ACADEMIC CURRICULA

Professional Elective Courses

AEROSPACE ENGINEERING

Regulations - 2018

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

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Kattankulathur, Kancheepuram, Tamil Nadu, India

Course Code	18ASE201T	Course Name	INDUSTRIAL AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC202J	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 :	Understand the application of aerodynamics in fields other than Aerospace
CLR-2 :	understand effect of terrain types on the wind flows
CLR-3 :	understand the concepts on wind energy and wind turbine aerodynamics
CLR-4 :	Understand how buildings are affected by wind flows and how to mitigate the unwanted aerodynamic forces
CLR-5 :	Understand how aerodynamics plays a major role in streamlining and drag reduction of automobiles
CLR-6 :	Understand the role of aerodynamics in sports balls and vortex induced vibrations

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Understand different aspects of atmosphere and atmospheric boundary layer	2	80	70	H	M	L	L	-	-	M	-	-	-	-	-	-	M	L
CLO-2 :	Acquire knowledge on Atmospheric boundary layer in a wind tunnel	2	80	70	H	M	M	L	-	-	M	-	-	-	-	-	H	M	M
CLO-3 :	Learn the working principles of wind turbines	2	80	70	H	L	L	L	-	-	H	-	-	-	-	-	-	M	M
CLO-4 :	Appreciate the usefulness of drag reduction devices	2	80	70	H	L	L	L	-	-	-	-	-	-	-	-	H	H	H
CLO-5 :	Gain knowledge on building aerodynamics	2	80	70	H	L	M	L	-	-	M	-	-	-	-	-	M	M	M
CLO-6 :	Acquire comprehensive understanding on sports aerodynamics	2	80	70	H	M	L	L	-	-	-	-	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Aerodynamics / Aviation Aerodynamics / Non-Aviation Aerodynamics	Need for renewable energy sources	Rolling resistance Vs Air resistance	Aerodynamics of race cars	Introduction to building aerodynamics
	SLO-2	Introduction to Industrial Aerodynamics	Wind energy and its importance	Need for automotive aerodynamics	Ground effects	Environmental winds in city blocks
S-2	SLO-1	Need for Industrial Aerodynamics	Wind turbine and its parts	History of Automotive Aerodynamics	Down force generation	Low-rise buildings (LRB)
	SLO-2	Branches of Industrial Aerodynamics	Classification of wind turbines	Evolution of Automobile styling	Frontal and rear wings	Roof suction effects
S-3	SLO-1	Atmospheric layers	Horizontal axis wind turbine (HAWT)	Classification of cars	Aerodynamic braking - Spoilers	High-rise buildings (HRB)
	SLO-2	Atmospheric circulations	Advantages and disadvantages of HAWT	Pressure distribution over cars	Aerodynamics of wheels	Dynamic loads
S-4	SLO-1	Local winds	Vertical axis wind turbine (VAWT)	Aerodynamic forces on Automobiles	Introduction to sports aerodynamics	Aerodynamic load mitigation techniques for LRB
	SLO-2	Terrain types	Advantages and disadvantages of VAWT	Lift, Drag and Moments	Aerodynamics of Cricket ball	Aerodynamic load mitigation techniques for HRB
S-5	SLO-1	Atmospheric Boundary Layer (ABL)	Wind power, Power coefficient	Sources of vortices in automobiles	Swing and Spin	Flow over a simplified building
	SLO-2	Aerodynamic Roughness length	Tip speed ratio, Solidity ratio	Flow separation and wake dynamics	Effect of dimples on golf ball	Pressure distribution
S-6	SLO-1	Mean velocity profiles	1-D Momentum theory	Aerodynamic Improvements	Vortex shedding	Wind loads – TVL Formula
	SLO-2	Power-law and Logarithmic law	Betz limit	Aerodynamics Vs Styling - Limitations	Strouhal number	Funneling effect
S-7	SLO-1	Variation of wind velocity with height in ABL for different terrain types	Power losses	Aerodynamics of motor bikes	Flow induced vibrations	Ventilation
	SLO-2	Turbulence Intensity and its variation in ABL	Energy density of different rotors	Aerodynamics of roofless vehicles	Fluid-structure interactions	HVAC
S-8	SLO-1	Need for ABL simulation	Aerodynamic power control	Aerodynamics of Trucks and Buses	Effect of Reynolds number on wake	Architectural Aerodynamics
	SLO-2	Boundary layer tunnels	Methods for power control	Aerodynamics of Trains	Aerodynamic flutter	Wind catchers

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*Simulation of ABL in a wind tunnel*	*Blade sections - Airfoils*	*Ahmed body – Generic automobile shape*	*Wake galloping*	*Building codes*
	SLO-2	*Methods to produce ABL*	*Wind turbine siting*	*Wind tunnel experiments and simulations*	*Vortex shedding control methods*	*Loads on launch vehicles subjected to winds*

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. Palani Kumar, CFD Application Expert, DJAIR, Korea. Email: kumar@djair.co.kr	*1. Dr .Arun Kumar Perumal, Mechanical Eng, IIT Jammu, arun.perumal@iitjammu.ac.in*	*1. Dr. Bharadwaj K K, SRMIST* *2. Dr. Kannan B T, SRMIST*

Course Code	18ASE202T	Course Name	APPLIED STRUCTURAL MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC201J*	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 :	*To familiarize the concept of external load acting on a rigid airplane.*
CLR-2 :	*To familiarize the concept of statically indeterminate beams.*
CLR-3 :	*To familiarize with various energy methods.*
CLR-4 :	*To familiarize with the columns.*
CLR-5 :	*To study the concepts of failure theories.*
CLR-6 :	*Utilize the concepts in better understanding of various structural elements dealing with loads.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. &	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Determine the forces or loads acting on an accelerated airplane.*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-2 :	*Determine the fixed end moments and plot shear force and bending moment diagram.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-3 :	*Determine the deflection of various structures by different energy methods.*	*2*	*75*	*70*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-4 :	*Determine the buckling load of a column under various end conditions.*	*2*	*85*	*80*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-5 :	*Application of theorem of three moments to solve for statically indeterminate beams.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-6 :	*Apply the concepts of theories of failure to determine the safe design.*	*3*	*80*	*70*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to limit loads, design loads and factor of safety.*	*Continuous beam concept. Derivation of Clapeyron’s equation of three moments.*	*Derivation of Strain Energy stored due to axial, bending and Torsional loads.*	*Introduction to columns and its classification. Buckling load, factor of safety.*	*Introduction to failure theories.*
	SLO-2	*Broad classification of external loads on a conventional aircraft.*	*Application of Clapeyron’s equation of three moments to continuous beam with simply supported ends.*	*Strain Energy stored due to shear loads, The theorem of Complementary Energy and Castigliano' s Theorem.*	*Failure of a short and long column, Euler’s theory for long columns.*	*Discussion about different materials and its properties*
S-2	SLO-1	*Problems involving accelerated motion of rigid airplane.*	*Problem solving*	*Derivation of Castigliano’s theorem I and II, Maxwell’s Reciprocal theorem*	*Assumptions followed in Euler’s theory for long columns. Different end conditions of a column, concept of buckling stress.*	*Maximum Principal stress theory: Derivation.*
	SLO-2		*Application of Clapeyron’s equation of three moments to continuous beam with fixed end supports.*	*Application of Castigliano’s theorem – I to find deflection of beams.*	*Derivation of Euler’s formula for crippling load when both ends are hinged*	*Maximum Principal stress theory: Problem solving*
S-3	SLO-1	*Landing Gear Structure*	*Problem solving*	*Problem solving*	*Derivation of Euler’s formula for crippling load when both ends are fixed*	*Maximum Principal strain theory Derivation.*
	SLO-2	*Problems of Calculating Reactions andLoads on Members of Landing Gear Units*	*Application of Clapeyron’s equation of three moments to continuous over-hanging beam.*	*Problem solving*	*Derivation of Euler’s formula for crippling load when one end fixed and the other hinged end.*	*Maximum Principal strain theory: Problem solving*
S-4	SLO-1	*Problem solving*	*Problem solving*	*Differences between statically determinate and statically indeterminate structures with examples*	*Derivation of Euler’s formula for crippling load when one end fixed and the other I free.*	*Maximum Shear stress theory: Derivation.*

Learning Resources	
	1 Rajput R. K., “Strength of Materials”, S.Chand publications, Sixth Edition, 2015. *2. John Case, and A.H.Chilver, “Strength of Materials and structures”, Edward Arnold Publishers Ltd., 2016.* *3. E. F. Bruhn, “Analysis and Design of Flight Vehicle Structures”, Tri-State Offset Company (U.S.A),1973*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@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.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Dr.T.Selvakumaran,SRMIST*

Course Code	18ASE203T	Course Name	EXPERIMENTAL STRESS ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18PYB101J, 18ASC201J*	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 :	*Understand the various aspects of measurements*
CLR-2 :	*Understand the different physical principles of strain measuring instruments.*
CLR-3 :	*Identify the different materials for resistance type strain gages*
CLR-4 :	*Know the various circuits for strain measuring purpose.*
CLR-5 :	*Know the principles and materials in photo elastic concepts.*
CLR-6 :	*Understand the various non-destructive testing methods.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the measuring process of various instruments*	2	85	75	H	-	H	H	L	H	H	H	-	-	-	M	M	M	M
CLO-2 :	*Describe about the various strain measuring devices*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-3 :	*Explain the physical principle and circuits used in resistance type strain gages*	2	85	75	H	-	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-4 :	*Explain the rosette analysis*	2	85	75	H	H	-	H	-	H	H	H	-	-	-	M	M	M	M
CLO-5 :	*Describe the various photo elastic concepts of stress measurements*	2	85	75	H	-	H	H	-	H	H	H	-	-	-	M	M	M	M
CLO-6 :	*Explain the various non destructive methods of flaw detection*	2	85	75	H	H	H	H	-	H	H	H	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Stress and strain*	*Properties of strain gage system*	*Introduction to resistance strain gage*	*Introduction to photoelasticity*	*NDT method-Introduction*
	SLO-2	*Introduction- Relation between stresses and strains for different materials*	*Basic characteristics of strain gage*	*Principle of operation of the resistance strain gage, Strain sensitivity*	*wave plates, polarized light*	*Classification of flaws, Steps in NDT*
S-2	SLO-1	*Principles of measurements*	*Huggenberger tensometer*	*Materials for resistance strain gage, Advance alloy, Isoelastic alloy, Karma alloy and other materials*	*Stress optic law*	*Fluorescent penetrant technique*
	SLO-2	*Aspects of measurements*	*Advantages and disadvantages, limitations*	*Types of electrical resistance strain gages- Unbonded wire strain gage, Bonded wire strain gage*	*Strain optic law*	*Magnetic particle inspection*
S-3	SLO-1	*Fundamental methods of measurements*	*Diffraction strain gage*	*Types of resistance strain gage-Bonded foil strain gage, Weldable strain gage*	*Plane polariscope , Derivation of intensity of light in circular polariscope*	*Eddy current testing*
	SLO-2	*Generalized measuring system*	*Advantages and disadvantages*	*Strain gage adhesives, Selection, Properties and types*	*Effect of stressed model in plane polariscope*	*Radiography*
S-4	SLO-1	*Accuracy and Precision*	*Interferometric strain gage*	*Mounting methods-Gage installation, Curing*	*Circular polariscope*	*Ultrasonic inspection*
	SLO-2	*Repeatability and Reproducibility*	*Advantages and disadvantages*	*Temperature compensation, Gage sensitivity, Gage factor*	*Derivation of intensity of light in circular polariscope*	*A scan, B scan and C scan*
S-5	SLO-1	*Tolerance and Range*	*Tuckerman strain gage*	*Strain gage circuits, Potentiometer circuit*	*Effect of stressed model in a circular polariscope*	*Thermography*
	SLO-2	*Bias and Linearity*	*Advantages and disadvantages*	*Temperature compensation ,sensitivity and range in potentiometer circuit*	*Explanation of fringe patterns*	*Holography*
S-6	SLO-1	*Sensitivity explanation*	*Capacitance strain gage*	*Wheatstone bridge circuit*	*Compensation techniques- Babinet soleil method of compensation*	*Acoustic emission technique*

Duration (hour)		9	9	9	9	9
	SLO-2	*Numerical solving*	*Advantages and disadvantages*	*Derivation of output voltage*	*Tardy method of compensation*	*Moire method of strain analysis*
S-7	SLO-1	*Hysteresis*	*Inductance strain gage*	*Circuit sensitivity and different arrangements in wheat stone bridge circuit*	*Fringe separation methods-Shear difference method, Interferometer method*	*Methods*
	SLO-2	*Dead space, Threshold and Resolution*	*Advantages and disadvantages*	*Rosette analysis, Different conditions of strain measurements*	*Electrical analogy method, Oblique-incidence method*	*Moire fringe pattern*
S-8	SLO-1	*Error Analysis- Classification*	*Semiconductor strain gage*	*Three element rectangular rosette*	*Fringe multiplication method*	*Physical explanation of moiré fringe pattern*
	SLO-2	*Error analysis- Sources*	*Advantages and disadvantages*	*Delta rosette*	*Explanation of fringe multiplication*	*Brittle coating methods*
S-9	SLO-1	*Error analysis numerical*	*Acoustical strain gage*	*Four element rectangular rosette*	*Properties of photoelastic materials*	*Types of brittle coating methods*
	SLO-2	*Calibration*	*Advantages and disadvantages*	*Tee delta rosette*	*Explanation of different photoelastic materials*	*Advantages and disadvantages of brittle coating methods*

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. *Pollock, A.A., Acoustic Emission in Acousticsand Vibrations Progress, ed. By StephensR.W.B., Chapman and Hall, 1983*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. L.R. Ganapathi Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE204T	Course Name	COMPOSITE MATERIALS AND STRUCTURES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC201J	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 :	Understand the mechanical behavior of composite materials
CLR-3 :	Understand the existing production technologies
CLR-4 :	Identifying the selection of materials
CLR-5 :	Identify material's Application
CLR-6 :	Understand the application of various composites

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	Learning 2	Learning 3	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10	PLO 11	PLO 12	PLO 13	PLO 14	PLO 15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Aware of the composite materials and it properties	2	80	70	H	H	-	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	Understands application of composite materials in different aircraft components	2	85	75	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-3 :	Identify different treatments to strengthen materials	2	75	70	H	-	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	Understand molding techniques	2	85	80	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-5 :	Understand Various terminologies used in composite Materials	2	85	75	H	-	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	Understand forming Techniques	2	80	70	H	-	-	-	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to Composite Materials	Hooke's law for Isotropic Materials	Micro Mechanics	Governing differential equation of general laminate	Manufacturing of Glass fibers
	SLO-2	Natural Composites	Numericals solving	Micro Mechanics		Block diagram of Manufacturing
S-2	SLO-1	Basic Definitions	Generalized Hooke's law	Derivation of Volume Fraction, Mass Fraction	Angle ply laminates	Manufacturing of Carbon Fibers
	SLO-2	Basic Definitions	Numericals solving	Density and Void Content	Cross ply laminates	Block diagram of Manufacturing
S-3	SLO-1	Introduction to Fibers	Hooke's law for 3D Orthotropic Materials	Numericals solving	Numericals solving	Fabrication of Composite Materials
	SLO-2	Types of Fibers	Hooke's law for 3D Orthotropic Materials	Numericals solving	Numericals solving	Molding Techniques
S-4	SLO-1	Matrices	Numericals solving	Strength of Materials approach	Laminate Codes	Hand Layup Process
	SLO-2	Types of Matrices		Evaluation of four Elastic Modulii	Laminate Codes	Spray layup process
S-5	SLO-1	Properties of Fibers	Hooke's law for 2D Unidirectional lamina	Numericals solving	Special cases of laminates	Compression Molding
	SLO-2	Properties of Matrices		Numericals solving	ABD Matrix representation	Resin Transfer molding
S-6	SLO-1	Classification of Composite Materials	Numericals solving	Elasticity approach to determine Material Properties	Maximum Stress failure theory	Vacuum Bag and Pressure bag Mödling
	SLO-2	Block Diagram of Classification	Numericals solving		Maximum Strain failure theory	Autoclave Processing
S-7	SLO-1	Application of Composites	Hooke's law for 2D Angle Lamina	Macro Mechanics	Tsai Hill failure theory	Filament winding process
	SLO-2	Application of Composites		Macro mechanics	Tsai wu failure theory	Pultrusion Process
S-8	SLO-1	Hooke's Law	Numericals solving	Stress strain relationship with respect to neutral axis and arbitrary axis	Basic concept of sandwich construction	Types of resins
	SLO-2	Basics of Hooke's Law	Numericals solving		Materials used in sandwich construction	Properties and Applications
S-9	SLO-1	Numericals solving	Numericals solving	Experimental characterization of Lamina	Failure modes of Sandwich panels	Netting Analysis
	SLO-2					

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@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.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. N. Bharat, SRMIST*

Course Code	18ASE205T	Course Name	THEORY OF PLATES AND SHELLS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC304J*	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 :	*Understand the mechanical behavior of Plates and shells*
CLR-3 :	*Understand the existing technologies*
CLR-4 :	*Identifying the selection of materials*
CLR-5 :	*Identify Plates Application*
CLR-6 :	*Understand the application of various Plates and shells*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Aware of the plates and shells and it properties*	2	80	70	H	H	-	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Understands application of plates and shells in different aircraft components*	2	85	75	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Identify different treatments to strengthen materials*	2	75	70	H	-	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Understand Problem solving techniques*	2	85	80	H	H	-	-	H	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Understand Various terminologies used in Plates and shells*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Understand forming Techniques*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Plates of Various shapes*	*Eigen value analysis*	*Approximate Methods*	*Introduction to shells*
	SLO-2	*Classical Plates theory*				
S-2	SLO-1	*Classical Plates theory- Assumptions*	*Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions*	*Stability of Rectangular Plates*	*Rayleigh – Ritz Method*	*Basic Concepts of Shell Type of Structures*
	SLO-2	*Theory*				
S-3	SLO-1	*Classical Plates theory-Differential equations*	*Leavy's Method of Solution for Rectangular Plates under Different Boundary Conditions-governing equations*	*Free Vibration Analysis of Rectangular Plates*	*Numericals solving*	*Membrane Theories for Circular Cylindrical Shells.*
	SLO-2					
S-4	SLO-1	*Classical Plates theory – Boundary conditions*	*Solution for Axi-symmetric loading*	*Numericals solving*	*Galerkin Methods*	*Bending Theories for Circular Cylindrical Shells.*
	SLO-2					
S-5	SLO-1	*Naviers method of solution for simply supported Rectangular plates*	*Numericals solving*	*Bending Theory of Plates*	*Finite Difference Method*	*Governing Equation for Buckling of Cylindrical Shells*
	SLO-2					
S-6	SLO-1	*Differential equation for cylindrical bending of plates*	*Annular Plates*	*Numericals solving*	*Numericals solving*	*Derivation of the Linearized Buckling Equation*
	SLO-2					
S-7	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Simply Supported Edges*	*Numericals solving*	*Bending-Membrane Theory of Plates*	*Application to Rectangular Plates for Static Analysis*	*Buckling under Axial Compression*
	SLO-2					
S-8	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Built-in Edges*	*Introduction to plates of other shapes*	*Numericals solving*	*Application to Rectangular Plates for free vibration analysis*	*Formulation for Buckling Stress and Buckling Mode*
	SLO-2					
S-9	SLO-1	*Cylindrical Bending of Uniformly Loaded Rectangular Plates with Elastically Built-in Edges*	*Theory of plates of other shapes*	*Equilibrium Equation and Boundary Conditions*	*Application to Rectangular Plates for stability analysis*	*Buckling Coefficient and Batdorf Parameter*
	SLO-2					

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
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2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. N. Bharat, SRMIST*

Course Code	18ASE206T	Course Name	THEORY OF ELASTICITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC304J*	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 :	*Understand the various assumption in solving elasticity problems, equilibrium equations*
CLR-2 :	*Familiarize with stress-strain relations, strain-displacement relations, compatibility equations*
CLR-3 :	*Understand the solutions by polynomials, stresses & displacements for simple, cantilever beams.*
CLR-4 :	*Familiarize with problems in polar coordinates for axisymmetric problems*
CLR-5 :	*Know the various theory of torsion for circular, elliptical, sections.*
CLR-6 :	*Get a better understanding of solving elasticity problems*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge to form equilibrium equations & compatibility conditions.*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-2 :	*Analyze the plane stress & plane strain problems.*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-3 :	*Apply the solutions of polynomials to solve simple two dimensional problems in Cartesian coordinate*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-4 :	*Analyze a two dimensional problems in polar coordinates.*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-5 :	*Analyze the stresses induce due to torsion for non circular cross-sections*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*
CLO-6 :	*Accrue comprehensive knowledge in theory of elasticity problems*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Theory of Elasticity*	*Introduction to equations of elasticity*	*Airy's stress function*	*Equations of equilibrium in polar coordinates*	*Introduction to torsion of non-circular members*
	SLO-2	*Definitions of stress & strain*	*Stress-strain relations*	*Biharmonic equation equations*	*Equations of equilibrium in polar coordinates*	*Saint-Venant's theory of torsion*
S-2	SLO-1	*Sign conventions, notations for stress & strain*	*Lame's constant-cubical dilatation*	*Solutions by polynomials of second degree*	*Stress-strain relations*	*General solutions of torsion problems*
	SLO-2	*Sign conventions, notations for stress & strain*	*Lame's constant-cubical dilatation*	*Solutions by polynomials of second degree.*	*Strain components in polar coordinates*	*General solutions of torsion problems*
S-3	SLO-1	*Components of stress*	*Compressibility of materials, Bulk Modulus*	*Solutions by polynomials of third degree*	*Strain-displacement relations*	*Boundary conditions*
	SLO-2	*Generalized Hooke's Law*	*Solving problems*	*Solutions by polynomials of third degree*	*Strain-displacement relations*	*Conditions at the end of a twisted bar*
S-4	SLO-1	*Components of strain*	*Compatibility equations for plane stress with constant body force*	*Solutions by polynomials of fourth degree*	*Equations of compatibility in polar coordinates.*	*Solving problems*
	SLO-2	*Solving problems*	*Compatibility equations for plane stress with general body force.*	*Solutions by polynomials of fourth degree*	*Equations of compatibility in polar coordinates.*	*Applications of shafts of elliptical cross-sections*
S-5	SLO-1	*Stress at a point*	*Compatibility equations for plane strain with constant body force.*	*Solutions by polynomials of fifth degree*	*Solving problems*	*Solving problems*
	SLO-2	*Boundary conditions*	*Compatibility equations for plane stress with general body force.*	*Solutions by polynomials of fifth degree*	*Solving problems*	*Solving problems*
S-6	SLO-1	*Strain at a point*	*Principal stresses and strain*	*Stresses due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution symmetrical about an axis*	*Applications of shafts of rectangular cross-sections*
	SLO-2	*Solving Problems*	*Solving problems*	*Stresses due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution symmetrical about an axis*	*Applications of shafts of rectangular cross-sections*

Duration (hour)		9	9	9	9	9
S-7	SLO-1	*Equations of equilibrium in 2D*	*Mohr's circle for plane stress*	*Displacements due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution in pure bending of curved bars*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Displacements due to bending of a cantilever beam in Cartesian coordinate*	*Stress distribution in pure bending of curved bars*	*Solving problems*
S-8	SLO-1	*Equations of equilibrium in 3D*	*Mohr's circle for plane strain*	*Stresses due to bending of a simply supported beam in Cartesian coordinate*	*Stress distribution in rotating disc*	*Applications of shafts of equilateral cross-sections*
	SLO-2	*Solving problems*	*Solving problems*	*Stresses due to bending of a simply supported beam in Cartesian coordinate*	*Stress distribution in rotating disc*	*Applications of shafts of equilateral cross-sections*
S-9	SLO-1	*Index notations for stress & strain*	*Saint-Venant's Principle*	*Displacements due to bending of a simply supported beam in Cartesian coordinate*	*Solving problems*	*Solving problems*
	SLO-2	*Solving problems*	*Solving problems*	*Displacements due to bending of a simply supported beam in Cartesian coordinate*	*Solving problems*	*Solving problems*

Learning Resources	1. *Timoshenko, S.P and Goodier J.N., Theory of Elasticity,McGraw-Hill Education, Third Edidtion., 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., Mthematical Theory of Elasticity, Mc-Graw-Hill Co., New York 1978.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE207T	Course Name	FUNDAMENTALS OF COMBUSTION	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC102J, 18ASC103T	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Aerospace Engineering*	Data Book / Codes/Standards	*Thermodynamic properties table of C-H-N-O system*		

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 applications of basic thermal and fluid sciences on Engineering systems.*
CLR-3 :	*Identify the significance of material identification for industrial applications, including burners and engines.*
CLR-4 :	*Create insights to the combustion in engines and gas turbines, controlled experimentation and computational combustion.*
CLR-5 :	*Analyze the principle of normal and microgravity flames for space activities and fire safety.*
CLR-6 :	*Utilize the combustion concepts for the broad understanding of system testing, validation and designing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the combustion phenomenon and its applications to Aerospace Engineering.*	*2*	*80*	*70*	*H*	*M*	*L*	*L*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*H*	*-*	*-*	*-*
CLO-2 :	*Comprehend the concept and applications of the fundamental combustion parameters.*	*2*	*80*	*70*	*H*	*M*	*M*	*M*	*-*	*-*	*L*	*-*	*-*	*L*	*-*	*H*	*M*	*M*	*M*
CLO-3 :	*Understand combustion regimes: flame and detonation, premixed and diffusion combustion problems with applications.*	*2*	*80*	*70*	*H*	*M*	*L*	*M*	*-*	*-*	*-*	*-*	*L*	*-*	*-*	*H*	*-*	*-*	*-*
CLO-4 :	*Understand the chemical kinetics, chain reactions and related processes.*	*2*	*80*	*70*	*H*	*M*	*M*	*M*	*-*	*-*	*M*	*M*	*M*	*M*	*L*	*H*	*M*	*M*	*M*
CLO-5 :	*Utilize the physical understanding of flame speed and Numerical modelling of combustion processes.*	*2*	*80*	*70*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*-*	*L*	*M*	*L*	*H*	*M*	*M*	*M*
CLO-6 :	*Understand normal and microgravity flames and apply the knowledge to Aerospace Engineering Applications.*	*2*	*80*	*70*	*H*	*M*	*M*	*M*	*M*	*L*	*L*	*M*	*L*	*M*	*L*	*H*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic Concepts: Ideal gases, mass and mole concept, fuel and oxidizer, basics of thermodynamics.*	*Combustion regimes and classification of combustible materials.*	*Introduction to Chemical kinetics, Rate laws, order and molecularity, Forward and Reverse Reactions.*	*Flame classification and structures.*	*Combustion in Normal and microgravity.*
	SLO-2	*Various modes of combustion and their characteristics*	*Flammability limits- Flame stabilization and material identification systems.*	*Energy Release Rates in a Chemical Reaction, Concentration, Law of Mass Action, Arrhenius Law.*	*Laminar flame speed, Factors affecting flame velocity--Methods of measuring flame velocity.*	*Factors affecting heat transfer and flame propagation in normal and low gravity flames.*
S-2	SLO-1	*Combustion and thermo chemistry - Review of property relations.*	*Maxwell equation and parametric analysis of enthalpies and internal energy*	*Variations of Reaction Rate, Temperature and Concentration in a Chemical Reaction with Time.*	*Stability limits of laminar flames.*	*Fire safety, Soot formation and related implications.*
	SLO-2	*Laws of thermodynamics-Reactant and product mixtures.*	*Phase transformation, Clausius Clapeyron equation and Gibbs-Helmholtz equation.*	*Rate of Reactions, Temperature dependence of rate coefficients, Pressure dependence of rate coefficients.*	*Flame propagation through combustible mixtures.*	*Interactive session with demo on practical working of premixed gas burners and candle flames.*
S-3	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-4	SLO-1	*Combustion Stoichiometry, Heat of Formation, Reaction, combustion.*	*Combustion products, Flow analysis and approaches.*	*Phase Rule for a System with Chemical Reactions. Thermodynamic Equilibrium Constant for a Gaseous Reaction.*	*Introduction to diffusion flames; appearance, structure, theoretical considerations.*	*Comparison of normal and microgravity experiments.*
	SLO-2	*Lower Calorific Value (LCV) and Higher Calorific Value (HCV), Relationships between Calorific Values, Reaction Enthalpies and Formation Enthalpies*	*Partial differential equations for combustion analysis.*	*Chain Reactions and Methods of Solving Chemical Kinetic Rate Equations.*	*Burning in convective atmospheres and Thermal spontaneous ignition.*	*Flame spread over thin fuels in actual and simulated microgravity conditions.*
S-5	SLO-1	*Thermochemical calculations: Enthalpies, Internal energy, Entropy.*	*Vectors and conservation equations for energy and momentum.*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Duration (hour)		9	9	9	9	9
	SLO-2	*Chemical reaction and Stoichiometric coefficients, Air-Fuel ratio, Equivalence ratio.*	*Application of Mass Energy and species Conservation.*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-6	SLO-1	*Calculation of Energy Release for Stoichiometric, oxidizer-rich and fuel rich Explosives.*	*Solving Problems*	*Introduction to diffusion mass transfer.*	*Image processing and combustion experimentation science.*	*Environnemental combustion considérations.*
	SLO-2	*Adiabatic flame temperature calculations: Analysis and practical considerations.*	*Solving Problems*	*Transport properties for gas mixtures.*	*Introduction to computational combustion and relevance.*	*Combustion, heat transfer and emission in industrial applications.*
S-7	SLO-1	*Chemical equilibrium, volumetric and gravimetric analysis.*	*Emission reduction and techniques in combustion instruments.*	*Mass transfer laws, Fick's law of Diffusion.*	*Numerical modeling of flame spreading phenomenon*	*Fire safety aspects of combustion sciences.*
	SLO-2	*Dissociation process and related issues.*	*Aerospace Engineering Applications of fundamental combustion physics.*	*Available and non-available energy of a source and finite body.*	*Numerical modeling of combustion processes.*	*Prospects in Aerospace propulsion and combustion.*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*
	SLO-2	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*

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.* 6. *Irvin Glassman and Richard A. Yetter., "Combustion", 4th Edition, Elsevier, 2008.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
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Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*20%*	*20%*	*20%*	*20%*	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Vinay Kumar Gupta, National Physical Laboratory, guptavinay@nplindia.org	*1. Prof. D.P. Mishra, IIT Kanpur, mishra@ iitk.ac.in. (NPTEL- Fundamentals of Combustion)*	*1. Dr. T. Selvakumaran, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Prof. Amit Kumar, IIT Madras, Chennai, amitk@ae.iitm.ac.in.*	*2. Dr. Pankaj Kumar, SRMIST*

Course Code	18ASE208T	Course Name	HEAT TRANSFER	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC102J, 18ASC103T	Co-requisite Courses	Nil	Progressive Courses	18ASE307T
Course Offering Department	Aerospace	Data Book / Codes/Standards		Heat & Mass Transfer Data Book, 9th edition by C P Kothandaraman, S Subramanyan	

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1 :	To familiarize the concept of different modes of heat transfer.
CLR-2 :	To familiarize the concept of conduction in plane wall and cylinders
CLR-3 :	To familiarize the Utilization of extended surface & Heat Generation
CLR-4 :	To familiarize the concept of convection mode and it various applications
CLR-5 :	To familiarize the concept of Radiationmode and it various applications
CLR-6 :	To solve the heat transfer practical problems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	Understand the heat diffusion equation under different coordinates	2	80	70	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-2 :	Estimate the heat transfer rate in a wall, composite walls and cylindrical objects	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-3 :	Estimate the size and numbers of extended surface or fin needed for heat transfer	2	75	70	H	H	H	-	-	-	-	-	-	-	-	M	H	M	M
CLO-4 :	Estimate the heat transfer rate in forced convection & natural convection	2	85	80	H	H	H	-	-	-	-	-	-	-	-	M	M	M	H
CLO-5 :	Estimate the heat transfer rate in Radiation mode	2	85	75	H	H	H	-	-	-	-	-	-	-	-	L	M	M	M
CLO-6 :	To solve the heat transfer practical problems	3	80	70	H	H	H	H	-	-	M	-	-	-	-	L	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to heat transfer, Different modes of heat transfer and general principles	Conduction with Thermal Energy Generation – Plane wall systems	physical mechanism on convection,	Laminar convective heat transfer analysis in flows between parallel plates	Radiation: Processes, Black body radiation- Stefan Boltzmann law, Planck'slaw& Wein's Displacement law
	SLO-2	Solving problems	Solving problems	classification of fluid flows,	Solving problems	Solving problems
S-2	SLO-1	Introduction to Conduction – Heat diffusion equation Cartesian systems	Conduction with Thermal Energy Generation – composite Plane wall	Governing equation: Continuity equation	Turbulent convective heat transfer analysis in flows between parallel plates	Radiation intensity
	SLO-2	Heat diffusion equation Cartesian systems - Derivation	Solving Problems	Governing equation: Momentum Equation	Solving problems	Solving problems
S-3	SLO-1	Heat diffusion equation forCylindrical systems	Conduction with Thermal Energy Generation –radial systems	Governing equation: Energy Equation	Laminar convective heat transfer analysis in flows over a flat plate	Radiation properties, kirchoff's law
	SLO-2	Heat diffusion equation for Cylindrical systems - Derivation	Solving problems	Governing equation: Energy Equation	Solving problems	Solving problems
S-4	SLO-1	Heat diffusion equation for Spherical systems	Conduction with Thermal Energy Generation – composite radial systems	velocity and thermal boundary layer	Turbulent convective heat transfer analysis in flows over a flat plate	. Radiation shape Factors& Its relations
	SLO-2	Heat diffusion equation for Spherical systems - Derivation	Solving problems	Rayleigh number &Grashoff number	Solving problems	Solving problems
S-5	SLO-1	One-Dimensional, Steady-State Conduction – plane wall	Heat Transfer from Extended Surfaces – Rectangular circumferential Fins of Uniform Cross-Sectional Area, Fin Performance, Overall Surface Efficiency	Empirical Correlations: External Free Convection Flows over a vertical & horizontal flat plate	Laminar convective heat transfer analysis in flows over a circular pipe	Concept of black surface -Heat Exchange between two black bodies
	SLO-2	Solving Problems	Solving problems	Solving Problems	Solving problems	Solving problems

Duration (hour)		9	9	9	9	9
S-6	SLO-1	*One-Dimensional, Steady-State Conduction – composite walls*	*Heat Transfer from Extended Surfaces – Cylindrical Fins of Uniform Cross-Sectional Area, Fin Performance, Overall Surface Efficiency*	*Empirical Correlations: External Free Convection Flows over a Inclined flat plate*	*turbulent convective heat transfer analysis in flows over a circular pipe*	*Radiation Heat Transfer in a grey surfaces - Net Radiation Heat Transfer between Any Two Surfaces*
	SLO-2	*Solving Problems*	*Solving problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-7	SLO-1	*One-Dimensional, Steady-State Conduction – Radial systems*	*Transient Conduction - The Lumped Capacitance Method,*	*Empirical Correlations: External Free Convection Flows over a vertical cylinder*	*Laminar convective heat transfer analysis in flows in a circular pipe*	*Radiation Heat Transfer in Two-Surface Enclosures*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-8	SLO-1	*One-Dimensional, Steady-State Conduction – Spherical systems*	*Transient Conduction - Large walls & long cylinders*	*Empirical Correlations: External Free Convection Flows over a horizontal cylinder*	*turbulent convective heat transfer analysis in flows in a circular pipe*	*Radiation Heat Transfer in Three-Surface Enclosures*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving problems*
S-9	SLO-1	*One-Dimensional, Steady-State Conduction – Radial & Spherical systems for Composite*	*Transient Conduction: Semi-infinite solids*	*Empirical Correlations: External Free Convection Flows over a Sphere*	*Laminar &turbulent convective heat transfer analysis in flows in a non-circular pipe*	*Radiation shields*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving problems*	*Solving 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
Level 2	Apply Analyze	*40%*	-	*40%*	-	*40%*	-	*40%*	-	*40%*	-
Level 3	Evaluate Create	*20%*	-	*30%*	-	*30%*	-	*30%*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1.Dr Raja Samikkannu, Senior Principal Scientist at National Aerospace Laboratories	*1.Dr.K.M.Parammasivam,Professor,, MIT, Chennai, Email Id:mparams@annauniv.edu*	*1. Mr. K.B.Ravichandrakumar,SRMIST*

Course Code	18ASE209T	Course Name	THEORY OF FIRE PROPAGATION AND SAFETY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC102J, 18ASC103T*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Identify the fire dynamics, the burning processes and implications.*
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 :	*Analyze the fire related hazards in practical, functional, engineering, industrial applications.*
CLR-6 :	*Utilize the fire safety principles for system testing, validation and designing.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand fire phenomenon, its applications and safety.*	2	80	70	H	M	L	L	-	-	-	-	-	-	-	H	-	-	-
CLO-2 :	*Comprehend the concept and applications of energy conservation in fires utilizations and apply the same for recent engineering advancement.*	2	80	70	H	M	M	M	-	-	L	-	-	L	-	H	M	M	M
CLO-3 :	*Understand basic knowledge to the physical principles governing fire growth.*	2	80	70	H	M	L	M	-	-	-	-	L	-	-	H	-	-	-
CLO-4 :	*Understand the behavior and chemical reactions related.*	2	80	70	H	M	M	M	-	-	M	M	M	M	L	H	M	M	M
CLO-5 :	*Apply the latest engineering capability in fire detection, prevention systems and life safety*	2	80	70	H	M	M	M	M	L	L	-	L	M	L	H	M	M	M
CLO-6 :	*Understanding prospects of normal and microgravity fire safety for Aerospace Engineering Applications.*	2	80	70	H	M	M	M	M	L	L	M	L	M	L	H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Fire Science, fires in history, fire losses, fire and combustion.*	*Importance of fire dynamics on a fire strategy.*	*Development and behavior of fire propagation in free and confined atmosphere.*	*Identifying fire spread hazards and risks.*	*Active and Passive Fire Protection Features.*
	SLO-2	*Relevant material properties, combustion and heat transfer.*	*Fundamentals of heat and mass transfer for fire, smoke production and transport.*	*Factors affecting fire growth.*	*Safety and financial implications, developing safe work systems.*	*Fire prevention-handling and storing flammable and combustible liquids/fuels/propellants.*
S-2	SLO-1	*Chemistry and classification of fires-Composition of Combustion- (Flame, heat, fire gases, smoke).*	*Fundamentals of ignition and flame propagation.*	*Buoyant Plumes, Combusting Plumes, Starting plume.*	*Introduction to Fires causes / Explosion hazards in Chemical, Electrical units.*	*Elimination of ignition sources.*
	SLO-2	*Review of Thermodynamics and Fluid Mechanics in fire behavior*	*Role of Material flammability in fire propagation.*	*Fireball, Transient Aspects of Fire Plumes.*	*Finite Real Fire Effects.*	*Fire protection in plants and factories, Fire walls, fire doors.*
S-3	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-4	SLO-1	*Heat and mass transfer. Relevance of fire classification and governing dynamics.*	*Parameters affecting ignition, flame spread.*	*Fire spread over liquid and solid fuel surfaces.*	*Fire hazards (health–flammability-reactivity (stability)).*	*Fire prevention/suppression features, Microgravity fires control.*
	SLO-2	*Material Flammability principles, Thermal Ignition.*	*Heat release rate and flame extinction phenomenon.*	*Enclosure fires, Incineration.*	*Air contaminants in fires-toxic effects of fire gases.*	*Fire suppression. Fixed automatic sprinklers. Sprinkler system and design.*
S-5	SLO-1	*Sources of ignition of combustible materials.*	*Explosions and fires –fundamental combustion principles.*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Application of Mass Energy and species Conservation.*	*Egress– principles and calculations.*	*Solving Problems*	*Solving Problems*	*Solving Problems*

Duration (hour)		9	9	9	9	9
S-6	SLO-1	*Rate of burning. Heat transfer from Flames-Ignition temperature.*	*Solving Problems*	*Forest fires Analysis of fire plumes.*	*Smoldering combustion science.*	*Environnemental fire propagation considérations.*
	SLO-2	*Flash point, Fire point, Flash over.*	*Solving Problems*	*Fire safety aspects of plumes.*	*Introduction to smoke formation, composition and movement, hazards.*	*Role of combustion detectors (Fire detection, smoke detection, types of ionization-photo electric-light intensity-scattered light detectors.*
S-7	SLO-1	*Components and objectives of a fire safety strategy.*	*Fire safety techniques in combustion instruments.*	*Standardized material flammability testing.*	*Essential conditions for explosion occurrence.*	*Heat detectors. Flame detectors -infra red detector - ultraviolet flame detector).*
	SLO-2	*Fire dynamics process and related issues.*	*Aerospace Engineering Applications of fire dynamics.*	*Solid, liquid and gaseous fuel combustion and its relation to fire safety.*	*Explosion characteristics and Prevention.*	*Portable fire Extinguishers-Types-extinguisher-location, Inspection–testing, principles and calculations.*
S-8	SLO-1	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
	SLO-2	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*	*Solving Problems*
S-9	SLO-1	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*
	SLO-2	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*	*Chapter Doubt clarification.*

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Vinay Kumar Gupta, National Physical Laboratory, guptavinay@nplindia.org	*1. Prof. Raghavan, V., IIT Madras, Chennai, raghavan@iitm.ac.in.*	*1.Dr. T. Selvakumaran, SRMIST*
	2. Prof. Amit Kumar, IIT Madras, Chennai, amitk@ae.iitm.ac.in.	*2.Mr. Vinayak Malhotra, SRMIST*

Course Code	18ASE210T	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 :	*Identify the type of welding and riveting process to be used in aircraft.*
CLR-2 :	*Perform Plastic and Composite material repair in Aircraft Structures*
CLR-3 :	*Carryout Assembly & Rigging of Aircraft Flight Controls.*
CLR-4 :	*Execution of Inspection & Maintenance of major and auxiliary systems*
CLR-5 :	*Identify the various hazardous materials and storage practices.*
CLR-6 :	*Utilize the knowledge acquired for repair and maintenance activities on aircraft structure.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge on welding and sheet metal repair operations and maintenance practices in aviation industry*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	L	L	M	M
CLO-2 :	*Gain knowledge on maintenance and repair procedures on plastics and composite structures*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Understand the Assembly & Rigging procedures and operation of Aircraft flight controls.*	2	80	70	H	-	L	L	M	-	-	-	M	-	-	L	M	M	M
CLO-4 :	*Learn the inspection and maintenance of major and auxiliary systems*	2	80	70	H	-	L	L	M	-	M	M	-	-	-	L	M	M	M
CLO-5 :	*Acquire knowledge on Hazardous materials, safety , Inventory Procedures & Troubleshooting practices*	2	80	70	H	L	L	L	M	-	-	-	-	M	-	L	H	H	M
CLO-6 :	*Acquire comprehensive knowledge onairframe maintenance and repair.*	2	80	70	H	L	L	L	M	-	M	M	M	M	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Aircraft Welding*	*Applications & Advantages of Plastics used in Aircraft.*	*Introduction to Aircraft Assembly and Rigging operations.*	*Inspection of Landing Gear System*	*Introduction to Hazardous Materials*
	SLO-2	*Nomenclature & Types.of Welding*	*Classification & Types of Plastics*	*Rigging Specifications*	*Maintenance of Landing Gear System*	*Types*
S-2	SLO-1	*Equipments used in Welding shop*	*Identification of Clear Plastics*	*Aircraft Leveling Procedure*	*Inspection of Air - conditioning System*	*Flammables - Handling, Storage & Emergency Procedure*
	SLO-2	*Need for Maintenance of Welding Equipments*	*Storage and Protection, Cutting, & Drilling of Plastics*	*Assembly of Major Structural Components*	*Maintenance of Air - conditioning System*	*Corrosives - Handling, Storage & Emergency Procedure*
S-3	SLO-1	*Maintenance of Welding Equipments*	*Forming of Plastics.*	*Assembly of Movable Control Surfaces*	*Inspection of Pressurization System*	*Toxins &Reactives - Handling, Storage & Emergency Procedure*
	SLO-2		*Cementing, Annealing & Cleaning of Plastics*	*Fixed Surface Alignment – Symmetry Check*	*Maintenance of Pressurization System*	*Physical & Biological Hazards*
S-4	SLO-1	*Characteristics of a good weld & Ensuring Quality Weld*	*Installation of Plastic Windows and Windshields*	*Demonstration of Symmetry Check in Cessna Aircraft*	*Inspection of Aircraft Instruments*	*Handling, Storage & Emergency Procedure*
	SLO-2	*Introduction to Non-fusion Welding Process - Soldering & Brazing*	*Inspection of Plastic Components*		*Maintenance of Aircraft Instruments*	*Osha's Hazardous Communication Standards*
S-5	SLO-1	*Requirements & Process*	*Repair of Cracks in Plastics.*	*Effects of Rigging on Flight*	*Testing of Instruments*	*Material Safety Data Sheet*
	SLO-2	*Advantages & Disadvantages.*	*Repair of Holes in Plastics.*	*Checking & Adjusting Dihedral angle.*	*Handling of Instruments*	*Inventory & Labeling*
S-6	SLO-1	*Classification of Damage*	*Introduction to Advanced Composites in Aircraft.*	*Checking & Adjusting Incidence angle.*	*Inspection of Fire Protection Systems*	*Introduction to Troubleshooting Theory*
	SLO-2	*Damage Investigation*	*Advantages of Composites over Metals in Aerospace Applications*	*Alignment Check of Empennage*	*Maintenance of Fire Protection Systems*	*Types*

Duration (hour)		9	9	9	9	9
S-7	SLO-1	*Repair Layout Techniques*	*Equipments used in Composite Fabrication*	*Alignment Check of Wings*	*Inspection of Ice Protection Systems*	*Troubleshooting with Chart*
	SLO-2	*Repair Practices*	*Wet Layup Process of Building Composite Parts.*	*Alignment Check of Engines.*	*Maintenance of Ice Protection Systems*	*Examples*
S-8	SLO-1	*Introduction to Riveting Process in Aviation Industry.*	*Prepreg Process of Building Composite Parts.*	*Demonstration of various checks in Cessna Aircraft*	*Inspection of Water & Waste Systems*	*Troubleshooting without chart*
	SLO-2	*Types & Nomenclature of Rivets*	*Repair of Composite Components*		*Maintenance of Water & Waste Systems*	*Examples*
S-9	SLO-1	*Equipments used for Riveting*	*Special Precautions*	*Need for Balancing Control Surfaces*	*Inspection of Position & Warning Systems*	*Troubleshooting intermittent discrepancies*
	SLO-2	*Installation of Rivets*	*NDT methods in Composite Materials.*	*Procedure for Balancing Control Surfaces*	*Maintenance of Position & Warning Systems*	*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 Aviation Administration, Flight Standards Service, 2012*	3. *Larry Reithmeir., Aircraft Repair Manual, Palamar Books, Marquette,1992.* 4. *Civil Aircarft Inspection Procedures Part I & II, CAA, English Book House, New Delhi 1986.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Wg.CdrK.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2..Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India , Bangalore ks_senthilkumar@yahoo.co	*2. Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com*	*2. Mr. G. Mahendra Perumal, SRMIST*

Course Code	18ASE211T	Course Name	AIRBORNE SENSORS AND ACTUATORS	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 :	*Understand the advanced concepts in airborne sensors and actuators*
CLR-2 :	*Provide mathematical knowledge for modelling*
CLR-3 :	*Understand the aircraft actuation systems*
CLR-4 :	*Understand the servo components*
CLR-5 :	*Learn the modeling of sensors and actuators*
CLR-6 :	*To solve problems in avionics engineering*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the concepts of airborne sensors and actuators*	*2*	*85*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	-
CLO-2 :	*To apply mathematical knowledge in modeling of sensors and actuators*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Describe the aircraft actuation systems*	*2*	*85*	*75*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	-
CLO-4 :	*Describe the servo components*	*2*	*85*	*75*	*H*	*H*	-	-	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-5 :	*Model the sensors and actuators*	*2*	*85*	*75*	*H*	-	*H*	-	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-6 :	*Solve problems in avionics engineering*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1 SLO-2	*Introduction to aircraft actuation systems*	*Servo Actuators*	*Linear and non linear actuation systems*	*Gyroscope principles*	*Testing philosophies*
S-2	SLO-1 SLO-2	*Introduction to aircraft actuation systems*	*Linear Servo Actuators and types*	*Modeling of actuation systems*	*Gyro equation*	*Testing protocols*
S-3	SLO-1 SLO-2	*Principles of aircraft actuation systems*	*Rotary Servo Actuators and types*	*Modeling of actuation systems*	*Rate gyro and integration*	*Testing process*
S-4	SLO-1 SLO-2	*Hardware elements for the actuation systems*	*Servo Valves*	*Servo loop analysis*	*Free gyro, Vertical and directional gyro*	*Solenoid voltmeter, wheatstone bridge*
S-5	SLO-1 SLO-2	*Functional block diagram of the actuation systems*	*Hydraulic servo valves and types*	*Servo loop analysis*	*Inertial navigation*	*EMF meter, electrometer*
S-6	SLO-1 SLO-2	*Types of actuation systems*	*Electro hydraulic servo valves and types*	*Actuator design*	*Basic principles theory and applications*	*Signal generators*
S-7	SLO-1 SLO-2	*Electromagnetic actuators*	*Servo amplifier pick off*	*Testing methodologies*	*Accelerometer- principle and theory*	*Performance testing of sensors*
S-8	SLO-1 SLO-2	*Electric motors*	*Selection factors of servo amplifier*	*Performance testing*	*Spring, mass, force balance*	*Data evaluation*
S-9	SLO-1 SLO-2	*Solenoid actuators*	*Power supply consideration for servo amplifier*	*Test equipment for actuation systems*	*Piezoelectric accelerometer and MEMS sensors*	*Calculation of performance parameters*

Learning Resources	1. *James Ephraim Johnson, Electro hydraulic servo systems, hydraulics 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 Moris, 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 linera control techniques for electro hydraulic actuators, 2017*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, National Aerospace Laboratories, Bangalore, raja@nal.res.in	*1. Dr.Parammasivam, professor, MIT, Chennai, mparams@mitindia.edu*	*1. Mr. Umar Rizwan M, SRMIST*

Course Code	18ASE301T	Course Name	AIRCRAFT CONTROL SYSTEMS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC305T*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes/Standards			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLR-1 :	*Understand the basics of control system*																		
CLR-2 :	*Understand the root locus analysis*																		
CLR-3 :	*Understand the frequency response analysis*																		
CLR-4 :	*Understand the time and frequency domain design of control system*																		
CLR-5 :	*Understand the control system design in state space*																		
CLO-6 :	*Understand control systems, various response analysis and control system in state space*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Design a mathematical model of a dynamic system*	*2*	*85*	*75*	*H*	-	-	-	-	-	-	-	-	-	-	-	-	*M*	*M*
CLO-2 :	*Analyze the system using Root Locus plot*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	-	-
CLO-3 :	*Analyze the system using Frequency response analysis*	*2*	*85*	*75*	*H*	-	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*
CLO-4 :	*Design a control system in time and frequency domain*	*2*	*85*	*75*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	-	*M*	*M*	-
CLO-5 :	*Design and analyze the control system in state space*	*2*	*85*	*75*	*H*	-	-	*H*	-	-	-	-	-	-	-	-	*M*	-	*M*
CLO-6 :	*Design and analyze control systems, various response analysis and control system in state space*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Control Systems*	*Introduction to Root Locus Analysis*	*Bode Diagrams*	*Introduction to time domain and frequency domain design of control system*	*Lyapunov Stability*
	SLO-2	*Open-Loop, Closed-Loop Control, Feedback control system*		*Rules for Constructing the Bode Plots*		
S-2	SLO-1	*Block Diagrams and their Simplification*	*General Rules for Constructing the Root Locus*	*Nyquist Plots*	*PD Controller Design*	*Asymptotic Stability*
	SLO-2			*Rules for Constructing the Nyquist Plots*	*PIController Design*	*Input-Output Stability*
S-3	SLO-1	*Mason's Gain Formula*	*Positive feedback Systems*	*Stability and Relative Stability Analysis*	*PID Controller Design*	*State Transition Matrix*
	SLO-2	*Numerical*				*Controllability and Observability*
S-4	SLO-1	*Mathematical Modeling ofDynamical Systems*	*Root Locus plot for positive feedback system*	*Systems with Transport Lags*	*Lead Compensation*	*The Lyapunov Equation*
	SLO-2				*Lag Compensation*	
S-5	SLO-1	*Modeling in the State Space*	*Negative feedback Systems*	*Gain Margin*	*Lead-Lag Compensation*	*Full-State Feedback Control Designand Pole Placement*
	SLO-2			*Phase Margin*		
S-6	SLO-1	*Transfer Functions*	*Root Locus plot for Negative feedback system*	*Closed-Loop Frequency Response*	*Sensitivity*	*Optimal State Space Control System*
	SLO-2	*ImpulseResponse Functions*				
S-7	SLO-1	*Delay Time, Rise Time, Peak Time, Maximum Overshoot,and Settling Time*	*Parameter Variation*	*Frequency Domain Performance Specifications*	*Complimentary Sensitivity Transfer Functions*	*Linear Quadratic Regulator*
	SLO-2	*Stability Analysis and Routh's Stability Criterion*				
S-8	SLO-1	*Proportional, Derivative, and Integral Control Actions*	*Stability analysis of positive feedback system using root locus*	*Peak Resonance*	*Disturbance Rejection*	*Classical Control Theory*
	SLO-2			*Resonant Frequency*		
S-9	SLO-1	*Steady-State Error Analysis in Feedback Systems*	*Stability analysis of Negative feedback system using root locus*	*Bandwidth*	*Loop Shaping*	*Modern Control Theory*
	SLO-2			*Numerical example*		

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 Control of Dynamic Systems, AddisonWesley, 1994.*	4. *Dorf, R.C., and Bishop, R.H., Modern Control Systems, Prentice Hall, 2001.* 5. *Nise, N.S., Control Systems Engineering, Benjamin-Cummings, 1995.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1. Dr.K.M.Parammasivam, Professor, MIT-Chennai. mparams@mitindia.edu*	*1. Mr.A.Vinoth Kumar, SRMIST.*

Course Code	18ASE302T	Course Name	HELICOPTER AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC202J	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 :	Understand the helicopter configurations, characteristics and its rotor systems
CLR-2 :	Learn the momentum theory used in the analysis of helicopter aerodynamics
CLR-3 :	Comprehend the performance of helicopter in hovering and climbing.
CLR-4 :	Understand the flow states of the rotor and helicopter vertical descent performance
CLR-5 :	Study the performance of helicopter in horizontal flight.
CLR-6 :	Acquaint with forward flight performance of helicopter and theory of blade stall.

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1	2	3	Program Learning Outcomes (PLO) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Acquire knowledge of helicopter fundamentals, configurations and rotor systems.	2	85	80	H	M	L	L	-	-	-	-	-	-	-	L	M	M	H
CLO-2 :	Apply momentum theory in the analysis of helicopter parameters.	2	90	75	H	H	M	M	L	-	-	-	-	-	-	L	H	M	M
CLO-3 :	Acquire theoretical foundation on the hovering and climbing performance of helicopter.	2	85	75	H	M	M	L	-	-	-	-	-	-	-	L	M	H	M
CLO-4 :	Analyze the vertical descent performance of helicopter.	2	80	70	H	M	L	L	-	-	-	-	-	-	-	L	M	M	M
CLO-5 :	Acquire basic understanding of helicopter performance in horizontal flight.	2	85	75	H	M	L	L	-	-	-	-	-	-	-	L	H	H	M
CLO-6 :	Accrue information on the helicopter performance in forward flight and theory of blade stall.	2	80	70	H	M	M	M	L	-	-	-	-	-	-	L	M	M	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Introduction to Helicopters – History	Momentum Theory - Introduction	Performance in Hovering and Climbing	Flow States of the Rotor – Introduction	Forward Flight – Performance Equation
	SLO-2	Helicopter Configurations – Single Rotor, Two Rotor and Multi Rotor Machines				
S-2	SLO-1	Specifics of Helicopters	Thrust Generation	Optimum Hovering Rotor	Normal Working, Vortex-Ring and Windmill States	Drag-Lift Ration – Forward Flight
	SLO-2	Articulated Rotor System				Parasite Drag Coefficient – Forward Flight
S-3	SLO-1	Definitions – Tip Path, Tip Path Plane, Axis of Rotation, Shaft Axis, Disc Area, Chord, Blade Angle, Angle of Attack	Hovering	Induced Torque	Vertical Descent Performance	Climb Drag-Lift Ratio – Forward Flight
	SLO-2					
S-4	SLO-1	Definitions – Feathering Angle, Feathering, Disc Loading, Blade Loading, Solidity, Flapping, Lead-Lagging	Figure of Merit	Profile Drag Torque	Curves for Calculating Vertical-Descent Velocities, Flight Modes of a Rotor, Autorotation Diagrams	Profile Drag-Lift Ratio – Forward Flight
	SLO-2					
S-5	SLO-1	Effect of Cyclic Pitch Change	Blade Element Theory	Numerical Problems on Optimum Hovering Rotor, Induced Torque, Profile Drag Torque	Performance in Horizontal Flight – Introduction	Induced Drag – Forward Flight
	SLO-2	Swash Plate				
S-6	SLO-1	Rotor Systems – Fully Articulated, Semi-Rigid Rotor, Rigid Rotor	General Expression for Induced Velocity	Performance Equation	Flapping and Lag Hinge – Horizontal Flight	Profile Power and Parasite Power in Forward Flight
	SLO-2				Steady Hover – Horizontal Flight	
S-7	SLO-1	The Atmosphere	Local Solidity	Optimum Rotor Design	Ideally Twisted Blade – Horizontal Flight	Introduction to Blade Stall
	SLO-2	International Standard Atmosphere (ISA)				
S-8	SLO-1		Tip Loss	Ground Effect	No Twist Case – Horizontal Flight	

Duration (hour)		9	9	9	9	9
	SLO-2	*Atmospheric Density and Power Required – Definitions of Rotor Profile Power, Induced Power, Parasite Power*	*Equivalent Chord*			*Introduction to Quadcopter / Multirotaor Aerodynamics*
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2					

Learning Resources	1. *Rathakrishnan E., Helicopter Aerodynamics, PHI Learning Private Limited, Delhi, 2019.* 2. *Nikolsky Alexander A., Helicopter Analysis, John Wiley & Sons Inc., New York, 1951* 3. *Alfred Gessow, Garry C. Myers Jr., Aerodynamics of the Helicopter, College Park Press, USA, 1999.* 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. *John Seddon, Simon Newman, Basic Helicopter Aerodynamics, 3rd Edition, John Wiley & Sons, Ltd., 2011.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
1.Dr. Manishankar C., Senior Scientist, NAL, Bangalore	*1. Prof. Arun Kumar P., Assistant Professor, IIT Jammu*	*1. Dr. S. M. Aravindh Kumar, SRMIST*

Course Code	18ASE303T	Course Name	ROCKET AERODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC301J*	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 :	*Understand the concept of boundary layer and its characteristics.*
CLR-2 :	*Learn basics of incompressible and compressible flat plate boundary layer, importance of shock-wave boundary layer interactions.*
CLR-3 :	*Understand and appreciate the qualitative aspects of hypersonic flow, hypersonic shock-wave and Expansion-wave relations, application of Newtonian theory in hypersonic flow*
CLR-4 :	*Study different classifications and external aerodynamic configurations of missiles.*
CLR-5 :	*Apply cross-flow analysis in the analysis of aerodynamics characteristics of missiles, vortex shedding and flow separation.*
CLR-6 :	*Understand the various aerodynamic launching problems of missiles.*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Acquire knowledge of boundary layer theory.*	*2*	*85*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	*L*	*H*	*M*	*M*
CLO-2 :	*Acquire the fundamental differences between incompressible and compressible boundary layers, importance of boundary layer interaction with shock layer.*	2	*80*	*70*	H	M	L	M	-	-	-	-	-	-	-	L	M	H	M
CLO-3 :	*Appreciate the various qualitative aspects of hypersonic flow.*	*2*	*85*	*75*	*H*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	*L*	*H*	*M*	*M*
CLO-4 :	*Accrue knowledge of different aerodynamic configurations of missiles, missile classification.*	*2*	*80*	*70*	*H*	*M*	*L*	*M*	-	-	-	-	-	-	-	*L*	*M*	*M*	*H*
CLO-5 :	*Acquire basic understanding of cross-flow analysis in study of missile aerodynamics*	*2*	*85*	*75*	*H*	*L*	*L*	*L*	-	-	-	-	-	-	-	*L*	*M*	*M*	*M*
CLO-6 :	*Accrue information on aerodynamic launching problems of missiles.*	*2*	*80*	*75*	*H*	*M*	*L*	*L*	-	-	-	-	-	-	-	*L*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Concept of Boundary Layer*	*Qualitative Aspects of Hypersonic Flow – Thin shock layer, Viscous Interaction, High Temperature Shock Layer.*	*Classification of Missiles*	*Aerodynamic Characteristics of Slender and Blunt Bodies*	*Aerodynamic Launching Problems*
	SLO-2	*Boundary Layer Definitions and Characteristics*				*Considerations for Safety of Parent Aircraft*
S-2	SLO-1	*Boundary Layer - Boundary Conditions, Laminar and Turbulent Boundary Layers*	*Qualitative Aspects of Hypersonic Flow – Entropy Layer, Low-Density Flow, High Temperature Effects, etc.*	*External Aerodynamic Configurations of Missiles - Wing Control, Canard Control Tail Control, Tail-Less (or Wing Control), Body Extension*	*Missiles at Small Angles of Attack*	*Considerations for Safety of Parent Aircraft (Air Launch) – Introduction to Missile-Aircraft Collision, Missile Structural Failure*
	SLO-2	*Boundary Layer Thickness - Types*			*Cross-Flow Analysis*	
S-3	SLO-1	*Displacement Thickness of Boundary Layer – Concept, Derivation*	*Aerodynamic heating of re-entry bodies – slender and blunt re-entry vehicles.*	*External Aerodynamic Configurations of Missiles - Nose Flap Control, Dorsal, Jet Control, Wing Arrangements (Monowing, Triform, Cruciform)*	*Total Lift on a Missile Body – Cross-Flow Analysis*	*Launch Boundaries – Introduction to Launch-Aircraft Trajectory, Missile Trajectory, Launch Boundary Determination*
	SLO-2		*Hypersonic Flight Paths – Velocity-Altitude Map*			
S-4	SLO-1	*Momentum Thickness of Boundary Layer – Concept, Derivation*	*Newtonian Theory*	*Forces Acting on Missile during Atmospheric Flight, Effect of Angle of Attack on Aerodynamics Forces and Moments*	*Total Lift on a Slender Wing – Cross Flow Analysis*	*Ground Launch – Problem of Launching Missiles from the Ground*
	SLO-2		*Newton's Sine-Squared Law – Derivation,*			*Sources of Detrimental Effects causing Excessive Missile Dispersion*
S-5	SLO-1	*Incompressible Boundary Layer - Incompressible flow over a flat plate, Governing Equations, Numerical Results.*	*Modified Newtonian Law Mach Number Independence*	*Introduction to Bodies of Revolution – Nose, Mid-Section, Boat-tail*	*Total Lift on a Wing-Body Combination – Cross-Flow Analysis*	*Factors Affecting Missile Launch Dispersion – Launcher Deflection, Tip-Off,*
	SLO-2					
S-6	SLO-1					

Duration (hour)		9	9	9	9	9
	SLO-2	*Compressible Boundary Layer - Compressible flow over a flat plate, Governing equations*	*Numerical Problems on Newtonian Theory and Exact Shock-Expansion Theory*	*Different Shapes of Missile Fore Bodies – Advantages and Disadvantages*	*Introduction to wing-body interference of missile*	*Factors Affecting Missile Launch Dispersion - Thrust and Fin Malalignment, Wind*
S-7	SLO-1	*Boundary Layer Separation – Introduction*	*Hypersonic Similarity Parameter*	*Boat Tail – Introduction and its Importance*	*Flow Separation on a Missile Body at Low and High Angles of Attack*	*Rocket separation – Importance of Rocket Separation, Separation Mechanisms*
	SLO-2			*Base Pressure*		
S-8	SLO-1	*Shock Wave Boundary Layer Interaction*	*Shock wave and Expansion Wave Relations of Inviscid Hypersonic Flows*	*Introduction to Missile Drag – Friction drag, Pressure drag, Induced drag, Interference drag*	*Vortex Shedding – Cross-Flow Regimes of Missile at Different Angles of Attack*	*Impulse Devices for Separation – Stage Ignition, Auxiliary Rockets, Thrust Reversal, Springs*
	SLO-2					
S-9	SLO-1	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*	*Tutorial*
	SLO-2					

Learning Resources	1. *John D. Anderson Jr., Fundamentals of Aerodynamics, 5th Edition, McGraw-Hill Companies, Inc., 2010.* 2. *John D. Anderson., Modern Compressible Flows, 3rd Edition, McGraw-Hill Companies, Inc., 2003.* 3. *Rathakrishnan E., High Enthalpy Gas Dynamics, John Wiley & Sons Singapore Pte. Ltd., 2015.*	4. *John D. Anderson Jr., Hypersonic and High-Temperature Gas Dynamics, 3rd Edition, AIAA Education Series, AIAA, 2003.* 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
1 Dr. Manishankar C., Senior Scientist, NAL, Bangalore	*1. Prof. Arun Kumar P., Assistant Professor, IIT Jammu*	*1. Dr. S. M. Aravindh Kumar, SRMIST*

Course Code	18ASE304T	Course Name	SPACE MISSION DESIGN & ANALYSIS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC306T, 18ASC303J*	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 :	*Understand the space mission profiles and types of space missions*
CLR-2 :	*Understand the mission objectives, constraints, needs, and requirements*
CLR-3 :	*Know the complete set of space systems and various modules of space system and spacecraft*
CLR-4 :	*Know the basics of spacecraft motions and the governing equations of spacecraft motions*
CLR-5 :	*Comprehend the satellite attitude dynamics and reentry vehicle dynamics*
CLR-6 :	*Interpret the interplanetary mission trajectories and associated concepts*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the space mission and the classifications of space mission*	2	85	80	H	-	M	M	-	-	-	-	-	-	-	-	-	L	-
CLO-2 :	*Describe the various aspects space environments, mission objective, needs and design of the space mission*	2	85	80	H	-	-	-	-	-	L	-	-	-	-	-	-	-	-
CLO-3 :	*Explain the importance of the spacecraft systems and instrumentation*	2	80	75	H	L	L	H	-	-	-	-	-	-	-	-	-	M	-
CLO-4 :	*Explain the necessity of Kepler's equations and orbit maneuvers*	2	80	75	H	H	M	M	-	-	-	-	-	-	-	-	-	-	-
CLO-5 :	*Describe the key features reentry flight physics and injection of spacecrafts*	2	80	75	H	M	M	H	-	-	L	-	-	-	-	-	-	L	-
CLO-6 :	*Demonstrate the interplanetary mission profile and the importance*	2	80	75	H	L	M	H	-	-	L	-	-	-	-	-	-	L	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Definition of space mission*	*Requirements, constraints of spacecraft design*	*The N-body problem*	*Basis of launching of a satellite*	*General aspects of interplanetary trajectory*
	SLO-2	*Classification of space missions*	*Design process of spacecraft*	*The N-body problem*	*General aspects of satellite injection*	*Interplanetary Hohmann transfer*
S-2	SLO-1	*Low Earth Orbit mission, medium altitude mission*	*Spacecraft configuration*	*The orbit equation*	*Launch vehicle ascent trajectory*	*Rendezvous opportunities*
	SLO-2	*Geosynchronous Earth Orbit mission, deep space mission*	*Integrating the spacecraft design*	*The energy law.*	*Dependence of orbital parameters on in-plane injection parameters*	*Sphere of influence*
S-3	SLO-1	*Space mission life cycle*	*Spacecraft payload design*	*Revision of circular orbits and elliptical orbits*	*Launch vehicle performance*	*Method of patched conics*
	SLO-2	*Mission objectives*	*Payload sizing process*	*Parabolic trajectories*	*Orbit deviation due to injection errors*	*Planetary departure*
S-4	SLO-1	*Identification of mission needs, requirements, and constraints*	*Mission requirements*	*Hyperbolic trajectories*	*Small injection errors*	*Planetary rendezvous*
	SLO-2	*Mission characterization*	*Observation of payload design*	*Keplers equation*	*Basics of reentry flight dynamics*	*Planetary flyby*
S-5	SLO-1	*Mission evaluation*	*Observation of payload sizing*	*Lamberts problem*	*Fundamentals of entry flight mechanics*	*Design of transfer ellipse*
	SLO-2	*Orbit design*	*Spacecraft subsystems*	*Restricted three body problem*	*Fundamentals of entry heating*	*Design of transfer ellipse*
S-6	SLO-1	*Constellation design*	*Propulsion subsystem selection and sizing*	*The Lagrange coefficients*	*Entry vehicle design*	*Design of departure trajectory*
	SLO-2	*Space environment peculiarities*	*Basic of rocket propulsion and its types*	*The Lagrange coefficients*	*Landing techniques*	*Design of arrival trajectory*
S-7	SLO-1	*Space environment survivability*	*Attitude determination and control*	*Jacobi constants*	*Recovery techniques*	*Gravity assist maneuver*
	SLO-2	*Selection of spacecraft material*	*Telemetry, tracking and command system*	*Introduction to orbit perturbation*	*Reentry errors*	*Establishing planetary orbit*
S-8	SLO-1	*Basic launch vehicle considerations*	*Command and data handling*	*Earth gravity harmonics*	*Overview of existing reentry mission*	*Motion of the Earth-Moon system*
	SLO-2	*Launch systems selection process*	*Power and thermal system*	*Lunisolar gravitational attractions*	*Challenges of existing reentry mission*	*Time of flight*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*Determining the spacecraft design envelop and environments*	*Guidance and navigation system*	*Radiation pressure effects, atmospheric drag*	*Parametric design of a reentry capsule*	*Time of injection velocity*
	SLO-2	*Payload environments*	*Ground system design*	*Tidal friction effects and Mutual gravitational attraction*	*Planetary entry vehicle optimization*	*Lunar patched conic*

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 (1979).*	4. *Tewari, Ashish. Atmospheric and space flight dynamics. Birkhũser Boston, 2007.* 5. *Griffin, Michael Douglas. Space vehicle design. AIAA, 2004.* 6. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Amit Palankar, GE aviation, Bangalore, palankr.amit@gmail.com*	1. *Dr. S. Elangovan, Professor and Dean, Dept. Of Aeronautical Engineering, Bharath Institute of Higher Education and Research, subelango@yahoo.co.in*	1. *Dr. Malaikannan G, SRMIST*

Course Code	18ASE305T	Course Name	VIBRATIONS AND ELEMENTS OF AEROELASTICITY	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC101T*	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:*	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Understand the concept of drawing a vibratory model*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-2 :	*Understand the methods of deriving the equations of motion*																		
CLR-3 :	*Identify the problems of vibration in aerospace industry*																		
CLR-4 :	*Know the functioning of various vibration measuring instruments*																		
CLR-5 :	*Learn the various approximate methods of solving natural frequency of various systems*																		
CLR-6 :	*Get an idea of the various aero elastic phenomena that arise in real time flight conditions.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Describe the elements of a vibratory model*	*2*	*85*	*75*	*H*	*-*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-2 :	*Describe the equations of motion of any vibratory system*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-3 :	*Explain the solving methods of approach to any vibration problem*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-4 :	*Explain the functionality of various vibration measuring instruments*	*2*	*85*	*75*	*H*	*H*	*-*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-5 :	*Describe the various approximate methods in determining the natural frequency of various vibratory systems.*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*
CLO-6 :	*Investigate the different aero elastic phenomena for different flight conditions*	*2*	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction-Basic Terminology*	*Single degree of freedom system*	*Multi degree of freedom system*	*A three degree of freedom rotor system*	*Introduction to Aeroelasticity*
	SLO-2	*Elements of vibratory system*	*Examples-spring mass system*	*Free body diagram and equations of motion*	*Numerical solving*	*Collar's triangle*
S-2	SLO-1	*Degrees of freedom*	*Solution of equation of motion-Complementary function*	*Natural modes of vibration*	*Vehicle suspension problem*	*Torsional divergence 2D case*
	SLO-2	*Examples of vibratory system*	*Forced damped vibratory system*	*Mode shapes*	*Automobile problem*	*Numerical solving*
S-3	SLO-1	*Simple Harmonic motion-Definition and explanation*	*Numerical solving –solution of equation of motion*	*Principal Coordinates*	*Discrete systems*	*Torsional divergence-finite wing*
	SLO-2	*Sum of harmonic motions-different conditions*	*Numerical solving –solution of equation of motion*	*Principal modes*	*Examples*	*Numerical solving*
S-4	SLO-1	*Numerical solving*	*Solution of equation of motion-Particular Integral*	*Orthogonal condition*	*Rayleigh method of finding the natural frequency*	*Aileron control reversal*
	SLO-2	*Numerical solving*	*Solution of equation of motion-Particular Integral*	*Eigen value problem*	*Numerical Solving*	*Numerical solving*
S-5	SLO-1	*Newton's law*	*Transient motion of damped forced vibration problem*	*Hamilton's principle*	*Semi-definite system*	*Flutter*
	SLO-2	*D'Alembert's principle*	*Numerical solving*	*Vibration of elastic bodies*	*Numerical solving*	*Numerical solving*
S-6	SLO-1	*Equation of motion-Newton's law of motion*	*Logarithmic decrement*	*Lateral Vibration of a string*	*Method of influence coefficient matrix*	*Bufeting*
	SLO-2	*Example*	*Numerical solving*	*Numerical solving*	*Numerical solving*	*Numerical solving*
S-7	SLO-1	*Equation of motion- Energy method*	*Elevator and control tab numerical*	*Longitudinal vibration of rod*	*Dunkerley method*	*Dynamic response*
	SLO-2	*Example*	*Helicopter rotor blade numerical*	*Numerical solving*	*Numerical –cantilever beam*	*Numerical solving*
S-8	SLO-1	*Free Vibrations-Forced Vibrations*	*Springs connected in series*	*Lateral vibration of beam*	*Lagrange's equation*	*Control Effectiveness*
	SLO-2	*Damped vibrations-Undamped vibrations*	*Springs connected in parallel*	*Numerical solving*	*Numerical solving*	*Numerical solving*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*Periodic vibrations-Aperiodic vibrations*	*Support Excitation*	*Torsional vibration of shaft*	*Holzer method*	*Case studies*
	SLO-2	Numerical Solving	Vibration measuring instruments	Numerical solving	Numerical solving	

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, 1995.* 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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@nal.res.in	*1. Dr. V.Arumugam, Madras Institute of Technology, Chennai, arumugam.mitaero@gmail.com*	*1. Dr. L.R. Ganapathi Subramanian, SRMIST*
2. Dr.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar,SRMIST*

Course Code	18ASE306T	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 :	*Understand the avionics systems and its design*
CLR-2 :	*Understand the avionics system Integration*
CLR-3 :	*Know the architecture & communication Protocols used in Avionics communication*
CLR-4 :	*Know the display techniques used in Glass cockpit*
CLR-5 :	*Know the Electromagnetic interference sources in the aircraft and cooling techniques*
CLR-6 :	*Understand the maintenance aspect of avionics systems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Describe the avionics systems and integration*	2	85	75	H	-	-	-	-	-	-	-	-	-	-	-	H	H	H
CLO-2 :	*Describe about Avionics certification and design*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	-	H	H	H
CLO-3 :	*Explain the architecture and communication protocols of the avionics systems*	2	85	75	H	-	H	H	-	-	-	-	-	-	-	-	M	H	H
CLO-4 :	*Differentiate the difference in display techniques used in Glass cockpit*	2	85	75	H	H	-	-	-	-	-	-	-	-	-	-	M	H	H
CLO-5 :	*Identify the electromagnetic sources and interference prevention techniques*	2	85	75	H	-	H	-	-	-	-	-	-	-	-	-	H	H	M
CLO-6 :	*Explain the maintenance procedures for avionics wiring, testing and maintenance*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	H	H	H

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Avionics*	*Network Topologies & types of data bus used in Avionics network*	*Introduction to Head Up Display*	*Electromagnetic interference (EMI) and its effect*	*Aluminum wires/cables*
	SLO-2	*Need for Avionics*	*Types Bit encoding & Types of communication Protocol*	*Principle & Optical configuration*	*EMI on current carrying conductor*	*Bonding*
S-2	SLO-1	*Role of Avionics in civil aircrafts*	*Introduction to ARINC 429*	*Functional description of HUD*	*Need for EMI prevention*	*Types of bonding in composite materials*
	SLO-2	*Role of Avionics in Military aircrafts*	*Hardware elements,Word format, Bit encoding and protocols*	*Introduction to Helmet mounted display*	*Shielding, Twisted pairs and bandwidth*	*Lightning protection in composite aircrafts*
S-3	SLO-1	*Top-Down design Procedure for Avionics system Design*	*Introduction to MIL-STD 1553B*	*Optical configurations*	*Radiated EMI*	*Earth Returns*
	SLO-2	*Avionics Design factors*	*Hardware element, Bit encoding*	*Helmet Design factors and Functional description of HMD*	*EMI susceptibility*	*Aircraft manuals*
S-4	SLO-1	*Ilities of Avionics Systems*	*Word format and protocols*	*Introduction to MFD*	*EMI reduction*	*Maintenance manuals*
	SLO-2	*Avionics certification*	*RT-BC, BC-RT & RT-RT protocols*	*Working of MFD*	*Continuing airworthiness*	*Wiring diagram manuals*
S-5	SLO-1	*FTA- Fault tree analysis*	*Introduction to AFDX network*	*Direct voice input techniques and HOTAS*	*Wire and cable installation*	*Circuit Testing*
	SLO-2	*Qualitative and quantitative methods*	*Hardware elements, Protocols*	*FLIR- IR vision*	*Cable definition*	*Avometer and its types*
S-6	SLO-1	*FMEA- Failure mode and effect analysis*	*Ethernet frame format, AFDX frame format*	*Evaluating Avionics cooling requirements*	*Failure modes of wires and cables*	*Bonding meter*
	SLO-2	*Steps in FMEA*	*Difference between CPIOM & GPM*	*Heat transmission in Avionics Rack*	*Wiring procedure*	*oscilloscopes*
S-7	SLO-1	*Pros & cons of FTA & FMEA*	*Trends in Display technologies*	*Avionics cooling specifications*	*Cables and wire looms*	*Automatic Test equipments*
	SLO-2	*Difference between FTA & FMEA*	*CRT construction & working*	*Avionics cooling for Airplanes*	*Current rating of wire looms*	*Built In Test equipment*
S-8	SLO-1	*Avionics Architectures evolution*	*LCD& LED construction and working*	*Avionics cooling for missiles*	*Guidelines for the installation of wire looms*	*Difference between ATE & BITE*
	SLO-2	*A320 & B777 architecture examples*	*Plasma panels And EL panels construction and working*	*Avionics cooling for satellites& Spacecrafts*	*Types of wire looms*	*Centralized Maintenance systems*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*A380 & B787 architecture examples*	*Comparison of CRT, LCD, LED, Plasma and EL panels*	*Radiation heat transfer in space*	*Hydrolysis in wires and cables*	*Aircraft communication and addressing systems*
	SLO-2	*Attributes of Data bus & transmission classes*	*Capacitive and resistive touch screen technologies*	*Effect of α/e ratio on temperature in space*	*Wire connectors*	*Cost of maintenance*

Learning Resources	1. *Carry R spitzer, "The Avionics Handbook", CRC Press,2000* 2. *Spitzer CR, "Digital Avionics systems",* 3. *Lan Moir, "Civil Avionics Systems", Second edition wiley publications, 1996*	4. *RPG Collinson, " Introduction to Avionics", Chapman and Hall, 1996* 5. *Dave S Steinberg, "Cooling Techniques for electronic equipments", Second edition,1991* 6. *Jim curren, "Trends in Advanced Avionics", IOWA state university, 1992*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, National Aerospace Laboratories, Bangalore, raja@nal.res.in	*1.Dr.Parammasivam, Professor, MIT, Chennaim,params@mitindia.edu*	*1. Mr. Umar Rizwan M, SRMIST* *2. Dr. P. Eswaran, SRMIST*

Course Code	18ASE307T	Course Name	COMPUTATIONAL HEAT TRANSFER AND FLUID DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18MAB202T, 18ASE208T	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 :	Introduce the students with various techniques of problem solving
CLR-2 :	Make the students to understand the governing equations for flow and heat transfer analysis
CLR-3 :	Provide sufficient background to the students to gain the ability to discretize fluid flow problems
CLR-4 :	Make the students to simulate and analyze fluid flow problems
CLR-5 :	Make the students to choose proper numerical schemes fluid flows
CLR-6 :	Enable the students to write computer programs for elementary fluid flow/heat transfer problems

Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	Understand the governing equations for flow and heat transfer analysis	2	80	70	H	H	H	H	M	-	-	-	-	-	-	L	L	H	L
CLO-2 :	Apply discretization techniques to solve the differential equations of fluid flow and heat transfer problems	2	80	70	H	H	H	H	H	-	-	-	-	-	-	-	M	H	-
CLO-3 :	Acquire the experience to judge the accuracy of numerical solutions and the numerical uncertainty.	2	80	70	H	H	H	H	M	-	-	-	-	-	-	L	M	H	-
CLO-4 :	Analyze convection-conduction problems through numerical algorithms	2	80	70	H	H	H	H	H	-	M	M	L	L	-	L	M	H	-
CLO-5 :	Gain fundamental knowledge about numerical code development	2	80	70	H	M	M	H	M	-	-	-	H	-	-	L	-	H	-

Duration (hour)		9	9	9	9	9
S-1	SLO-1	The Three Fundamental Approaches to problem solving - Analytical, Experimental & Numerical	Basics of Finite Difference Method	Discretization of 1 – D unsteady diffusion Equation	Discretization of 1 – D convection diffusion Equation	Collocated Grid
	SLO-2	Introduction to CFD	Finite Difference Approximation of derivatives			Staggered Grid
S-2	SLO-1	Processes involved in CFD	Truncation error	Interface conductivity	Central differencing scheme	Checker-board pressure oscillations
	SLO-2	Applications of CFD	Order of magnitude of error	Nonlinearity	Numerical oscillations of Central differencing scheme	Basics of Pressure-velocity coupling algorithm
S-3	SLO-1	Conservation Principles	Basics of Finite volume Method	Explicit Approaches	Properties of Discretization scheme	Discretization of 2D continuity equation
	SLO-2	Lagrangian vs Eulerian Approach	Integration Over a Control Volume	Implicit Approaches	Scarborough Criterion	Discretization of two-dimensional u-momentum equation
S-4	SLO-1	Derivation of continuity equation	Discretization of Computational Domain	Illustrative example	Transportiveness	Discretization of two-dimensional v-momentum equation
	SLO-2		Discretization of 1 – D diffusion equation		Conservativeness	
S-5	SLO-1	Derivation of momentum equations	Example of numerical solution – 1-D steady Heat conduction problem in a rod	Tri – diagonal Matrix Algorithm	Assessment of central differencing scheme	Pressure correction equation formulation
	SLO-2					
S-6	SLO-1	Newton's hypothesis for fluid flow	Example of numerical solution – cooling of a circular fin by convective heat transfer	Analysis of Numerical oscillations	Upwind Differencing Scheme	SIMPLE Algorithm
	SLO-2	Navier-Stokes equations			First order upwind scheme	Applications of SIMPLE
S-7	SLO-1	Conservation law for Energy equation		Stability condition for Explicit Approach	Assessment of Upwind Differencing Scheme	Overview of other pressure-velocity coupling algorithms
	SLO-2	Work done by surface forces & Energy flux due to heat conduction	Comparison with analytical solution	Stability condition for Implicit Approach		
S-8	SLO-1	Derivation of Energy equation	Coding using MATLAB	Overrelaxation and underrelaxation	Overview of other upwind schemes	Types of practical boundary conditions
	SLO-2			Grid layout-2D domain		
S-9	SLO-1	Equilibrium and marching problems	Discretization of 2 – D diffusion equation	Discretization of 2 – D unsteady diffusion Equation	Numerical Diffusion	Grid independency Test
	SLO-2	Initial and boundary conditions	General forms of discretized equations			Best practices for CFD solution

Learning Resources	1. *Anil Date, Introduction to CFD Cambridge University Press First Edition (2005)* 2. *Versteeg. H.K and Malalasekera. W, "An Introduction to Computational Fluid Dynamics, the Finite Volume Method" Addison Wesley Longmen Limited, Second Edition (2007)*	3. *Patankar. S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing corporation, First Edition (1980.)* 4. *John.D.Anderson jr., "Computational Fluid Dynamics – The basics with applications" McGraw Hill First Edition (1995)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. N. R. Hero Hemaraj, Senior Data Scientist, General Electric, Bangalore*	1. *Dr. B. Premachandran, Professor, Mechanical Engineering, IIT Delhi*	1. *Dr. S. Senthilkumar, SRMIST*

Course Code	18ASE308T	Course Name	ROCKETS AND MISSILES	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC303J*	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 :	*To impart design basics of rockets and missiles systems, their construction and functions.*
CLR-2 :	*To focus on design principles, materials selection, testing and performance assessment.*
CLR-3 :	*To understand aerodynamics, flight dynamics, optimization of performance of multi-stage rockets and separation dynamics.*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design,	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*To learn about the different systems of rockets and missiles, formulation of the equation of motion and about the advanced rockets for future missions*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	*-*	*-*	*-*	*-*	*-*	*-*	*M*	*H*	*H*	*L*
CLO-2 :	*To understand the function of the solid propellant propulsion and pyrotechnic systems and the design principles*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*-*	*M*	*-*	*-*	*M*	*M*	*M*	*H*	*H*	*-*
CLO-3 :	*To understand the function of the liquid propellant propulsion and control systems and the design principles*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*M*	*-*	*M*	*-*	*-*	*M*	*M*	*M*	*H*	*H*	*-*
CLO-4 :	*To formulate the equation of motions for a mission and spent stage separation dynamics, understanding the principles of navigation, guidance and control of rockets and missiles, and design of a multistage rocket*	*2*	*80*	*70*	*H*	*H*	*H*	*H*	*H*	*-*	*H*	*-*	*L*	*L*	*H*	*H*	*H*	*H*	*-*
CLO-5 :	*To understand the system design, construction, function, performance and testing aspects. and to familiarize with the selection of suitable materials for different rocket systems*	*3*	*80*	*70*	*H*	*M*	*M*	*H*	*M*	*L*	*H*	*L*	*H*	*M*	*H*	*H*	*H*	*H*	*L*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction*	*Solid propellant rocket fundamentals*	*Liquid propellant rocket fundamentals*	*Multi-staging of rockets*	*Design of prototype rocket*
	SLO-2	*Classification of launch vehicles and missiles*				
S-2	SLO-1	*Different space missions*	*Propellant ingredients, Propellant properties*	*Liquid propellant rocket applications*	*Performance estimation of multi-stage rockets*	*Requirement and design approach*
	SLO-2	*Rocket flight systems*	*Propellant grain processing*	*Liquid propellant rocket types*		
S-3	SLO-1	*Forces and moments acting on a rocket*	*Propellant Grain types, requirements*	*Design of propellant feed system*	*Multi-stage vehicle optimization techniques*	*Product design*
	SLO-2	*Propulsion, aerodynamics*				
S-4	SLO-1	*Gravity, control systems*	*Grain design, properties*	*Gas pressure feed system*	*Flight trajectory optimisation*	*Process planning aspects*
	SLO-2	*Stability analysis*			*Constraints in optimisation*	
S-5	SLO-1	*Inertial and non-inertial frames, coordinate transformation*	*Ballistics of missiles*	*Design of fuel tanks*	*Rocket flight simulation techniques*	*Material selection criteria*
	SLO-2	*Coriolis theorem*		*Turbo-pump design*		*Super alloys, Composites*
S-6	SLO-1	*equations of motion for three dimensional motion through vacuum and atmosphere*	*Burn rate control design and evaluation*	*Liquid propellant rocket engine cycle*	*Stage separation system*	*Test and Qualification*
	SLO-2				*Stage separation dynamics*	
S-7	SLO-1	*Reentry flight dynamics*	*Solid rocket components*	*Cooling systems*	*Separation techniques*	*Types of tests*
	SLO-2				*reentry vehicles landing techniques*	
S-8	SLO-1	*Rocket flight performance dispersion*	*Solid rocket motor design*	*Liquid Slosh, Pogo*	*Navigation, guidance and control systems in launch vehicle*	*Environmental tests*
	SLO-2	*Computation methods*		*Water hammer, Geyser effect*		
S-9	SLO-1	*Introduction to single stage to orbit concepts, reusable launch vehicles*	*Separation systems*	*Thrust vector control (TVC) system*	*Missiles guidance*	*Planning details*
	SLO-2	*Advanced space propulsion systems*	*Pyrotechnic devices*	*Performance improvement of TVC*	*Aerodynamic control systems*	*Concluding a normal and incomplete test*

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40 %	-	30 %	-	30 %	-	30 %	-	30%	-
Level 2	Apply Analyze	40 %	-	40 %	-	40 %	-	40 %	-	40%	-
Level 3	Evaluate Create	20 %	-	30 %	-	30 %	-	30 %	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Manishankar C., Senior Scientist, NAL, Bangalore	1. Prof. Arun Kumar P., Assistant Professor, IIT Jammu	1. Dr. S. M. Aravindh Kumar, SRMIST
		2. Mr. K. Allwyn, SRMIST

Course Code	18ASE309T	Course Name	FATIGUE AND FRACTURE MECHANICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC304J*	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 :	*Understand the concepts of plotting S-N curve, mean stress, stress concentration*
CLR-2 :	*Emphasis the study of low cycle fatigue, load histories, cumulative damage & statistical aspects of fatigue.*
CLR-3 :	*Familiarize with physical aspects, surface effects, temperature effects of fatigue.*
CLR-4 :	*Familiarize with types of fracture, strain energy release rate, theoretical strength of materials.*
CLR-5 :	*Familiarize the various design philosophies, case histories, fatigue resistance of fiber laminates..*
CLR-6 :	*Get a better understanding of solving Fatigue problems*

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Apply the knowledge to plot S-N curve for various materials.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-2 :	*Analyze low cycle fatigue & load histories problems.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-3 :	*Apply the physical aspects of fatigue for solving problems.*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M
CLO-4 :	*Analyze fracture of various materials*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-5 :	*Analyze the various design philosophies.*	2	85	75	H	H	H	-	-	-	-	-	-	-	-	M	M	M	M
CLO-6 :	*Accrue comprehensive knowledge in fatigue & fracture problems*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	M	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Fatigue & Fracture*	*Low cycle fatigue*	*Structural aspects of fatigue, Crack initiation, slip band crack growth*	*Types of fracture in metals*	*Introduction to various design philosophies*
	SLO-2	*S-N curve*	*High cycle fatigue*	*Structural aspects of fatigue, Crack initiation, slip band crack growth*	*Types of fracture in metals*	*Safe life and fail safe design philosophy*
S-2	SLO-1	*Endurance limit*	*Coffin-Manson's relation*	*Crack growth on planes of high tensile stress, Ultimate fracture*	*Theoretical cohesive strength*	*Infinite life and manage tolerant design philosophies*
	SLO-2	*Effect of mean stress on fatigue*	*Transition life*	*Crack growth on planes of high tensile stress, Ultimate fracture.*	*Theoretical cohesive strength*	*Infinite life and manage tolerant design philosophies*
S-3	SLO-1	*Goodman diagram*	*Solving problems*	*Fatigue crack propagation, Paris law*	*Solving problems*	*Uncertainties, scatter and safety margins*
	SLO-2	*Gerber and Soderberg relations*	*Solving problems*	*Fatigue crack propagation, Paris law*	*Solving problems*	*Uncertainties, scatter and safety margins*
S-4	SLO-1	*Solving problems*	*Cyclic hardening, cyclic softening, cyclic stress strain curve*	*Solving problems*	*Griffith theory of brittle fracture.*	*Some case histories, Improved shoulder fillets*
	SLO-2	*Solving problems*	*Cyclic hardening, cyclic softening, cyclic stress strain curve*	*Solving problems*	*Irwin-Orwin theory.*	*Secondary bending due to non-symmetric holes.*
S-5	SLO-1	*Notches and Stress concentrations*	*Solving problems*	*Size effects on fatigue*	*Solving problems*	*Cracked aircraft wing panel repaired with a poorly designed patch*
	SLO-2	*Notches and Stress concentrations*	*Solving problems*	*Surface effects on fatigue*	*Solving problems*	*Online structural monitoring of the Tsing Ma bridge*
S-6	SLO-1	*Solving problems*	*Strain life equations*	*Surface roughness, surface properties*	*Strain energy release rate*	*Fatigue resistance of fiber-metal laminates, laminated sheet without fibers*
	SLO-2	*Solving problems*	*Solving problems*	*Surface residual stresses*	*Stress intensity factor, Crack deformation modes*	*Fatigue resistance of fiber-metal laminates, laminated sheet without fibers*

Duration (hour)		9	9	9	9	9
S-7	SLO-1	*Neuber's stress concentrations*	*Analysis of load histories*	*Fatigue under combined stresses*	*Solving problems*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*
	SLO-2	*Solving problems*	*Level crossing method*	*Fatigue under combined stresses*	*Solving problems*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*
S-8	SLO-1	*Plastic stress concentration*	*Range counting method, Rain flow method*	*Effects of metallurgical variables on fatigue*	*Fracture toughness and design*	*Fiber-metal laminate Arall and Glare, Fiber metal laminate concept*
	SLO-2	*Solving problems*	*Solving problems*	*Corrosion fatigue, fretting*	*Plane strain toughness testing*	*Fiber-metal laminates as sheet material*
S-9	SLO-1	*Notched S-N curve*	*Cumulative damage, Miner's rule*	*Effect of low temperature fatigue*	*Solving problems*	*Crack growth on Glare*
	SLO-2	*Solving problems*	*Solving problems*	*Effect of high temperature fatigue*	*Solving problems*	*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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. G.Balamurugan, National Aerospace Laboratories, Bangalore, gbala@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.A. Sakthivel, CEMILAC, Bangalore, asakthironika@gmail.com	*2. Dr. R.Velmurugan, Indian Institute of Technology Madras, rvel@ae.iitm.ac.in*	*2. Mr. S. Chandra Sekhar, SRMIST*

Course Code	18ASE310T	Course Name	CRYOGENIC ENGINEERING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC103T	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 :*
CLR-1 :	*To have a detailed study of the basics of cryogenic systems and to provide the knowledge of evolution of low temperature science*
CLR-2 :	*To familiarize with various Gas-Liquefaction Systems, Cryo-coolers and gas Refrigeration Systems*
CLR-3 :	*To provide the knowledge of cryogenic insulations and Cryogenic technology*
CLR-4 :	*To gain knowledge about different cryogenic instrumentation and to understand Cryo pumping.*
CLR-5 :	*To provide design aspects of cryogenic storage and transfer lines.*
CLR-6 :	*To understand cryogenic systems, gas liquefaction system and pumping system and applcations*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	2: Problem Analysis	3: Design & Development	4: Analysis, Design, Research	5: Modern Tool Usage	6: Society & Culture	7: Environment & Sustainability	8: Ethics	9: Individual & Team Work	10: Communication	11: Project Mgt. &	12: Life Long Learning	13: PSO - 1	14: PSO - 2	15: PSO – 3
CLO-1 :	*Analyze the Cryogenic systems*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	H	-	-	M
CLO-2 :	*Have a detailed knowledge of, Gas-Liquefaction Systems, cryo-coolers and gas Refrigeration Systems*	2	85	75	H	H	H	H	-	-	-	-	-	-	-	-	M	-	M
CLO-3 :	*Understand Cryogenic Insulations and Cryogenic Technology.*	2	75	70	H	H	H	H	-	-	-	-	-	-	-	H	M	M	-
CLO-4 :	*Understand different cryogenic instrumentation*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	H	-	M	M
CLO-5 :	*Know and to understand various cryogenic fluid storage and transport systems*	2	85	75	H	-	-	-	-	-	-	-	-	-	-	-	H	M	-
CLO-6 :	*Know cryogenic systems, gas liquefaction system and pumping system and applications*	2	85	75	H	H	H	H								H	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction - Cryogenic propellants*	*Claude cycle*	*Vuilleumier refrigerator*	*Numerical Problems on Gas Separation System*	*Mechanical vacuum pumps*
	SLO-2	*Liquid hydrogen, liquid oxygen*		*Cryogenic regenerators*		
S-2	SLO-1	*liquid nitrogen, liquid helium*	*Claude Liquefaction System*	*Numerical Problems on Cryogenic Refrigeration system*	*Numerical Problems on Gas Separation System*	*Diffusion pumps*
	SLO-2	*Properties of cryogenic fluids at cryogenic temperature - Mechanical properties*				
S-3	SLO-1	*Thermal properties*	*Heylandt System*	*Thermodynamic ideal Gas separation system*	*Pre purification of Air*	*Cryo-Pumping*
	SLO-2	*Electrical properties*	*Comparison of Claude and L.H system*	*Principles of gas separation*	*Vacuum Technology- Introduction*	*Cryogenic fluid storage vessels*
S-4	SLO-1	*Ortho Hydrogen & Para Hydrogen*	*Numerical Problems on Claude cycle*	*Linde single column gas separation*	*Production of high vacuum*	*Cryogenic Insulation - Introduction*
	SLO-2	*Safety in Cryogenics*		*Linde double column gas separation*		
S-5	SLO-1	*Applications in Space Technology*	*Numerical Problems on L-H cycle*	*Argon and Neon separation systems*	*Flow Regimes in Vacuum*	*Methods of Cryogenic Insulation*
	SLO-2		*Cryocoolers- Introduction*			
S-6	SLO-1	*Gas Liquefaction systems- Introduction*	*Classification of Cryocoolers*	*Cryogenic Gas Adsorption*	*Conductance in Vacuum*	*Evacuated powder insulation*
	SLO-2		*Stirling Cryo – cooler*		*Pressure drop- Slip flow and mixed flow*	*Opacified powder insulation*
S-7	SLO-1	*Joule Thomson effect*	*Gifford-McMahon Cry cooler*	*Cryo-condensation Process*	*Numerical Problems on Vacuum Technology*	
	SLO-2	*Joule Thomson Coefficient*	*Gas Cycle Refrigeration system- Introduction*			*Gas filled powders Multilayer super-insulation*
S-8	SLO-1	*Linde –Hampson cycle*	*Classification of Gas Cycle refrigeration*	*Numerical problems on Gas separation system*	*Numerical Problems on Vacuum Technology*	*Fibrous materials Multilayer super-insulation*
	SLO-2					*Propellant servicing*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	Linde –Hampson System	Pulse tube refrigerator	Numerical problems on Gas separation system	Numerical Problems on Vacuum Technology	Propellant management
	SLO-2		Solvay cycle refrigerator			Cryogenic fluid transfer systems

Learning Resources	1. *Randall F. Barron., "Cryogenic Systems", Oxford University, Second edition,1985* 2. *Walker.G ,"Cryocoolers", Plenum Press, First edition,New York (1983)* 3. *Mamata Mukhopadhyay ,"Fundamentals of Cryogenic Engineering",PHI Learning (P) Ltd, India, Fourth edition 2010*	4. *J.H.Bell ,"Cryogenic Engineering" , Prentice Hall, Englewood Cliffs,First edition,1963* 5. *Parner, S. F., "Propellant Chemistry", Reinhold Publishing Corpn., New York,1985* 6. *R.B.Scott , "Cryogenic Engineering" , Van Nostrand Co, New Jercy,1959*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	40%	-	30%	-	30%	-	30%	-	30%	-
Level 2	Apply Analyze	40%	-	40%	-	40%	-	40%	-	40%	-
Level 3	Evaluate Create	20%	-	30%	-	30%	-	30%	-	30%	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1.Dr.Parthasarathi Ghosh, Head, Cryogenic Engineering Centre, IIT Kharagpur psghosh@hijli.iitkgp.ernet.in*	*1.Mr. G. Saravanan SRMIST*
	2. Dr P.K Dsah, Professor and Head, Department of Aeronautical Engineering Nitte Menakshi Institute of Technology, Bangalore. drpdash@gmail.com	*2.Mr Vinayak Malhotra SRMIST*

Course Code	18ASE311T	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:	Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-1 :	*Identify the type ofReciprocating enginefuel metering system and its components used in aircraft.*																		
CLR-2 :	*Layout the components and accessories of gas turbine engine fuel system.*																		
CLR-3 :	*Demonstrate the type ofinduction and exhaust system in aircraft engines.*																		
CLR-4 :	*Identify the electrical systems used in in aircraft engines.*																		
CLR-5 :	*Identify the various aircraft engine instruments and their functions.*																		
CLR-6 :	*Utilize the knowledge acquired for design, development & maintenance of aircraft & aero engine systems.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	*Understand the operation of Reciprocating enginefuel metering system and its components used in aircraft.*	2	80	70	H	-	L	L	L	-	-	-	-	-	-	L	L	M	M
CLO-2 :	*Acquire knowledge on components and accessories of gas turbine engine fuel system.*	2	80	70	H	-	M	L	M	-	-	-	-	-	-	-	M	M	M
CLO-3 :	*Learn the working of induction and exhaust system in aircraft engines.*	2	80	70	H	-	L	L	M	-	-	-	-	-	-	L	M	M	M
CLO-4 :	*Appreciate the need and functions of aircraft electrical systems used in in aircraft engines.*	2	80	70	H	-	L	L	L	-	M	M	-	-	-	L	M	M	M
CLO-5 :	*Gain knowledge on principle and operation of various aircraft engine instruments.*	2	80	70	H	L	L	L	M	-	-	-	-	M	-	L	H	H	M
CLO-6 :	*Acquire comprehensive knowledge of aircraft systems, engine systems and its instrumentation.*	2	80	70	H	L	L	L	M	-	M	M	-	M	-	L	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Reciprocating Engines*	*Introduction to Gas Turbine Engines*	*Introduction to Induction Systems*	*Electrical Power Evolution*	*Introduction to Aircraft Engine Instruments*
	SLO-2	*Design and Construction, modular concept*	*Gas Turbine Enginesmodular concept*	*Reciprocating Engine Induction Systems*	*Aircraft Electrical Systems*	*Reciprocating engine instruments*
S-2	SLO-1	*Fuels and their characteristics for IC engines.*	*Fuels and their characteristics for gas turbine engines*	*Basic Carburetor Induction System*	*Basic Aircraft Electrical Systems*	*Operation of Oil pressure*
	SLO-2	*Contamination of fuels and prevention*	*Contamination of fuels and prevention*	*Induction System Icing,Induction System Filtering*	*Power Generation*	*Oil temperature indicators*
S-3	SLO-1	*Fuel system- Basic Fuel System*	*Turbine Engine Fuel System*	*Supercharged Induction Systems*	*DC Power Generation*	*Operation of Cylinder head temperature (CHT) indicator*
	SLO-2	*Fuel System Requirements*	*General Requirements*	*Operation & Advantages*	*Typical Aircraft DC System*	*Manifold pressure indicator*
S-4	SLO-1	*Fuel Metering Devices for Reciprocating Engines*	*Hydro mechanical Fuel Control*	*Reciprocating Engine Exhaust Systems*	*AC Power Generation*	*Operation of Fuel quantity, Fuel pressure*
	SLO-2	*Fuel/Air Mixtures, Carburetion Principles*	*Hydromechanical/Electronic Fuel Control*	*Exhaust Systems With Turbocharger.*	*Inverters, rectifiers*	*Carburetor temperature, Tachometer indicators*
S-5	SLO-1	*Application of Venturi Principle to Carburetor*	*Operation of Hydromechanical/Electronic Fuel Control*	*Gas Turbine Engines engine inlet systems*	*Transformers, Batteries*	*Introduction to Gas Turbine Engine instruments types*
	SLO-2	*Carburetor Systems,Carburetor Types*	*Introduction to FADEC*	*Compressor Inlet Screens*	*Airplane lighting systems*	*Principle & Operation of Oil pressure*
S-6	SLO-1	*Float-Type Carburetors, Float Chamber Mechanism System*	*FADEC Fuel Control Systems*	*Turboprop and Turboshaft Compressor Inlets*	*Classification of lighting systems*	*Exhaust gas temperature (EGT)*
	SLO-2	*Main Metering,Idling, Accelerating and EconomizerSystem*	*FADEC for an Auxiliary Power Unit*	*Turbofan Engine Inlet Sections*	*External Lighting Systems*	*Turbine inlet temperature (TIT) or turbine gas temperature (TGT)*
S-7	SLO-1	*Pressure Injection Carburetors*	*FADEC Fuel Control Propulsion Engine*	*Gas Turbine Engines Engine Exhaust Systems*	*Internal Lighting Systems*	*Engine pressure ratio (EPR)*

Duration (hour)		9	9	9	9	9
	SLO-2	*Operation of Pressure Injection Carburetors*	*Operation and its Advantages*	*Turbine engine exhaust nozzles*	*Airplane lighting– Power utilization in airplanes*	*Principle & Operation of Fuel quantity, Fuel pressure*
S-8	SLO-1	*Manual Mixture Control*	*Engine Fuel System Components*	*Thrust Reversers*	*Ground Power*	*Fuel flow indicator*
	SLO-2	*Automatic Mixture Control (AMC)*	*Main Fuel Pumps, Fuel Heater, Fuel Filters*	*Afterburning / Thrust augmentation*	*Emergency Power Generation*	*Principle & Operation of Tachometer (percent calibrated) N1 and N2 compressor speeds*
S-9	*SLO-1*	*Fuel-Injection Systems*	*Flow Divider,Fuel Pressurizing and Dump Valves*	*Thrust Vectoring*	*Ram Air Turbine, Backup Power Converters*	*Principle & Operation of Torquemeter*
	SLO-2	*Bendix/Precision Fuel-Injection System*	*Fuel Spray Nozzles and Fuel Manifolds*	*Engine noise suppression, Turbine engine emissions.*	*Permanent Magnet Generators (PMGs)*	*Torquemeter (on turboprop and turboshaft engines)*

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 – Powerplant, 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. *Adrian P. Mouritz, "Introduction to aerospace materials" Woodhead Publishing Limited, 2012* 5. *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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Wg.CdrK.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2.. *Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India* , Bangalore *ks_senthilkumar@yahoo.co*	2. *Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com*	*2. Mr. S. Raj Kumar SRMIST*

Course Code	18ASE312T	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:*	Learning			Program Learning Outcomes (PLO)														
CLR-1 :	*Identify the type of rotor, helicopter controls ,gears, bearings and ground handling*	1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CLR-2 :	*Layout the main rotor system components and its maintenance.*	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLR-3 :	*Demonstrate the engine power transmission to rotors.*																		
CLR-4 :	*Identify the power plant installation and maintenance*																		
CLR-5 :	*Identify the various airframe construction and related systems.*																		
CLR-6 :	*Utilize the knowledge acquired for design, development & maintenance of Helicopter.*																		
Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*																		
CLO-1 :	*Understand the helicopter fundamentals and its main components.*	2	*80*	*70*	*H*	-	*L*	*L*	*L*	-	-	-	-	-	-	*L*	*L*	*M*	*M*
CLO-2 :	*Acquire knowledge on main rotor components and its maintenance.*	2	*80*	*70*	*H*	-	*M*	*L*	*M*	-	-	-	-	-	-	-	*M*	*M*	*M*
CLO-3 :	*Learn the working of helicopter transmission system.*	2	*80*	*70*	*H*	-	*L*	*L*	*M*	-	-	-	-	-	-	*L*	*M*	*M*	*M*
CLO-4 :	*Acquire knowledge of installation and maintenance of helicopter engines.*	2	*80*	*70*	*H*	-	*L*	*L*	*M*	-	*M*	*M*	-	-	-	*L*	*M*	*M*	*M*
CLO-5 :	*Gain knowledge on helicopter fuselage construction and related systems.*	2	*80*	*70*	*H*	*L*	*L*	*L*	*M*	-	-	-	-	*M*	-	*L*	*H*	*H*	*M*
CLO-6 :	*Acquire comprehensive knowledge of helicopter rotors ,transmission, fuselage and other components and its maintenance activities*	2	*80*	*70*	*H*	*L*	*L*	*L*	*M*	-	*M*	*M*	-	*M*	-	*L*	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction to Helicopters*	*Head maintenance*	*Gradient control boosts*	*Different types of power plant*	*Structural components and materials-Body structure*
	SLO-2	*Evolution of helicopter*	*Blade alignment*	*Maintenance in control rigging*	*Different types of power plant maintenance*	*Bottom structure*
S-2	SLO-1	*Helicopter rotor arrangements*	*Static main rotor balance*	*Inspection in control rigging*	*Maintenance of typical Eurocopter Engine*	*Cabin section*
	SLO-2	*Rigid rotor arrangements*	*Vibration, Tracking methods*	*Engine transmission coupling*	*Tail rotor system*	*Rear section*
S-3	SLO-1	*Semi-rigid rotor arrangements*	*Spanwise dynamic balance*	*Drive shaft*	*Servicing tail rotor track*	*Tail Boom*
	SLO-2	*Helicopter flight controls*	*Blade sweeping*	*Maintenance clutch*	*System rigging*	*Vertical fin*
S-4	SLO-1	*Basic directions ,colour codes*	*Electronic balancing*	*Freewheeling units*	*Rotary wing fuselage structural construction*	*Horizontal stablizer*
	SLO-2	*Ground handling*	*Dampener maintenance*	*Spray clutch*	*Tubular, sheet metal construction*	*Skid gear*
S-5	SLO-1	*Towing*	*Counter weight adjustments*	*Roller unit*	*Bonded construction*	*Antivibration device*
	SLO-2	*Towing precautions*	*Auto rotation adjustments*	*Torque meter*	*Bell-206*	*Special purpose equipments*
S-6	SLO-1	*Helicopter protection*	*Mast& Flight Control rotor*	*Rotor brake*	*Eurocopter BO-105*	*High skid gear*
	SLO-2	*protection equipments*	*Mast Stabilizer*	*Rotor brake maintenance of roller unit*	*Fueslage*	*Floats*
S-7	SLO-1	*Bearing and It's types*	*Mast Dampeners*	*Rotor brake maintenance of torque meter*	*Fuselage maintenance*	*Resque hoists*
	SLO-2	*Bearing installation*	*Swash plate flight control systems collective*	*Vibrations in transmission systems*	*Airframe systems*	*Cargo Hooks*
S-8	SLO-1	*Bearing maintenance*	*Cyclic*	*Mounting systems*	*Stress and loads on airframe*	*Litter Installations*
	SLO-2	*Elastomeric bearings*	*Push-pull tubes*	*Transmissions*	*Wheel*	*Light Installations*
S-9	SLO-1	*Gear, types*	*Torque tubes, bell cranks*	*Fixed wing power plant modifications*	*Skid gear*	*Spray equipment*
	SLO-2	*Gear pattern*	*Mixer box*	*Installation of typical Eurocopter engine*	*Visibility*	*Stabilation devices*

Learning Resources	1. *Jeppesen,Helicopter Maintenance Hand Book, Jeppesons and Sons Inc,2000.* 2. *Gupta L,Helicopter Engineering , Himalayan books ,1996*	3. *Civil Aircraft Inspection procedures part I and II ,CAA.English Book House ,New Delhi,1986.* 4. *Larry Reiethmier ,Aircraft repair manual ,Palamar Books Marquette,1992*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Wg.CdrK.Manoharan (Retd), Blue Dart Aviation Ltd., manoharank@bluedart.com	*1. Dr. A. P. Haran, Park College of Engineering & Technology, ap_haran@rediffmail.com*	*1. Dr. S. Sivakumar, SRMIST*
2. Mr.K.Senthilkumar,Deputy Chief Aircraft Engineer, Air India , Bangalore ks_senthilkumar@yahoo.co	*2. Dr.Wg.Cdr.N.Muthusamy, Rajalakshmi Engineering college, Chennai, muthusamy55@gmail.com*	*2. Mr. S. Raj Kumar SRMIST*

Course Code	18ASE313T	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			

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand the kinematics and dynamics of fixed wing unmanned aerial vehicle*
CLR-2 :	*Understand the kinematics and dynamics of multirotor micro aerial vehicle.*
CLR-3 :	*Understand the State estimation of Aerial Robots*
CLR-4 :	*Understand the flight controls methods of Aerial Robots*
CLR-5 :	*Understand the applications of Aerial Robots*
CLO-6 :	*Know dynamics of different types of aerial vehicle,, flight control methods and its applications*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Mathematically model the kinematics and dynamics of fixed wing unmanned aerial vehicle*	2	*85*	*75*	*H*	*-*	*H*	*-*	*-*	*-*	-	-	-	-	-	-	-	-	*M*
CLO-2 :	*Mathematically model the kinematics and dynamics of multirotor micro aerial vehicle*	2	*85*	*75*	*H*	*-*	*H*	*-*	*-*	*-*	-	-	-	-	-	-	*M*	*M*	-
CLO-3 :	*Estimate the state of Aerial Robots*	2	*85*	*75*	*H*	*H*	*H*	*H*	*-*	*-*	-	-	-	-	-	-	*M*	*M*	*M*
CLO-4 :	*Design flight controls of Aerial Robots*	2	*85*	*75*	*H*	*-*	*-*	*-*	*H*	*-*	-	-	-	-	-	-	*M*	*M*	*M*
CLO-5 :	*Utilise the applications of Aerial Robots*	2	*85*	*75*	*H*	*-*	*-*	*-*	*-*	*H*	-	-	-	-	-	-	-	-	-
CLO-6 :	*Understand dynamics of different types of aerial vehicle, flight controls and its applications*	2	*85*	*75*	*H*	*-*	*H*	*H*	*H*	*H*	-	-	-	-	-	-	*M*	*M*	*M*

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Introduction of Fixed Wing Unmanned Aerial Vehicle(FWUAV)*	*Introduction of Multirotor Micro Aerial Vehicle (MMAV)*	*Navigational Sensors*	*Introduction to Control Methods of UAV*	*Applications of Aerial Robots*
	SLO-2					
S-2	SLO-1	*History of Fixed Wing Unmanned Aerial Vehicle*	*History of Multirotor Micro Aerial Vehicle(MMAV)*	*Inertial Sensors*	*PID Control*	*Aerial Robots for Military*
	SLO-2					*Reconnaissance*
S-3	SLO-1	*Classification of Fixed Wing Unmanned Aerial Vehicle*	*Classification of Multirotor Micro Aerial Vehicle(MMAV)*	*Magnetometer*	*Lateral control of MMAV using PID*	*Target attacking aerial robots*
	SLO-2			*Pressure Sensor*		*Civil Applications*
S-4	SLO-1	*Modelling and Dynamics Formulation*	*Propeller Theory*	*GPS based Navigation*	*LQR Control*	*Surveying Aerial Robots*
	SLO-2					*Aerial mapping*
S-5	SLO-1	*Frame Rotations and Representations*	*Thrust and Drag moment*	*Camera based Navigation*	*Design of LQR servo control in MATLAB*	*Aerial robots for Precision Agriculture*
	SLO-2	*Euler angles*				
S-6	SLO-1	*Quaternion*	*Dynamics of a Multirotor Micro Aerial Vehicle(MMAV)*	*Position Estimation*	*Model Predictive Control for UAV*	*Payload Delivery*
	SLO-2					*Film making*
S-7	SLO-1	*Gravitational force modelling of FWUAV*	*Gravitational force modelling of MMAV*	*Velocity Estimation*	*Linear Model Predictive Control*	*Scientific Research*
	SLO-2	*Propulsive force modelling of FWUAV*	*Propulsive force modelling of MMAV*			
S-8	SLO-1	*Aerodynamic Force modelling FWUAV*	*Aerodynamic Force modelling MMAV*	*Inertial Navigation Systems*	*Design ofa Linear MPC for MMAV*	*Search and Rescue*
	SLO-2	*Moments acting on FWUAV*	*Moments acting on MMAV*			
S-9	SLO-1	*Dynamics of a Fixed-Wing Unmanned Aerial Vehicle*	*Mathematical modelling of Multirotor Micro AerialVehicle(MMAV)*	*Attitude estimation*	*Implementation of a Linear MPC for MMAV*	*Mineral Exploration Aerial Robots*
	SLO-2					

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. S. Raja, Senior Principal Scientist and Professor, NAL – Bangalore. raja@nal.res.in	*1. Dr.K.M.Parammasivam, Professor, MIT-Chennai. mparams@mitindia.edu*	*1. Mr.A.Vinoth Kumar, SRMIST.*

Course Code	18ASE314T	Course Name	TURBULENCE AND TURBULENCE MODELING	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC202J*	Co-requisite Courses	*Nil*	Progressive Courses	*18ASE307T*
Course Offering Department	*Aerospace Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*Understand turbulent flow physics*
CLR-2 :	*Understand closure and need for turbulence models*
CLR-3 :	*Identify the type of model for turbulent flow simulations*
CLR-4 :	*Assess the methodologies for turbulent flow simulations*
CLR-5 :	*Understand the classification of shear flows*
CLR-6 :	*Utilize the knowledge acquired towards turbulent flow simulations and experiments*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Understand different aspects of turbulent flows*	2	80	70	H	-	H	L	-	-	M	-	-	-	-	-	-	M	L
CLO-2 :	*Acquire knowledge on turbulence closure and models*	2	80	70	H	-	H	L	-	-	-	-	-	-	-	-	H	M	M
CLO-3 :	*Derive the governing equations for turbulent flows*	2	80	70	H	-	H	L	-	-	-	-	-	-	-	-	-	M	M
CLO-4 :	*Appreciate the usefulness of RANS*	2	80	70	H	-	H	L	H	-	-	-	-	-	-	-	H	H	H
CLO-5 :	*Gain knowledge on LES and DNS*	2	80	70	H	-	H	L	M	-	-	-	-	-	-	-	M	M	M
CLO-6 :	*Acquire comprehensive understanding on turbulent flow simulations and experiments*	2	80	70	H	-	M	L	-	-	M	-	-	-	-	-	M	M	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Review of basic fluid dynamics*	*Turbulent jets*	*Velocity at a point*	*One equation model*	*v^2-f model*
	SLO-2	*Fluid properties and flow properties*	*Flow field physics of jets*	*Velocity time series*	*Spalart-Allamaras model*	*v^2-f model*
S-2	SLO-1	*Conservation laws*	*Turbulent wakes*	*Statistics*	*k-equation model*	*Q-ζ model*
	SLO-2	*Mass, momentum and transport equations*	*Flow field physics of wakes*	*Statistical properties*	*Advantages and disadvantages*	*Q-ζ model*
S-3	SLO-1	*Flow classification*	*Mixing layers*	*Reynolds Decomposition*	*Two equation models*	*k – kl – ω model*
	SLO-2	*Laminar Vs Turbulent flow*	*Flow field physics of mixing layers*	*Reynolds Averaging*	*Advantages and disadvantages*	*k – kl – ω model*
S-4	SLO-1	*Reynolds number*	*Wall bounded shear flows*	*Derivation of Reynolds Averaged Continuity equation*	*Standard k-ε model*	*Higher order model*
	SLO-2	*Effect of Reynolds number on flow*	*Wall bounded shear flows*	*Derivation of Reynolds Averaged Continuity equation*	*Standard k-ε model*	*Complete closure*
S-5	SLO-1	*How to define turbulence*	*Wall Y^+*	*Derivation of Reynolds Averaged Momentum equation*	*RNG k-ε model*	*Reynolds Stress Transport Model (RSTM)*
	SLO-2	*Characteristics of turbulence*	*Wall shear stress*	*Derivation of Reynolds Averaged Momentum equation*	*RNG k-ε model*	*Reynolds Stress Transport Model (RSTM)*
S-6	SLO-1	*Ways of describing turbulent flows*	*Layers in boundary layers*	*Reynolds Stress*	*Realizable k-ε model*	*Wall functions*
	SLO-2	*Various scales associated with turbulent flows*	*Layers in boundary layers*	*Reynolds stress tensor*	*Realizable k-ε model*	*Wall damping functions*
S-7	SLO-1	*How to measure turbulence*	*Energy cascade*	*Closure problem*	*Standard k-ω model*	*Assessment of turbulence models and its selection*
	SLO-2	*Hot-wire Anemometer, LDA, PIV*	*Transfer of energy*	*Need for modeling*	*Standard k-ω model*	*Need for transient simulations - LES*
S-8	SLO-1	*Classification of turbulent shear flows*	*Kolmogorov scales*	*Eddy viscosity*	*SST k-ω model*	*Governing equations for LES*
	SLO-2	*Classification of turbulent shear flows*	*Dissipation*	*Eddy viscosity hypothesis*	*SST k-ω model*	*Sub grid scale modeling*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*Free shear flows*	*Homogeneous turbulence*	*Zero equation model*	*Advanced models*	*Hybrid models (DES)*
	SLO-2	*Free shear flows*	*Isotropy and Anisotropy*	*Mixing length model*	*Requirements and needs for advanced models*	*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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.,

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. C. Palani Kumar, CFD Application Expert, DJAIR, Korea. Email: kumar@djair.co.kr	*1. Dr. Joydeep Bhowmik, Aerospace and Applied Mechanics, IIEST Shibpur email: joydeep@aero.iiests.ac.in*	*1. Dr. Kannan B T, SRMIST* *2. Dr. Bharadwaj K K, SRMIST*

Course Code	18ASE315T	Course Name	HIGH TEMPERATURE GAS DYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	18ASC301J	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 :	Understand the high temperature flow, classification of gases and chemically reacting gas
CLR-2 :	Know the microscopic nature of gas and the associated probable state and its calculations
CLR-3 :	Demonstrate equilibrium and nonequilibrium normal and oblique shock flows
CLR-4 :	Understand the inviscid high temperature equilibrium flows and its consequences
CLR-5 :	Know the governing equation for inviscid high temperature nonequilibrium and its performance characteristics
CLR-6 :	Understand the viscous high temperature flows and its significance in the real-world engineering problems

		Learning			Program Learning Outcomes (PLO)														
		1	2	3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Course Learning Outcomes (CLO):	At the end of this course, learners will be able to:	Level of Thinking (Bloom)	Expected Proficiency (%)	Expected Attainment (%)	Engineering Knowledge	Problem Analysis	Design & Development	Analysis, Design, Research	Modern Tool Usage	Society & Culture	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO - 1	PSO - 2	PSO – 3
CLO-1 :	Describe the high temperature flow and discern between calorically and thermally perfect gas	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	M	M	L
CLO-2 :	Describe molecular perspective of gases and its most probable state	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	M	H	L
CLO-3 :	Explain the significance of equilibrium and nonequilibrium normal and oblique shock wave	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	M	L
CLO-4 :	Explain key aspects of high temperature equilibrium flows	2	80	75	H	M	-	L	-	-	-	-	-	-	-	-	M	H	L
CLO-5 :	Describe the equations which are governs the niviscid high temperature nonequilibrium flows	2	80	75	H	M	-	L	-	-	-	-	-	-	-	-	M	M	L
CLO-6 :	Explain the viscous high temperature flows	2	80	75	H	M	-	L	-	-	-	-	-	-	-	-	H	M	L

Duration (hour)		9	9	9	9	9
S-1	SLO-1	Nature of high temperature flow	Intro to statistical thermodynamics	Governing equations for inviscid equilibrium flows	Governing equations for inviscid nonequilibrium flows	Governing equations for chemically reacting viscous flow
	SLO-2	Definition of real gases and perfect gases	Microscopic description of gases, most probable microstate			
S-2	SLO-1	Various forms of the perfect-gas equation state	Limiting case: Boltzmann distribution	Equilibrium normal and oblique shock-wave flows	Nonequilibrium normal and oblique shock-wave flows	Alternate form of the energy equation
	SLO-2					
S-3	SLO-1	Various descriptions of the composition of gas mixture	Evaluation of thermodynamic properties in terms of partition function	Equilibrium quasi-one-dimensional nozzle flows	Nonequilibrium quasi-one-dimensional nozzle flows	Boundary layer equations for chemically reacting gas
	SLO-2					
S-4	SLO-1	Calorically perfect gas, thermally perfect gas	Evaluation of partition function in terms of T and V	Frozen and equilibrium fows: the distinction	Nonequilibrium blunt-body flows	Boundary conditions: catalytic walls
	SLO-2					
S-5	SLO-1	Chemically reacting mixture of perfect gas and real gases	Practical evaluation of thermodynamic properties for a single chemical species	Frozen and equilibrium flows: equilibrium and frozen specific heats	Binary scaling for nonequilibrium flows	Boundary layer solutions : stagnation-point heat transfer for a dissociating gas
	SLO-2					
S-6	SLO-1	First and second law of thermodynamics	Calculation of the equilibrium constant	Frozen and equilibrium flows: equilibrium speed of sound	Nonequilibrium flow over blunted sharp cone	Boundary layer solutions : nonsimilar flows
	SLO-2	Calculation of entropy	Chemical equilibrium			
S-7	SLO-1	Gibbs free energy and entropy produced by chemical equilibrium	Calculation of the equilibrium composition for high-temperature air	Equilibrium conical flow	Nonequilibrium effect on shock-wave shape for space shuttle	Viscous-shock-layer solutions to chemically reacting flows
	SLO-2					
S-8	SLO-1	Composition of equilibrium chemically reacting mixture: the equilibrium constant	Thermodynamic properties of an equilibrium chemically reacting gas	Equilibrium blunt-body flows: circular cone	Nonequilibrium mehod of characteristics	Parabolized Navier-Stokes solutions to chemically reacting flow
	SLO-2					
S-9	SLO-1	Composition of equilibrium chemically reacting mixture: heat of reaction	Equilibrium properties of high temperature air	Equilibrium blunt-body flows: space shuttle orbiter	Chemically reacting nonequilibrium flow behind a normal shock wave	Full Navier-Stokes solutions to chemically reacting flows
	SLO-2					

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 (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

CLA – 4 can be from any combination of these: Assignments, Seminars, Tech Talks, Mini-Projects, Case-Studies, Self-Study, MOOCs, Certifications, Conf. Paper etc.

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
Mr. Amit Palankar, GE aviation, Bangalore, palankr.amit@gmail.com	*Dr.Arun Kumar P, Indian Institute of Technology Jammu, email: arun.perumal@iitjammu.ac.in*	*Dr. Malaikannan G, SRMIST*

Course Code	18ASE316T	Course Name	HYPERSONIC AEROTHERMODYNAMICS	Course Category	E	Professional Elective	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*18ASC301J*	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 :	*Understand the hypersonic flow and importance of hypersonic flows*
CLR-2 :	*Understand various characteristics of the hypersonic flow and associated physics related to high speed vehicles*
CLR-3 :	*Demonstrate the shock-wave and expansion-wave and their significance in hypersonic flow*
CLR-4 :	*Know various approximate models for hypersonic flow*
CLR-5 :	*Know the governing equation for viscous and inviscid flows, boundary layer equations and shock-wave boundary layer interaction*
CLR-6 :	*Understand the various hypersonic experimental facilities and hypersonic vehicle aerodynamics*

Course Learning Outcomes (CLO):	*At the end of this course, learners will be able to:*	Learning 1: Level of Thinking (Bloom)	Learning 2: Expected Proficiency (%)	Learning 3: Expected Attainment (%)	PLO 1: Engineering Knowledge	PLO 2: Problem Analysis	PLO 3: Design & Development	PLO 4: Analysis, Design, Research	PLO 5: Modern Tool Usage	PLO 6: Society & Culture	PLO 7: Environment & Sustainability	PLO 8: Ethics	PLO 9: Individual & Team Work	PLO 10: Communication	PLO 11: Project Mgt. & Finance	PLO 12: Life Long Learning	PLO 13: PSO - 1	PLO 14: PSO - 2	PLO 15: PSO – 3
CLO-1 :	*Describe the hypersonic flow and the characteristic of the hypersonic flow*	2	85	80	H	-	-	-	-	-	-	-	-	-	-	-	H	M	L
CLO-2 :	*Describe shock-wave and expansion-wave relations for hypersonic flow*	2	80	75	H	M	-	-	-	-	-	-	-	-	-	-	H	M	L
CLO-3 :	*Explain the importance of the simplified models for hypersonic flow*	2	80	70	H	-	-	-	-	-	-	-	-	-	-	-	H	M	L
CLO-4 :	*Explain various forms shock-shock interactions and governing phenomena*	2	80	75	H	M	-	M	-	-	-	-	-	-	-	-	H	H	L
CLO-5 :	*Describe role of hypersonic shock-wave boundary layer interaction and viscous interaction*	2	80	75	H	M	-	M	-	-	-	-	-	-	-	-	H	M	L
CLO-6 :	*Explain the various techniques and visualization techniques for hypersonic flow*	2	85	80	H	M	-	H	L	-	-	-	-	-	-	-	M	H	M

Duration (hour)		9	9	9	9	9
S-1	SLO-1	*Basic concepts of hypersonic flow*	*Newtonian flow model for hypersonic flows*	*Governing equations for hypersonic flow*	*Governing equations for hypersonic viscous flow*	*Intro to hypersonic vehicle aerodynamics*
	SLO-2	*Importance and physical aspects of hypersonic flow*				
S-2	SLO-1	*Thin shock layer*	*Newtonian flow model for flat plate, circular cylinder of infinite span and sphere*	*Hypersonic small disturbance equations*	*Similarity parameters and boundary conditions for viscous hypersonic flow*	*Reentry capsule aerodynamics*
	SLO-2	*Entropy layer*				
S-3	SLO-1	*Viscous interaction*	*Modified Newtonian theory*	*Hypersonic similarity parameter*	*Boundary layer equation for hypersonic flow*	*Shuttle orbiter aerodynamics*
	SLO-2	*Classification of hypersonic space transport vehicle*	*Centrifugal force corrections to Newtonian theory*	*Hypersonic equivalence principle*		
S-4	SLO-1	*Effects if high temperature flow*	*Comparison of Newtonian with exact theory*	*Blast-wave theory*	*Self-similar and non-similar solutions of hypersonic boundary layer*	*Pre-flight prediction of the orbiter aerodynamics*
	SLO-2		*Newtonian-Busemann theory*		*Hypersonic transition*	*Flight measurements of the orbiter aerodynamics*
S-5	SLO-1	*Communication blackout*	*Mach number independence principle*	*Thin shock layer theory*	*Prediction of transition*	*X-15 aerodynamics*
	SLO-2	*Low density flow*			*Hypersonic turbulent boundary layer*	
S-6	SLO-1	*Free molecular flow*	*Tangent-wedge Tangent-cone methods*	*Correlation for hypersonic shock-wave shapes*	*Hypersonic aerodynamic hearting and its effects on entropy layer*	*Experimental techniques and measurements for hypersonic flow*
	SLO-2	*Hypersonic flight paths*				
S-7	SLO-1	*Hypersonic shock-wave relations for high Mach numbers*	*Shock-expansion method*	*Shock-shock interactions in hypersonic flow*	*Hypersonic shock-wave/boundary layer interactions*	*Hypersonic wind-tunnel*
	SLO-2					*Hypersonic shock tunnel*
S-8	SLO-1	*Hypersonic Expansion-wave relations for high Mach numbers*	*Shock-expansion method for airfoil and an ogive and its comparison with experiment and method of characteristics*	*Different types of shock-shock interactions*	*Strong and weak hypersonic viscous interaction*	*Gun tunnel, arc-jets*
	SLO-2					*Free piston wind tunnel*

Duration (hour)		9	9	9	9	9
S-9	SLO-1	*Hypersonic shock-wave relation in terms of similarity parameter*	*Aerodynamic coefficient predictions using Newtonian theory*	*CFD techniques for hypersonic inviscid flow*	*Role of similarity parameter in hypersonic viscous interaction*	*Ludwig tube*
	SLO-2	*Tutorial problems*	*Tutorial problems*	*Tutorial problems*	*Tutorial problems*	*Measurement and visualization techniques in hypersonic flow*

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.* 6. *Burtschell, Y., R. Brun, and D. Zeitoun. "Two dimensional numerical simulation of the Marseille University free piston shock tunnel-TCM2." Shock Waves. Springer, Berlin, Heidelberg, 1992. 583-590.*

Learning Assessment											
	Bloom's Level of Thinking	Continuous Learning Assessment (50% weightage)								Final Examination (50% weightage)	
		CLA – 1 (10%)		CLA – 2 (15%)		CLA – 3 (15%)		CLA – 4 (10%)#			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember Understand	*40 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
Level 2	Apply Analyze	*40 %*	-	*40 %*	-	*40 %*	-	*40 %*	-	*40%*	-
Level 3	Evaluate Create	*20 %*	-	*30 %*	-	*30 %*	-	*30 %*	-	*30%*	-
	Total	100 %		100 %		100 %		100 %		100 %	

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Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Expert
Mr. Amit Palankar, GE aviation, Bangalore, palankr.amit@gmail.com	*Dr.Arun Kumar P, Indian Institute of Technology Jammu, email: arun.perumal@iitjammu.ac.in*	*Dr. Malaikannan G, SRMIST*