AEROSPACE ENGINEERING

Table AE-1

B.Tech. Aerospace Engineering - 2018-22

COURSE COMPONENTS AND CURRICULUM

S.No	Category	Credits
1	Basic Science Courses	27
2	Engineering Science courses	23.5
3	Humanities & Social Sciences Including Management Courses	10
4	Professional Core Courses	58.5
5	Professional Elective Courses	17
6	Open Elective Courses	9
7	Internship/ Industrial Training & Project Work	15
	Total Credits	160

Basic Science Courses (BSC)						
Sl. No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	18PH1001	Engineering Physics - Electromagnetism, Optics and Properties of Matter	3	1	0	4
2	18PH1002	Engineering Physics - Electromagnetism, Optics and Properties of Matter Lab	0	0	3	1.5
3	18CH1003	Engineering Chemistry	3	1	0	4
4	18CH1002	Applied Chemistry Laboratory	0	0	3	1.5
5	18MA1001	Calculus and Linear Algebra	3	1	0	4
6	18MA1008	Ordinary Differential Equations and Complex Variables	3	1	0	4
7	18MA2005	Partial Differential Equations, Probability and Statistics	3	1	0	4
8	18MA2014	Numerical Mathematics and Computing	3	1	0	4
					Total Credits	27

Engineering Science courses (ESC)						
Sl.No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	18ME1001	Engineering Drawing	0	0	4	2
2	18ME1002	Engineering Graphics Laboratory (AutoCAD)	0	0	2	1
3	18EE1003	Basic Electrical & Electronics Engineering	3	1	0	4
4	18EE1004	Basic Electrical & Electronics Engineering Laboratory	0	0	2	1
5	18CS1001	Programming for Problem Solving	3	0	0	3
6	18CS1002	Programming for Problem Solving Lab	0	0	3	1.5
7	18ME1004	Workshop/ Manufacturing Practices Laboratory	0	0	2	1
8	18ME1003	Engineering Mechanics	3	1	0	4
9	18AE2001	Introduction to Aerospace Engineering	3	0	0	3
10	18AE2002	Aerospace Materials and Processes	3	0	0	3
					Total Credits	23.5

Humanities & Social Sciences Including Management Courses(HSMC)						
Sl.No	**Code No.**	**Subject**	**L**	**T**	**P**	**Credits**
1	18EN1001	English	2	0	0	2
2	18EN1002	English Language Lab	0	0	2	1
3	18MS2012	Engineering Economics	3	0	0	3
5	18ME2074	Operations Research	3	0	0	3
6	18ME2075	Technical Aptitude	1	0	0	1
7		Constitution of India	0	0	0	0
8	18CH2001	Environmental Sciences	0	0	0	0
					Total Credits	10

Professional Core Courses(PCC)						
Sl.No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	18AE2003	Basics of Fluid Mechanics	3	0	0	3
2	18AE2004	Fluid Mechanics Laboratory	0	0	2	1
3	18AE2005	Strength of Materials	3	0	0	3
4	18AE2006	Strength of Materials Laboratory	0	0	2	1
5	18AE2007	Thermodynamics	3	0	0	3
6	18AE2008	Thermodynamics Laboratory	0	0	2	1
7	18AE2009	Aerodynamics	3	0	0	3
8	18AE2010	Aerospace Structures-I	3	0	0	3
9	18AE2011	Propulsion-I	3	0	0	3
10	18AE2012	Propulsion Laboratory	0	0	3	1.5
11	18AE2013	Airplane performance	3	0	0	3
12	18AE2014	Gas dynamics	3	0	0	3
13	18AE2015	Aerodynamics Laboratory	0	0	3	1.5
14	18AE2016	Aerospace Structures-II	3	0	0	3
15	18AE2017	Aerospace Structures Laboratory	0	0	3	1.5
16	18AE2018	Propulsion-II	3	0	0	3
17	18AE2019	Aircraft Stability and Control	3	0	0	3
18	18AE2020	Flight Stability and Aeromodelling Laboratory	0	0	2	1
19	18AE2021	CAD/CAM Laboratory	0	0	3	1.5
20	18AE2022	Aircraft Instrumentation & Avionics	3	0	0	3
21	18AE2023	Navigation, Guidance and Control of Aerospace Vehicles	3	0	0	3
22	18AE2024	Aircraft Instrumentation & Control Laboratory	0	0	3	1.5
23	18AE2025	Space Dynamics	3	0	0	3
24	18AE2026	Aircraft Design Project	0	0	4	2
25	18AE2027	Heat and Mass Transfer	3	0	0	3
					Total Credits	58.5

Professional Elective Courses(PEC)						
Sl.No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	18AE2028	Computational Fluid Dynamics	3	0	0	3
2	18AE2029	Computational Fluid Dynamics Laboratory	0	0	2	1
3	18AE2030	Boundary layers	3	0	0	3
4	18AE2031	Applied Aerodynamics	3	0	0	3
5	18AE2032	Applied Aerodynamics Laboratory	0	0	2	1

6	18AE2033	Introduction to Hypersonic Flows	3	0	0	3
7	18AE2034	Wind tunnel Techniques	3	0	0	3
8		Helicopter Aerodynamics	3	0	0	3
9	18AE2036	Aeroacoustics	3	0	0	3
10	18AE2037	Aerothermodynamics	3	0	0	3
11	18AE2038	Finite Element Analysis	3	0	0	3
12	18AE2039	Finite Element Analysis Laboratory	0	0	2	1
13	18AE2040	Manufacturing Technology	3	0	0	3
14	18AE2041	Manufacturing Laboratory	0	0	2	1
15	18AE2042	Theory of elasticity	3	0	0	3
16	18AE2043	Experimental Stress Analysis	3	0	0	3
17	18AE2044	Design and Analysis of Composite Structures	3	0	0	3
18	18AE2045	Introduction to Non Destructive Testing	3	0	0	3
19	18AE2046	Fatigue and Fracture Mechanics	3	0	0	3
20	18AE2047	Structural Dynamics and Aeroelasticity	3	0	0	3
21	18AE2048	Cryogenic Propulsion	3	0	0	3
22	18AE2049	Fundamental of Combustion	3	0	0	3
23	18AE2050	Combustion Laboratory	0	0	2	1
24	18AE2051	Solar Thermal Energy	3	0	0	3
25	18AE2052	Rocket and Missiles	3	0	0	3
26	18AE2053	Advanced Heat Transfer	3	0	0	3
27	18AE2054	Aero Engine Maintenance and Repair	3	0	0	3
28	18AE2055	Advanced Space Dynamics	3	0	0	3
29	18AE2056	Space Mission Design and Optimization	3	0	0	3
30	18AE2057	Air Traffic Control and Aerodrome Details	3	0	0	3
31	18AE2058	Unmanned Aircraft Systems	3	0	0	3
32	18AE2059	Optimization Techniques in Engineering	3	0	0	3
33	18AE2060	Aircraft Systems	3	0	0	3
					Total Credits	**17**

Open Elective Courses(OEC)*

Sl.No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	18AE2061	Basics of Aerospace Engineering	3	0	0	3
2	18AE2062	Road Vehicle Aerodynamics	3	0	0	3
3	18AE2063	Wind Turbine Design	3	0	0	3
4	18AE2064	Building Aerodynamics	3	0	0	3
5	18AE2065	Introduction to Unmanned Aircraft System	3	0	0	3
6	18AE2066	Space Engineering	3	0	0	3

*for other departments students.
Aerospace students will be take 9 credits of Open Elective Courses offered by other department.

Internship/ Industrial Training & Project Work (ISP)

Sl.No	**Code No.**	**Name of the Course**	**L**	**T**	**P**	**Credits**
1	ITP2901	Internship/ Industrial Training-I	-	-	-	1
2	ITP2902	Internship/ Industrial Training-II	-	-	-	1

3	MP2951	Mini- Project	-	-	-	2
4	18AE2997	Project Work-Literature Survey	-	-	-	3
5	18AE2998/ 2299	Project Work (Part Semester/Full Semester)	-	-	-	5/10
					Total Credits	15

SEMESTER-WISE CURRICULUM

SEMESTER-I

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	BSC	18MA1001	Calculus and Linear Algebra	3	1	0	4	4
2	BSC	18PH2001	Engineering Physics Engineering Physics - Electromagnetism, Optics and Properties of Matter	3	1	0	4	4
3	BSC	18PH2001	Engineering Physics - Electromagnetism, Optics and Properties of Matter Lab	0	0	3	3	1.5
4	ESC	18CS1001	Programming for Problem Solving	3	0	0	3	3
5	ESC	18CS1002	Programming for Problem Solving Lab	0	0	3	3	1.5
6	HSMC	18EN1001	English	2	0	0	2	2
7	HSMC	18EN1002	English Language Lab	0	0	2	2	1
8	ESC	18ME1004	Workshop/ Manufacturing Practices Laboratory	0	0	2	2	1
						Total Contact Hours per Week	**25**	
						Total Credits		**18**

SEMESTER-II

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	BSC	18MA1008	Ordinary Differential Equations, Complex Variables	3	1	0	4	4
2	BSC	18CH1003	Engineering Chemistry	3	1	0	4	4
3	BSC	18CH1002	Applied Chemistry Laboratory	0	0	3	3	1.5
4	ESC	18ME1003	Engineering Mechanics	3	1	0	4	4
5	ESC	18AE2001	Introduction to Aerospace Engineering	3	0	0	3	3
6	ESC	18ME1001	Engineering Drawing	0	0	4	4	2
7	ESC	18ME1002	Engineering Graphics Laboratory(AutoCAD)	0	0	2	2	1
8	ESC	18EE1003	Basic Electrical & Electronics Engineering	3	1	0	4	4
9	ESC	18EE1004	Basic Electrical & Electronics Engineering Laboratory	0	0	2	2	1
						Total Contact Hours per Week	**28**	
						Total Credits		**24.5**

SEMESTER-III

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	BSC	18MA2005	Partial Differential Equations, Probability and Statistics	3	1	0	4	4
2	PCC	18AE2003	Basic of Fluid Mechanics	3	0	0	3	3
3	PCC	18AE2004	Fluid Mechanics Laboratory	0	0	2	2	1
4	PCC	18AE2005	Strength of Materials	3	0	0	3	3

5	PCC	18AE2006	Strength of Materials Laboratory	0	0	2	2	1
6	PCC	18AE2007	Thermodynamics	3	0	0	3	3
7	PCC	18AE2008	Thermodynamics Laboratory	0	0	2	2	1
8	HSMC	18MS2012	Engineering Economics	3	0	0	3	3
9	ESC	18AE2002	Aerospace Materials and Processes	3	0	0	3	3
						Total Contact Hours per Week	**22**	
						Total Credits		**22**

SEMESTER-IV

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	BSC	18MA2014	Numerical Methods and Computing	3	1	0	4	4
2	PCC	18AE2009	Aerodynamics	3	0	0	3	3
3	PCC	18AE2010	Aerospace Structures-I	3	0	0	3	3
4	PCC	18AE2011	Propulsion-I	3	0	0	3	3
5	PCC	18AE2012	Propulsion Laboratory	0	0	3	3	1.5
6	PCC	18AE2013	Airplane performance	3	0	0	3	3
7	PCC	18AE2021	CAD/CAM Laboratory	0	0	2	3	1.5
8	PCC	18AE2025	Space Dynamics	3	0	0	3	3
9	**MC**	18CH2001	Environmental Sciences	0	0	0	0	0
						Total Contact Hours per Week	**27**	
						Total Credits		**22**

SEMESTER-V

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	PCC	18AE2014	Gas dynamics	3	0	0	3	3
2	PCC	18AE2015	Aerodynamics Laboratory	0	0	3	3	1.5
3	PCC	18AE2016	Aerospace Structures-II	3	0	0	3	3
4	PCC	18AE2017	Aerospace Structures Laboratory	0	0	3	3	1.5
5	PCC	18AE2018	Propulsion-II	3	0	0	3	3
7	PCC	18AE2019	Aircraft Stability and Control	3	0	0	3	3
8	PCC	18AE2020	Flight Stability and Aeromodelling Laboratory	0	0	2	2	1
9	PCC	18AE2022	Aircraft Instrumentation & Avionics	3	0	0	3	3
10	OEC		Open Elective Courses-I	3	0	0	3	3
11	ISP	ITP2901	Internship/ Industrial Training-I	15 Days				1
12	**MC**	MEMC-II	Constitution of India	0	0	0	3	0
						Total Contact Hours per Week	**29**	
						Total Credits		**23**

SEMESTER-VI

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	PCC	18AE2027	Heat and Mass Transfer	3	0	0	3	3
2	PEC		Professional Elective Courses-1	3	0	0	3	3
3	PEC		Professional Elective Courses-2	0	0	2	2	1
4	PEC		Professional Elective Courses-3	3	0	0	3	3
5	PEC		Professional Elective Courses-4	3	0	2	2	1
6	OEC		Professional Elective Courses-5	3	0	0	3	3
7	OEC		Open Elective Courses-II	3	0	0	3	3
8	HSMC	18ME2075	Technical Aptitude	1	0	0	1	1
9	PCC	18AE2026	Aircraft Design Project	0	0	4	4	2
						Total Contact Hours per Week	**20**	

								Total Credits	20

SEMESTER-VII

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	HSMC	18ME2074	Operations Research	3	0	0	3	3
2	PCC	18AE2023	Navigation, Guidance and Control of Aerospace Vehicles	3	0	0	3	3
3	PCC	18AE2024	Aircraft Instrumentation & Control Laboratory	0	0	3	3	1.5
4	PEC		Professional Elective Courses-5	3	0	0	3	3
5	PEC		Professional Elective Courses-6	3	0	0	3	3
6	PEC		Open Elective Courses-III	3	0	0	3	3
7	ISP	18AE2997	Project Work-Literature Survey	-	-	-	5	3
8	ISP	ITP2902	Internship/ Industrial Training-II	15 days				1
			Total Contact Hours per Week				**26**	
							Total Credits	**20.5**

SEMESTER-VIII

Sl.No	Category	Code No.	Name of the Course	L	T	P	TCH	Credits
1	ISP	18AE2999	Project Work – Full Semester	-	-	-	40	10
2	ISP	18AE2998	Project Work – Part Semester				20	5
							Total Credits	10/5

Table AE-2
LIST OF COURSES

Sl.No	Code No.	Name of the Course	L	T	P	Credits
1	18AE2001	Introduction to Aerospace Engineering	3	0	0	3
2	18AE2002	Aerospace Materials and Processes	3	0	0	3
3	18AE2003	Basic of Fluid Mechanics	3	0	0	3
4	18AE2004	Fluid Mechanics Laboratory	0	0	2	1
5	18AE2005	Strength of Materials	3	0	0	3
6	18AE2006	Strength of Materials Laboratory	0	0	2	1
7	18AE2007	Thermodynamics	3	0	0	3
8	18AE2008	Thermodynamics Laboratory	0	0	2	1
9	18AE2009	Aerodynamics	3	0	0	3
10	18AE2010	Aerospace Structures-I	3	0	0	3
11	18AE2011	Propulsion-I	3	0	0	3
12	18AE2012	Propulsion Laboratory	0	0	3	1.5
13	18AE2013	Airplane performance	3	0	0	3
14	18AE2014	Gas dynamics	3	0	0	3
15	18AE2015	Aerodynamics Laboratory	0	0	3	1.5
16	18AE2016	Aerospace Structures-II	3	0	0	3
17	18AE2017	Aerospace Structures Laboratory	0	0	3	1.5
18	18AE2018	Propulsion-II	3	0	0	3
19	18AE2019	Aircraft Stability and Control	3	0	0	3
20	18AE2020	Flight Stability and Aeromodelling Laboratory	0	0	2	1
21	18AE2021	CAD/CAM Laboratory	0	0	3	1.5
22	18AE2022	Aircraft Instrumentation & Avionics	3	0	0	3

23	18AE2025	Space Dynamics	3	0	0	3
24	18AE2026	Aircraft Design Project	0	0	4	2

18AE2001	INTRODUCTION TO AEROSPACE ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

1. To introduce the basic concepts of aircrafts, rockets and their functions.
2. To give an introduction on aerodynamics, aircraft structure and aircraft propulsion.
3. To provide knowledge about the basic parts and their function and construction details of aerospace vehicles.

Course Outcomes:

After completing the course the student will be able to

1. Understand the nature of aerospace technologies.
2. Identify the different types of Aircraft components and their functions.
3. Assess the forces and moments due to flow over the aircraft components.
4. Apply the principles of aerodynamics to different parts of an aeroplane.
5. Evaluate the performance of propulsion system.
6. Apply the knowledge of gravitational law, Kepler's law and Newton's law to the space vehicle

MODULE 1: HISTORICAL EVOLUTION AND STANDARD ATMOSPHERE (8 LECTURE HOURS)

History of aviation, History and Mission of Indian Space Research Organization, National Aerospace Laboratories(NAL), Gas Turbine Research Establishment (GTRE), Hindustan Aeronautics Limited (HAL)& Defence Research and Development Organisation. Different types of flight vehicles and Classifications, Components of an airplane and their functions, Standard atmosphere-Isothermal layer and gradient layer.

MODULE 2: PRINCIPLES OF FLIGHT (8 LECTURE HOURS)

Basic aerodynamics, Aerofoils, wings and their nomenclature; lift, drag and pitching moment coefficients, centre of pressure and aerodynamic centre, NACA airfoil nomenclature.

MODULE 3: AEROSPACE STRUCTURES (8 LECTURE HOURS)

General types of construction, Types of structure, typical wing and fuselage structure-monocoque-Semi-monocoque, Honeycomb and Sandwich structure, Aircraft materials.

MODULE 4: PROPULSION SYSTEMS (7 LECTURE HOURS)

Principles of Thrust generation, Reciprocating engine, propeller, turboprop engine, Basic ideas about jet propulsion, Types of jet engines - turbofan and turbojet engines.

MODULE 5: ROCKETS & MISSILES (7 LECTURE HOURS)

Principles of operation of rocket, Rocket engine-specific impulse, Rocket equation, Single and Multi-stage rockets, Types of Rockets, Types of Missiles. Rocket and Missile developed by India.

MODULE 6: SPACE FLIGHT (7 LECTURE HOURS)

Introduction to space mission, Kepler's, laws, Introduction to earth and planetary entry.

Text Books:

1. Anderson, J.D., "Introduction to Flight", Tata McGraw-Hill, sixth Edition, 2013
2. Kermode A C., "Mechanics of Flight", Pearson Education Low Price Edition, 2005.

Reference:

1. Kermode, A.C., "Flight without Formulae", McGraw-Hill, 1997.
2. Sutton, G.P. "Rocket Propulsion Elements", John Wiley,
3. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
4. Megson, T.M.G., "Aircraft Structures for Engineering Students", 2007

5. Howard D. Curtis, “Orbital Mechanics for Engineering Students”, Elsevier Butterworth-Heinemann, Third Edition, 2010.
6. https://www.hal-india.co.in, https://www.isro.gov.in, https://www.nal.res.in, https://www.ada.gov.in , https://www.drdo.gov.in
7. https://www.grc.nasa.gov/WWW/K-12/UEET/StudentSite/aeronautics.html
8. https://en.wikipedia.org/wiki/History_of_aviation

		L	T	P	C
18AE2002	**AEROSPACE MATERIALS AND PROCESSES**	**3**	**0**	**0**	**3**

Course Objectives:
1. To impart the knowledge on crystal structure and microstructures of metals and alloys
2. To impart the knowledge on Aerospace Materials properties
3. To impart the knowledge on Material Characterisation

Course Outcomes:
After completing the course the student will be able to
1. Explain how the mechanical properties of metals and alloys are influenced by their microstructure
2. Understand the material properties
3. Classify the different materials
4. Choose the manufacturing methods
5. Identify the testing method of materials
6. Select the right material for a particular application
7. Develop new material combination based on requirement

MODULE 1: THE STRUCTURE OF METALS AND ALLOYS & PHASE DIAGRAMS. (8 LECTURE HOURS)
Introduction, Nature of metallic bonding, Crystal structures of metals-Body centred cubic (BCC) crystal, Face centred cubic (FCC) crystal and Hexagonal close packed (HCP) crystal, structure of alloys, Imperfections in crystals, experimental study of structure. **Phase Diagrams:** The Phase rule, Binary phase diagrams, Free energy composition curves for binary systems, Microstructural changes during cooling, The Iron Carbon Equilibrium diagram, Effect of alloying elements on the Fe-C diagram, The Copper-Zinc Phase diagram.

MODULE 2: TESTING OF AIRCRAFT MATERIALS (7 LECTURE HOURS)
Basics terms: Hardness; Brittleness; Malleability; Ductility; Elasticity, Density Fusibility; Conductivity; Contraction and Expansion. *Heat-treatment Terms:* Critical Range, Annealing; Normalizing; Heat Treatment; Hardening; Quenching, Tempering'; Carburizing; Casehardening. *Physical-test Terms:* Strain; Stress; Tensile Strength; Elastic Limit; Proportional Limit; Proof Stress; Yield Strength: Yield Point; Elongation (Percentage); Reduction of Area (Percentage); Modulus of Elasticity. **Testing**: Tension Testing, Hardness Testing Bending Tests, Reverse Bend Test, Flattening Test, Impact Tests: Crushing Tests, Hydrostatic Test, Torsion Test, Fatigue Testing, Inspection Methods: NDT. ASTM. Standards for testing materials.

MODULE 3: STEEL AND ITS ALLOYS (8 LECTURE HOURS)
Plain Carbon Steels, Alloy Steels, Effect of Individual Elements: Carbon; Manganese; Silicon, Sulphur; Phosphorus; Nickel; Chromium; Molybdenum; Vanadium; Tungsten; Titanium, S.A.E. Steel Numbering System, Air Force-Navy Aeronautical Specifications, Military specifications. Carbon Steels, Nickel Steels, Nickel-chromium Steels, Molybdenum Steels, Chrome-vanadium Steels, Special Steels: Silicon-chromium Steel; Nitriding Steel; Austenitic Manganese Steel. Heat Treatment of Steel.

MODULE 4: NICKEL, COPPER AND ITS ALLOYS (8 LECTURE HOURS)
Inconel, Monet, K Monet: Chemical Properties; Physical Properties; Annealing and Stress Relieving; Working Properties; Welding; Soldering and Brazing; Corrosion Resistance: Available Shapes; Uses, Specifications. **Copper:** Copper Tubing; Copper-Silicon-Bronze Tubing; Copper Wire; Beryllium Copper. **Brass:** Muntz Metal; Manganese Bronze (Brass); Hy-Ten-SI Bronze; Naval Brass (Tobin Bronze); Red Brass. **Bronze:** Gun Metal; Phosphor Bronze; Phosphor Bronze Casting Alloy;

Aluminum Bronze; Aluminum Bronze Casting Alloy; Bronze Cable, Season Cracking. **Pure Magnesium**: Production Methods; Physical Properties,

MODULE 5: MAGNES1UM, TITANIUM AND ITS ALLOYS (7 LECTURE HOURS)

Magnesium Alloys: Chemical Composition, Magnesium-alloy. Wrought Magnesium Alloys: Extrusions; Forgings; Sheet, Plate, Strip Shop Fabrication Processes: Machining; Shearing. **Titanium:** Physical Properties: Metallurgy; Chemical Composition; Specifications; Mechanical Properties; Elevated Temperature. Shape memory alloys.

MODULE 6: WROUGHT ALUMINUM ALLOYS (7 LECTURE HOURS)

Nomenclature, Classification of Wrought Alloys, Corrosion, Alclad Aluminum Alloys, Extrusions, Forgings, Spot-welding Aluminum Alloys, Heat Treatment: Heat Treatment of Aluminum-Alloys, **Aluminum-Alloy Castings:** Sand Casting: Applications. Permanent-mold Castings: Applications. Die Casting. Design of Castings: Heat-treated Castings.

Text Book:

1. Raghavan, V. ―Physical Metallurgy: Principles and Practice‖. PHI Learning, 2015.
2. George F. Titterton, "Aircraft Materials and Processes" Himalayan Books, reprinted 2015.

References:

1. Cantor, B., Assender, H., and Grant, P. (Eds.), Aerospace Materials, CRC Press 2001.
2. Reed, R. C., The Superalloys: Fundamentals and Applications, Cambridge Univ. Press 2006.
3. ASM Speciality Handbook: Heat Resistant Materials, ASM International (1997).
4. Campbell, F. C., Manufacturing Technology for Aerospace Structural Materials, Elsevier 2006.
5. Kainer, K. U. (Ed.), Metal Matrix Composites, Wiley-VCH 2006.
6. https://www.astm.org/Standards/aerospace-material-standards.html

18AE2003	**BASICS OF FLUID MECHANICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Course Objectives:

1. To introduce the basic concepts of fluid statics
2. To provide knowledge of basic laws governing fluid motion and its application
3. To introduce the concept of basic airflow

Course Outcomes:

After completing the course the student will be able to

1. Know the properties of different fluids and pressure measurements
2. Apply mathematical knowledge to predict the properties and characteristics of a fluid.
3. Understand the nature of buoyancy of submerged and floating bodies
4. Attain the Knowledge of flow measurement systems
5. Estimate the friction factor of pipe flow and losses associated it
6. Get knowledge of the non-dimensional parameters used in airflow.

MODULE 1: BASICS OF FLUID FLOW (8 LECTURE HOURS)

Definition of a fluid – Continuum hypothesis – Fluid properties - Pressure, Temperature, Density, Viscosity - stress-strain rate relationship, Measurement of pressure –Fluid statics – Total and Centre of pressure of submerged surfaces-Stability of submerged and floating bodies.

MODULE 2: BASIC EQUATIONS (8 LECTURE HOURS)

Motion of a fluid particle – Types of flow-Continuity equation-Velocity and acceleration-velocity potential and stream function- Path lines, Stream lines and Streak lines,-Fluid deformation– Rotation-Vorticity, Elementary flows- Uniform flow, Source flow, Sink flow, Doublet flow, Vortex flow, Super imposed flows- Semi-Infinite Body, Rankine Body.

MODULE 3: INCOMPRESSIBLE INVISCID FLOW (8 LECTURE HOURS)

Equations of motion-Euler's equation of motion- Energy equation-Momentum equation – Bernoulli's equation and its Applications –– Flow measurement – Orifice meter – Venturimeter- Pitot tube.

MODULE 4: INCOMPRESSIBLE VISCOUS FLOW(7 LECTURE HOURS)

D' Alembert's Paradox, Viscous stress-strain rate relationship, Flow of viscous fluid through circular pipes – Velocity profiles – Frictional loss in pipe flow-Calculation of minor and major energy losses in pipes.

MODULE 5: DIMENSIONAL ANALYSIS (7 LECTURE HOURS)

Dimensional analysis – The Buckingham-Pi theorem – Nondimensional numbers-Mach Number, Reynolds Number, Strouhal Number, Knudsen Number, etc.,

MODULE 6: IMPACT OF JETS (7 LECTURE HOURS)

Impact of jets –Force exerted by a jet on stationary and moving vertical, horizontal and inclined plates.

Text Books:

1. Rathakrishnan.E, "Fundamentals of Fluid Mechanics", Prentice-Hall, 2007
2. White F.M., "Fluid Mechanics", 7th Edition, Tata McGraw-Hill Education, 2011

References:

1. Robert W Fox & Alan T Mc.Donald, "Introduction to fluid Mechanics", John Wiley and Sons,1995
2. Kuethe, A.M. and Chow, C.Y., "Foundations of Aerodynamics", First Indian Reprint, John Wiley & Sons, 2010.
3. Yuan S W, "Foundations of fluid Mechanics", Prentice-Hall, 1987
4. Graebel, W.P. "Engineering Fluid Mechanics" Taylor and Francis, 2001
5. Fluid Mechanics : http://nptel.ac.in/courses/112105171/
6. Fluid Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/fluid-mechanics/

		L	T	P	C
18AE2004	**FLUID MECHANICS LAB**	**0**	**0**	**2**	**1**

Co- requisite: 18AE2003 Basics of Fluid Mechanics

Course Objectives:

1. To give hands on training on principle and working of different flow measuring instruments
2. To impart knowledge on working of different types of turbines.
3. To demonstrate energy losses in pipe connections

Course Outcomes:

After completing the course the student will be able to

1. Recall the principles of instruments used in flow related measurements
2. Describe the flow measurement methods
3. Demonstrate energy losses in pipe connections
4. Appraise the flow measurement techniques
5. Select flow measuring techniques.
6. Investigate the operation of flow measuring instruments

List of Experiments

1. Determination of Darcy's Friction Factor.
2. Calibration of Flow Meters.
3. Flow over weirs / Notches.
4. Flow through Mouth piece / orifice.
5. Determination of Minor Losses in pipes
6. Determination of Manning's Co-efficient of Roughness.
7. Calibration of pressure Gauges.
8. Impact of jet on vanes.
9. Reynolds' Experiment.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

18AE2005	STRENGTH OF MATERIALS	L	T	P	C
		3	0	0	3

Course Objectives:

1. To provide an understanding the concepts of stress and strain, Shear force and Bending moment
2. To provide knowledge regarding the methods of determining the deflections of beams and Torsion of shaft
3. To impart basic knowledge about Joints and springs

Course Outcome:

After completing the course the student will be able to

1. Understand the basic material behaviour like elasticity, plasticity etc.
2. Draw the shear force and bending moment diagram for different loading of beams
3. Predict the deflection of beams under bending loads
4. Arrive at the methods to solve torsional problems
5. Analysis of a spring under different load condition
6. Identify the structural Joints for Aircraft repair in different applications

MODULE 1: STRESSES AND STRAINS (7 LECTURE HOURS)

Introduction, types of structures, Elasticity, Plasticity, loads and stresses , Hooke's law, stress-strain curve, Analysis of bars of varying sections, Analysis of bars of composite sections, thermal stresses, thermal stresses in composite bars, elastic constants ; Principle planes and stresses, Analytical and graphical methods for determining stresses on oblique section.

MODULE 2: SHEAR FORCE AND BENDING MOMENT DIAGRAM (10 LECTURE HOURS)

Types of beams, important points for drawing shear force and bending moment diagram, Shear force and bending moment for different beams carrying point load, uniformly distributed load, gradually varying loads and combinations of these at different sections of the beam.

MODULE 3: DEFLECTION OF BEAMS (10 LECTURE HOURS)

Simple bending, Theory of simple bending, Expression for bending stress, bending stress in symmetrical section, Relation between deflection, slope and radius of curvature, Methods for determining deflection- Double integration method, Macaulay's method and Moment Area method.

MODULE 4: TORSION OF SHAFTS (7 LECTURE HOURS)

Shear stress produced in a shaft subjected to torsion, torque and power transmitted by a solid and circular shaft, Strength of a shaft and Polar moment of inertia, Torque in terms of polar moment of inertia, strength of a shaft of varying sections and composite shaft, combined bending and torsion, strain energy stored in a body due to torsion.

MODULE 5: SPRINGS & JOINTS (7 LECTURE HOURS)

Stiffness of a spring, Types of spring, Closely-coiled Helical Springs- Axial load- Axial twist, Open coiled helical spring, Torsion spring – Problems. Types of Structural joints, bonded joints, Bolted joints- Riveted Joints, Aircraft Structural Repair Joints.

MODULE 6: THEORIES OF FAILURE (4 LECTURE HOURS)

Introduction, Maximum principal stress theory, Maximum principal strain theory, Maximum shear stress theory, Maximum strain energy theory, Maximum shear strain energy theory.

Text Books:

1. Stephen Timoshenko, "Strength of Materials: Elementary Theory and Problems", 3rd edition, CBS Publishers &Distributors PVT.LTD.
2. James M. Gere, Barry J. Goodno, "Mechanics of Materials", 8th edition, Cengage Learning, 2007

References:

1. Rajput R K, "Strength of Materials", S Chand & Co Ltd, New Delhi, 2006
2. Sun C T, " Mechanics of Aircraft Structures", Wiley, India, 2010
3. Dr Sadhu Singh, "A Textbook on Strength of Materials", Khanna Publishers Pvt. Ltd**,** New Delhi , 2013

4. Bansal R K., “Strength of Materials”, Laxmi Publishing Co, New Delhi, 2007
5. Ramamurtham.S. “Strength of Materials” Dhanpat Rai Publishing Co, New Delhi, 2008.
6. http://nptel.ac.in/courses/Webcourse-contents/IIT-ROORKEE/strength%20of%20materials/homepage.htm

18AE2006	STRENGTH OF MATERIALS LABORATORY	L	T	P	C
		0	0	2	1

Co- requisite: 18AE2005 Strength of Materials

Course Objective

1. To apply the theory of structural mechanics on real specimens
2. To give hands on training on testing of real specimens
3. To provide knowledge in failure of material

Course Outcome

After completing the course the student will be able to

1. Determine the important mechanical properties of materials
2. Identify the materials behavior
3. Verify the theorems studied in structural mechanics
4. Understand the structural behavior based on various loads, supports and shape
5. Estimate stiffness of springs
6. Choose material based on requirement

Experiments

1. Tensile Test of solid rod using Universal Testing Machine
2. Verification of Maxwell Theorem on Cantilever Beam
3. Verification of Maxwell Theorem on Simply Supported Beam
4. Torsion Test of shaft and Beam
5. Rockwell’s Hardness Test
6. Brinell’s Hardness Test
7. Vickers Hardness Test
8. Charpy’s Impact test
9. Izod Impact Test
10. Compression of open coil helical spring

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

References:

1. Jindal, U.C, “Strength of Materials”, Asian Books Pvt. Ltd, 2007

18AE2007	THERMODYNAMICS	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to make students to learn:

1. To impart the knowledge of work, heat, and laws of thermodynamics.
2. To impart the knowledge of the concept of entropy and exergy
3. To impart the knowledge of the working of gas turbine cycles

Course Outcomes:

After completing the course the student will be able to

1. Define fundamental thermodynamic laws and concepts, work, various types of works and heat and its applications,
2. Explain Zeroth, First & Second law of thermodynamics and its applications.
3. Explain entropy and Exergy in thermodynamic systems
4. Calculate the performance of various gas power cycles.

5. Explain the principles of combustion in engines
6. Explain the selection of air conditioning system; evaluate thermal performance of refrigeration cycles.

MODULE 1: FUNDAMENTALS OF THERMODYNAMICS (9 LECTURES HOURS)

Thermodynamic definition and scope, Microscopic and Macroscopic approaches. Thermodynamic properties; definition and units, intensive, extensive properties, specific properties, pressure, specific volume, Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic; processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium,

Work and Heat: Thermodynamic definition of work; examples, sign convention, Shaft work; Electrical work. Other types of work. Heat; definition, units and sign convention.

MODULE 2: THERMODYNAMIC LAWS (8 LECTURE HOURS)

Laws of Thermodynamics Zeroth law of thermodynamics, Temperature; concepts, scales, - thermometer - Joules experiments, Statement of the First law of thermodynamics, steady state-steady flow energy equation, applications, analysis of unsteady processes. Keivin –Planck & Clausius statement of Second law of Thermodynamics, PMM I and PMM II. Clausius Theorem & inequality, Available and unavailable energy.

MODULE 3: ENTROPY (7 LECTURE HOURS)

Entropy : Increase of Entropy principle – Entropy change in Pure substances – Isentropic Processes – Property diagrams – Entropy change of liquids and solids - Ideal gases and Entropy change – Isentropic efficiencies of steady flow devices – Entropy Balance.

MODULE 4: GASES AND GAS MIXTURES (7 LECTURE HOURS)

Avogadro's law – equation of state of a gas – Ideal gas – Equations of state – virial expansions – law of corresponding states – Properties of mixtures – Law of partial pressures – Properties of gas mixtures

MODULE 5: COMBUSTION THERMODYNAMICS AND GAS POWER CYCLES (7 LECTURE HOURS)

Fuels and combustion – Theoretical and Actual combustion – Enthalpy of formation and combustion – Adiabatic flame temperature. **Gas power cycles** : Basic considerations – Carnot cycle – Air standard cycles and assumptions – Otto cycle – Diesel Cycle – Brayton cycle – with regeneration – with inter cooling, reheat and regeneration – ideal jet propulsion cycles

MODULE 6: REFRIGERATION AND PSYCHROMETRY (7 LECTURE HOURS)

Refrigeration: Vapour absorption refrigeration system, vapor compression refrigeration system; description, analysis, refrigerating effect, capacity, power required, units of refrigeration, COP, Refrigerants and their desirable properties. **Psychrometry:** Dry bulb temperature, wet bulb temperature, dew point temperature; specific and relative humidity - psychrometric processes; heating, cooling, dehumidifying and humidifying. Adiabatic mixing of moist air. Summer and winter air conditioning.

Text Books:

1. Nag. P. K, Engineering Thermodynamics, Tata McGraw Hill Pub. 5th Edition, 2013.
2. Yunus, A. Cenegal and Michael A.Boies, Thermodynamics: An engineering approach, Tata MacGraw Hill publishing company, Seventh Edition 2011.

References:

1. Holman J. P, Thermodynamics, McGraw Hill, Fifth edition, 2007
2. Rathakrishnan.E, Fundamentals of Engineering Thermodynamics, Prentice-Hall, India, 2005.
3. Arora C. P, Thermodynamics, McGraw Hill, 2003.
4. Ramalingam K K, Thermodynamics, Sci-Tech Publications, 2006.
5. Van Wylen G J and R.E. Sontang, Fundamental of Classical Thermodynamics, Wiley eastern, third edition, 1985.
6. Basic Thermodynamics: http://nptel.ac.in/courses/112105123/
7. https://www.grc.nasa.gov/WWW/K-12/airplane/thermo.html
8. https://www.edx.org/course/thermodynamics-iitbombayx-me209-1x-1
9. Combustion: http://nptel.ac.in/courses/101106037/

18AE2008	THERMODYNAMICS LABORATORY	L T P C 0 0 2 1

Co-requisite: 18AE2007 Thermodynamics
Course Objectives:
1. To impart the knowledge of laws of thermodynamics
2. To give hands on training to Estimate the performance of thermodynamics system
3. To impart knowledge on working of IC Engines.

Course Outcomes:
After completing the course the student will be able to
1. Estimate the performance of Heat pump,
2. Estimate the performance of Refrigerator
3. Estimate the performance of Air-conditioning
4. Measure the performance of compressors and draw the characteristic curves
5. Measure the performance of blowers and draw the characteristic curves blowers
6. Study the valve timing and port timing of IC engines

List of Experiment:
1. Determination of COP of Heat pump
2. Determination of Performance of Refrigeration
3. Determination of Performance of Air compressor
4. Performance characteristics of Compressor
5. Performance of Blower
6. Performance test on IC engine
7. Heat balance test on IC engine
8. Valve timing diagram of Four stroke Engine
9. Port timing diagram of Two stroke engine
10. Study of Nozzle and Diffuser

The faculty conducting the Laboratory will prepare a list of minimum 6 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

18AE2009	AERODYNAMICS	L T P C 3 0 0 3

Prerequisite: 18AE2003 Basics of Fluid Mechanics
Course Objectives:
1. To impart knowledge of basics of air flow
2. To provide details regarding the flow over aerofoils and wings
3. To impart knowledge of forces and moments over an aerofoil

Course Outcomes:
After completing the course the student will be able to
1. Understand the aerodynamic variable connected with airflow
2. Apply the conservation laws for given aerodynamic situation
3. Analyse the basic flows satisfying the governing equations
4. Assess the flow field over the aerofoils
5. Estimate the flow over aircraft wings and Fuselage
6. Evaluate the forces and moments over vehicles utilizing different kinds of flows

MODULE 1: BASICS OF AIR FLOW (8 LECTURE HOURS)
Fundamental Aerodynamic variables, Aerodynamic forces and moments, Centre of pressure, Aerodynamics Centre, Types of flow, Gradient of Scalar and vector fields, Line, surface and volume

integrals and the relationships between them. Continuity equation. Momentum equation and drag of a two dimensional body. Energy equation

MODULE 2: FLUID FLOW (8 LECTURE HOURS)

Euler's and Bernoulli's equations. Pitot tube, Pressure co-efficient. Stream function, Velocity potential and their relationship. Laplace Equation and relationship with continuity equation, Path lines, Stream lines and Streak lines, Overview of Elementary flows, non-lifting and lifting flow over cylinders. Kutta – Joukowski theorem and generation of lift.

MODULE 3: INCOMPRESSIBLE FLOW OVER AIRFOIL (8 LECTURE HOURS)

Joukowski transformation and conformal mapping. -Airfoil characteristics. Airfoil Nomenclature. The vortex sheet. The Kutta condition. Kelvin's circulation theorem. Introduction to classical thin airfoil theory – symmetric and cambered airfoil.

MODULE 4: INCOMPRESSIBLE FLOW OVER FINITE WINGS (7 LECTURE HOURS)

Down wash and induced drag. Vortex filament, Helmholtz theorems. Biot-Savart law, Introduction to Prandtl's lifting line theory and Elliptic lift distribution.

MODULE 5: NUMERICAL METHODS (7 LECTURE HOURS)

2-D Panel Methods-Source panel method-vortex panel methods, Vortex Lattice Methods.

MODULE 6: BOUNDARY LAYERS (7 LECTURE HOURS) Introduction to Boundary Layers and Reynolds number effects. Development of Boundary Layer equations. Boundary layer thickness-Displacement thickness – Momentum Thickness – Energy Thickness. Momentum integral theorem and applications.

Text Books:

1. John D. Anderson, Jr., "Fundamentals of Aerodynamics", Fifth edition, McGraw-Hill publications, 2010
2. E.Rathakrishnan., "Theoretical Aerodynamics" , John Wiley & Sons, 2013

References:

1. E L Houghton and PW Carpenter, "Aerodynamics for Engineering students", Sixth edition, Edward Arnold publications, 2012
2. L.M Milne Thomson, "Theoretical Aerodynamics", 1996
3. Jan Roskam, Chuan-Tau Edward Lan, Airplane Aerodynamics and Performance, DAR Corporation, 1997
4. John J Bertin, "Aerodynamics for Engineers", Sixth edition, Edward Arnold publications, 2012
5. https://www.edx.org/course?search_query=Aerodynamics
6. http://www.nptel.ac.in/courses/101105059/
7. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-100-aerodynamics-fall-2005/

18AE2010	AEROSPACE STRUCTURES – I	L T P C 3 0 0 3

Prerequisite: 18AE2005 Strength of Materials

Course Objective:

1. To impart the knowledge of aircraft material and it behaviour.
2. To impart the knowledge on the methods of structural analysis under different types of loads.
3. To provide the knowledge on basic theory of vibrations, elasticity and failures.

Course Outcome:

After completing the course the student will be able to

1. Identify the suitable aircraft material and it behaviour
2. Apply the methods of statically determinate and indeterminate structural analysis under different conditions
3. Understand the concept of Column buckling
4. Solve the vibration problem with different DOF
5. Get the knowledge in basic theory of elasticity
6. Analyse the airframe structures

MODULE 1: INTRODUCTION TO AEROSPACE STRUCTURES ANALYSIS (5 LECTURE HOURS)
Stress strain curve- young's modulus- Poisson's ratio, basics of elasticity: Plane stress, Plane strain, Stress-Strain Relationships, Two dimensional problems, St. Venant's Principle.
MODULE 2: TRUSS (8 LECTURE HOURS)
Plane Truss Analysis – Method of Joint and Space Truss Analysis, Plane Truss-Deflection of Joints: Energy methods of analysis, Virtual Load method.
MODULE 3: BEAMS (12 LECTURE HOURS)
Beam-Shear force and Bending Moment: Maxwell's Reciprocal theorem, Claypeyron's three moment equation, Moment Distribution. Method. Castigliano's principles, Symmetrical and Unsymmetrical Bending: Stresses and deflections in beams of symmetrical and unsymmetrical sections. Stiffened Thin walled Beam.
MODULE 4: BUCKLING OF COLUMN (7 LECTURE HOURS)
Buckling of columns, Inelastic buckling, Effect of initial imperfections, Stability of beams under transverse and axial loads, Energy method for the calculation of buckling loads in columns, Flexural-torsional buckling of thin-walled columns.
MODULE 5: BASIC THEORY OF VIBRATION (8 LECTURE HOURS) Free and forced vibrations of undamped and damped SDOF systems, free vibrations of undamped 2-DOF systems-Mode shape, Oscillation of beams, Approximation methods for determining natural frequencies Problems.
MODULE 6: FATIGUE AND FRACTURE MECHANICS (5 LECTURE HOURS)
Historical background and overview-Case Study: Fatigue -Comet airplane, Different approaches to fatigue. Fracture mechanics and its implications for fatigue-Griffith fracture theory- Case study: Damage –tolerant design of aircraft fuselage.

Text Book:

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", fourth edition, Elsevier Ltd, 2010.
2. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.

References:

1. Donaldson B K, "Analysis of Aircraft Structures" Cambridge Aerospace Series, 2008.
2. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
3. Rajput R K, "Strength of Materials",S.Chand (P)LTP, 2006.
4. G Lakshmi Narasaiah "Aircraft Structures", BS Publications.,2010
5. Sun C T, " Mechanics of Aircraft Structures", Wiley India,2010
6. F.S.Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibration", Prentice Hall of India Pvt., Ltd.,New Delhi, 1988.
7. R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.
8. S.Suresh, "Fatigue of Materials", Second Edition, Cambridge University press, 2003
9. Aerospace Structural Dynamics: http://nptel.ac.in/courses/101105022/
10. Introduction to Aerospace Structures and Materials: https://www.edx.org/course/introduction-to-aerospace-structures-and-materials
11. Structural Mechanics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-20-structural-mechanics-fall-2002/

18AE2011	PROPULSION-I	L T P C 3 0 0 3

Prerequisite: 18AE2007 Thermodynamics
Course Objective:
1. To familiarize with Principles of Propulsion systems
2. To introduce working principles of Compressors and turbines
3. To familiarize with the concept of Matching of compressors and turbines and Off design performance

Course Outcome:

After completing the course the student will be able to

1. Understand the performance of air breathing engines
2. Analyse the performance of different propulsion cycles.
3. Understand the working of sub-systems of the propulsion system.
4. Assess the performance of compressor and turbine
5. Evaluate the combustion chamber, cooling and afterburner performance
6. Find the causes of under-performance and remedial measures

MODULE 1: FUNDAMENTALS OF AIR-BREATHING ENGINES (7 LECTURE HOURS)

Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, cycle analysis jet engines. Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust

MODULE 2: AIR-BREATHING ENGINES PERFORMANCE (8 LECTURE HOURS)

Efficiency and engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Principles of pulsejets and ramjets, thermodynamic cycle, performance parameters

MODULE 3: CENTRIFUGAL COMPRESSOR: (7 LECTURE HOURS)

Thermodynamics of Compressors, types of compressor, Centrifugal compressor: Centrifugal compressor stage dynamics, inducer, impeller and diffuser work done and pressure rise – Velocity diagrams.

MODULE 4: AXIAL COMPRESSOR: (7 LECTURE HOURS)

Angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reactionVelocity triangles – degree of reaction.

MODULE 5: COMBUSTION CHAMBERS: **(7 LECTURE HOURS)**

Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Fuels and their properties and Fuel injection systems, Flame tube cooling – Flame stabilization – Use of flame holders and after burners.

MODULE 6: TURBINES: (9 LECTURE HOURS)

Thermodynamics of turbines, types of turbines, principle of operation of axial and radial turbine– design considerations – performance parameters turbine stage efficiency - basics of blade design principles–choice of blade profile, pitch and chord. Impulse and reaction blading of gas turbines – velocity triangles and power output– Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – methods of blade cooling

Text Books:

1. V. Ganesan, "Gas Turbines", Tata Mc Graw - Hill Publishing Company Ltd, 2010
2. Hill, P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion", Addison – Wesley Longman INC, 1999.

References:

1. Irwin E. Treager, `Gas Turbine Engine Technology`, GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003.
2. Cohen, H, Rogers. G.F.C. and Saravanamuttoo. H.I.H., "Gas Turbine Theory", Pearson Education, 1989.
3. Oates, G.C., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.
4. Mathur. M.L, and Sharma. R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors, Delhi, 1999.
5. Jet Aircraft Propulsion: http://nptel.ac.in/courses/101101002/
6. Aerospace Propulsion: http://nptel.ac.in/courses/101106033/
7. Introduction to Propulsion Systems: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/index.htm
8. Internal Flows in Turbomachines: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-540-internal-flows-in-turbomachines-spring-2006/

18AE2012	PROPULSION LABORATORY	L T P C 0 0 3 1.5

Co-requisite: 18AE2011 Propulsion -I

Course Objectives:
1. To impart knowledge on basic concepts and operation of various parts of jet engine
2. To provide practical exposure to the operation of various propulsion systems.
3. To impart knowledge on shock waves.

Course Outcomes:

After completing the course the student will be able to
1. Analyse the working of different parts of aircraft engine
2. Estimate of calorific value of fuels
3. Understand the performance of injector.
4. Evaluate the performance of axial compressor blades
5. Estimate ignition delay of fuels using shock tube
6. Evaluate the performance of nozzle.

LIST OF EXPERIMENTS
1. Study of an aircraft jet engine
2. Estimation of calorific value of fuels
3. Study on injector calibration
4. Shock speed measurement studies
5. Ignition delay studies using shock tube.
6. Storage losses of cryogenic fluids.
7. Cascade testing of a model for axial compressor blade row (symmetrical)
8. Cascade testing of a model for axial compressor blade row(cambered)
9. Study of convective heat transfer coefficient for liquids
10. Free convection heat transfer
11. Forced convection heat transfer
12. Nozzle performance test.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 9 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

18AE2013	AIRCRAFT PERFORMANCE	L T P C 3 0 0 3

Prerequisite: 18AE2001 Introduction to Aerospace Engineering

Course Objectives:
1. To impart knowledge about the concepts of Flight performance
2. To introduce the various parameters affecting the performance
3. To introduce the various theories of propeller analysis and design

Course Outcomes:

After completing the course the student will be able to
1. Understand the preliminary design of aircraft based on the performance.
2. Differentiate performance characteristics of jet engine from propeller engine
3. Estimate the performance characteristics in level Flight
4. Assess the performance during turning maneuvers of aircraft
5. Realize the ground effects on performance
6. Estimate the pitch angle from performance characteristics of propeller and its applications

MODULE 1: BASICS OF AERODYNAMICS AND WING GEOMETRY (7 LECTURE HOURS)

Introduction - Aircraft Shape and Orientation - Effects of the Reynolds Number– Airfoil-lift - Drag Components - Drag polar, Drag Reduction Methods-High Lifting Devices. Numerical Problems

MODULE 2: EFFECTS OF ENGINE CHARACTERISTICS ON PERFORMANCE (8 LECTURE HOURS)

Introduction – Performance – Variation of Power and Specific fuel consumption with Velocity and Altitude –Reciprocating Engines – Gas Turbine Engines.

MODULE 3: PERFORMANCE CHARACTERISTICS OF LEVEL FLIGHTS (8 LECTURE HOURS)

Steady Level Flight –Fundamental Parameters - Equation of motion-Thrust Required-Fundamental Parameters-Thrust available and maximum speed- Power Required- Power available and maximum speed -Effect of Drag Divergence on Maximum Velocity- Minimum Drag Condition. Numerical Problems

MODULE 4: PERFORMANCE CHARACTERISTICS OF CLIMBING FLIGHTS (8 LECTURE HOURS)

Range and Endurance –Breguet formula - Introduction Maximum Climb Angle, Maximum Rate of Climb, Angle of climb and their variations with altitude- Effect of wind-Rate of Climb-Absolute ceiling and service ceiling ; Hodograph, Factors Influencing the Rate of Climb - Gliding Flight Maneuvering in the Vertical Plane. Numerical Problems

MODULE 5: TURNING CHARACTERISTICS (07 LECTURE HOURS)

Introduction- Level Turn- Minimum Turn Radius- Maximum Turn Rate- Instantaneous turn-Pull up and Pull down maneuvers, Cobra Maneuver. Numerical Problems.

MODULE 6: TAKEOFF AND LANDING CHARACTERISTICS (07 LECTURE HOURS)

Introduction to Take-off, Estimation of take-off distance-ground roll, obstacle clearing distance and height, Take off assist devices –Spoilers and landing distance–approach distance and flare distance. Numerical Problems.

Text Books:

1. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
2. Roskam, Jan and Lan, Chuan-tau E, "Airplane Aerodynamics and Performance", DAR Corporation, Lawrence, Kansas, USA, 1997.

Reference:

1. Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010.
2. Houghton, E L and Carruthers, N B; "Aerodynamics for Engineering Students", Edward Arnold Publishers, 1988.
3. Filippone, A, "Advanced Aircraft Flight Performance, Cambridge University Press, 2012.
4. David G. Hull, "Fundamentals of Airplane Flight Mechanics" Springer-Verlag Berlin Heidelberg 2007.
5. S.K. Ojha, "Flight Performance of Aircraft", AIAA, 1995.
6. Aircraft Performance, Stability and control with experiments in Flight: http://nptel.ac.in/courses/101104007/

18AE2014	**GAS DYNAMICS**	**L T P C** **3 0 0 3**

Prerequisite: 18AE2009 Aerodynamics

Course Objectives:

1. To provide information regarding the behavior of compressible fluid flow
2. To impart knowledge regarding the difference between subsonic and supersonic flow
3. To Estimate flow over flying vehicles at subsonic and supersonic speeds

Course Outcome:

After completing the course the student will be able to

1. Understand the influence of compressibility to distinguish between the flow regime
2. Apply compressibility corrections for flow in C-D passages and instrument like Pitot static tube
3. Estimate the sudden changes in the flow field

4. Analyse the compressible flow field over an airfoil and finite wings
5. Estimate the influence of friction and heat transfer in the flow field
6. Choose proper flow visualisation techniques for the given situation

MODULE 1: ONE DIMENSIONAL COMPRESSIBLE FLOW: (8 LECTURES HOURS)
Compressibility, Velocity of sound, Concept of Mach Number, Isentropic relations, Normal shock and its relations, Prandtl equation and Rankine – Hugoniot relation, Flow through converging-diverging passages, Performance under various back pressures, corrections of Pitot static tube for subsonic and supersonic Mach numbers.
MODULE 2: OBLIQUE SHOCKS AND EXPANSION WAVES: (8 LECTURES HOURS)
Oblique shocks and corresponding equations, Hodograph and flow turning angle, shock polar, Flow past wedges, Strong, weak and detached shocks, Expansion waves & its corresponding equations, Flow
MODULE 3: FANNO AND RAYLEIGH FLOW (8 LECTURES HOURS)
Influence of Friction on compressible flow, governing equations, relation between flow parameters and length, diameter and friction coefficient of pipe. Limiting Mach number, Length and Mach number, Limiting length of pipe, Influence of Heat transfer on compressible flow, governing equations, relation between flow parameters and Heat Transfer. Limiting Mach number, Maximum heat transfer
MODULE 4: DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS: (7 LECTURES HOURS)
Potential equations, Small perturbation potential theory, solutions for supersonic flows - flow over a wavy wall and flow over airfoil, Prandtl-Glauert correction for subsonic flows.
MODULE 5: HIGH SPEED FLOW OVER AIRFOIL: (7 LECTURES HOURS)
Linearised two dimensional supersonic flow theory, Lift, drag, pitching moment and center of pressure of supersonic profiles, Lower and upper critical Mach numbers, Lift and drag divergence, shock induced separation.
MODULE 6: HIGH SPEED FLOW OVER FINITE WING: (7 LECTURES HOURS)
Finite wing, tip effects, Characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, transonic area rule, flow visualisation Techniques.

Text Books

1. Rathakrishnan, E., “Gas Dynamics”, Third Edition, Prentice Hall of India, 2010
2. Shapiro, A.H., “Dynamics and Thermodynamics of Compressible Fluid Flow”, Ronald Press,1982

References:

1. Anderson Jr., D., – “Modern compressible flows”, McGraw-Hill Book Co., New York 1999
2. Robert D Zucker, Oscar Biblarz, Fundamental of Gas Dynamics, Second Edition, John Willey &Sons, 2002
3. Liepmann H W and Roshko A, “Elements of Gasdynamics”, John Willey & Sons, 2001.
4. Zucrow, M.J. and Joe D Hoffman, “Gas Dynamics”, John Willey & Sons, 1976.
5. Compressible Flow: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-120-compressible-flow-spring-2003
6. Gas Dynamics: http://www.nptel.ac.in/courses/101106044/

18AE2015	AERODYNAMICS LABORATORY	L T P C 0 0 3 1.5

Co- requisite: 18AE2014 Gas Dynamics
Course Objectives:
1. To provide details regarding the flow over aerofoils and wings
2. To impart knowledge of forces and moments over an aerofoil
3. To impart knowledge of shock wave over various model

Course Outcomes:
After completing the course the student will be able to

1. Understand the aerodynamic variable connected with airflow
2. Draw pressure distribution over the various aerofoils.
3. Visualize subsonic flow over various model
4. Estimate effect of Reynolds number of low speed airfoil
5. Evaluate the forces and moments over aircraft model
6. Visualize shock wave and Estimate shock angle over various model

List of Experiments:

1. Calibration of subsonic wind tunnel for different velocities.
2. The pressure distribution over a symmetric and cambered aerofoil.
3. Smoke and Tuft flow visualization of symmetric and cambered aerofoil.
4. Estimation of the Lift and drag of symmetric and cambered aerofoil.
5. The pressure distribution over a cascade aerofoil.
6. Identify the trailing vortices over a rectangular wing using smoke and tuft flow visualization technique.
7. Force and moment measurements of rectangular wing
8. Smoke and tuft flow visualization Flow visualization over a car, building and aircraft using Water tunnel facility.
9. Boundary layer calculation in the test section of subsonic wind tunnel.
10. Assessment of small scale wind turbine by using Wind turbine tunnel.
11. Effect of Reynolds number of low speed airfoil using subsonic wind tunnel.
12. The calibration of Pitot tube for different velocities and different shapes.
13. Calibration and runtime calculation of supersonic wind tunnel for different Mach.
14. Flow visualisation over a sharp and blunt cone model using Schlieren technique.
15. Flow visualisation over a double wedge model using Schlieren technique.
16. Flow visualisation over a sharp and blunt cone model using shadowgraph technique.
17. Flow visualisation over a double wedge model using shadowgraph technique.
18. Flow visualisation over a sharp and blunt edge delta wing model using shadowgraph and Schlieren technique.
19. Effect of back pressure study of C-D nozzle using Open Jet Facility.

NOTE: The faculty conducting the Laboratory will prepare a list of minimum 9 experiments and get the approval of HoD/Director and notify it at the beginning of the semester.

18AE2016	AEROSPACE STRUCTURE-II	L	T	P	C
		3	0	0	3

Prerequisite: 18AE2011 Aerospace Structures-I

Course Objective:

1. To impart the knowledge on the structural behaviour of aircraft components under different types of loads
2. To provide the understanding in structural design methods for aerospace vehicles
3. To impart the knowledge on the force distribution of different structures in Aircraft.

Course Outcome:

After completing the course the student will be able to

1. Predict the shear flow and shear centre in open and closed sections with effective and ineffective wall
2. Analysis the buckling characteristics of plates
3. Choose proper methods to analysis aerospace structural members.
4. Assess the load and stress distribution of wing and fuselage section.
5. Design the fail-safe and safe-life Aircraft structures.
6. Selection composites material for aerospace application.

MODULE 1: STRUCTURAL IDEALIZATION (8 LECTURE HOURS)

Principle, Idealization of a panel, Effect of idealization on the analysis of open and closed section beams, Deflection of open and closed section beams.

MODULE 2: SHEAR FLOW IN OPEN SECTIONS (8 LECTURE HOURS)

Thin walled beams, Concept of shear flow, Shear center, Elastic axis, with one axis of symmetry with effective and ineffective wall in bending, Unsymmetrical beam section.

MODULE 3: SHEAR FLOW IN CLOSED SECTION (8 LECTURE HOURS)

Bredt- Batho formula, Single and multi-cell structures, approximate methods, Shear flow in single and multi-cell structures under torsion, Shear flow in single and multi-cell structures under bending with effective and ineffective wall, Box Beams.

MODULE 4: BUCKLING OF PLATE (8 LECTURE HOURS)

Buckling of thin plates, Inelastic buckling of plates, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Crippling stresses by Needham's and Gerard's methods. Buckling of Thin Walled Beam of Open and Closed section.

MODULE 5: WING & FUSELAGE ANALYSIS (9 LECTURE HOURS) Shear force, bending moment and torque distribution along the span of the Wing-Tension field beam and Semi tension field beam (Wagner Bam). Shear and bending moment distribution along the length of the fuselage. Aeroelasticity: Introduction to Aeroelasticity, Aeroelasticity Triangle, instability and failures of Aircraft structure.

MODULE 6: COMPOSITE MATERIALS (4 LECTURE HOURS)

Composites: metal matrix composites, polymer based composites, ceramic based composites, carbon-carbon composites. Smart Materials- type and Characteristics. Composite Manufacturing processes. Composite Joints. Aerospace Applications.

Text Book:

1. Donaldson B K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2008
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Elsevier Ltd.,2010

References:

1. G Lakshmi Narasaiah, "Aircraft Structures", BS Publications, 2010
2. Sun C T, " Mechanics of Aircraft Structures", Wiley India, 2010
3. Peery, D.J., "Aircraft Structures", McGraw–Hill, N.Y., 2011.
4. Stephen P. Timoshenko & S.Woinovsky Krieger, "Theory of Plates and Shells", 2nd Edition, McGraw-Hill, Singapore, 1990.
5. Rivello, R.M., "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993.
6. Composite Materials and Structures: http://www.nptel.ac.in/courses/101104010/

18AE2017	AEROSPACE STRUCTURES LABORATORY	L T P C 0 0 3 1.5

Co-requisite: 18AE2016 Aerospace Structures-II

Course Objective:

1. To provide the basic knowledge of the testing equipment for various structural components.
2. To impart the practical exposure with the measuring equipments and sensors.
3. To impart the practical exposure with composite material manufacturing

Course Outcome:

After completing the course the student will be able to

1. Select test equipment for different types of static loading
2. Conduct tests, analyze results, document and compare with analytical/theoretical results
3. Analyse the different types of structural failures
4. Manufacture the different Composite laminates
5. Choose strain gauge for different application
6. Understand the stress distribution based on cross-section shape and loading condition

Experiments

1. Deflection of simply supported and cantilever beams - Verification of Castigliano's Theorem
2. Determine the stiffness factors of an Elastically Supported Beam
3. Determine the tensile strength of Flat plates, riveted joints and bolted joints using UTM.

4. Compression test on columns, critical buckling loads – Southwell plot
5. Unsymmetrical bending of beams
6. Determination of the effective bending stiffness of a composite beam with the combination of Aluminium and steel
7. Determination of the natural frequency of vibrations of a cantilever beam
8. Shear center location for open sections
9. Torsion of a thin walled tube having closed cross section at the ends
10. Structural behaviour of a semi tension field beam (Wagner Beam)
11. Using photo elastic techniques: Calibration of circular disc in compression to find the fringe value and Determination of stress concentration factor due to compression in circular ring
12. Composite material Manufacturing and Testing- Tensile and Three point bending

The faculty conducting the Laboratory will prepare a list of 9 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

18AE20018	PROPULSION-II	L T P C 3 0 0 3

Prerequisite: 18AE2011 Propulsion-I

Course Objective:
1. To impart knowledge on fundamentals of rocket propulsion
2. To impart knowledge on solid and liquid propulsion systems
3. To impart knowledge on advanced propulsion systems

Course Outcome:

After completing the course the student will be able to
1. Understand and evaluate the performance of chemical propellant
2. Select and design a suitable air inlets and nozzles
3. Select and design a suitable solid rocket motor
4. Select and design a suitable liquid rocket motor
5. Understand the working of sub-systems of the propulsion system.
6. Assess the performance of electric propulsion systems

MODULE 1: INLETS FOR AIR-BREATHING ENGINES AND NOZZLES: (8 LECTURE HOURS)

Internal flow and stall in subsonic inlets –major features of external flow near a subsonic inlet – external deceleration -relation between minimum area ratio and external deceleration ratio – Diffuser performance – Supersonic inlets- Modes of inlet operation.

Theory of flow in isentropic nozzles – convergent / convergent – divergent nozzles; nozzle efficiency – losses in nozzles – over expanded and under – expanded nozzles, types of nozzles conical nozzles, bell shaped nozzles, spike nozzles, expansion deflection nozzles, thrust reversal.

MODULE 2: FUNDAMENTAL OF ROCKET PROPULSION (7 LECTURE HOURS)

Overview of rockets, thrust equation and specific impulse, performance parameters, mass flow rate, characteristic velocity, thrust coefficient, efficiencies vehicle acceleration, drag, gravity losses, multi-staging of rockets staging and clustering, classification of chemical rockets.

MODULE 3: CHEMICAL PROPULSION: (7 LECTURE HOURS)

Molecular mass, specific heat ratio, energy release during combustion, stoichiometric & mixture ratio, types and classifications, criteria for choice of propellant, solid propellants, requirement, composition and processing, liquid propellants, energy content, storability.

MODULE 4: SOLID PROPULSION SYSTEMS: (8 LECTURE HOURS)

Classifications, booster stage and upper stage rockets, hardware components and functions, propellant grain configuration and applications, burn rate, burn rate index for stable operation, mechanism of burning, ignition and ignitors types, relation between web shape and thrust, action time and burn time, factors influencing burn rates, thrust vector control, performance of solid rockets. Micro grain structure of solid rocket motor.

MODULE 5: LIQUID PROPULSION SYSTEMS: (8 LECTURE HOURS)

Liquid propellant engines, thrust chamber and its cooling, injectors and types, propellant feed systems, turbo pumps, bipropellant rockets, mono propellant thrusters, cryogenic propulsion system, special features of cryogenic systems and performance of liquid rockets.

MODULE 6: ADVANCE PROPULSION SYSTEMS: (7 LECTURE HOURS)

Hybrid propellants and gelled propellants, electrical rockets, types and working principle of nuclear rockets, solar sail, concepts of advance propulsion systems, introduction to scramjet – preliminary concepts in supersonic combustion, integral ram-rocket.

Text books:

1. Sutton, G.P., Oscar Biblarz "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edn., 2016.
2. Cohen, H., Rogers, G.F.C. and Saravanamutoo, H.I.H., "Gas Turbine Theory", 7th Edition, Longman Co., ELBS Ed., 2017

References:

1. Gordon C. Oates., "Aero thermodynamics of Gas Turbine and Rocket propulsion", AIAA Education series, New York, 1997
2. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", standard Publishers, New Delhi, 2014
3. Vigor Yang, "Liquid rocket thrust chamber: Aspect of modeling, analysis and design", American Institute of Aeronautics and Astronautics, 2004
4. Hill P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley publishing company INC, 1999.
5. Rocket Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/
6. Space Propulsion: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-522-space-propulsion-spring-2015/
7. Aerospace Propulsion: http://nptel.ac.in/courses/101106033/
8. Jet and Rocket Propulsion: http://nptel.ac.in/courses/101104019/

18AE2019	AIRCRAFT STABILITY AND CONTROL	L T P C 3 0 0 3

Prerequisite: 18AE2013 Aircraft Performance

Course Objectives:

1. To introduce the concept of Stability and control of Aircraft.
2. To impart knowledge about various Aircraft motions and related stability.
3. To introduce the concept of dynamic stability of Aircraft.

Course Outcomes:

After completing the course the student will be able to

1. Understand the degree of freedom of aircraft system.
2. Analyse the static stability behaviour of the aircraft.
3. Understand the dynamic longitudinal stability of aircraft.
4. Perform the dynamic analysis to determine stability of aircraft.
5. Estimate the requirement of control force and power plant.
6. Assess the motion of unstable aircraft and related modes of instability.

MODULE 1: STATIC LONGITUDINAL STABILITY-I (09 LECTURE HOURS)

Degrees of Freedom of a system, Basic equations of motion- Wing and tail contribution; Effects of Fuselage and nacelles- Stick fixed neutral points- Power effects-Jet driven airplane and Propeller driven airplane, Elevator Requirements

MODULE 2: STATIC LONGITUDINAL STABILITY-II (08 LECTURE HOURS)

Basic equations of motion Elevator hinge moment, Estimation of hinge moment parameters, Stick Force gradients and Stick force per g load; Stick free Static Longitudinal Stability: Trim Taps, Stick free Neutral Point

MODULE 3: STATIC DIRECTIONAL STABILITY (08 LECTURE HOURS)

Basic equations of motion- Stick fixed Directional Stability- Contribution of wing –Fuselage –Vertical tail- Propeller, Directional control- Adverse yaw, One engine In-operative Conditions, Cross wind Landing, Spin recovery- Rudder effectiveness- Rudder Lock –Dorsal Fins- Stick free Directional Stability

MODULE 4: STATIC LATERAL STABILITY (08 LECTURE HOURS)

Dihedral Effect- Criterion for stabilizing dihedral effect -Selection of dihedral angle-Contribution of wing –Fuselage –Vertical tail- Propeller and Flaps- Rolling moment and its convention; Lateral Control- Aileron effectiveness, Aileron control force requirements, Aerodynamic Balancing.

MODULE 5: DYNAMIC STABILITY-I (07 LECTURE HOURS) Equations of motion-stick fixed and stick free, stability derivatives, Phugoid and short period, Longitudinal Dynamic Stability.

MODULE 6: DYNAMIC STABILITY-II (5 LECTURE HOURS)

Equation of motion- Lateral Dynamic Stability- Aileron fixed and free, Routh's discriminant, Dutch roll and Spiral instability, Auto rotation and Spin recovery

Text Books:

1. Perkins, C D and Hage, R E; "Airplane Performance Stability and Control", Willey Toppan, 2010
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2014

Reference:

1. J D Anderson, "Aircraft performance and Design", McGraw-Hill, New York, 2000.
2. Etkin, Bernard, and Lloyd Duff Reid. "Dynamics of Flight Stability and Control", Third Edition, John Wiley, New York, 1995.
3. Jan Roskam, J.Roskam, "Airplane Flight Dynamics and Automatic Flight Controls". Design, Analysis and Research Corporation. 2003
4. David G. Hull, "Fundamentals of Airplane Flight Mechanics" Springer-Verlag Berlin Heidelberg 2007
5. M.V.Cook, "Flight Dynamics Principles" Second Edition, Elsevier, 2007.
6. Stevens, B., and F. Lewis. *Aircraft Control and Simulation*. 2nd ed. New York: Wiley-Interscience, 2003.
7. Blakelock, John H. Automatic Control of Aircraft and Missiles. 2nd ed. New York: Wiley-Interscience, 1991.
8. Franklin, Gene F., J. David Powell, and Abbas Emami-Naeini. *Feedback Control of Dynamic Systems*. 4th ed. Upper Saddle River, NJ: Prentice Hall, 2002.
9. McRuer, Duane, Irving Ashkenas, and Dunstan Graham. *Aircraft Dynamics and Automatic Control*. Princeton, NJ: Princeton University Press, 1973.
10. Bryson, Arthur E. *Control of Spacecraft and Aircraft*. Princeton, NJ: Princeton University Press, 1994.
11. Abzug, M., and E. Larrabee. Airplane Stability and Control. 2nd ed. New York: Cambridge University Press, 2002.
12. McCormick, B. Aerodynamics, Aeronautics, and Flight Mechanics. 2nd ed. New York: Wiley, 1994.
13. Flight Dynamics II (Stability): http://nptel.ac.in/courses/101106042/
14. Flight dynamics II - Airplane stability and control: http://nptel.ac.in/courses/101106043/
15. Aircraft Stability and Control: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-333-aircraft-stability-and-control-fall-2004/

18AE2020	FLIGHT STABILITY AND AEROMODELLING LABORATORY	L	T	P	C
		0	0	2	1

Co-requisite: 18AE2019 Aircraft Stability and Control

Course Objectives:

1. To incorporate awareness about the basic terminology, models and prototypes of UAV
2. To impart knowledge on design considerations of UAV systems
3. To obtain knowledge on aerodynamics and communication systems of UAV

Course Outcomes:

After completing the course the student will be able to
1. Know the evolution of UAS and the various models and prototypes
2. Understand the design parameters of UAV systems
3. Obtain knowledge on the application of aerodynamic principles to design UAS
4. Understand the principles of communication systems used in UAVs
5. Obtain knowledge on payloads and launch systems for UAS
6. Understand the application of UAS to various societal applications

List of Experiments:
1. Modelling and Testing of Paper Planes
2. Modelling and Testing of Unpowered Glider
3. Modelling and Testing of Powered Glider
4. Calibration of Remote Control system.
5. Aircraft “Jacking” procedure
6. Aircraft “Leveling” procedure
7. Calculation of CG of the Cessna 152 Aircraft
8. Parameters measurement of the Cessna 152 Aircraft.
9. Longitudinal Stability of the Cessna 152 Aircraft.
10. Directional Stability of the Cessna 152 Aircraft.
11. Lateral Stability of the Cessna 152 Aircraft.
12. Aircraft Stability Check using Flight Simulator

The faculty conducting the Laboratory will prepare a list of 6 experiments and get the approval of HoD/Director and notify it at the beginning of each semester.

		L	T	P	C
18AE2021	**CAD/CAM LABORATORY**	**0**	**0**	**3**	**1.5**

Course Objective:
1. To impart the knowledge on the usage of computer in design and manufacturing
2. To impart the knowledge to visualization of objects in three dimensions and producing orthographic, sectional and auxiliary views of it.
3. To impart the knowledge of drafting.

Course Outcome:

After completing the course the student will be able to
1. Understand the CAD packages like Solid Works.
2. Develop 2D and 3D aircraft parts using software.
3. Create parts and assemble these for functional assembly
4. Draw the drafting diagram for manufacturing
5. Write CNC Program for different machining process
6. Get the hands-on experience of CNC manufacturing

List of Experiments:

Computer Aided Design (CAD)
1. 2D Sketch
2. Solid Modelling.
3. Surface modelling
4. Sheet Metal Design
5. Assembly of the Aircraft parts.
6. Drafting of Different parts.

Computer Aided Manufacturing (CAM)

7. CNC -Profile cut using Linear and circular interpolation codes
8. CNC - Step turning
9. CNC - Taper turning
10. CNC - Circular pocketing and slotting
11. CNC - Drilling
12. CNC -Thread cutting

The faculty conducting the Laboratory will prepare a list of minimum 9 experiments (Minimum 3 experiments from each CAD and CAM) and get the approval of HoD/Director and notify it at the beginning of each semester.

18AE2022	AIRCRAFT INSTRUMENTATION & AVIONICS	L T P C 3 0 0 3

Course Objectives:

1. To provide the knowledge regarding basic concepts of flight instruments, their significance and operation.
2. To impart the concepts of measurements using air data sensor, Gyroscope and engine data.
3. To provide understanding of the basic concepts and functioning of the avionic system data buses

Course Outcomes:

After completing the course the student will be able to

1. Understand the basics of measurements and different parameters
2. Identify the fundamental cockpit instruments and their working principles
3. Differentiate various sensors and transducers used in aerospace vehicles
4. Apprehend the principles behind temperature, pressure, fuel flow and engine measurements
5. Analyse the functioning of military/civil aircraft data buses and communication process between them.
6. Identify display technologies and their working principles.

MODULE 1: GENERAL CONCEPTS OF MECHANICAL INSTRUMENTATION (8 LECTURE HOURS)

Generalized measurement system, Classification of instruments as indicators, recorders and integrators - their working principles, Precision and accuracy: measurement error and calibration, Functional elements of an instrument system and mechanisms

MODULE 2: CLASSIFICATION OF AIRCRAFT INSTRUMENTS (8 LECTURE HOURS)

Classification of aircraft instruments - Air data instruments – pitot static systems and instruments, gyroscopic instruments - Gyroscope and its properties, vacuum driven systems, heading instruments,

MODULE 3: AIRCRAFT INSTRUMENTS & SENSORS (8 LECTURE HOURS)

Position and displacement transducers and accelerometer, Temperature measuring instruments, Pressure measuring instruments, Engine Instruments, Fuel Quantity measurement, Fuel flow measurement, Position and displacement transducers and accelerometers.

MODULE 4: DIGITAL AVIONICS (7 LECTURE HOURS)

Introduction to Avionics, Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems and design, defining avionics System/subsystem requirements-importance of 'ilities' of avionic sub-system, Avionics system architectures.

MODULE 5: AVIONICS DATA BUSES (7 LECTURE HOURS)

Military and Commercial Data Buses: MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements

MODULE 6: COCKPIT DISPLAY SYSTEMS (7 LECTURE HOURS)

Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit. Power requirements.

Text Books:

1. A.K. Sawhney, "A course in Electrical and Electronic Measurement and Instrumentation", Dhanpat Raj and Sons, New Delhi, 1999.
2. Pallet, E.H.J., "Aircraft Instruments & Integrated systems", Longman Scientific and Technical, McGraw-Hill, 1992.
3. Spitzer, C.R., "Digital Avionics Systems", Prentice Hall, Englewood Cliffs, N.J., U.S.A., 1987

Reference Books:

1. Cary R. Spitzer, "The Avionics Handbook", CRC Press, 2000.
2. Collinson R.P.G., "Introduction to Avionics", Chapman and Hall, 1996Middleton, D.H. "Avionics Systems", Longman Scientific and Technical, Longman Group UK Ltd., England, 1989.
3. Jim Curren, "Trend in Advanced Avionics", IOWA State University, 1992
4. Doeblin.E.O., "Measurement Systems Application and Design", McGraw-Hill, New York, 1999.
5. Horowitz, P., and W. Hill. The Art of Electronics. 2nd ed. Cambridge, UK: Cambridge University Press, 1989.
6. Prototyping Avionics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-682-prototyping-avionics-spring-2006/
7. Principles of Automatic Control: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-06-principles-of-automatic-control-fall-2012/

18AE2025	SPACE DYNAMICS	L T P C 3 0 0 3

Prerequisite: 18AE2001 Introduction to Aerospace Engineering

Course Objectives:

1. To familiarize with the performance and stability of rockets
2. To impart knowledge of basics of orbital mechanics and its applications.
3. To familiarize with various factors affecting the satellite orbits

Course Outcome:

After completing the course the student will be able to

1. To estimate performance and stability of rockets.
2. To attain a general knowledge of laws governing the orbital motion.
3. To compute the orbits of the satellites.
4. To study the effects of perturbations on the orbital motion.
5. To compute preliminary orbit of a space object based on the initial data.
6. To generate preliminary design of inter-planetary trajectories.

MODULE 1: PERFORMANCE AND STABILITY OF ROCKETS (6 LECTURES)

Rocket performance – Specific impulse; Derivation of rocket equation; Single and two stage rockets. Static and dynamic stability of rockets.

MODULE 2: THE SOLAR SYSTEM (6 LECTURES)

Solar system – planets, moons, asteroids, comets and meteoroids; Kepler's laws of motion; Reference frames – geocentric, geographic, topocentric, heliocentric; Time systems, Julian days; The ecliptic - motion of vernal equinox.

MODULE 3: THE TWO-BODY PROBLEM (8 LECTURES)

Properties of conics; Angular momentum; Computation of position and velocity vectors from orbital elements and vice-versa; Solution of Kepler's equation – elliptic and hyperbolic orbits; Central force motion.

MODULE 4: ORBIT PERTURBATIONS (10 LECTURES)

Orbit perturbations – Osculating ellipse, In-plane and out-of-plane perturbation components, Earth's oblateness, Sun-synchronous orbits, air drag; Introduction to general and special perturbation methods; Cowell's and Encke's methods.

MODULE 5: PRELIMINARY ORBIT DETERMINATION (7 LECTURES)

Laplace method; Gauss method; Gibbs method from three position vectors.

MODULE 6: ORBITAL MANEUVERS (9 LECTURES)

Single impulse maneuvers; Plane change maneuvers; Hohmann transfers from circular to circular orbits; Sphere of influence; Synodic period, Method of patched conics; planetary rendezvous.

Textbooks:

1. Vladimir A. Chobotov, “Orbital Mechanics”, AIAA Education Series, AIAA Education Series, Published by AIAA, 2002.
2. Howard D. Curtis, “Orbital Mechanics for Engineering Students”, Elsevier Butterworth-Heinemann, Third Edition, 2010.

References:

1. Pini Gurfil, and P. Kenneth Seidelmann, “Celestial Mechanics and Astrodynamics: Theory and Practice”, Springer, 2016
2. Gerald R. Hintz, "Orbital Mechanics and Astrodynamics: Tools and Techniques", Springer, 2015
3. J.W.Cornelisse, H.F.R. Schoyer, and K.F. Wakker, “Rocket Propulsion and Spaceflight Dynamics”, Pitman, 2001.
4. William E.Wiesel, “Spaceflight Dynamics”, Aphelion Press, USA, Third Edition, 2010.
5. David. A. Vallado, “Fundamentals of Astrodynamics and Applications”, Microcosm and Kluwer, Second Edition, 2004.
6. J. M. A. Danby, “Fundamentals of Celestial Mechanics”, Willmann-Bell, Inc., USA, 1992.
7. Battin, Richard. An Introduction to the Mathematics and Methods of Astrodynamics. Revised ed. Reston, VA: AIAA, 1999.
8. Space Systems Engineering: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-83x-space-systems-engineering-spring-2002-spring-2003/
9. Space Flight Mechanics: http://nptel.ac.in/courses/101105029/
10. Space Technology: http://nptel.ac.in/courses/101106046/
11. Introduction to Aerospace Engineering: Astronautics and Human Spaceflight: https://www.edx.org/course/introduction-aerospace-engineering-mitx-16-00x-1
12. Human Spaceflight - An introduction: https://www.edx.org/course/human-spaceflight-introduction-kthx-sd2905-1x-0
13. Astrodynamics: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-346-astrodynamics-fall-2008/

18AE2026	AIRCRAFT DESIGN PROJECT	L	T	P	C
		0	0	4	2

Prerequisite: 18AE2019 Aircraft Stability and Control

Course Objectives:

1. To impart the knowledge of Aerodynamic design of Aircraft.
2. To impart the knowledge of Performance analysis and stability aspects of different types of aircraft/Spacecraft.
3. To impart the knowledge of the structural design of the aircraft/space craft.

Course Outcomes:

After completing the course the student will be able to

1. Choose the type of aircraft/spacecraft for comparative studies
2. Calculate the aerodynamic parameter
3. Design the aircraft and assess the performance of the design
4. Analyse the stability of the designed vehicle
5. Design the aircraft wings, tail, fuselage, landing gears
6. Design and assess the strength of a structure

Activities to be carried out:

1. Comparative studies of different types of airplanes and their specifications and performance details with reference to the design work under taken.
2. Preliminary weight estimation, Selection of design parameters, power plant selection, aerofoil selection, fixing the geometry of Wing, tail, control surfaces Landing gear selection. Area Rule.
3. Preparation of layout drawing, construction of balance and three view diagrams of the airplane under consideration.
4. Drag estimation, Performance calculations, Stability analysis and V-n diagram.

5. Preliminary design of an aircraft wing – Shrenck's curve, structural load distribution, shear force, bending moment and torque diagrams
6. Detailed design of an aircraft wing – Design of spars and stringers, bending stress and shear flow calculations – buckling analysis of wing panels
7. Preliminary design of an aircraft fuselage – load distribution on an aircraft fuselage 4. Detailed design of an aircraft fuselage – design of bulkheads and longerons – bending stress and shear flow calculations – buckling analysis of fuselage panels
8. Design of control surfaces - balancing and maneuvering loads on the tail plane and aileron, rudder loads
9. Design of wing-root attachment
10. Landing gear design
11. Preparation of a detailed design report with CAD drawings
12. Aerodynamic and Stability Analyse using open source software like XFLR5.

References:

1. Jan Roskam and J. Roskam, " Airplane Design Part I : Preliminary Sizing of Airplanes" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
2. Jan Roskam and J. Roskam, "Airplane Design, Part II : Preliminary Configuration Design and Integration of the Propulsion System" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
3. Jan Roskam and J. Roskam, "Airplane Design Part III: Layout Design of Cockpit, Fuselage, Wing and Empennage: Cutaways and Inboard Profiles (Volume 3)" Fifth Printing, Design, Analysis and Research Corporation (DARcorporation), 2017.
4. Jan Roskam and J. Roskam, "Airplane Design Part IV: Layout Design of Landing Gear and Systems (Volume 4)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
5. Jan Roskam and J. Roskam, "Airplane Design Part V: Component Weight Estimation" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
6. Jan Roskam and J. Roskam, "Airplane Design Part VI : Preliminary Calculation of Aerodynamic Thrust and Power Characteristics" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
7. Jan Roskam and J. Roskam, "Airplane Design Part VII: Determination of Stability, Control and Performance Characteristics (Volume 7)" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
8. Jan Roskam and J. Roskam, "Airplane Design Part VIII: Airplane Cost Estimation: Design, Development, Manufacturing and Operating" Fifth Printing, Design, Analysis and Research Corporation (DAR corporation), 2017.
9. Daniel P. Raymer, "Aircraft Design: A Conceptual Approach" 5th Edition,
10. Daniel P. Raymer, "Simplified Aircraft Design for Homebuilders" 2002.
11. Snorri Gudmundsson, "General Aviation Aircraft Design: Applied Methods and Procedures" Butterworth-Heinemann, 2016. Chris Heintz, "Flying on Your Own Wings: A Complete Guide to Understanding Light Airplane Design"
12. Ira H. Abbott (Author), A. E. von Doenhoff (Author), "Theory of Wing Sections: Including a Summary of Airfoil Data"
13. Leland Nicolai, Grant Carichner, "Fundamentals of Aircraft and Airship Design" AIAA Education Series, 2010.
14. Aircraft Design : http://nptel.ac.in/courses/101104069/