharadwaj, SRMIST*

Course Code	21ASE402T	**Course Name**	COMPUTATIONAL HEAT TRANSFER AND FLUID DYNAMICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the various techniques of problem solving*
CLR-2:	*explain the governing equations for flow and heat transfer analysis*
CLR-3:	*apply discretization methods to linearize the fluid flow equations*
CLR-4:	*model fluid flow problems*
CLR-5:	*use proper numerical schemes fluid flows*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the governing equations for flow and heat transfer analysis*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply discretization techniques to solve steady diffusion equations*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*apply discretization techniques to solve unsteady diffusion equations*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*formulate numerical schemes for convection-conduction problems*	*3*	*3*	-	-	*1*	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*identify numerical solution methods for incompressible flow problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Governing Equations and Boundary Conditions	***9 Hour***
The Three Fundamental Approaches to problem solving -Analytical, Experimental & Numerical, Computational Fluid Dynamics-Advantages–Applications-Processes, Review of Conservation Principles, Reynolds transport theorem, Lagrangian vs Eulerian Approach, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, General scalar transport equation, Classification of governing equations, Approximate Solutions of Differential Equations, Initial and boundary conditions, Overview of grid structures	
Unit-2 - Discretization Approaches and Numerical Solution of Steady Diffusion Equation	***9 Hour***
Discretization of 1 – D unsteady diffusion Equation – implicit- fully explicit- and- Crank-Nicholson schemes, Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consistency, Stability, Convergence, Grid independent and time independent study- Coding using programming language (MATLAB/PYTHON), Stability analysis of parabolic and hyperbolic equations. Finite Volume Discretization of 2-D unsteady State Diffusion type Problems	
Unit-3 - Numerical Solution of Unsteady Diffusion Equation	***9 Hour***
Discretization of 1 – D unsteady diffusion Equation – implicit- fully explicit- and- Crank-Nicholson schemes, Important Consequences of Discretization of Time Dependent Diffusion Type Problems: Consistency, Stability, Convergence, Grid independent and time independent study- Coding using programming language (MATLAB/PYTHON), Stability analysis of parabolic and hyperbolic equations. Finite Volume Discretization of 2-D unsteady State Diffusion type Problems	
Unit-4 - Numerical Solution of Convection - Diffusion Equation	***9 Hour***
Discretization of 1 – D convection diffusion Equation, Central differencing scheme, Numerical oscillations of Central differencing scheme, Properties of Discretization scheme, Scarborough Criterion, Transportiveness, Conservativeness, Assessment of central differencing scheme, first order upwind scheme, Assessment of upwind scheme- Coding using programming language (MATLAB/PYTHON), Numerical Diffusion, Overview of other upwind schemes	

Unit-5 - Incompressible Flow Field Calculation	***9 Hour***
Collocated Grid, Staggered Grid, Checker-board pressure oscillations, Basics of Pressure-velocity coupling algorithm, Discretization of 2D incompressible continuity and momentum equations, Pressure correction equation formulation, SIMPLE Algorithm, Applications of SIMPLE, Overview of other pressure-velocity coupling algorithms, Types of practical boundary conditions, the basic structure of a CFD code-CFD Solution of Simple flows using ANSYS-FLUENT	

Learning Resources	*1. Versteeg, H.K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics – The finite volume method, Longman Scientific & Technical, 1995.* *2. Patankar, S.V., Numerical Heat Transfer & Fluid Flow, Hemisphere, 1980.* *3. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.*	*4. Tannehill, J.E., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, 2nd ed., Taylor & Francis, 1997.* *5. Anderson J.D., Computational Fluid Dynamics – The basics with Applications, Mc Graw-Hill, 1995.* *6. Date A.W., Introduction to Computational Fluid Dynamics, Cambridge University Press, 2005.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. R. Krishnamurthy, DRDL- DRDO, Hyderabad, murthy_cfd@yahoo.com	*1. Dr. B. Premachandran, IIT Delhi, prem@mech.iitd.ac.in*	*1. Dr. S. Senthilkumar, SRMIST*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. M. Arun, National Institute of Technology (NIT), Karnataka, m.arun1978@gmail.com*	*2. Mr. K. B. Ravichandrakumar, SRMIST*

Course Code	21ASE403T	Course Name	TURBULENCE AND TURBULENCE MODELING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain turbulent flow physics*
CLR-2:	*discuss about closure and need for turbulence models*
CLR-3:	*identify the type of model for turbulent flow simulations*
CLR-4:	*list the methodologies for turbulent flow simulations*
CLR-5:	*discuss the classification of shear flows*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify different aspects of turbulent flows*	*3*	-	*3*	*1*	-	-	*2*	-	-	-	-	-	*2*	-	-
CO-2:	*discuss about turbulence closure and models*	*3*	-	*3*	*1*	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*derive the governing equations for turbulent flows*	*3*	-	*3*	*1*	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*discuss the usefulness of RANS*	*3*	-	*3*	*1*	*3*	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*apply knowledge on LES and DNS*	*3*	-	*3*	*1*	*2*	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - Turbulence and Measurements	***9 Hour***
Fluid and flow properties, Conservation laws and transport equations, Flow classification, Laminar vs turbulent flow, Reynolds number, Effect of Reynolds number on flow, Turbulence and its Characteristics, Ways of describing turbulent flows, Various scales associated with turbulent flows, turbulent flow measurements - Hot-wire Anemometer - LDA and PIV	
Unit-2 - Turbulent Shear Flows	***9 Hour***
Classification of turbulent shear flows, Free shear flows, Flow field physics of jets, wakes and Mixing layers, Wall bounded shear flows, Wall Y+, Wall shear stress, Layers in boundary layers, Energy cascade, Transfer of energy, Kolmogorov scales, Dissipation, Homogeneous turbulence, Isotropy and Anisotropy	
Unit-3 - Turbulence Modelling	***9 Hour***
Velocity at a point, Velocity time series, Statistics, Statistical properties, Reynolds Decomposition, Reynolds Averaging, Reynolds Averaged equations, Reynolds Stress, Reynolds stress tensor, Closure problem, Need for modeling, Eddy viscosity, Eddy viscosity hypothesis, Zero equation model, Mixing length model, One equation model, Spalart-Allamaras model, k-equation model	
Unit-4 - First-Order Closure Modelling	***9 Hour***
Two equation models, Standard k-ε model, Wall treatment - Enhancement and damping functions, RNG k-ε model, Realizable k-ε model, Standard k-ω model, SST k-ω model, Advanced models and its requirements, v2-f model, Q-ζ model, k – kl – ω model	
Unit-5 - Advanced Models and Methods	***9 Hour***
Higher order model, Complete closure, Reynolds Stress Transport Model (RSTM), Assessment of turbulence models and its selection, Need for transient simulations – LES, Governing equations for LES, Sub grid scale modeling, Hybrid models (DES), Direct numerical simulation	

Learning Resources	*1. Tennekes H, Lumley J.L., "A first course in turbulence", MIT Press, 1972.* *2. Pope S. B., "Turbulent flows", South Asian Edition, Cambridge University Press, 2009*	*3. Kundu P. K., Cohen I M and Dowling D R, "Fluid Mechanics", 5th Edition, Academic Press, 2014,* *4. Malalasekera, W., and H. K. Versteeg. An introduction to computational fluid dynamics: the finite volume method. PEARSON, 2009*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-		-
Level 6	*Create*	-	-	-	-		-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. R. Krishnamurthy, DRDL- DRDO, Hyderabad, rkmurthy@drdl.drdo.in	*1. Dr. M. Arun, National Institute of Technology (NIT), Karnataka. isloor@yahoo.com*	*1. Dr. Kannan B T, SRMIST*
2. Dr. Raja S, CSIR-NAL, Bangalore, raja@nal.res.in	*2. Dr. Surendra Bogadi, Rajalakshmi Engineering College, aero.academic@gmail.com*	*2. Dr. S Senthilkumar, SRMIST*

Course Code	21ASE404T	Course Name	HIGH TEMPERATURE GAS DYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*discuss the high temperature flow, classification of gases and chemically reacting gas*
CLR-2:	*interpret equilibrium and nonequilibrium normal and oblique shock flows*
CLR-3:	*explain the inviscid high temperature equilibrium flows and its consequences*
CLR-4:	*describe the governing equation for inviscid high temperature nonequilibrium and its performance characteristics*
CLR-5:	*demonstrate the viscous high temperature flows and its significance in the real-world engineering problems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the high temperature flow and discern between calorically and thermally perfect gas*	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO-2:	*explain the significance of equilibrium and nonequilibirum normal and oblique shock wave*	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*examine key aspects of high temperature equilibrium flows*	2	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*describe the equations which are governs the inviscid high temperature nonequilibrium flows*	2	2	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-5:	*explain the viscous high temperature flows*	2	1	-	-	-	-	-	-	-	-	-	1	2	-	-

Unit-1 - Introduction to High Temperature Gas Dynamics **9 Hour**

Nature of high-temperature flows, real gases and perfect gases, several of forms of the perfect-gas equation of state, chemically reacting mixture of perfect gases, real gases. Second law of TD and calculation of entropy, Gibbs free energy and the entropy produced by chemical nonequilibrium, concepts of equilibrium and non-equilibrium gas flows.

Unit-2 - Statistical Thermodynamics **9 Hour**

Microscopic description of gases, most probable microstate, limiting case: Boltzmann distribution, Thermodynamic properties in terms of the partition function. Partition function in terms of T and V, Thermodynamic properties for a single chemical species. Determination of macrostate using any programming languages

Unit-3 - Inviscid High-Temperature Equilibrium Flows **9 Hour**

Governing equations, equilibrium normal and oblique shock-wave flows, equilibrium quasi-one-dimensional nozzle flows. Equilibrium and frozen specific heats, equilibrium speed of sound

Unit-4 - Inviscid High-Temperature Nonequilibrium Flows **9 Hour**

Governing equations: species continuity equation, nonequilibrium normal and oblique shock-wave flows. Nonequilibrium quasi-one-dimensional nozzle flows, nonequilibrium blunt-body flows. Simulation techniques for high-temperature non-equilibrium flows.

Unit-5 - Viscous High-Temperature Flows **9 Hour**

Governing equations for chemically reacting viscous flow, alternate forms of the energy equation, boundary layer equation for a chemically reacting gas. Boundary conditions: catalytic walls. Non-dimensional numbers associated with viscous high-temperature flows: Prandtl number, Lewis number, Eckert number. Experimental facilities associated with high temperature flows.

Learning Resources	1. *Anderson Jr, John D. Hypersonic and high-temperature gas dynamics. American Institute of Aeronautics and Astronautics, 2006.* 2. *Bose, Tarit K. "High temperature gas dynamics." High Temperature Gas Dynamics. Springer, Berlin, Heidelberg, 2004. 259-281.*	3. *Rathakrishnan, Ethirajan. High enthalpy gas dynamics. John Wiley & Sons, 2014.* 4. *Zucker, Robert D., and Oscar Biblarz. Fundamentals of gas dynamics. John Wiley & Sons, 2002.* 5. *Anderson, John David. Modern compressible flow: with historical perspective. Vol. 12. New York: McGraw-Hill, 1990.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mrs. Smrutisudha Sahoo, DRDO, s.sahoo.pxe@gov.in*	1. *Dr. Rakesh Kumar,Indian Institute of Technology Kanpur,rkm@iitk.ac.in*	1. *Dr. Malaikannan G, SRMIST*
2. *Mr. Dhanabal K, S & I Engineering Solutions Pv.t. Ltd. dhanabal@sandi.co.in*	2. *Dr. Arun Kumar P. Indian Institute of Technology Kanpur, akp@iitk.ac.in*	2. *Dr. Kannan B T, SRMIST*

Course Code	21ASE405T	**Course Name**	THEORY OF PLATES AND SHELLS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify Plates and Shells*
CLR-2:	*determine the mechanical behavior of Plates and shells*
CLR-3:	*explore the existing technologies*
CLR-4:	*identifying the selection of materials and Plates Applications*
CLR-5:	*demonstrate the application of various Plates and shells*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe of the plates and shells and it properties*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explain application of plates and shells in different aircraft components*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*identify different treatments to strengthen materials*	*3*	*2*	-	*1*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*solve Various problems in plates and shells*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*explain Various terminologies used in Plates and shells*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Classical Plate Theory	***9 Hour***
Classical Plate Theory – Assumptions – Differential Equations – Boundary Conditions – Axi-Symmetric Loading - Numericals solving	
Unit-2 - Plates of Various Shades	***9 Hour***
Navier's Method of Solution for Simply Supported Rectangular Plates – Levy's Method of Solution for Rectangular Plates under Different Boundary Conditions – Annular Plates – Plates of other shapes - Numericals solving	
Unit-3 - Eigen Value Analysis	***9 Hour***
Eigen value analysis - Stability of Rectangular Plates - Free Vibration Analysis of Rectangular Plates - Bending Theory of Plates - Bending-Membrane Theory of Plates - Equilibrium Equation and Boundary Conditions - Stability and Free Vibration Analysis of Rectangular Plates - Numericals solving	
Unit-4 - Approximate Methods	***9 Hour***
Approximate Methods - Rayleigh – Ritz Method - Galerkin Methods - Finite Difference Method - Application to Rectangular Plates for Static Analysis - Application to Rectangular Plates for free vibration analysis - Application to Rectangular Plates for stability analysis - Numericals solving	
Unit-5 - Shells	***9 Hour***
Introduction to shells - Basic Concepts of Shell Type of Structures - Membrane Theories for Circular Cylindrical Shells - Bending Theories for Circular Cylindrical Shells - Governing Equation for Buckling of Cylindrical Shells - Derivation of the Linearized Buckling Equation - Buckling under Axial Compression - Formulation for Buckling Stress and Buckling Mode - Buckling Coefficient and Batdorf Parameter - Numericals solving	

Learning Resources	1. *Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw-Hill Book Co. 1990.* 2. *T. K. Varadan and K. Bhaskar, "Theory of Plates and Shells", 1999, Narosa.*	3. *Flugge, W. "Stresses in Shells", Springer – Verlag, 1985.* 4. *Timoshenko, S.P. and Gere, J.M., "Theory of Elastic Stability", McGraw-Hill Book Co. 1986*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	*1. Dr. V. Arumugam, MIT, Chennai, arumugam.mitaero@gmail.com*	*1. Mr. N. Bharat, SRMIST*
2. Dr. Manoj Kumar Buragohain, DRDO, Hyderabad, buragohainm@yahoo.com	*2. Dr. K. Vadivuchezhian, NIT, Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	*2. Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE406T	Course Name	VIBRATIONS AND ELEMENTS OF AEROELASTICITY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the vibration concepts and deriving equation of motion of single degree of freedom systems*
CLR-2:	*describe forced vibration and vibration measuring instruments*
CLR-3:	*explain multi degree of freedom system modes of vibration and mode shapes*
CLR-4:	*describe the various approximate methods of solving natural frequency of various systems Explain the various aero elastic phenomena that arise in real time flight conditions*
CLR-5:	*explain the various aero elastic phenomena that arise in real time flight conditions*

		Program Outcomes (PO)												**Program Specific Outcomes**		
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*solve the equation of motion of a single degree of system vibration model*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-2:	*apply the concepts in free, force vibration problems and vibration measuring instruments*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-3:	*determine natural frequency and mode shapes of multi degree of freedom system*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-
CO-4:	*describe the various approximate methods in determining the natural frequency of various vibratory systems*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-
CO-5:	*explain the different aero elastic phenomena for different flight conditions*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-

Unit-1 - Elements of Vibratory System	***9 Hou***
Overview of vibratory system - Types - Mathematical modelling - Single degree of freedom system - Equation of motion - Simple harmonic motion - Modelling and simulation of single degree of freedom system using MATLAB	
Unit-2 - Two Degree of Freedom Systems	***9 Hour***
Damped vibration - Types - Forced Vibrations - Solution of equation of motion -Two degree of freedom system - Vibration measuring instruments	
Unit-3 - Multi Degree of Freedom Systems	***9 Hour***
Multi degree of freedom system - Eigen value problems - Two and three degree of freedom systems - Modelling and simulation of multi degree of freedom system using MATLAB	
Unit-4 - Approximation Methods	***9 Hour***
Continuous Systems - Lateral Vibration of a string - Longitudinal vibration of rod - Lateral vibration of beam - Torsional vibration of shaft - Approximation Methods - Dunkerley method - Rayleigh method - Holzer method - Matrix iteration method - Jacobi method - Case Studies	
Unit-5 -Elements of Aeroelasticity	***9 Hour***
Significance of aeroelasticity - Collar's triangle - Static aeroelasticity - Torsional divergence - Control reversal - Dynamic aeroelasticity - Flutter - Buffeting - Solving vibration problem using finite element approach	

Learning Resources	*1. Timoshenko S., "Vibration Problems in Engineering" – John Wiley and Sons, New York, 1993* *2. Fung Y.C.,"An Introduction to the Theory of Aeroelasticity -John Wiley & Sons, New York, 1993* *3. Bisplinghoff R.L., Ashley H and Hoffman R.L., "Aeroelasticity"- Addison Wesley Publication, New York, 1983*	*4. Tse, F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations", Prentice Hall, New York, 1984* *5. Scanlan R.H. & Rosenbaum R., "Introduction to the study of Aircraft Vibration & Flutter", John Wiley and Sons. New York, 1982* *6. Tongue. B.H., "Principles of Vibration ". Oxford University Press, 2000*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	*1. Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2. Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com	*2. Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in*	*2. Dr. S. Gurusideswar, SRMIST*

Course Code	21ASE407T	**Course Name**	FATIGUE AND FRACTURE MECHANICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*describe the concepts of plotting S-N curve, mean stress, stress concentration*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*emphasis the study of low cycle fatigue, load histories, cumulative damage & statistical aspects of fatigue*															
CLR-3:	*explain the physical aspects, surface effects, temperature effects of fatigue*															
CLR-4:	*describe the types of fracture, strain energy release rate, theoretical strength of materials*															
CLR-5:	*demonstrate the various design philosophies, case histories, fatigue resistance of fiber laminates*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*describe the knowledge to plot S-N curve for various materials*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*discuss low cycle fatigue & load histories problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*demonstrate the physical aspects of fatigue for solving problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*describe fracture of various materials*	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	*3*	-	-
CO-5:	*differentiate the various design philosophies*	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	*3*	-	-

Unit-1 - Fatigue of Structures	***9 Hour***
Definition of fatigue - S-N curve - Endurance limit - Effect of mean stress on fatigue - Goodman diagram - Gerber and Soderberg relations - Notches and Stress concentrations - Neuber's stress concentrations - Plastic stress concentration - Notched S-N curve	
Unit-2 - Statistical Aspects of Fatigue Behavior	***9 Hour***
Low cycle fatigue - High cycle fatigue - Coffin-Manson's relation - Transition life - Cyclic hardening, softening and stress strain curve - Strain life equations - Analysis of load histories - Level crossing method - Range counting method - Rain flow method - Cumulative damage - Miner's rule	
Unit-3 - Physical Aspects of Fatigue	***9 Hour***
Types of fracture in metals - Theoretical cohesive strength - Griffith theory of brittle fracture - Irwin-Orwin theory - Strain energy release rate - Stress intensity factor - Crack deformation modes - Fracture toughness and design - Plane strain toughness testing	
Unit-4 - Fracture Mechanics	***9 Hour***
Types of fracture in metals - Theoretical cohesive strength - Griffith theory of brittle fracture - Irwin-Orwin theory - Strain energy release rate - Stress intensity factor - Crack deformation modes - Fracture toughness and design - Plane strain toughness testing	
Unit-5 - Fatigue Design and Testing	***9 Hour***
Overview of various design philosophies - Safe life and fail safe design philosophy - Infinite life and manage tolerant design philosophies - Uncertainties, scatter and safety margins - Case histories - Improved shoulder fillets - Secondary bending due to non-symmetric holes - Cracked aircraft wing panel repaired with a poorly designed patch - Online structural monitoring of the Tsing Ma bridge - Fiber-metal laminate - ARALL and GLARE -Crack growth and Fatigue properties of GLARE components	

Learning Resources	1. George E.Dieter., "Mechanical Metallurgy", McGraw Hill Education (India) Private Limited, New Delhi, Third Edition, 2013 2. Jaap Schijve, "Fatigue of structures and materials" Springer, Second edition, 2009	3. Barrels, W., and Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983 4. Knott J.F., "Fundamentals of fracture Mechanics", Butterworth & Co., (Publisher) Ltd., London, 1983

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	60%	-	60%	-	60%	-
Level 4	*Analyze*	-	-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. D. Saji, National Aerospace Laboratories, Bangalore, saji@nal.res.in	1. Dr. V. Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com	1. Dr. L. R. Ganapathy Subramanian, SRMIST
2. Dr. Manoj Kumar Buragohain, Defense Research and Development Organization, Hyderabad, buragohainm@yahoo.com	2. Dr. K. Vadivuchezhian, National Institute of Technology Karnataka, Surathkal, vadivuchezhian_k@yahoo.co.in	2. Dr. S. Gurusideswar, SRMIST

Course Code	21ASE408T	**Course Name**	ROCKETS AND MISSILES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the different rockets and missiles configurations, and their significance*
CLR-2:	*examine different flight systems, flight performance and fundamental equations of rockets and missiles*
CLR-3:	*describe the properties of solid propellant and its importance in rocket motor*
CLR-4:	*explain the fundamentals of liquid propellant, its properties and associated systems*
CLR-5:	*examine the performance of multi-stage rockets and understand their stage separation techniques*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the various configurations of the rockets and missiles*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-2:	*apply the fundamental equations of motion of rockets and missiles*	*3*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-3:	*explain the significance of solid propellant rocket motor and its properties*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-4:	*discuss the liquid propellant rocket types, applications and related systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*predict the performance of multi-stage rockets, the stage separation systems and techniques*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-

Unit-1 - Rockets and Missiles Configurations ***9 Hour***

Classification of rockets / missiles, External aerodynamic configurations – Types of design and control, Bodies of revolution, Forces acting on missile during atmospheric flight, Missile sections, Missile fore bodies, Boat-tail, Drag Estimation methods

Unit-2 - Rocket Flight Dynamics ***9 Hour***

Classification of launch vehicles and missiles, Space missions types, Rocket flight systems, Forces and moments acting on a rocket, Inertial and non-inertial frames, Coordinate transformation, Coriolis theorem, Equations of motion for three dimensional motion through vacuum and atmosphere, Reentry flight dynamics, Rocket flight performance, rocket dispersion , Single stage to orbit concepts, Reusable launch vehicles

Unit-3 - Solid Propulsion and Control Systems ***9 Hour***

Solid propellant rocket, Propellant ingredients, Propellant properties, Propellant grain-processing, requirements and design, Ballistic and burn-rate control design, Solid rocket – components, motor design, Separation systems, Pyrotechnic devices

Unit-4 - Liquid Propulsion and Control Systems ***9 Hour***

Liquid propellant rocket-types, applications, Design of propellant feed system, Gas pressure feed system, Design of fuel tanks, Turbo-pump design, Liquid propellant rocket engine cycle, Cooling systems, Liquid Slosh, Pogo, Water hammer, Geyser effect, Thrust vector control (TVC) system

Unit-5 - Rocket Multi-Staging, Performance, and Auxiliary Systems ***9 Hour***

Multi-staging of rockets, multi-stage rockets – Performance estimation, Optimization techniques, Flight trajectory optimization, Constraints in optimization, Rocket flight simulation techniques, Stage separation system, Reentry vehicles landing techniques, Navigation, guidance, and control systems in the launch vehicle, Missiles guidance and aerodynamic control

Learning Resources	1. Ramamurthi.K: "Rocket Propulsion", Macmillan Publishers, New Delhi-110002, March, 2010 2. George.P.Sutton, Oscar Biblarz: "Rocket Propulsion Elements" John Wiley India,New Delhi-110002, June,2010 3. Taylor, Travis. S:" Introduction to rocket science and engineering" CRC Press, New York, 2009. 4. Cornelisse, J.W, Schoyer H F R, and Wakker K F, "Rocket Propulsion and Space Dynamic", Pitman Publishing Co., 1979 5. Ashish Tewari, "Atmospheric and Space Flight Dynamics", Birkhauser Boston, 2007	6. Martin J L Turner, "Rocket and Spacecraft Propulsion", Springer Praxix Publising Co, 2004 7. Ronald Humble, Henry and Larson, "Space Propulsion Analysis and Design", McGraw-Hill,1995 8. George M Siouris, "Missile guidance and control systems", Springer, 2004 9. W J Larson and J R Wertz, "Space Mission Analysis and Design", Kluwer Academic Publishers,1999 10. Michael Griffin, "Space Vehicle Design", AIAA education series, 2004

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	60%	-	60%	-	60%	-
Level 4	Analyze	-	-	-	-	-	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. RS Praveen, VSSC, ISRO, Thiruvananthapuram rs_praveen@vssc.gov.in	1. Dr S.R.Chakravarthy, IITMadras, src@ae.iitm.ac.in	1. Dr.G.Saravanan, SRMIST
2. Dr . Lakshmi VM, SVSSC, ISRO, Thiruvananthapuram vm_lakshmi@vssc.gov.in	2. Dr. Rajesh Sadanandan, IIST, Thiruvananthapuram, rajeshsadanandan@iist.ac.in	2. Dr.S.M.Aravindh Kumar, SRMIST

Course Code	21ASE409T	**Course Name**	CRYOGENIC ENGINEERING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the basics of cryogenic systems and it's applications*
CLR-2:	*predict the performance of Gas-Liquefaction Systems, Cryo-coolers and gas Refrigeration Systems*
CLR-3:	*explain the various methods of gas separation and Cryo pumping*
CLR-4:	*describe the different cryogenic insulations and vacuum technology*
CLR-5:	*apply the design aspects of cryogenic fluid storage and transfer lines*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the Cryogenic systems*	2	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*design and develop Gas-Liquefaction Systems, cryo-coolers and gas Refrigeration Systems*	-	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*describe the cryo gas separation and cryo pumping*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*explain the cryogenic insulation methods and vacuum technology*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	-	-
CO-5:	*examine the various cryogenic fluid storage and transfer systems*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*2*	-	-

Unit-1 - Properties of Cryogenics	***9 Hour***
Cryogenic propellants- Liquid hydrogen, liquid oxygen, liquid nitrogen, liquid helium- Mechanical, Thermal and Electrical properties- Ortho Hydrogen & Para Hydrogen - Helium4 and Helium3 - production of low temperature - Cryogenic Instrumentation-superconductivity and its aerospace applications - cryogenics in aerospace applications	
Unit-2 - Gas Liquefaction Systems	***9 Hour***
Joule Thomson effect, Joule Thomson Coefficient - Classification of cryogenic cycles - cryogenic heat exchangers, turbo expander, compressor and J-T valves-Linde – Hampson cycle, Claude cycle - Linde – Hampson system, Claude Liquefaction System, Heylandt System, Comparison of Claude and L.H system	
Unit-3 - Cryocoolers	***9 Hour***
Cryo coolers and it's classification, Stirling cryocooler, Gifford-McMahon cryocooler - Cryogenic Refrigeration system- Classification of Gas cycle refrigeration- Pulse tube refrigerator, Solvay cycle refrigerator, Vuilleumier refrigerator	
Unit-4 - Gas Separation and Gas Purification Systems	***9 Hour***
Principles of gas separation - Linde single and double column gas separation - Argon and Neon separation systems - Cryogenic Gas Adsorption - Cryo-condensation Process - Pre purification of Air - Vacuum Technology- vacuum pumps, vacuum line, gauges, valves -Production of high vacuum, Flow regimes in a vacuum, Conductance in a vacuum, Pressure drop, Slip flow, and mixed flow	
Unit-5 - Storage and Handling of Cryogens	***9 Hour***
Cryogenic fluid storage vessels, Cryogenic Insulations - Methods of cryogenic insulation - Evacuated powder insulation, Opacified powder insulation, Gas filled powders Multilayer super insulation, Fibrous materials multilayer super insulation - - cryogenic instrumentation-Propellant servicing - Propellant management - Cryogenic fluid transfer systems-Safety in cryogenics	

Learning Resources	1. R.B.Scott,“Cryogenic Engineering", Hassell Street Press,2021 2. Thomas Flynn, Cryogenic Engineering, CRC Press; 2nd edition, 2020 3. Mamata Mukhopadhyay,” Fundamentals of Cryogenic Engineering”, PHI Learning (P) Ltd, India, Fourth edition, 2010 4. Randall F. Barron.,“Cryogenic Systems", Oxford University, Second edition,1985	5. J. G. Weisend, Handbook of Cryogenic Engineering, II ed., Taylor & Francis, Philadelphia,1998 6. Milind D. Atrey, “Cryocoolers: Theory and Applications”, 1st Edition, Kindle Edition,2020 7. Zuyu Zhao and Chao Wan,” Cryogenic Engineering and Technologies: Principles and Applications of Cryogen-Free Systems”, 1st Edition, CRC Press; 1st edition, 2022

Learning Assessment							
	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*60%*	-	*60%*	-	*60%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr RS Praveen, VSSC, ISRO, Thiruvananthapuram ,rs_praveen@vssc.gov.in	1. Dr. Parthasarathi Ghosh, IIT, Kharagpur, psghosh@hijli.iitkgp.ernet.in	1. Dr.G. Saravanan, SRMIST
2. Dr Lakshmi VM, VSSC, ISRO, Thiruvananthapuram, vm_lakshmi@vssc.gov.in	2. Dr. Rajesh Sadanandan, IIST, Thiruvananthapuram, rajeshsadanandan@iist.ac.in	2. Mr.Vinayak Malhotra, SRMIST

Course Code	21ASE410T	**Course Name**	HYPERSONIC AEROTHERMODYNAMICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*discuss the hypersonic flow and importance of hypersonic flows*
CLR-2:	*interpret the shock-wave and expansion-wave and their significance in hypersonic flow*
CLR-3:	*explain various approximate models for hypersonic flow*
CLR-4:	*describe the governing equation for viscous and inviscid flows, boundary layer equations and shock-wave boundary layer interaction*
CLR-5:	*explain the various hypersonic experimental facilities and hypersonic vehicle aerodynamics*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the hypersonic flow and the characteristic of the hypersonic flow*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*describe shock-wave and expansion-wave relations for hypersonic flow*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*explain the importance of the simplified models for hypersonic flow*	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*examine role of hypersonic shock-wave boundary layer interaction, shock-shock interactions and viscous interaction*	*2*	*3*	-	-	-	-	-	-	-	-	-	*1*	*3*	-	-
CO-5:	*explain the various techniques and visualization techniques for hypersonic flow*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	*2*	-

Unit-1 - Fundamentals of Hypersonic Flow	***9 Hour***
Basic concepts of hypersonic flow – importance - physical aspects. Thin shock layer, entropy layer, viscous interaction. Effects of high temperature and communication blackout. Low density flow, free molecular flow. Hypersonic Shock and Expansion Wave Relations: shock-wave and expansion-wave relations for high Mach numbers. Historical context of hypersonic flow and current advancement in the hypersonic flow	
Unit-2 - Local Surface Inclination Methods	***9 Hour***
Newtonian flow model, Newtonian flow model for flat plat, circular cylinder of infinite span and sphere. Modified Newtonian theory, Newtonian-Busemann theory, Mach-number independence principle, Tangent-wedge and Tangent-cone methods, Shock-expansion method. Applications of local surface inclination methods	
Unit-3 - Hypersonic Inviscid Flow	***9 Hour***
Governing equations, hypersonic small disturbance equations, hypersonic similarity parameter. Hypersonic equivalence principle, blast-wave theory, thin shock layer theory, Shock-shock interactions in hypersonic flow and different types of shock-shock interactions. CFD techniques for hypersonic inviscid flow.	
Unit-4 - Hypersonic Viscous Flow	***9 Hour***
Governing equations, similarity parameters and boundary conditions, boundary layer equation for hypersonic flow, Hypersonic transition, prediction of transition, turbulent boundary layer, hypersonic aerodynamic heating and its effects on entropy layer. Hypersonic shock-wave/boundary-layer interactions, strong and weak hypersonic viscous interaction. Simulation techniques for hypersonic viscous flow	
Unit-5 - Hypersonic Vehicle Aerodynamics and Experimental Techniques	***9 Hour***
Reentry capsule aerodynamics, Review of existing reentry vehicles, Design aspects of reentry vehicle, shuttle orbiter aerodynamics: pre-flight prediction of the orbiter aerodynamics, flight measurements of the orbiter aerodynamics, X-15 aerodynamics, Design aspects of re-entry vehicle. Experimental Techniques: Hypersonic wind-tunnel, hypersonic shock tunnel, arc-jets, Measurement techniques	

Learning Resources	1. *Anderson Jr, John D. Hypersonic and high-temperature gas dynamics. American Institute of Aeronautics and Astronautics, 2006.* 2. *Bertin, J. J. "Hypersonic Aerothermodynamics, AIAA, Education Series, Washington, D." (1994)*	3. *Hayes, Wallace. Hypersonic flow theory. Elsevier, 2012.* 4. *Brun, Raymond. Introduction to reactive gas dynamics. OUP Oxford, 2009.* 5. *Davis, Harry J., and Herbert D. Curchack. Shock tube techniques and instrumentation. No. HDL-TR-1429. Harry Diamond Labs Adelphi MD, 1969.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	60%	-	60%	-	60%	-
Level 4	Analyze		-		-		-
Level 5	Evaluate	-	-		-	-	-
Level 6	Create	-	-		-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mrs. Smrutisudha Sahoo, DRDO, s.sahoo.pxe@gov.in*	1. *Dr. Rakesh Kumar,Indian Institute of Technology Kanpur iitk@iitk.ac.in*	1. *Dr. Malaikannan G, SRMIST*
2. *Mr. Dhanabal K, S & I Engineering Solutions Pv.t. Ltd. dhanabal@sandi.co.in*	2. *Dr. Rajesh G, Indian Institute of Technology Madras,rajesh@ae.iitm.ac.in*	2. *Dr. Aravindh Kumar S M, SRMIST*

Course Code	21ASE411T	**Course Name**	DIGITAL AVIONICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the avionics systems, its design and Integration*
CLR-2:	*explain the architecture & communication Protocols used in Avionics communication*
CLR-3:	*describe the display technologies in Glass cockpit and avionics cooling and packaging*
CLR-4:	*distinguish the Electromagnetic interference sources in the aircraft*
CLR-5:	*explain the maintenance aspect of avionics systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the avionics systems, its design and integration*	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*explain the architecture and communication protocols of the avionics systems*	3	2	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-3:	*differentiate the display technologies in Glass cockpit and avionics cooling and packaging*	3	-	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-4:	*identify the electromagnetic sources and interference prevention techniques*	3	2	-	-	-	-	-	-	-	-	-	1	2	-	-
CO-5:	*explain the maintenance procedures for avionics wiring, testing equipments and maintenance*	3	-	-	-	-	-	-	-	-	-	1	-	2	-	-

Unit-1 - Introduction to Avionics ***9 Hour***

Need for Avionics - Role of Avionics in aircrafts and space systems - Avionics system Design - Top-Down design - Ilitis of Avionics Systems - Integrated avionics and weapon systems - Fault tree analysis - Qualitative and quantitative methods - Failure mode and effect analysis - Steps in FMEA-Pros & cons of FTA & FMEA

Unit-2 - Digital Avionics Architecture ***9 Hour***

Avionics system Architecture - Data Buses used in Avionics Network – Attributes - Transmission classes - Network Topologies - Types Bit encoding - Types of communication Protocol - ARINC 429 - Word format, Bit encoding and protocols - MIL-STD 1553B- Word format, Bit encoding and protocols - AFDX network

Unit-3 - Flight Decks and Cockpits ***9 Hour***

Trends in Display technologies - CRT, LCD, LED, Plasma, and EL panels - Capacitive and resistive touch screen technologies - Head Up Display - - Helmet Mounted Display – MFDs - Direct Voice Input and HOTAS – FLIR - IR vision - Avionics cooling requirements - - Avionics cooling specifications - Avionics cooling for Airplanes, missiles, satellites & Spacecrafts - Radiation heat transfer in space - Effect of α/e ratio on temperature in space - Avionics Rack and Packaging

Unit-4 - Electro Magnetic Interference ***9 Hour***

Electromagnetic interference (EMI) and its effect-EMI on current carrying conductor-Need for EMI prevention-Shielding, Twisted pairs and bandwidth-Radiated EMI-EMI susceptibility-EMI reduction-Continuing Airworthiness-Wire and cable installation-Cable-Failure modes of wires and cables-Wiring procedure-Cables and wire looms-Current rating of wire looms-Guidelines for the installation of wire looms-Types of wire looms-Hydrolysis in wires and cables-Wire connectors

Unit-5 - Testing Equipments and Maintenance ***9 Hour***

Aluminum wires/cables-Bonding-Types of bonding in composite materials-Lightning protection in composite aircrafts-Earth Returns-Aircraft Manuals-Maintenance Manuals-Wiring diagram manuals-Circuit Testing-Avometer and its types-Bonding meter-oscilloscopes-Automatic Test equipment-Built In Test equipment-Centralized Maintenance systems-Aircraft communication and addressing systems-Cost of maintenance

Learning Resources	1. *Carry R spitzer, "The Avionics Handbook", CRC Press, 2001* 2. *Spitzer CR, "Digital Avionics Systems", Blackburn Press, 2001* 3. *Lan Moir, "Civil Avionics Systems", Wiley publications, 2013*	4. *RPG Collinson, "Introduction to Avionics", Springer US, 2013* 5. *Dave S Steinberg, "Cooling Techniques for electronic equipment", Wiley,1991* 6. *Mike T & David W," Aircraft Electrical and Electronic Systems Principles, Operation and Maintenance", Elsevier Ltd, 2009*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	50%	-	50%	-	50%	-
Level 2	*Understand*	50%	-	50%	-	50%	-
Level 3	*Apply*	-	-	-	-	-	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Blue Dart Aviation. manoharank@bluedart.com*	1. *Dr. Rajesh Joseph Abraham, Department of Avionics, IIST Thiruvananthapuram, rja@iist.ac.in*	1. *Mr. K. Iynthezhuthon, SRMIST*
2. *Wg.Cdr R.Annamalai, IAF, Tambaram, annamalai.ramasamy2@gmail.com*	2. *Dr. A. Kaviyarasu, MIT, Chennai, isrokavi@gmail.com*	2. *Dr. K. Saravanakumar, SRMIST*

Course Code	21ASE412T	**Course Name**	AIRCRAFT CONTROL SYSTEMS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the basics of the control system*
CLR-2:	*explain the root locus analysis*
CLR-3:	*summarize the frequency response analysis*
CLR-4:	*explain the time and frequency domain design of the control system*
CLR-5:	*describe the control system design in state space*

		Program Outcomes (PO)												**Program Specific Outcomes**		
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss a mathematical model of a dynamic system*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-2:	*describe the system using the Root Locus plot*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*paraphrase the system using Frequency response analysis*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*discuss a control system in the time and frequency domain*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-5:	*restate and analyze the control system in state space*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - Introduction to Automatic Control Systems **9 Hour**

Introduction to Control Systems - Open-Loop, Closed-Loop Control, - Feedback control system - Block Diagrams and their Simplification - Numerical - Mathematical Modeling of Dynamical Systems - Modeling in the State Space Transfer - Functions - Impulse - Response - Functions - Delay - Time, Rise Time, Peak Time, Maximum Overshoot and Settling - Time Stability Analysis and Routh's Stability - Criterion Proportional - Derivative and Integral Control Actions - Steady-State Error Analysis in Feedback Systems

Unit-2 - Open and Closed Loop Systems **9 Hour**

Introduction to Root Locus - Analysis - General Rules for Constructing the Root Locus - Positive feedback Systems - Negative feedback Systems - Root Locus plot for Negative feedback system - Parameter - Variation Stability analysis of positive feedback system using root locus - Stability analysis of Negative feedback system using root locus

Unit-3 - Transient and Steady State Response Analyses **9 Hour**

Bode Diagrams - Rules for Constructing the Bode Plots - Nyquist Plots - Rules for Constructing the Nyquist Plots Systems with Transport Lags Gain Margin Phase - Margin - Closed-Loop - Frequency Response - Frequency Domain Performance - Specifications - Peak Resonance - Resonant Frequency Bandwidth

Unit-4 - Stability Analysis **9 Hour**

Introduction to time domain and frequency domain design of control system - PD Controller Design - PI Controller Design - PID Controller Design - Lag Compensation - Lead-Lag Compensation - Sensitivity - Complementary Sensitivity - Transfer Functions - Disturbance - Rejection - Loop Shaping-Filters and its uses.

Unit-5 - Sampled Data Control System **9 Hour**

Lyapunov Stability - Asymptotic Stability - Input-Output Stability - State Transition Matrix - The Lyapunov Equation - Full-State Feedback - Control Design and Pole Placement - Optimal State Space Control System Linear Quadratic Regulator - Classical Control Theory-Modern Control Theory-Sliding mode Control Theory

Learning Resources	1. *Ogata, K., Modern Control Engineering, Prentice Hall, 2002* 2. *Kuo, B.C., Automatic Control Systems, Prentice Hall, 1991* 3. *Franklin, G.F., Powell, J.D., and Emami-Naeini, A., Feedback*	4. *Control of Dynamic Systems, Addison-Wesley, 1994.* 5. *Dorf, R.C., and Bishop, R.H., Modern Control Systems, Prentice Hall, 2001.* 6. *Nise, N.S., Control Systems Engineering, Benjamin-Cummings, 1995*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Blue Dart Aviation. manoharank@bluedart.com*	1. *Dr. Rajesh Joseph Abraham, IIST Thiruvananthapuram. rja@iist.ac.in*	1. *Mr.Iynthezhuthon.K, SRMIST*
2. *Wg. Cdr R.Annamalai, IAF, Tambaram, annamalai.ramasamy2@gmail.com*	2. *Dr. A. Kaviyarasu, MIT, Chennai. isrokavi@gmail.com*	2. *Dr. Allwyn, SRMIST*

Course Code	21ASE413T	**Course Name**	AERIAL ROBOTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the kinematics and dynamics of fixed wing unmanned aerial vehicle*
CLR-2:	*describe the kinematics and dynamics of the Multirotor micro aerial vehicle*
CLR-3:	*discuss the State estimation of Aerial Robots*
CLR-4:	*summarize the flight controls methods of Aerial Robots*
CLR-5:	*describe the applications of Aerial Robots*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the kinematics and dynamics of fixed wing unmanned aerial vehicle*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-2:	*explain the kinematics and dynamics of Multirotor micro aerial vehicle*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-3:	*describe the state of Aerial Robots*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*discuss flight controls for Aerial Robots*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-5:	*explain the applications of Aerial Robots*	*3*	-	-	-	-	-	-	-	-	-	-	*1*	*2*	-	-

Unit-1 - Aircraft Actuation System	***9 Hour***
Introduction of Fixed Wing Unmanned Aerial Vehicle (FWUAV) - History of Fixed Wing Unmanned Aerial Vehicle - Classification of Fixed Wing Unmanned -Mathematically Modelling the Dynamics of FWUAV-Quaternion Formulation- Gravitational force modelling of FWUAV - Aerodynamic Force modelling of FWUAV – Thrust Force Modelling of FWUAV	
Unit-2 - Kinematics and Dynamics of Multirotor Micro Aerial Vehicle (MMAV)	***9 Hour***
Introduction of Multirotor Micro Aerial Vehicle (MMAV) - History of Multirotor Micro Aerial Vehicle (MMAV) - Classification of MMAV - Propeller Theory- Mathematically Modelling the Dynamics of MMAV - Gravitational force modelling of MMAV - Aerodynamic Force modelling of MMAV-Thrust force modelling of MMAV	
Unit-3 - State Estimation	***9 Hour***
Navigational Sensors - Inertial Sensors - Magnetometer – GPS-based Navigation-Ultrasonic Sensor-LIDAR-Sensor Fusion - Position Estimation-Velocity Estimation - Inertial Navigation Systems - Attitude estimation	
Unit-4 - Flight Control	***9 Hour***
Introduction to Control Methods of UAV-PID Control-Lateral control of MMAV using PID-LQR Control-Sliding Mode Control-Model Predictive Control for UAV - Linear Model Predictive Control (MPC)-Design of a Linear MPC for MMAV - Implementation of a Linear MPC for MMAV	
Unit-5 - Motion Planning and Applications	***9 Hour***
Applications of Aerial Robots - Aerial Robots for Military application- Target attacking aerial robots - Surveying Aerial Robots - Payload Delivery - Scientific Research, Search and Rescue Mineral Exploration – Defense Aerial Robots.	

Learning Resources	*1. R. Beard, and T. W. McLain, 'Small Unmanned Aircraft: Theory and Practice' Princeton University Press, 2012.* *2. R.C. Nelson., Flight Stability and Automatic Control, McGraw Hill, New York 1998.*	*3. L.R. Newcome., Unmanned Aviation, a Brief History of Unmanned Aerial Vehicles, American Institute of Aeronautics and Astronautics, Reston 2004.* *4. Kuo, B.C., Automatic Control Systems, Prentice Hall, 1991.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Wg.Cdr retd. Manoharan, Blue Dart Aviation. manoharank@bluedart.com	*1. Dr. Rajesh Joseph Abraham, IIST Thiruvananthapuram. rja@iist.ac.in*	*1. Mr.Iynthezhuthon.K, SRMIST*
2. Wg. Cdr R.Annamalai, IAF, Tambaram, annamalai.ramasamy2@gmail.com	*2. Dr. A. Kaviyarasu, MIT, Chennai. isrokavi@gmail.com*	*2. Dr. Allwyn, SRMIST*

							L	T	P	C
Course Code	21ASE414T	**Course Name**	AIRBORNE SENSORS AND ACTUATORS	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the advanced concepts in airborne sensors and actuators*
CLR-2:	*summarize mathematical knowledge for modelling*
CLR-3:	*discuss the aircraft actuation systems*
CLR-4:	*determine the servo components*
CLR-5:	*define the testing of sensors and actuators*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the concepts of airborne sensors and actuators*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*2*	*-*	*-*
CO-2:	*explain mathematical knowledge in the modeling of sensors and actuators*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*2*	*-*	*-*
CO-3:	*describe the aircraft actuation systems*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*2*	*-*	*-*
CO-4:	*examine the servo components*	*3*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*2*	*-*	*-*
CO-5:	*identify the sensors and actuators testing*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*2*	*-*	*-*

Unit-1 - Aircraft Actuation Systems	***9 Hour***
Introduction to aircraft actuation systems - Introduction to aircraft actuation systems - Principles of aircraft actuation systems - Hardware elements for the actuation systems - Types of actuation systems - Electromagnetic actuators - Electric motors Solenoid actuators	
Unit-2 - Servo Components	***9 Hour***
Servo Actuators - Linear Servo Actuator and its types-Rotary Servo Actuator and its type-Servo Valves – Electro-hydraulic servo valve and its type - Servo amplifier pick off - Selection factors of servo amplifier - Power supply consideration for the servo amplifier	
Unit-3 - Modeling, Design and Testing	***9 Hour***
Linear and non-linear actuation systems - Modelling of actuation systems - Modelling of actuation systems - Servo loop analysis - Actuator design - Testing methodologies - Performance testing - Test equipment for actuation systems	
Unit-4 - Inertial Sensors	***9 Hour***
Gyroscope principles - Gyro equation - Rate gyro integration-free gyro - Vertical and directional gyro - Basic principles theory and applications – Accelerometer - principle and theory Spring, mass, force balance piezoelectric accelerometer and MEMS sensors, Contact and Non-Contact Sensors and its type.	
Unit-5 - Sensor Testing	***9 Hour***
Testing philosophies - testing protocols - testing process - Solenoid voltmeter - Wheatstone bridge - Signal generators - Performance testing of sensors - Data evaluation - Calculation of performance	

Learning Resources	1. *James Ephraim Johnson, Electrohydraulic servo systems, hydraulic and pneumatic magazines, 1984* 2. *Pallett, EHJ, Aircraft instruments, principles and applications, pitman publishers, London, 1981* 3. *Neal E wood et al., Electromechanical actuation development AFFDL-TR-150. Dec 1978*	4. *Alan S Morris, Measurement and instrumentation principles, Third edition, 2001* 5. *J Jaidev vyas et al., Electro-hydraulic actuation systems: Design testing, Identification and validation, 2019* 6. *Oing Guo, Non-linear control techniques for electro-hydraulic actuators, 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
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2. *Wg. Cdr R.Annamalai, IAF, Tambaram, annamalai.ramasamy2@gmail.com*	2. *Dr. A. Kaviyarasu, MIT, Chennai. isrokavi@gmail.com*	2. *Dr Allwyn, SRMIST*

Course Code	21ASE415T	**Course Name**	AVIATION SAFETY MANAGEMENT	**Course Category**	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*Aerospace Engineering*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*comprehend about the Aviation safety*															
CLR-2:	*comprehend about the human factors in aviation safety*															
CLR-3:	*identify aviation safety program elements*															
CLR-4:	*empathize about the aircraft maintenance safety*															
CLR-5:	*distinguish about the airports and heliports*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*concept of safety, accident causes, prevention methodology and risk management*	2	-	-	-	-	-	-	-	-	-	-	1	3	-	-
CO-2:	*examine risk theory, Human difficulties, training, performance and its factors*	2	-	-	-	-	-	-	-	-	-	-	1	3	-	-
CO-3:	*define Internal Reporting Systems, Aviation Safety Committees, Inspection Programs and Evaluation, Flight Operation Safety Inspection and Format, Aviation Safety Education and Training and Safety Awards Programs*	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*interpret Aircraft Discrepancies, Configuration Control, Maintenance Engine Runs and Taxiing, Maintenance Test Flights, maintenance Analysis, Tool Control*	2	-	-	-	-	-	-	-	-	-	-	1	3	-	-
CO-5:	*describe Airport Certification Manual, Emergency Plan, Airports/Heliports criteria, Foreign Object Control and maintenance of airports*	2	-	-	-	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Aviation Safety	***9 Hour***
Economic of Aviation Safety – Safety Vs Mission – Randomness of Damage and Injury – Zero Accident Rate – Accident causes – Multiple Vs Single Cause – Aircraft Accident - Aircraft Mishap – Aircraft Incident - Building Aviation Safety Program – Prevention Methodology – Risk Management	
Unit-2 - Theory of Risk	***9 Hour***
Changing the Behavior of the risk takers – Attitudes – Discipline – Punishment – Protection of Safety - Motivating Safe Behaviour – Human factors difficulties – Training involving human factors – Human Performance Concerns – Human Performance Factors	
Unit-3 - Investigation Reports	***9 Hour***
Internal Reporting Systems - Information Distribution systems – Aviation Safety - Committees – Aviation Safety Inspection Programs - Aviation safety program Evaluation – Flight Operation Safety Inspection – Safety Inspection report Format – Accident Preparation and Investigation	
Unit-4 - Flight Line Practice	***9 Hour***
Aircraft Discrepancies – Delayed and Deferred Discrepancies – Training – Configuration Control – Maintenance Engine Runs and Taxiing – Maintenance Test Flights – maintenance Analysis – Tool Control – Hazardous Waste Disposal – Bogus parts – Technical Data – maintenance Inspections – Flight Line Practices – Maintenance Safety Programs – Maintenance Safety Inspections	
Unit-5 - Airport Inspection Procedures	***9 Hour***
Airport Certification Manual – Airport Emergency Plan – Airports/Heliports criteria – Airfield Criteria – Airspace Criteria – Foreign Object Control – Bird Hazards – Snow and Ice Removal – Fuel Handling – Vehicle Control – Airport and Heliport Safety Inspections	

Learning Resources	1. *Aviation Safety Programs - A Management Handbook - Richard H. Wood*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*50%*	-	*50%*	-	*50%*	-
Level 2	*Understand*	*50%*	-	*50%*	-	*50%*	-
Level 3	*Apply*		-		-		-
Level 4	*Analyze*		-		-		-
Level 5	*Evaluate*	-	-		-	-	-
Level 6	*Create*	-	-		-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Wg.Cdr retd. Manoharan, Continuing Airworthiness Manager,Blue Dart viation.manoharank@bluedart.com*	1. *Dr. V.Arumugam, Madras Institute Of Technology Campus, Anna University, Chennai, arumugam.mitaero@gmail.com*	1. *Dr. S. Sivakumar, SRMIST*
2. *Wg.cdr R.Annamalai,Chief training co-ordinating officer IAF, Tambaram, annamalai.ramasamy2@gmail.com*	2. *Dr.S.Nadaraja pillai, Sastra university Thanjavur, nadarajapillai@mech.sastra.edu*	2. *Mr. K. Iyenthezhuthon, SRMIST*

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