B Tech Curriculum – 2022-2026

Flexible Total Credits: 160/168/180/188
Mandatory Learning Courses (MLC): 12 Credits (2+9+1)
Flexible Core - Choice Based Credit System (CBCS)
Provisions for awarding credits to students for their performance in NCC and Major Projects (optional) - OEs
Scope for Component Level Self Directed Learning (SDL) in a few courses
Mandatory Mini Project for Minor Specialization

ACADEMIC YEAR	NO. OF CREDITS	REMARKS
FIRST	22 + 22 = 44	EG-I & EG-II – 1 credit each Universal Human Values & professional ethics– 1 credit Human Rights and Constitution – 1 credit
SECOND	22 + 21 = 43	ODD SEM: Core + Labs EVEN SEM: Core + Labs
THIRD	21 + 21 = 42	ODD SEM: FLEXIBLE Core + Labs + OE EVEN SEM: FLEXIBLE Core + OE + PEs + Labs CHOICE BASED CREDIT SYSTEM FOR CORE COURSES MANDATORY OE - CPI
FOURTH	18 + 13 = 31	ODD SEM: PEs + OE EVEN SEM: Project Work/Practice School, Industrial Training

FIRST YEAR B Tech CURRICULUM 2022 (Common to all branches)

PHYSICS CYCLE

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I		Engineering mathematics - I	3	1	0	4		Engineering mathematics - II	3	1	0	4
		Engineering Physics	2	1	0	3		Engineering Chemistry	2	1	0	3
		Mechanics of Solids	2	1	0	3		Biology for Engineers	3	0	0	3
		Basic Electronics	2	1	0	3		Basic Electrical Technology	2	1	0	3
		Basic Mechanical Engineering	2	1	0	3		Problem Solving Using Computers	2	1	0	3
		Communication Skills in English	2	0	0	2		Environmental Studies	2	0	0	2
		Universal Human Values and Professional Ethics (MLC)	1	0	0	1		Human Rights and Constitution (MLC)	1	0	0	1
		Engineering Physics Lab	0	0	3	1		Engineering Chemistry Lab	0	0	3	1
		Workshop Practice	0	0	3	1		PSUC Lab	0	0	3	1
		Engineering Graphics - I	0	0	3	1		Engineering Graphics - II	0	0	3	1
		Creativity, Problem Solving & Innovation*(MLC)	1	0	0	--*		Creativity, Problem Solving & Innovation* (MLC)	1	0	0	--*
			15	**5**	**9**	**22**			**16**	**4**	**9**	**22**
	Total Contact Hours (L + T + P)		**29**				**Total Contact Hours (L + T + P)**		**29**			

*After completing a project work along with other activities which are assessed periodically the students would earn 3 credits which would be considered in lieu of an open elective for Fifth semester B Tech

FIRST YEAR B Tech CURRICULUM 2022 (Common to all branches)

CHEMISTRY CYCLE

Year	FIRST SEMESTER						SECOND SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
I		Engineering mathematics - I	3	1	0	4		Engineering mathematics - II	3	1	0	4
		Engineering Chemistry	2	1	0	3		Engineering Physics	2	1	0	3
		Biology for Engineers	3	0	0	3		Mechanics of Solids	2	1	0	3
		Basic Electrical Technology	2	1	0	3		Basic Electronics	2	1	0	3
		Problem Solving Using Computers	2	1	0	3		Basic Mechanical Engineering	2	1	0	3
		Environmental Studies	2	0	0	2		Communication Skills in English	2	0	0	2
		Human Rights and Constitution (MLC)	1	0	0	1		Universal Human Values and Professional Ethics (MLC)	1	0	0	1
		Engineering Chemistry Lab	0	0	3	1		Engineering Physics Lab	0	0	3	1
		PSUC Lab	0	0	3	1		Workshop Practice	0	0	3	1
		Engineering Graphics – I	0	0	3	1		Engineering Graphics - II	0	0	3	1
		Creativity, Problem Solving & Innovation (MLC)*	1	0	0	--*		Creativity, Problem Solving & Innovation (MLC)*	1	0	0	--*
			16	**4**	**9**	**22**			**15**	**5**	**9**	**22**
	Total Contact Hours (L + T + P)		**29**				**Total Contact Hours (L + T + P)**		**29**			

*After completing a project work along with other activities which are assessed periodically the students would earn 3 credits which would be considered in lieu of the open elective for Fifth semester B Tech

B Tech in Aeronautical Engineering

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
II		Engineering Mathematics - III	2	1	0	3		Engineering Mathematics - IV	2	1	0	3
		Introduction to Aircraft Structures	2	1	0	3		Incompressible Aerodynamics	3	1	0	4
		Materials and Processing Techniques	3	0	0	3		Air-Breathing Propulsion	3	0	0	3
		Engineering Thermodynamics	3	1	0	4		Linear Control Theory	2	1	0	3
		Fluid Dynamics	3	1	0	4		Aircraft Performance	2	1	0	3
		Introduction to Aerospace Engineering	3	0	0	3		Advanced Aircraft Structures	3	0	0	3
		Fluid and Thermal Engineering Lab	0	0	3	1		Aerodynamics & Propulsion Lab	0	0	3	1
		Structures Lab	0	0	3	1		Numerical Computation Lab	0	0	3	1
						22*						**21***
	Total Contact Hours (L + T + P)		**26**				**Total Contact Hours (L + T + P)**		**25**			

*The departments may interchange the credits of Third and Fourth semesters based on need

B Tech in Aeronautical Engineering

Year	FIFTH SEMESTER						SIXTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
III		Engineering Economics and Financial Management	3	0	0	3		Essentials of Management	3	0	0	3
		Flexible Core 1: Industrial IOT / Finite Element Method/ Rocket Propulsion	3	0	0	3		**Flexible Core 2:** Machine Learning and AI / Computational Fluid Dynamics/ Theory of Vibrations	2	1	0	3
		Flight Dynamics and Control	3	1	0	4		Aircraft Design	3	1	0	4
		Compressible Aerodynamics	3	0	0	3		PE – 1 / Minor Specialization	3	0	0	3
		Avionics and Navigation System	2	1	0	3		PE – 2 / Minor Specialization	3	0	0	3
		OE – Creativity, Problem Solving and Innovation** (MLC) - mandatory	3	0	0	3		OE – 1** (MLC)	3	0	0	3
		Geometric Modeling Lab	0	0	3	1		Avionics Lab	0	0	3	1
		Flight Dynamics and Control Lab	0	0	3	1		Structural Design and Analysis Lab	0	0	3	1
						21						**21**
	Total Contact Hours (L + T + P)		**25**				**Total Contact Hours (L + T + P)**		**25**			

*Courses of three independent tracks A, B, C to be identified by the department

** Performance of students to be recorded in Eighth semester grade sheet

B Tech in Aeronautical Engineering

Year	SEVENTH SEMESTER						EIGHTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
IV		PE – 3 / Minor Specialization	3	0	0	3		Industrial Training (MLC)				1
		PE – 4 / Minor Specialization	3	0	0	3		Project Work				12
		PE – 5	3	0	0	3		Project Work (B Tech – honours) * (V - VIII sem)				20
		PE – 6	3	0	0	3		B Tech – honours Theory – 1* (V semester)				4
		PE – 7	3	0	0	3		B Tech – honours Theory – 2* (VI semester)				4
		OE – 2** (MLC)	3	0	0	3		B Tech – honours Theory – 3* (VII semester)				4
		Mini Project (Minor specialization)***				8						
						18/26* **						**13/33***
	Total Contact Hours (L + T + P)		**18/26*** **				**Total Contact Hours (L + T + P)**					

*Applicable to eligible students who opted for and successfully completed the B Tech – honours requirements

** Performance of students to be recorded in Eighth semester grade sheet

***Applicable to students who opted for minor specialization

Minor Specialisation

Aerodynamics

- Applied Aerodynamics
- Turbomachinery Aerodynamics
- Experimental Aerodynamics
- High Speed Aerodynamics

Avionics System Engineering

- Unmanned Aircraft Systems, Sensors, and Instrumentation
- Antenna Design, Analysis, and its Applications
- Aerospace Embedded Systems, Software, Safety and Security
- Aircraft Communication and Networking

Program Electives

- Advanced Propulsion Systems
- Aeroelasticity
- Aircraft Electrical System Design and EMI/EMC Analysis
- Airship Technology
- Aviation Fuels & Combustion
- Aviation Management
- Composite Materials and Structures
- Computer Integrated Manufacturing
- Design of fixed wing unmanned aerial vehicle
- Digital Manufacturing
- Electrochemical Energy Storage Systems
- Experimental Mechanics
- Heat Transfer
- Helicopter Engineering
- Industrial Automation and Robotics
- Lean Manufacturing
- Navigation, Guidance and Control
- Non-linear Control Systems
- Numerical Methods for Scientific Computing
- Operations Research
- Optimal Control
- Optimization Techniques in Engineering
- Spaceflight Dynamics
- Spaceflight Mechanics
- Statistical Quality Control and Reliability
- Surrogates and Approximations in Engineering Design
- Systems Engineering
- Total Quality Management
- Wind Energy Engineering

Open Electives:

- Introduction to Aerospace Engineering
- Introduction to Avionics and Navigation System

III SEMESTER

MAT ****: ENGINEERING MATHEMATICS III [2-1-0-3]

Gradient, divergence and curl, Line, surface and volume integrals. Green's, divergence and Stoke's theorems. Fourier series of periodic functions. Half range expansions. Harmonic analysis. Fourier integrals. Sine and cosine integrals, Fourier transform, Sine and cosine transforms. Partial differential equation- Basic concepts, solutions of equations involving derivatives with respect to one variable only. solutions by indicated transformations and separation of variables. One-dimensional wave equation, one dimensional heat equation and their solutions. Numerical solutions of boundary valued problems, Laplace and Poisson equations and heat and wave equations by explicit methods.

References:

1. *Erwin Kreyszig: Advanced Engineering Mathematics,Wiley Eastern(1985).*
2. *S.S.Sastry : Introductory Methods of Numerical Analysis, Prentice Hall(1990).*
3. *B.S.Grewal : Higher Engg.Mathematics, edn., Khanna Publishers(1989)*
4. *Murray R.Spiegel : Vector Analysis, Schaum Publishing Co(1959).*

AAE ****: INTRODUCTION TO AIRCRAFT STRUCTURES [2-1-0-3]

Introduction to Aircraft Structural Components and their functions, Loads on Airframe, Stresses: Tensile, Compressive and Shear, Determination of Stresses on Inclined Planes, Principal Stresses, Strain. Analysis of Plane Truss – Method of Joints – 3 D Truss -Plane Frames - Composite Beam. Propped Cantilevers-- Fixed- Fixed Beam- Clapeyron's Three Moment Equation - Moment Distribution Method. Strain Energy due to Axial, Bending and Torsional Loads - Castigliano's theorem - Maxwell's Reciprocal Theorem, Unit load Method - Application to Beams, Trusses, Frames, Rings, etc. Euler buckling of columns, Inelastic buckling, Effect of Initial Imperfections, Beam Columns, Stability of Beams under Transverse and Axial Loads. Theory of pure Bending. Torsion of Beams. Theory of symmetrical and unsymmetrical bending of beams. Ductile and Brittle Materials Maximum Stress theory – Maximum Strain Theory – Maximum Shear Stress Theory – Distortion Theory – Maximum Strain energy theory and simple problems of shaft under combined loading.
Self-study topics recommended.

References:

1. *Ramamurtham, S., Strength of Materials, Dhanpat Rai Publishing Co, New Delhi, (2014).*
2. *Megson, T.H.G., Aircraft Structures for Engineering Students,Elsevier ltd., (2017).*
3. *Donaldson B K, Analysis of Aircraft Structures, Cambridge Aerospace Series, McGraw-Hill, (2008).*
4. *Timoshenko, S., Strength of materials, Vols. I & II, Princeton, D.Von Nostrand Co., (1988).*
5. *Peery, D.J., Aircraft Structures, McGraw-Hill, N.Y., (2011).*
6. *Rivello, R.M., Theory and Analysis of Flight Structures, McGraw Hill, (1993).*

AAE ****: MATERIALS AND PROCESSING TECHNIQUES [3-0-0-3]

Materials classification. Crystallography SC, FCC, BCC, HCP structures. APF. Miller indices: miller bravais indices, defects. Plastic Deformation of Metals and Alloys. Role of Dislocation; slip and twinning, Solid solution, Hume Rothery's rules, Phase diagrams, Phase and Lever Rules relationship of micro Structure and properties, Isomorphous systems. super alloys and Ashby chart. Introduction to powder metallurgy. Finishing and super finishing processes. Merits and demerits, limitations and applications. Rapid Prototyping techniques. Chip less machining, Internal and external thread rolling, Spline rolling, High Energy rate forming processes, Non-traditional machining techniques, Process principles, Process capabilities, Applications, Advantages and Limitations of Electromagnetic forming, Explosive forming, Magnetic pulse forming, shearing.

References:

1. *Raghavan V, Material science and engineering, ,Prantice Hall India, (2004).*
2. *Avner Sidney, Introduction to physical metallurgy, Mc Graw Hill International, (1991).*
3. *Shackelford, Materials science for Engineers. Prantice Hall New Jersey, (1996).*
4. *Van Vlack, Materials science and Engineering, Addison Wesley, New York, (1989).*
5. *William D Callister, Material science and engineering, Wiley India, (2007).*
6. *Michael F Ashby , Material Selection in Mechanical design' Elsevier Science (2016)*
7. *Kalpakjian S., Manufacturing Engineering and Technology, Addison Wesley Publishing, Delhi, (2000).*
8. *Degarmo paul, Black & Kohser, Materials and Processes in Manufacturing (8/e), Prentice Hall of India, New Delhi, (2003).*
9. *Dalela S., Manufacturing Science and Technology" (Vol. II & III), Umesh Publishers, Delhi, (1998).*

AAE **: ENGINEERING THERMODYNAMICS [3-1-0-4]**

Introduction to Thermodynamics-System, Zeroth Law of Thermodynamics, First law applied to a Process – applied to a flow system – Steady Flow Energy Equation- Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump , Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence / Corollaries, PMM of Second kind, Carnot's principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Increase – Energy Equation, Availability and Irreversibility – Thermodynamic Potentials, Gibbs and Helmholtz Functions, Maxwell Relations –Third Law of Thermodynamics, Pure Substances-Mollier Charts, Phase Transformations – Triple point at critical state properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation Property tables. Mollier charts – Various Thermodynamic processes and energy Transfer – Steam Calorimetry, Ideal and Real gases- Perfect Gas Laws – Equation of State, specific and Universal Gas constants, Deviations from perfect Gas Model – Vander Waals Equation of State – Compressibility charts – variable specific Heats – Gas Tables. Mixtures of perfect Gases – Mole Fraction, Mass friction Gravimetric and volumetric Analysis – Dalton's Law of partial pressure, Avogadro's Laws of additive volumes – Mole fraction , Volume fraction and partial pressure, Equivalent Gas const. And Molecular Internal Energy, Enthalpy, sp. Heats and Entropy of Mixture of perfect Gases and Vapour, theory of psychrometry, Otto, Diesel, Dual Combustion cycles, Sterling Cycle, Atkinson Cycle, Ericcson Cycle, Lenoir Cycle –Thermal Efficiency, Mean Effective Pressures on Air standard basis – comparison of Cycles. Brayton and Rankine cycles – Performance Evaluation – combined cycles, Bell- Coleman cycle, Vapour compression cycle-performance.

Self-study topics recommended.

References:

1. *Cengel Yunus A and Boles Michael A, Thermodynamics, Tata Mcgraw-Hill (2011)*
2. *Nag P K, Engineering Thermodynamics, Tata McGraw-Hill (2006)*
3. *Rajput, R.K., A textbook of Engineering Thermodynamics, Laxmi Publications (2010)*
4. *Mayhew A. and Rogers B., Engineering Thermodynamics, E.L.B.S. Longman (1994)*
5. *P L Ballaney, Thermal Engineering, Khanna Publishers (2012)*

AAE **: FLUID DYNAMICS [3-1-0-4]**

Fluid Properties and Fluid Statics: Hydrostatic law, Piezometer, Simple and differential manometers, pressure gauges. Hydrostatic forces on surfaces. Fluid Kinematics: Continuity equation, stream function, velocity potential function.Potential flow-Unifrom, sourse,sink and superimposed flow. Fluid Dynamics: Bernoulli's equation and application, Euler's equation, Flow Measurement devices: Venturimeter, Orifice meter, pitot tube. Dimensional analysis and Similitude. Flow through notches and weirs. Laminar and turbulent flow through pipes, Navier Stokes equation. Boundary layer theory and flow separation. Flow around submerged bodies- lift and drag. Introduction to compressible flow, speed of sound.

Self-study topics recommended

References:

1. *Yunus A Cengel, and Johm M Cimbala, Fluid Mechanics-Fundamentals and Application, McGraw-Hill, (2013).*
2. *Bansal R.K., A Text Book of Fluid Mechanics and Fluid Machine, Laxmi Publications, (2010).*
3. *Frank N white, Fluid Mechanics,McGraw Hill, (2011).*
4. *Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Alric P. Rothmayer, Fundamentals of Fluid Mechanics,John Wiley and Sons, New Jersey, (2013).*
5. *Clayton T. Crowe, Donald F Elger, Barbara C Williams,John A Roberson, Engineering Fluid Mechanics, John Wiley and Sons, New Jersey, (2009).*

AAE **: INTRODUCTION TO AEROSPACE ENGINEERING [2-1-0-3]**

Introduction and Overview of The History of Flight, Fundamental Thoughts, Ballooning, Basic/Constructive Principles of Fluid Mechanics-Bernoulli's Theorem and Control Volume Approaches, The Sources of all Aerodynamic Forces, Standard Atmosphere, Hydrostatic Equation, Incompressible and Compressible Flows, Elementary Thermodynamics and Isentropic flow, Flow Regimes and Estimation of Viscous, Thermal Effects, Basics of Aerodynamics, Airfoil Nomenclature, Lift, Drag and Moment Coefficient, Infinite vs Finite Wings, Pressure Coefficients, Elements of Airplane Performance, Astronautics, Basics of Propulsion. Orbital Mechanics

Self-study topics recommended
References:

1. *Anderson Jr. JD, Introduction to Flight, McGraw Hill International Edition, (2012)*

2. *Dava Newman, Interactive Aerospace Engineering and Design, McGraw Hill International Edition, (2002)*
3. *A.C. Kermode, Flight without Formulae, Pearson Education (United Kingdom), (1990)*
4. *Howard D Curtis., Orbital mechanics for Engineering Students, Butterworth Heinemann, (2013)*
5. *Anderson Jr. JD, Fundamental of Aerodynamics, McGraw Hill International Edition, (2017)*

AAE **: FLUID AND THERMAL ENGINEERING LAB [0-0-3-1]**

Irrigation Lab: Venturi meter, orifice meter, orifice, friction in pipes.

Thermal Engineering Lab: Closed cup and open cup flash point and fire point, Saybolt viscometer, redwood viscometer, boys' gas calorimeter.

Heat transfer lab: Measurement of emissivity, forced convection, and thermal conductivity in a metal bar.

References:

1. *Yunus A Cengel, Fluid Mechanics, Tata McGraw Hill, (2010)*
2. *Ethirajan Rathakrishnan, Fluid Mechanics An Introduction, PHI publisher, (2013).*
3. *Kumar K. L., Chand S. & Co, Engineering Fluid Mechanics, (2005)*
4. *Frank N white, Fluid Mechanics, Mc-Graw Hill, (2011)*
5. *John F Douglas, Fluid Mechanics, Pearson Educations publishers, (2005)*

AAE **: STRUCTURES LAB [0-0-3-1]**

Experiments based on Tensile, Torsion, Bending, Compression, Fatigue, Impact and hardness properties of different structural materials. Helical spring, Deflection of beams, Poisson ratio calculations, Non-destructive testing.

References:

1. *Megson, T.H.G., Aircraft Structures for Engineering Students, 6th edition, Elsevier ltd., (2017)*
2. *Donaldson, B.K, Analysis of Aircraft Structures – An Introduction (2e), McGraw Hill, (2008)*
3. *Timoshenko, S., Strength of materials, Vols. I & II, Princeton, D.Von Nostrand Co., (1988)*
4. *Joseph A. Untener and Robert L. Mott, Applied Strength of materials, PHI, (2016)*
5. *Egor P. Popov, Engineering Mechanics of Solids, PHI, (2004)*

IV SEMESTER

MAT **: ENGINEERING MATHEMATICS IV [2-1-0-3]**

Special Functions: Series solutions of Bessel and Legendre differential equations, Recurrence formulae, generating functions and Orthogonal properties for $J_n(x)$ and $P_n(x)$.. Probability, finite sample space, conditional probability and independence, Bayes' theorem, one dimensional random variable: mean and variance, Chebyshev's inequality. Two and higher dimensional random variables, covariance, correlation coefficient, regression, least square principle of curve fitting. Distributions: binomial, Poisson, uniform, normal, gamma, chi-square and exponential. Moment generating function, Functions of one dimensional and two-dimensional random variables, Sampling theory, Central limit theorem and applications.

References:

1. *Kreyzig E -. Advanced Engineering Mathematics, Wiley Eastern(1999).*
2. *Meyer P.L. - Introduction to probability and Statistical applications, American Publishing Co.(1965)*
3. *Hogg & Craig - Introduction of Mathematical Statistics, MacMillan(1975)*
4. *B. S. Grewal- Higher Engg.Mathematics, Khanna Publishers(1989)*

AAE **: INCOMPRESSIBLE AERODYNAMICS [3-1-0-4]**

Fluid motion Basics:- Streamline, pathline, types of flows, basic aerodynamics forces, boundary layer, Potential flows: stream function, velocity potential, their properties, Inviscid incompressible flows: governing equations, Blasius theorem, boundary layer equations, application of momentum theory, Low speed aerodynamics: airfoils: elementary flows, Kutta Joukowsky theorems, Kutta condition, circulation theorem , Flow over a wing: vortex element, downwash , induced drag, effect of aspect ratio, Conformal transformations, Zhokowsky transformation and its application, Wind Tunnel Techniques.

References:

1. *Anderson, J. D., Fundamentals of Aerodynamics, McGraw-Hill International(2011).*
2. *Houghton, E. L. and Carruthers N.B., Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (2003).*
3. *Clancy L. J., Aerodynamics, Sterling Book House (2006).*
4. *L M Milne Thomson, Theoretical Aerodynamics, Courier Corporation (2011).*
5. *Ethirajan Radhakrishnan, theoretical aerodynamics, John Willey and Sons, Singapore Pte Ltd, (2013)*

AAE **: AIRBREATHING PROPULSION [2-1-0-3]**

Classification of propulsion systems, difference between airbreathing and non-airbreathing systems; types of nozzles, isentropic flow in nozzles, performance parameters of jet engines, factors affecting thrust, engine performance parameters, Ideal and Real Brayton cycles with intercooling, reheating and regeneration, Brayton cycle efficiency, ideal and real Brayton cycles for jet engines, such as, turbojet, turbofan, turboprop and turboshaft engines, Thrust produced by jet engine, specific thrust, TSFC, specific impulse, performance of a turbojet engine, advantages & disadvantages of jet engines, Ramjet engine, classification, construction and working, efficiency of ramjet, advantages & disadvantages, ideal and real cycles, thrust estimation from Ramjet, Pulse jet engines, construction and working, advantages and disadvantages, valved type and valveless pulse jet engines..

References:

1. *Kroes Michael J; Wild Thomas W; Aircraft Powerplants, Tata-Mcgraw-Hill, (2010).*
2. *Hill Philip, Peterson Carl, Mechanics and Thermodynamics of Propulsion, Addison Wesly. (1992).*
3. *Roy Bhaskar, Aircraft Propulsion, Elsevier, India, (2008).*
4. *Mattingly J D, Elements of Propulsion - Gas Turbines and Rockets, AIAA Education series, (2006).*
5. *El-Sayed Ahmed, Aircraft Propulsion and gas Turbine Engines, Taylor and Francis, CRC press, (2008).*
6. *Saravanamuttoo, H.I.H., Rogers G.F.C., Cohen H. Gas Turbine Theory, Pearson(2001).*
7. *Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, (1999).*

AAE **: LINEAR CONTROL THEORY [2-1-0-3]**

Brief overview of the historical development of Control system theory, Basic terminologies of the control systems, Mathematical modeling of Mechanical and electrical systems to determine the transfer functions. Development of block diagrams from governing differential equations, Rules for reducing the block diagrams, examples of block diagram reduction. Introduction to signal flow graph, Mason's gain formula. Introduction to time domain analysis, types of signals and their mathematical representation. Time domain response of I and II order systems to different types of signals. Error analysis and its impact on the system output. Introduction to frequency domain analysis, Graphical techniques- Bode and Polar plots. Routh Hurwitz stability criteria, Root locus technique. State space techniques.

References:

1. *Ogata, K., Modern Control Engineering, Prentice Hall, (2010).*
2. *Norman S Nise, Control systems Engineering, John Wiley, (2019).*
3. *Kuo, B.C., Automatic Control System, Prentice Hall, (2014).*
4. *Gopal. M., Control Systems: Principles and Design,Tata McGraw-Hill, (2012).*
5. *Nagrath & Gopal, Modern Control Engineering, New Ages International (2014).*
6. *E. Bryson and Y-C Ho, Applied Optimal Control, Taylor and Francis, e book, (2017)*

AAE **: AIRCRAFT PERFORMANCE [2-1-0-3]**

Atmosphere and Flight Speeds: International Standard Atmosphere; Flight Speeds – IAS, CAS, EAS and TAS.

Review of Aerodynamics and Propulsion: Aircraft Lift and Drag Aerodynamics. Aerodynamic Efficiency. Aircraft Propulsion - Piston Engine - Propeller Aircraft, Turboprop and Turbojet/Turbofan Aircraft, Power and Thrust variation – Altitude and Speed. Specific Fuel Consumption.

Aircraft Performance: Performance Analysis -Steady Level Flight, Stall Speed. Flight Envelope. Climbing and Gliding Performance. Landing and Takeoff Performance. Balanced Field Length. Manoeuvre Load Factor. Level and climb Turn. Loop. Manoeuvre. V-n Diagram. Range and Endurance. Range and Pay Load Trade Off. .

Mission Performance: Transport and Fighter Aircraft. Mission Analysis

Energy Heights and Unsteady Flights: Energy Climb Performance. Unsteady Flights – Constant Energy Zoom Climb and Transonic Dive.

References:

1. *Anderson, Jr, J, D, Aircraft performance and design, McGraw Hill (1999).*
2. *Anderson, Jr, J, D: Introduction to flight, McGraw Hill (2005).*
3. *Yechout, T. R: Introduction to aircraft flight mechanics. AIAA (2003).*
4. *Pamadi, B: Performance, stability, dynamics and control of an airplane, AIAA (2004).*
5. *Ruijgrok G,J,J,: Elements of airplane performance, VSSD (2009).*
6. *Phillips, W,F,: Mechanics of flight, John Wiley (2010).*

AAE **: ADVANCED AIRCRAFT STRUCTURES [2-1-0-3]**

General types of construction, Types of Structure, Typical Wing and Fuselage Structure-Monocoque, Semi-Monocoque, Honeycomb and Sandwich structure, Aircraft materials, Bending Stresses in Beams of Unsymmetrical Sections. Thin Walled Beams, Concept of Shear Flow, Shear Centre, Elastic axis. With one Axis of Symmetry, With Wall Effective and Ineffective in Bending, Structural Idealization, Shear Flow Variation in Idealized Sections. Bredth – Batho Formula, Single and Multi – Cell Structures. Shear Flow in Single & Multicell Structures under Torsion. Shear Flow in Single and Multicell under Bending with Walls Effective and Ineffective. Buckling of Plates. Loads on an Aircraft – the V-n diagram – Shear Force and Bending Moment Distribution over the Aircraft Wing and Fuselage and other types of Wings and Fuselage, Thin Webbed Beam. With Parallel and non-Parallel Flanges, Shear Resistant Web Beams, Tension Field Web Beams (Wagner's). Composite Materials in Aerospace Applications.

References:

1. *Donaldson B.K., Analysis of Aircraft Structures, Cambridge Aerospace Series, McGraw-Hill, (2008)*
2. *Bruhn E.F., Analysis and Design of Flight Vehicle Structures, Tristate Offset Co., (1980)*
3. *Peery D.J., Aircraft Structures, McGraw-Hill, N.Y., (2011)*
4. *Megson T.M.G., Aircraft Structures for Engineering Students, Edward Arnold, (2007)*
5. *Rivello R.M., Theory and Analysis of Flight Structures, McGraw-Hill, (1993)*

AAE **: AERODYNAMICS & PROPULSION LAB [0-0-3 1]**

Introduction to Wind tunnel and Propulsion labs and familiarizing the apparatus, Introduction to wind tunnel and its calibration, flow over a cylinder, Pressure distribution and flow over symmetric and cambered airfoils,Boundary layer calculations, Calculation of zero lift angle and hot wire anemometer, Calculation of drag of a cylinder and airfoil by using wake survey method, Demonstration of 6 component balance and water tunnel visualization, Performance of mini gas turbine, Axial flow fan performance, Free jet and wall jet experiment, Calculation of burning velocity, forced & natural convection, Performance of convergent nozzle, Bomb calorimeter, propeller test rig experiment.

References:

1. *Jewel B Barlow, William H Rae, Alan Pope Low speed wind tunnel testing, Wiley-Interscience, (1999).*
2. *J.D. Anderson, Fundamental of Aerodynamics, McGraw-Hill Education; (2016).*
3. *George P. Sutton, Rocket Propulsion Elements, Wiley India Pvt Ltd, (2010).*
4. *National Aeronautics and Space Administration. 1985. Aeronautical Facilities Catalogue. 1: Wind Tunnels (NASA RP-1132). Washington, D.C. National Academies of Sciences, Engineering, and Medicine. 1992. Aeronautical Technologies for the Twenty-First Century. Washington, DC: The National Academies Press. https://doi.org/10.17226/2035.*

AAE *: NUMERICAL COMPUTATION LAB [0-0-3-1]**

Introduction to MATLAB Programming: Basics of MATLAB programming – Array operations in MATLAB – Loops and execution control – Working with files: Scripts and Functions – Plotting and program output; Approximations and Errors; Numerical Differentiation and Integration; Linear equations; Non-linear equations; Regression and Interpolation; Ordinary differential equation (ODE solvers).

References:

1. *Robert J. Schilling and Sandra L. Harries, Applied Numerical Methods for Engineers using MATLAB and C, Thomson Learning Inc., (2000).*
2. *Brian R Hunt, et al, Guide To MATLAB: For Beginners and Experienced Users, Cambridge University Press, (2011).*
3. *Fausett L.V., Applied Numerical Analysis Using MATLAB, Pearson Education, (2007).*
4. *Chapra S.C. and Canale R.P., Numerical Methods for Engineers, McGraw Hill, (2006)*
5. *william palm, Introduction to MATLAB for Engineers (2010)*

V SEMESTER

HUM ****: ENGINEERING ECONOMICS AND FINANCIAL MANAGEMENT [2-1-0-3]

Time value of money, Interest factors for discrete compounding, Nominal & effective interest rates, Present and future worth of Single, Uniform, and Gradient cash flow. Related problems and case studies. Bases for comparison of alternatives, Present worth amount, Capitalized equivalent amount, Annual equivalent amount, Future worth amount, Capital recovery with return, Rate of return method, Incremental approach for economic analysis of alternatives, Replacement analysis. Break even analysis for single product and multi product firms, Break even analysis for evaluation of investment alternatives. Physical & functional depreciation, Straight line depreciation, declining and double declining balance method of depreciation, Sum-of-the-Years Digits, Sinking Fund and Service Output Methods, Case Study. Balance sheet and profit & loss statement. Meaning & Contents. Ratio analysis, financial ratios such as liquidity ratios, Leverage ratios, Turn over ratios, and profitability ratios, Drawbacks. Safety and Risk, Assessment of Risk and safety, Case study, Risk Benefit Analysis and Reducing Risk.

References:

1. *Chan S. Park, "Contemporary Engineering Economics",Pearson Prentice Hall (2007).*
2. *Thuesen G. J, "Engineering Economics", Prentice Hall of India, New Delhi (2005).*
3. *Blank Leland T. and Tarquin Anthony J., "Engineering Economy", McGraw Hill, Delhi (2002).*
4. *Prasanna Chandra, "Fundamentals of Financial Management", Tata McGraw Hill, Delhi (2006).*

Flexible Core 1

AAE ****: INDUSTRIAL IOT [3-0-0-3]

Industrial Networks and IIoT: Now and Future Trends, Wireless Communication for the Industrial IoT, IoT-Driven Advances in Commercial and Industrial Building Lighting, Automation Trends in Industrial Networks and IIoT, Security in Decentralised Computing, IoT and Industrial IoT, Intrusion Detection in Industrial Networks via Data Streaming, Technological Aspects of Industry 4.0 and IIoT, Enabling Technologies of IIoT, Applications and Case Studies.

Self-Study topics recommended.

References:

1. *Ismail Butun, Industrial IoT Challenges, Design Principles, Applications, and Security, Springer (2020).*
2. *Giacomo Veneri Antonio Capasso Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0, Ingram short title publications (2018).*
3. *Sandeep Misra, Chandana Roy, Anandarup Mukherjee Introduction to Industrial Internet of Things and Industry 4.0, Taylor and Francis (2021).*
4. *Alasdair Gilchrist,Industry 4.0: The industrial Internet of Things, Apress (2016).*
5. *Sudan Jha Usman Tariq, Gyanendra Prasad Joshi Vijender Kumar Solanki, Industrial Internet of Things Technologies, Design, and Applications , Taylor and Francis (2022)*

AAE ****: FINITE ELEMENT METHODS [2-1-0-3]

Introduction: Origin of FEM, Applications, basic steps, differential equations of physical problem, analytical and approximate solution, difference between Fem and Finite Difference Method. Preprocessing, processing and post processing, computational tools etc. Brief matrix notation and operation, advantages and dis advantages of FEM.

Finite Element Formulation: Weighted residual method, Rayleigh Ritz Method, principal of minimum potential energy.

One-Dimensional FEM: Formulation of one-dimensional element equation (bar/spring element, truss, beam element)

2/3-Dimensional analysis: Plane stress, Plane strain. FE formulation of Constant Strain Triangular and Linear Strain triangular element, FE formulation of 3D element.

Practical consideration in Finite Element Modeling: General Considerations, Aspect Ratio and Element Shapes, Use of Symmetry, Sizing of Elements and the h, p, and r Methods of Refinement, Concentrated or Point Loads and Infinite Stress, Connecting (Mixing) Different Kinds of Elements.

Equilibrium and Compatibility of Finite Element result, Convergence of Solution, Contact Modelling and large deformation modelling.

Self-Study topics recommended.

References:

1. *Logan D L, First course in the Finite Element Method, Cengage learning, (2016).*
2. *Sheshu P., Textbook of Finite Element Analysis, PHI Learning Private Limited, (2003)*
3. *Robert D Cook, David S Malkus, Micheal E Plesha, Concept and Application of Finite Element Analysis, John Wiley and Sons (1989).*
4. *Singiresu S Rao, The Finite Element Method in Engineering, Elsevier Inc,(2018).*
5. *Saeed Moaveni,Finite Element Analysis:Theory and application with ANSYS, Prentice Hall(1999).*

AAE **: ROCKET PROPULSION [2-1-0-3]**

Rockets: introduction, classification. Rocket nozzles: C-D nozzle fundamentals, nozzle coefficients, operation regimes, performance, and classification. Chemical rocket propulsion: fundamentals, thrust, exhaust velocity, total and specific impulse, performance parameters. Rocket equation, staging and analysis. Liquid propulsion: Propellant feed mechanism, tanks, injectors and thrust chambers, propellants, and cooling. Solid rockets: Construction, performance relations, propellant grain and configuration, propellant ingredients, burning rate, thrust chamber cooling. Hybrid rockets- construction, propellants, performance analysis.

References:

1. *Hill, P. G. and Peterson, C. R., Mechanics and thermodynamics of propulsion, Reading, Massachusetts: Addison Wesley Publishing Company, (1992).*
2. *Sutton, G. P. and Biblarj, O., Rocket propulsion elements, New York: Wiley Interscience Publications, (2001).*
3. *Mukunda, H. S., Understanding aerospace propulsion, Bangalore: Interline Publishing, (2004).*
4. *Ramamurthi K., Rocket Propulsion, Macmillan, (2009).*
5. *Misra D. P., Fundamentals of Rocket Propulsion, CRC Press, (2017).*

AAE **: FLIGHT DYNAMICS AND CONTROL [3-1-0-4]**

Aircraft Equations of Motion, Modelling of Longitudinal Aerodynamic Forces and Moments in Steady State, Modelling of Longitudinal Aerodynamic Forces and Moments in Perturbed State, Modelling of Lateral Directional Aerodynamic Forces and Moments in Steady state, Modelling of Lateral Directional Aerodynamic Forces and Moments in Perturbed State, Static Stability, Modelling of Longitudinal and Lateral Directional Thrust Forces and Moments in both Steady and Perturbed State, Dynamic Stability, Solutions to Longitudinal Equations, Longitudinal Dynamic Modes and Approximations: Short Period and Phugoid, Lateral Directional Dynamic Modes and Approximations: Spiral, Roll Subsidence and Dutch Roll, sensitivity analysis and Cooper Harper Ratings.

Reference Books:

1. *M.R. Napolitano" Aircraft Dynamics from Modeling and Simulation", WILEY Publications, (2012).*
2. *Schmidt L.V. "Introduction to Aircraft Flight Dynamics", AIAA Education Series, (2001).*
3. *McRuer Det. Al. Aircraft Dynamics and Automatic Control" Princeton University Press, NJ, (2004).*
4. *Stengel R.F., "Flight Dynamics", Princeton University Press, NJ, (2004).*
5. *Jan Roskam, "Airplane Flight Dynamics and Automatic Flight Controls", DAR Corporation, (2001).*

AAE **: COMPRESSIBLE AERODYNAMICS [2-1-0-3]**

Fundamentals of compressible fluid dynamics and application to external and internal flows. Quasi-one-dimensional channel flow, extensions, and analysis of multi-dimensional flows in nozzles, diffusers, and inlets. Forces, moments, and loss generation resulting from compressible fluid flow interactions with aerodynamic shapes in subsonic, supersonic, transonic, and hypersonic flight, shock waves, and vortices. Disturbance behavior in unsteady compressible flow.

References:

1. *Anderson, J.D., Modern Compressible Flow: With Historical Perspective, McGrawHill, (2002).*

2. *Liepmann and Roshko ,Elements of Gas dynamics, Dover Publications(2013).*
3. *Philip A Thompson ,Compressible-fluid Dynamics, Mc Graw Hill(1971).*
4. *Robert W. Fox and Alan T. McDonald , Introduction to Fluid Mechanics,John Wiley & Sons (2004).*
5. *Thompson, P. A. Compressible Fluid Dynamics. Maple Press Company (1984).*

AAE **: AVIONICS AND NAVIGATION SYSTEMS [2-1-0-3]**

Introduction Unmanned Air Vehicle, UAV Instrumentations and Sensors, Introduction to Avionics in aircraft, Organization framework, avionics architectures generation, types of payloads, Cockpit Layout of old and modern aircrafts, Essential and Non-essential Avionics equipments, Displays, Packaging, ARINC and DOD Types, System Cooling, EMI/EMC Requirements; Aircraft Power Systems, Aircraft Embedded Systems, Analog and Digital Communication, Fiber Optic Comm. Antenna and types of antenna, software to design antenna, Satellite Communication, Flight control laws, FBW, Autopilot, FMS, LRU, IMA & Mission Systems, Warning systems, Engine Control. Inertial Sensors and Inertial Navigation Systems, Elements of Navigation Systems, Satellite Navigation Systems, Radar & Mechanics of landing and types Landing Systems. Software Standards-CERT, MISRA, DO178B/C.

References:

1. *Cary R. Spitzer: Digital Avionics Handbook-Avionics Development and Implementation , CRC Press, Taylor & Francis Group, (2007).*
2. *Arjun Singh: Airport Ground Navigation Systems, Tata McGraw Hill Education Pvt. Ltd, (2012).*
3. *Thomas K. Eismin, Aircraft Electricity and Electronics, Tata McGraw Hill Education Pvt. Ltd, (2014).*
4. *R.P.G. Collinson: Introduction to Avionics Systems, Springer, (2002).*
5. *Myron Kayton & Walter R. Fried: Avionics Navigation Systems, Wiley-interscience, (1997).*
6. *Steven R. Hirshorn, NASA Systems Engineering Handbook, National Aeronautics and Space Administration, (2007).*
7. *Mohinder S Grewal: Global Navigation Satellite Systems, Inertial Navigation and Integration, John Wiley, (2013).*

AAE **: GEOMETRICAL MODELLING LAB [0-0-3-1]**

Sketcher Exercises- 2D, Part Modelling tool for 3D Modelling of components and Assembly Exercises, Generative Wireframe and Surface for Surface Modelling.

References:

1. *Sham R Tickoo "CATIA V5:6R2015 for Designers", CADCIM Technologies, (2009)*
2. *Jaecheol Koh "Catia V5-6r2014 Surface Design: A Step by Step Guide", Createspace Independent Publishers, (2015).*

AAE **: FLIGHT DYNAMICS AND CONTROL LAB [0-0-3-1]**

Introduction to control system, Stability analysis of the system using Root locus, Bode plot, Nyquist plot and Polar plot techniques. Airborne vehicle system modelling: Differential Equation, Transfer Function, state space analysis. Familiarization with SIMULINK, Control system toolbox, Aerospace Toolbox, Navigation Toolbox, UAV Toolbox, Communication Toolbox, Mass-Spring-Damper Systems, Classical Control: PID Design, DC Motor position and speed controller, Aircraft pitch control.

References:

1. *Brian L. Stevens, Frank L. Lewis, Eric N. Johnson : Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems, Wiley (2025).*
2. *S. Hasan Saeed: Automatic Control Systems (With Matlab Programs,Arihant (2013)*
3. *Modeling, Analysis and Design of Control Systems in MATLAB and Simulink. Mathworks Ebook.*
4. *Robert F. Stengel, Flight Dynamics, 1st edition, Princeton University Press (2004)*
5. *Rama K. Yedavalli, Flight Dynamics and Control of Aero and Space Vehicles, John Wiley & Sons, Inc (2020)*

VI SEMESTER

HUM **: ESSENTIALS OF MANAGEMENT [2-1-0-3]**

Definition of management and systems approach, Nature & scope. The Functions of managers, Principles of Management. Planning: Types of plans, steps in planning, Process of MBO, how to set objectives, strategies, policies and planning premises, Strategic planning process and tools. Nature and purpose of organizing, Span of management, factors determining the span, Basic departmentation, Line and staff concepts, Functional authority, Art of delegation, Decentralization of authority. HR theories of planning, Recruitment, Development and training. Theories of motivation, Special motivational techniques. Leadership – leadership behavior & styles, Managerial grid. Basic Control Process, Critical Control Points & Standards, Budgets, Non-budgetary control devices. Profit and Loss control, Control through ROI, Direct, Preventive control. PROFESSIONAL ETHICS - Senses of Engineering Ethics, Variety of moral issues, Types of inquiry, Moral dilemmas, Moral Autonomy, Kohlberg's theory, Gilligan's theory, Consensus and Controversy, Models of professional roles, Theories about right action, Self-interest, Customs and Religion, Uses of Ethical Theories. GLOBAL ISSUES - Managerial practices in Japan and USA & application of Theory Z. The nature and purpose of international business & multinational corporations, unified global theory of management, Entrepreneurship and writing business plans. Multinational Corporations, Environmental Ethics, Computer Ethics, Weapons Development, Engineers as Managers, Consulting Engineers, Engineers as Expert Witnesses and Advisers, Moral Leadership, Code of Conduct, Corporate Social Responsibility.

References:

1. *Harold Koontz & Heinz Weihrich ,Essentials of Management, McGraw Hill, New Delhi(2020).*
2. *Peter Drucker ,The practice of management, Harper and Row, New York(2004).*
3. *Vasant Desai, Dynamics of entrepreneurial development & management, Himalaya Publishing House(2007).*
4. *Poornima M Charantimath, Entrepreneurship Developmen, Pearson Education (2006).*

Flexible Core 2

AAE **: Machine learning and Artificial Intelligence [3-0-0-3]**

Introduction – Overview and Historical Perspective, Tuning test, Physical Symbols Systems and the scope of Symbolic AI, Agents; State Space Search – Depth First Search, Breadth First Search, DFID; Heuristic Search – Best First Search, Hill Climbing, Beam Search, Tabu Search; Randomized Search – Simulated Annealing, Genetic Algorithms, Ant Colony Optimization; Finding Optimal Paths – Branch and Bound, A*, IDA*, Divide and Conquer approaches, Beam Stack Search; Problem Decomposition – Goal Trees, AO*, Rule Based Systems, Rete Net; Game Playing – Minimax Algorithm, AlphaBeta Algorithm, SSS*; Planning and Constraint Satisfaction – Domains, Forward and Backward Search, Goal Stack Planning, Plan Space Planning, Constraint Propagation; Logical and Inferences – Propositional Logic, First Order Logic, Soundness and Completeness, Forward and Backward Chaining.

Self-study topics recommended.

References:

1. *Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India), (2013).*
2. *Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications, Morgan Kaufmann, (2011).*
3. *John Haugeland. Artificial Intelligence: The Very Idea, A Bradford Book, The MIT Press, (1985).*
4. *Pamela McCorduck. Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence, A K Peters/CRC Press, (2004).*
5. *Zbigniew Michalewicz and David B. Fogel. How to Solve it: Modern Heuristics, Springer, (2004).*
6. *Judea Pearl. Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley, (1984).*
7. *Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill, (1991).*
8. *Stuart Russell and Peter Norving. Artificial Intelligence: A Modern Approach, Prentice Hall, (2009).*
9. *Patrick Henry Winston. Artificial Intelligence, Addison-Wesley, (1992).*

AAE **: COMPUTATIONAL FLUID DYNAMICS [2-1-0-3]**

Derivation of governing equations of fluid dynamics and discussion on characteristic of the governing equations, the initial and boundary conditions. The mathematical behaviour of different classes of partial differential equations. Discretization of governing equations using Finite Difference and Control Volume approach. The basic solution techniques for steady-state and transient equations. Solutions of Diffusion Problems. Numerical methods for steady 1-D convective flow with diffusion. The need for a staggered grid. Discussion on SIMPLE, SIMPLER and PISO algorithms. Implementation of Boundary Conditions in Computational Fluid Dynamics.

References:

1. *John D Anderson Jr., Computational Fluid Dynamics- The Basics with Applications, International Edition. McGraw Hill. New York (2013).*

2. *Suhas V Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere / McGraw Hill New York (2018).*
3. *Versteeg H. K., Malalasekera W. An Introduction to Computational Fluid Dynamics- The Finite Volume Method, Pearson Education Limited, London (2007).*
4. *Anderson D. A, Tannehill J. C, and Pletcher R. H., Computational Fluid Mechanics and Heat Transfer, Taylor and Francis Group. New York (2020).*
5. *Chung T. J., Computational Fluid Dynamics, Cambridge University Press South Asia Edition (2013).*
6. *Fletcher C. A. J., Computational Techniques for Fluid Dynamics, Springer- Verlag. Berlin, (2012).*

AAE **: THEORY OF VIBRATIONS [2-1-0-3]**

Vibrations terminology, free undamped and damped vibrations, governing differential equations of different systems and computing natural frequencies. Coulomb damping and derivation of differential equation. Forced vibrations harmonic excitation and rotating unbalance. Base excitation and concept of displacement and force transmissibility ratio and isolation. Force vibration with Coulomb damping. Analyzing 2DOF sprig mass undamped system and deriving the natural frequency and concept of mode shapes. Coordinate coupling and numerical examples. Concept of Dynamic vibration and Pendulum absorber. Analysis of MDOF systems, concept of influence coefficients. Determining natural frequency and mode shapes of MDOF systems- by direct approach and numerical methods. Concept of continuous systems. - Vibrations measuring instruments and concept of NVH..

References:

1. *Singirisu Rao S, Mechanical Vibration, Pearson Education (2018).*
2. *Dukkapatti Rao V, Text Book of Mechanical Vibration,Prentice Hall of India Ltd (2012).*
3. *Daniel Imnan J., Engineering Vibration , Prentice Hall, New Delhi, (2007).*
4. *Groover G.K., Mechanical Vibrations, Nemchand And Bros, Roorkee, (2009).*
5. *Thomson W.T., Theory of Vibrations with Applications, Chapman and Hall (2008).*
6. *C Sujatha, Vibrations and Acoustics-Measurement and Signal analysis, Mc Graw Hill India, (2017).*

AAE **: AIRCRAFT DESIGN [3-1-0-4]**

Overview of the Design Process, Airfoil and Geometry Selection, Design constraint diagram - Thrust-to-Weight Ratio and Wing Loading, Takeoff Weight and Empty weight. Initial Sizing. Control-Surface Sizing, Engine selection; Configuration Layout - Wing, Landing Gear and Engine location. 3 View diagram, Aerodynamic Considerations, Structural Considerations, Vulnerability Considerations, Propulsion and Fuel System Integration, Design Cycle of a New Design – Feasibility, Configuration Design, Detailed Design phases - Aerodynamics, Propulsion, Flight Performance, Structures and Loads, Weight and CG, Group Weights Method, Longitudinal Static Stability and Control, Lateral-Directional Static Stability and Control and Handling Qualities. Design Compliance Matrix.

References:

1. *Leland Nicolai, Grant Carichner, Fundamentals of aircraft and airship design, AIAA Educational Series (2010).*
2. *Daniel P Raymer, Aircraft Design – A Conceptual approach, AIAA series (2018).*
3. *Lloyd R Jenkinson, Paul Simpkin, Parren Rhodes ,Civil Jet Aircraft Design , AIAA series( )*
4. *L. R Jenkionson, J.F. Machman, Aircraft Design projects for engineering students ,Butterworth Heinemann (2003)*
5. *Steven A. Brandt , Randall J. Stiles, John J. Bertin, Ray Whitford ,Introduction to Aeronautics: A Design Perspective, AIAA Education Series (2015).*

AAE **: PROGRAM ELECTIVE 1/MINOR SPECIALIZATION [3-0-0-3]**

Details at the end

AAE **: PROGRAM ELECTIVE 2/MINOR SPECIALIZATION [3-0-0-3]**

Details at the end

AAE **: OPEN ELECTIVE 1 [3-0-0-3]**

Details at the end

AAE **: AVIONICS LAB [0-0-3-1]**

Digital Circuits: Digital Circuit Verification, Microprocessor: Assembly Programming, Embedded Systems –Keil, Vivado, LDRA Tool/DO178B/C, LabVIEW, Standard, Unmanned Aircraft Systems and Instrumentation, Communication, Autopilot and Payloads, PCB design and manufacturing, Circuit design and simulation, Aircraft Electrical Test Rig and parameter test and analysis EMI/EMC test, Antenna Design, manufacturing and testing, Satellite communication, Testing using VNA, RF Source and Spectrum analyzer. Communication protocols, aircraft databus, Flight Simulator, UAV flying. MATLAB and Simulink.

References:

1. *K.V. Shibu: Introduction to Embedded Systems,, McGraw Hill Education India Private Limited(2009).*
2. *C.A. Balanis: Antenna Theory - Analysis and Design , John Wiley, (2016)*
3. *Michael Barr, Anthony Massa: Programming Embedded Systems, Second Edition with C and GNU Development Tools , O'Reilly Media, (2009)*
4. *Brian L. Stevens, Frank L. Lewis & Eric N. Johnson: Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems , Wiley-Blackwell, (2015)*
5. *Roger Hu: PCB Design and Layout Fundamentals for EMC, Independent Publsihed, (2019)*
6. *Dr. Reinaldo J. Perez: Handbook of Aerospace Electromagnetic Compatibility, IEEE Press, Wiley, (2018)*
7. *Mike Tooley and David Wyatt: Aircraft Electrical and Electronic Systems: Principles, Operation and Maintenance, Butterworth-Heinemann: Elsevier, (2009)*

AAE **: STRUCTURAL DESIGN AND ANALYSIS LAB [0-0-3-1]**

Analysis of Truss/Link Elements, Beam Elements, Shell Elements, Plane Stress/ Plane Strain analysis, 3D Structural analysis, Thermal Analysis, Modal Analysis, Fluid Flow CFX, Modal analysis.

References:

1. *Erdogan Madenci and Ibrahim Guven,The Finite Element Method and Applications in Engineering Using ANSYS, Springer Publications, (2016).*
2. *Guangming Zhang,Engineering Analysis with Pro/Mechanica and Ansys, College House Enterprises, LLC, (2017).*
3. *Sham Tickoo,Ansys Workbench 14.0 for Engineers and Designers, Dream Tech Press, US (2013).*

VII SEMESTER

AAE **: PROGRAM ELECTIVE 3/MINOR SPECIALIZATION [3-0-0-3]**

Details at the end

AAE **: PROGRAM ELECTIVE 4/MINOR SPECIALIZATION [3-0-0-3]**

Details at the end

AAE **: PROGRAM ELECTIVE 5 [3-0-0-3]**

Details at the end

AAE **: PROGRAM ELECTIVE 6 [3-0-0-3]**

Details at the end

AAE **: PROGRAM ELECTIVE 7 [3-0-0-3]**

Details at the end

AAE **: OPEN ELECTIVE 2 [3-0-0-3]**

Details at the end

AAE **: MINI PROJECT FOR MINOR SPECIALIZATION*** [0-0-0-8]**

***Applicable to students who opted for minor specialization

VIII SEMESTER

AAE **: INDUSTRIAL TRAINING [0-0-0-1]**

Student is to undergo industrial training for a minimum period of 4 weeks during the vacation. After successful completion of training, student is to submit a report to the department and also makes a presentation on training.

AAE **: PROJECT WORK / PRACTICE SCHOOL [0-0-0-12]**

The student is required to carry out a project work in the institution / industry / research laboratory / institution of higher learning. The minimum duration of the project work/practice school is 16 weeks. As part of project work / practice school, the student is also required to prepare a project report and make a presentation on the work carried out.

AAE **: PROJECT WORK (FOR BTECH HONOURS)* [0-0-0-2-0]**

AAE **: BTECH HONOURS THEORY 1(V SEMESTER)* [0-0-0-4]**

AAE **: BTECH HONOURS THEORY 2(VI SEMESTER)* [0-0-0-4]**

AAE **: BTECH HONOURS THEORY 3(VII SEMESTER) * [0-0-0-4]**

*Applicable to eligible students who opted for and successfully completed the B Tech – honours requirements

PROGRAM ELECTIVES

AAE ****: ADVANCED PROPULSION SYSTEMS [3-0-0-3]

Introduction to advanced propulsion and aerothermodynamics, limitations of turbojets and turbofans. Need for supersonic combustion; Ramjet engines, working principle, basic consideration, operating principles and performance, basic principle of operation, thrust calculation, efficiency, Inlet types, nozzle considerations, Scramjet, spill-over drag, plume drag. Isolator, combustor, thermal protection, Combined cycle engines-turbo-ramjet, Airturbo-rocket (ATR), ejector ramjet, Liquid-air collection engine (LACE)- need, principle, construction, operation, performance, pulsejet, types and working principle; Nuclear propulsion history, Power, thrust, energy. Nuclear fission-basics, sustainable chain reaction, neutron leakage, control, reflection, prompt and delayed neutrons, thermal stability. Principles and fuel elements. The nuclear thermal rocket engine types, start-up and shutdown.

Electrical propulsion systems, Definitions, thrust equations, performance parameters, Limitations of chemical rocket engines. Electric propulsion systems-structure, types, generation of thrust. Electro static thrusters, electromagnetic thrusters, applications to space missions, pulsed plasma thrusters (PPT) for micro-spacecraft, solar electric propulsion.

Micro-propulsion, application of MEMS, chemical, electric micro-thrusters, principle, description, Propellantless propulsion, teethers, momentum exchange, Photon rocket, beamed energy propulsion, solar, magnetic sails.

References:

1. *Ahmed F.El-Sayed ,Aircraft Propulsion and Gas Turbine Engines, CRC Press (2017).*
2. *Cornelisse, J. W., SchoyerH.F.R. and Wakker, K.F., Rocket propulsion and space flight Dynamics, Pitman, (1979).*
3. *Turner, M.J.L., Rocket and Spacecraft Propulsion, Springer, (2001).*
4. *Flack, R. D. ,Fundamentals of Jet Propulsion with Applications, Cambridge University Press(2005).*
5. *Mattingly J.D.,Elements of Gas Turbine Propulsion, Mc Graw Hill Education(1996).*
6. *Roy Bhaskar, Aircraft Propulsion,Elseiver, India, (2008)*
7. *William R Corliss, Propulsion systems for space flight, Mc GrawHill, (1970).*
8. *Philip Hill, Carl Peterson, Mechanism and Thermodynamics of Propulsion, Pearson, (2010).*
9. *D P Mishra, Fundamentals of Rocket Propulsion, CRC Press, (2017).*
10. *William Emrich, Principles of Nuclear Rocket Propulsion, Elsevier, (2016).*

AAE ****: AEROELASTICITY [3-0-0-3]

Introduction to Aeroelastic problems and Aircraft Structures, Deformation of Structures and Influence Coefficients, Energy Methods, Lagrange's Equation, Static Aeroelasticity, Divergence of lifting surfaces, Divergence of a 2D Airfoil, Control Reversal and Effectiveness, Symmetric and Anti-Symmetric Flow Conditions. Effect of Sweep in Divergence, Dynamic Aeroelasticity, Flutter Speed Calculations, Flutter Conics, Buffeting.

References:

1. *J Wright and J Cooper, Introduction to Aircraft Aeroelasticity and Load, John Wiley and Sons UK, (2007).*
2. *R.L.Bisplingshoff, H Ashley, R.L.Halfman, Aeroelasticity, Dover Publications Inc, New York, (1996).*
3. *Y.C. Fung, An Introduction to the Theory of Aeroelasticity, Dover Publications Inc, New York, (1993).*
4. *Ulgen Gulcat. Fundamentals of Modern Unsteady Aerdynamics, Springer Publications, (2011).*
5. *Dowell E.H., Curtiss H.C, Scalan R.H., Sisto F, A Modern Course in Aeroelasticity, Sijthoff and Noordhoff, (1978).*

AAE ****: AIRCRAFT ELECTRICAL SYSTEM DESIGN & EMI EMC ANALYSIS [3-0-0-3]

Overview of Aircraft Electrical System: Electrical fundamentals, Electric Measuring Instruments. Aircraft Batteries and other source, Electrical power generation, conversion, distribution and protection theory and equipment's used, Wiring Installation, Circuit protection, shielding/screening, power distribution, Aircraft Electrical Systems, Aircraft Lighting Systems, Electrical System Components, Electrical and magnetic field. Introduction to E3 Models and Techniques, Deterministic and Statistical EMC Models, HEMP, HIRF and Lightning, Techniques to Design Robust Lightning Protection Circuits, Pyrotechnic Systems, EMC Testing in aircraft, spacecraft, UAV and flight control, System level testing etc. Charging.

References:

1. *Mike Tooley and David Wyatt: Aircraft Electrical and Electronic Systems: Principles, Operation and Maintenance, Butterworth-Heinemann: Elsevier, (2009).*
2. *Dr. Reinaldo J. Perez: Handbook of Aerospace Electromagnetic Compatibility, IEEE Press, Wiley, (2018).*
3. *Ian Moir, Allan Seabridge: Aircraft Systems: Mechanical, Electrical, and Avionics Subsystems Integration, Aerospace Series, Wiley, (2011).*
4. *Thomas K. Eismin: Aircraft Electricity and Electronics, McGraw Hill Education (India) Private Limited, (2014).*

5. *EHJ Pallett: Aircraft Electrical Systems, PEARSON India Education Services Pvt. Ltd, (1997).*
6. *Len Buckwalter: Avionics Training: Systems, Installation, and Troubleshooting, Avionics Communications Inc., (2005).*

AAE **: AIRSHIP TECHNOLOGY [3-0-0-3]**

Background and Introduction to LTA systems; Historical Perspectives of LTA Systems; Static Lift Concepts; Static Lift Estimation; Variation of Net Static Lift; Pressure Height Calculations; Envelope Materials and Ground Handling of LTA Systems; Airship Design Methodology; Airship Propulsion Systems and Case studies in Airship Operation; Aerostat Design Methodology; High Altitude Airships and Hybrid LTA systems.

References:

1. *Taylor, J. A., Principles of Aerostatics, The Theory of Lighter-Than-Air Aircraft, Createspace Independent Publishing , ISBN13:978-1-49481-053-5, (2014).*
2. *Khoury, G., ed., Airship Technology, 2nd Edition, Cambridge Aerospace Series, Cambridge University Press, ISBN-13 978-1107019706, (2012).*
3. *Pant, R. S., Course Material for Design and Development of LTA systems, Curriculum Development Program, IIT Bombay, (2010).*
4. *Carichner, G. E., and Nicolai, L. M., Fundamentals of Aircraft and Airship Design, Volume 2 – Airship Design and Case Studies, AIAA Education Series, ISBN-13: 978-1600868986, (2013).*
5. *Hunt, P. V., Advanced Airship Technologies and Design Approaches, AIAA Education Series, ISBN-13 978-1-62410-351-3, (2015).*

AAE **: AVIATION FUELS AND COMBUSTION [3-0-0-3]**

Introduction, different types of fuels (solid, liquid and gaseous) and their properties, storage and handling of fuels, fuel requirements and specifications, cracking, polymerization, Combustion process, basic thermodynamics, stoichiometry, flash and fire points, calorific value, theoretical flame temperature, minimum air requirement for complete combustion, flue and exhaust gas analysis, combustion kinetics, different chemical reactions, laminar and turbulent flames, different burners, combustion emission, combustion in ramjets and scramjets, storage and handling of rocket propellants and explosives.

References:

1. *Samir Sarkar: Fuels and Combustion , Universities Press (2009).*
2. *H. Joshua Philips: Fuels – Solids, liquids and gases, Nabu Press (2011).*
3. *S.R. Turns: An introduction to combustion – Concepts and applications, Tata McGraw- Hill, (2000).*
4. *John Griswold: Fuels Combustion and Furnaces, Mc-Graw Hill Book Company Inc., (1946)*
5. *Fundamentals of Combustion, D P Mishra, University Press, (2010).*

AAE **: AVIATION MANAGEMENT [3-0-0-3]**

An introduction to air transport: Aerospace industry, air transport industry, Historical perspective: Formative period, growth years, maturity, Economics development, General aviation. Regulations and associations: Department of transportation, Federal aviation administrations, Transport security administration. Airline management and organization: Management, organization, staff department, line department, Forecasting methods: purpose of forecasting methods, forecasting methods. Managerial aspects of airlines: Airline passenger marketing, Airline pricing, demand, Air cargo etc.

References:

1. *Air Transportaion – A management perspective, Sixth edition John G Wensveen. Ashgate Publishing Limited, ISBN 978-0-7546-7165-7, (2007)*
2. *Fundamentals of Air Traffic Control, Fourth edition, Nolan, M.S., Thomson Learning, ISBN-13:978-0-534-39388-5, (2004)*
3. *Air Transportation Systems Engineering, Donohue, G. L. et al., (Editors), AIAA, ISBN 1-56347-474-3, (2003)*
4. *Avionics Navigation Systems, Keyton, M. and Fried, W. R., John Wiley, ISBN 0-471-54795-6, (2001)*
5. *Introduction to Flight, John D. Anderson, Jr., Tata McGraw-Hill Publishing Company, Fifth Edition, Fifth Edition,ISBN 13: 978-0-07-066082-3, (2007).*

AAE **: COMPOSITE MATERIALS AND STRUCTURES [3-0-0 3]**

Introduction, Types of matrix materials, Types of synthetic fibers, properties, manufacturing process of fibers, types of manufacturing process of composite laminates, hand lay-up, vacuum bagging, compression molding, autoclave curing, resin transfer molding, Classification of composite materials, Characterization of composite materials, Mechanical behavior of composite materials, Basic terminologies of composites, Review of basic equations of mechanics and materials, Linear elastic model and its application, Stress-strain relations for a unidirectional lamina, Stress-strain relations for isotropic/orthotropic lamina, Effective Modulii of a continuous fibre reinforced lamina, Models based on mechanics of materials, Force-Displacement relations for laminates, Laminate stiffness, Single general orthotropic layer, Inter-laminar stresses, Failure of continuous fiber-reinforced orthotropic lamina, Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion.

Self-Study topic is recommended.

References:

1. *Mallick, P.K, Fiber-reinforced Composites: Materials, Manufacturing, and Design, CRC Press, (2008).*
2. *Gibson R. F., Principles of Composite Material, (4e), Mechanics, CRC Press, (2016).*
3. *Kollar L. P., George S Springer, Mechanics of Composite Structures, Cambridge University Press, (2009).*
4. *Agarwal B. D., Broutman L. J. and Chandrashekhara K., Analysis and Performance of Fiber Composites, (3e), John Wiley & Sons, (2006).*
5. *R. M. Jones, Mechanics of Composite Materials, (2e), Taylor & Francis,(2005).*
6. *Madhujit Mukhopadhyay, Mechanics of Composite Materials and Structures, Orient Longman, (2004).*

AAE **: COMPUTER INTEGRATED MANUFACTURING [3-0-0-3]**

Introduction, Definition of N.C. Machine, Classification, Advantages and disadvantages of N.C. machine, Design consideration of N.C. Machine tools, general construction requirements, Co-ordinate systems, point to point and contour programming, manual method (word address format only), NC programming with interactive graphics, manual data input. Problem with conventional NC, Computer Numerical Control, Direct Numerical Control, Introduction to Robotics, Robot anatomy physical configurations, Manipulator Kinematics, Technical features, programming the robot, robot programming language, end effecters, work cell design, work cell control and interlock, robotic sensor, robotic applications, Part classification and coding, production flow analysis, machine cell design, benefits of group technology, Types of Manufacturing System, Machine Tools and related equipment, Material Handling System, Flexible Manufacturing System, FMS work station, Types of FMS Layouts, Planning the FMS, Computer aided Process planning, Computer integrated planning systems. Material requirement planning. Capacity planning, shop floor control, factory data collection systems, automatic identification systems – Bar code technology, automated data collection systems.

References:

1. *Yoram Koren, Computer Control of Manufacturing Systems and Computer Integrated Manufacturing, PHI, New Delhi, (2006).*
2. *Mikel P Groover, Automation, Production Systems and computer Integrated manufacturing, PHI, New Delhi, (2008).*
3. *Yoram Koren, Joseph Ben Uri, Numerical Control of Machine Tools, Khanna Publishers, New Delhi, (2005).*
4. *Mikell P Groover and Emory W Zimmers, Computer Aided Design & Manufacturing, PHI, New Delhi, (2008).*
5. *Roger Hannam, Computer Integrated Manufacturing: From Concept to Relaisation,Addison Wesley(1997).*

AAE **: DESIGN OF FIXED WING UNMANNED AERIAL VEHICLE [3-0-0-3]**

Introduction: Fixed-wing UAV, Design and Basic Design Parameters; Design Algorithm: Case Study, Mission Requirements, Feasible Design Parameters; Configuration Layout: Airfoil Selection Configuration, Planform Geometry Selection; Weight and C.G. Estimation; Analytical Parameter Estimation; Performance and Stability Analysis; Simulation; Detailed Sizing; Estimation of Inertial Properties Using 3D Modelling; Prototype Fabrication; Wind Tunnel Testing; Aerodynamic Characterization through Wind Tunnel Testing.

References:

1. *Andrew J. Keane, András Sóbester, and James P. Scanlan, Small Unmanned Fixed-wing Aircraft Design: A Practical Approach, John Wiley & Sons Ltd., (2017).*
2. *Mohammad Sadraey, Unmanned Aircraft Design, Morgan and Claypool Publishers, (2017).*
3. *Randal W. Beard and Timothy W. Mclain, Small Unmanned Aircraft Theory and Practice, Princeton University Press, (2012).*
4. *Daniel P. Raymer, Aircraft Design: A Conceptual Approach, AIAA Education Series, Sixth Edition, 2018.*

5. *Nicolai and Carichner, Fundamentals of Aircraft and Airship Design Volume 1 – Aircraft Design, AIAA Education Series, (2010).*

AAE **: DIGITAL MANUFACTURING [3-0-0-3]**

Introduction: definition, features and developments of Digital Manufacturing (DM). Modeling theory and methods of DM science. Computing Manufacturing in DM. Manufacturing informatics in DM. Intelligent manufacturing in DM. Industry 4.0, Industrial IoT, Cyber Physical Systems, M2M technology, Management of Technology in DM. Rapid Manufacturing., Digital Manufacturing Security, Smart Factories. Future Development of DM.

References:

1. *Zude Zhou, Shane (Shengquan) Xie Dejun Chen, Fundamentals of Digital Manufacturing Science, Springer-Verlag London Limited, (2012)*
2. *Kaushik Kumar, Divya Zindani, J. Paulo Davim (Editors) Digital Manufacturing and Assembly Systems in Industry 4.0 CRC Press, (2020)*
3. *Antonella Petrillo, Raffaele Cioffi, Fabio De Felice, Digital Transformation in Smart Manufacturing Intech Publishers Croatia, (2018)*
4. *Hopkinson N, Hague R. J. M., Dickens P.M. Rapid Manufacturing, John Wiley and sons, (2006)*
5. *Zhuming Bi,Practical Guide to Digital manufacturing, Springer(2021).*

AAE **: ELECTROCHEMICAL ENERGY STORAGE [3-0-0-3]**

Introduction to Energy storage and battery terminology: History of electrochemical energy storage, Requirement of energy storage, Definitions and measuring methods. Electrochemistry and Thermodynamics: Electrochemical Cell, Faradays law of electrochemistry, Redox potential, Electromotive force, Nernst's law, Electrical double layer, Polarization and over potential. Heat Generation and Porous media. Batteries: Types of batteries, Lead Acid, Nickel metal hydride, Nickel-Zinc batteries, Zinc-air and Redox flow batteries. Li-ion batteries: Operational mechanisms of lithium ion batteries, Properties of electrode material, Dendrite formation. Fuel cells and Super capacitors: Introduction, Types of fuel cells, Proton exchange membrane fuel cell, Alkaline fuel cells, Phosphoric acid fuel cell, Solid oxide fuel cells, Molten carbonate fuel cells, Direct methanol fuel cells. Fundamentals of capacitors, Energy stored, Double layer capacitor, Charging and discharging behaviour of super-capacitors. Basic elements of in Lithium-ion batteries and Fabrication: Introduction, Positive electrodes, Negative electrodes, electrolytes, Current collectors, Manufacturing and packaging.

References:

1. *Glaize, Christian, and Sylvie Genies. Lithium batteries and other electrochemical storage systems. John Wiley & Sons, (2013).*
2. *Sundén, Bengt. Hydrogen, Batteries and Fuel Cells. Academic Press, (2019).*
3. *Sterner, Michael, and Ingo Stadler, eds. Handbook of energy storage: Demand, technologies, integration. Springer, (2019).*
4. *Newman, John, and Karen E. Thomas-Alyea. Electrochemical systems. John Wiley & Sons, (2012).*
5. *Braun, Artur. "Electrochemical Energy Systems." Electrochemical Energy Systems. de Gruyter, (2018).*

AAE **: EXPERIMENTAL MECHANICS [3-0-0-3]**

Overview of experimental stress analysis, Stress analysis – Analytical, Numerical and Experimental approaches, Specific domain of these approaches, Advantages and disadvantages. Stress, Strain and Displacement Fields- Beam under pure bending, Analytical solution, Fringe contours from various experimental methods. Physical Principle of Strain Gauges, Photo-elasticity, Physical principle behind various experimental techniques, Strain Gauges, Photoelasticity, Grids for determining plastic strains. Multi-Scale Analysis in Experimental Mechanics- Review of solid mechanics, definition of free surface, ambiguity in associating the correct value of principal stress direction to the magnitude of the principal stress, Eigen value approach or use of Mohr's circle, Shear distribution in a three-point bend specimen.

Self-Study topics recommended

References:

1. *Cesar A. Sciammarella, Federico M. Sciammarella, Experimental Mechanics of Solids, John Wiley &Sons, (2012)*
2. *Emmannuel D Gdoutos, Recent advances in experimental mechanics, Kluwer Academic Publications, (2002)*
3. *Jerome Molimard: Experimental Mechanics of Solids and Structures, ISTE, John Wiley & Sons, (2016)*
4. *Rivka Gilat, Leslie Bank-Sills, Advances in Mathematical Modelling and Experimental Methods for Materials and Structures, Springer Science, (2010)*

5. *U C Jindal, Experimental Stress Analysis,Pearson Education India (2012)*

AAE **: HEAT TRANSFER [2-1-0-3]**

Different modes of heat transfer, heat conduction with and without heat generation through slabs, cylinders and spheres, transient heat conduction, different boundary conditions, heat transfer through fins, fin effectiveness and fin efficiency, heat transfer by free and forced convection, classification of fluid flows, internal and external forced convection, mechanism of natural convection, different dimensionless numbers, radiation heat transfer, black body radiation, Kirchhoff's law, Wein's displacement law, radiation view factor, and it's relations, radiation heat transfer between black and non-black surfaces, radiation shield, heat exchangers, parallel and counter-flow heat exchangers, LMTD and effectiveness-NTU methods, boiling and condensation heat transfer.

Self-study topics recommended

References:

1. *F.P. Incropera, D.P. Dewitt, Fundamentals of Heat and Mass Transfer, John Wiley and Sons, (2006).*
2. *Y.A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, McGraw Hill Education, (2017).*
3. *S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press, (2005).*
4. *P.K. Nag, Heat and Mass Transfer, McGraw Hill Education, (2011).*
5. *R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Internationals, (2017).*
6. *J. Holman, Fundamentals of Heat and Mass Transfer, McGraw Hill Education, (2017).*

AAE **: HELICOPTER ENGINEERING [3-0-0-3]**

Introduction: Historical Development of Helicopters – Helicopter Configuration – Control Requirements – Types of Rotor Systems – Basic Power Requirements; Introduction to Hovering Theory: Momentum Theory – Blade Element Theory – Combined Blade Element and Momentum theories for non-uniform inflow calculation – Ideal Rotor Vs Optimum Rotor; Vertical Flight: Various flow states of Rotor – Autorotation in Vertical Descent – Ground Flight; Forward Flight: Momentum Theory – Variable Inflow Models – Blade Element Theory – Rotor Reference Planes – Hub Loads – Power variation with forward speed – Rotor Blade flapping Motion: Simple Model.

Self-study topics recommended

References:

1. *Leishman, J.G., 'Principles of Helicopter Aerodynamics, Cambridge University Press, (2000).*
2. *Johnson, W. Helicopter Theory, Princeton Univ. Press, New Jersey, (1980).*
3. *Johnson, W., Rotorcraft aeromechanics, Cambridge University Press, (2013).*
4. *Prouty, R.W., Helicopter performance, Stability and Control, R.E. Krieger Pub. Co., Florida, (1990).*
5. *Seddon, J., Basic Helicopter Aerodynamics, AIAA series, (1990).*

AAE **: INDUSTRIAL AUTOMATION AND ROBOTICS [3-0-0-3]**

Introduction, classification compressors, actuators, flow control valves, direction control valves, Time delay valve, Counter, Solenoids, Sensors, Multiple actuation system, P E convertor, Design of pneumatic and electronic circuits. Introduction to Robotics, Rigid-Body Kinematics, Dynamics of Robots, Trajectory Planning for Flexible Robots, Robotic Sensors, Robot End Effectors, Robot Programming, Industrial Applications.

Self-Study topics recommended

Architecture of Industrial Automation Systems, Measurement Systems Characteristics, Measurement Systems Characteristics ,Data Acquisition Systems, Data Acquisition Systems,Practice Problems with MATLAB in Rotation matrices, Kinematics: Derivation of Link Transformations, Problem Solving DH Parameters, Forward Kinematics, Inverse Kinematics.

References:

1. *Joji P, Pneumatic Controls, Wiley India Pvt. Ltd, (2013).*
2. *Prede G. and Scholz D. , Electropneumatics Basic Level , Festo Didactic GMBH & Co, Germany, (2002).*
3. *Peter Croser, Frank Ebel, Pneumatics Basic Level TP 101, Festo Didactic GMBH & Co, Germany, (2002).*

4. *A.K. Gupta, S.K. Arora and J. Riescher Westcott: Industrial Automation and Robotics, Mercury Learning and Information (2016).*
5. *Thomas R. Kurfess, Robotics and Automation Handbook, CRC Press, (2004).*
6. *Martin Klas Nilsson J. Norberto Pires, Industrial Robotics, Springer, (2007).*

AAE **: LEAN MANUFACTURING [3-0-0-3]**

History of Lean and comparison to other methods – The 7 Wastes, their causes and the effects – An overview of Lean Principles / concepts / tools – Stockless Production. The Tools of Lean Manufacturing: Continuous Flow – Continuous Flow Manufacturing and Standard Work Flow – 5S and Pull Systems (Kanban and ConWIP systems) – Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) – Kaizen Event examples. Toyota production systems, Ford production systems. Value Stream Mapping – Future State: Key issues in building the Future State Map – Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop – Example of completed Future State Maps – Application to factory simulation – Implementation of lean practices – Best Practices in Lean Manufacturing. House of Lean -5S's and Waste Walks, Visual Management, Value Stream Mapping-Understanding the current state and designing the future state Managing lean enterprise: – Finance, Career ladders, geographic spread and advantages of global enterprise. Additional Interests: Develop VSM Current and Future state diagram using Microsoft Visio or Similar Software Package. Six sigma concepts: History, definitions, Statistical definitions, quality levels, Technical aspects, Six sigma for all: benefits to organizations, customers, suppliers and employers, Design for Six Sigma, DMAIC principles, DMADV principles, merits and demerits.

References:

1. *Toyota Production System -An integrated approach to Just in Time – Yasuhiro Monden, – Engineering and Management Press -Institute of Industrial Engineers, (1983)*
2. *James P Womack, Daniel T Jones, and Daniel Roos, The Machine that changed the World. The Story of Lean Production -Harper Perennial edition, (1991)*
3. *Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, Second Edition Hardcover, (2012)*
4. *Value Stream Mapping: How to Visualize Work and Align Leadership for Organizational Transformation Paperback – by Karen Martin, Mike Osterling, (2016)*
5. *Lean and Six Sigma – Six Sigma Black Belt Enterprise-Wide Deployment Paper Back by Suvabrata Mitra, (2007)*

AAE **: NAVIGATION, GUIDANCE AND CONTROL [3-0-0-3]**

Introduction of navigation, Inertial sensors and inertial navigation system, multi sensor navigation systems, different types of navigation radar and its types; other types of navigation, satellite based navigation systems, Ground based navigation equipment's, Augmentation and Integration, GPS denied environment, Visual navigation. navigation sensor design and navigation data analysis, Introduction of guidance, guided missiles, classification and systems in missiles. Fundamentals of guidance; Interception and Avoidance; Taxonomy of guidance laws, Classical and empirical guidance laws; guidance laws: pursuit, LOS and PN laws, Applied optimal control and optimal guidance laws; Differential games and pursuit evasion problems; Recent advances in guidance theory; Collision detection and avoidance strategies; Classical & modern control systems, adaptive control application, Artificial intelligence and biological inspired optimization in control systems and its application. Applications to guided missiles, Unmanned aerial vehicles and Mobile robots.

Self-Study topics recommended

References:

1. *Mohinder S Grewal: Global Navigation Satellite Systems, Inertial Navigation and Integration, John Wiley, (2013).*
2. *Zarchan P.: Tactical and Strategic Missile Guidance, AIAA Series, (2007).*
3. *Katsuhiko Ogata: Modern Control Engineering , Pearson,(2009).*
4. *Myron Kayton & Walter R. Fried: Avionics Navigation Systems, Wiley-interscience, (1997).*
5. *G.M. Siouris: Missile Guidance and Control Systems, Springer Verlag, (2004).*
6. *Ching-Fang Lin: Modern Navigation, Guidance, and Control Processing, Prentice Hall, (1991).*
7. *Asher Clark (Editor): Global Navigation Satellite Systems and Their Applications, Larsen and Keller Education, (2017).*

AAE **: NON-LINEAR CONTROL SYSTEMS [3-0-0-3]**

Introduction of linear and nonlinear systems, nonlinear system behaviour, Mathematical preliminaries: open and closed sets, compact set, dense set, Topology, sequence, Continuity of functions, Lipschitz condition, smooth functions, basic linear algebra: Vector space, norm of a vector, normed linear space, inner product space. Well-posedness of ordinary differential

equations, Lipschitz continuity and contraction mapping theorem. Phase plane analysis-phase portrait, phase plane analysis of linear and nonlinear system, existence of limit cycle, equilibrium points, linearization and local stability, Direct method, system analysis using Lyapunov direct method, Advance stability theory: Lyapunov stability for autonomous and non-autonomous systems, Linear Time Variant, Instability theorem, function, Barbalat's Lemma, Function analysis. Nonlinear control systems design: Feedback linearization, Backstepping, Input-output stability, Input-to-state stability, Passivity and Dissipativity, Nonlinear observer, Sliding control and adaptive control, Nonlinear control system for multi-input systems, Example-Mass spring damper, Robotics, Spacecraft control, Robot trajectory etc.

References:

1. *Slotine, J-J. E. and Li, W.: Applied Nonlinear Control, Prentice-Hall, (1991).*
2. *Horacio J. Marquez: Nonlinear Control System Analysis and Design John Wiley & Sons, (2003)*
3. *Kwatny, H. G. and Blankenship: Nonlinear Control & Analytical Mechanics, Birkhauser, (2000).*
4. *Isidori, Alberto: Nonlinear Control Systems-(3rd edition), Springer-Verlag, (1995).*
5. *Nijmeijer, H. and H. J. van der Schaft: Nonlinear Dynamical Control*
6. *Khalil, H. K.: Nonlinear Systems , MacMillan, (1996).*
7. *Shimkin N.: Nonlinear Control Systems. In: Binder M.D., Hirokawa N., Windhorst U. (eds) Encyclopedia of Neuroscience, (2009).*

AAE **: NUMERICAL METHODS FOR SCIENTIFIC COMPUTING [3-0-0-3]**

Mathematical review and computer arithmetic – numbers and errors; Nonlinear equations; Direct methods for linear systems; Iterative Methods for Linear Systems; Eigenvalues and Eigenvectors – power method, inverse power method, QR method; Approximation Theory – norms, orthogonalization, polynomial approximation, piecewise polynomial approximation, trigonometric approximation, rational approximation, wavelet bases; Numerical Differentiation; Numerical Integration – Romberg Integration, Gauss Quadrature, Adaptive Quadrature; Numerical Ordinary Differential Equations – single step and multi-step methods, Runge-Kutta method, predictor corrector method, stiffness, stability, shooting methods; Introduction to parallel programming – system architectures, shared and distributed memory programming, performance.

References:

1. *John A. Trangenstein, 'Scientific Computing - Vol I, II, III, Springer, (2010).*
2. *Parviz Moin, Fundamentals of Engineering Numerical Analysis, Cambridge, (2010).*
3. *Steven C. Chapra, Applied Numerical Methods, McGraw Hill, (2012).*
4. *Walter Gander, Martin J. Gander, Felix Kwok, Scientific Computing, Springer, (2010).*
5. *A.S. Ackleh, E.J. Allen, R.B. Hearfott, P. Seshiyer, Modern Numerical Analysis, CRC, (2009).*
6. *Amos Gilat, Vish Subramaniam, Numerical Methods for Engineers and Scientists, Wiley, (2014).*

AAE **: OPERATIONS RESEARCH [3-0-0-3]**

Introduction: Evolution of OR, Definitions, scope and applications of OR, Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP): Formulation, graphical solution, simplex method, Revised simplex method, duality in LPP. Transportation Problem: formulation, Initial basic solution, Optimality in transportation problem. Assignment Problem: Formulation and solutions. Traveling salesman problem. Network analysis: PERT and CPM. Queuing theory: M/M/1 and M/M/C queuing models. Dynamic Programming.

References:

1. *Hamdy A. Taha, Operations Research- An Introduction, Pearson India (2016)*
2. *Hillier and Lieberman, Introduction to Operations Research,McGraw Hill International (2017)*
3. *Vohra N D. Quantitative Techniques in Management, Tata McGraw Hill, (2007)*
4. *Pannerselvam, Operations Research, Prantice Hall India (2009)*
5. *Gupta P K, Hira D S, Operations Research S. Chand Publishers (2015).*

AAE **: OPTIMAL CONTROL [3-0-0-3]**

Nonlinear optimization, Formulation of optimal control problems, Parameter optimization versus path optimization, Local and global optima; general conditions on existence and uniqueness. Some basic facts from finite-dimensional optimization, the

Euler-Lagrange equation, path optimization subject to constraints, weak and strong extrema, Calculus of variations applied to optimal control, Pontryagin's minimum principle, Optimal control with state and control constraints, Time-optimal control, Singular solutions, Hamilton-Jacobi-Bellman (HJB) equation and dynamical programming, Finite-time and infinite-time state (or output) regulators, Riccati equation and its properties, Tracking and disturbance rejection, Kalman filter and duality, The LQR design, The LQG design, Estimator /Observer design:-MIMO System and SVD, Holonomic & Nonholonomic System Optimal Control, Game Theoretic Optimal Control Design, Signals and system norms.

References:

1. *A.E. Bryson and Y.C. Ho: Applied Optimal Control , Blaisdel., (1975).*
2. *Naidu D.S: Optimal Control Systems, CRC Press, (2002).*
3. *Sinha A.: Linear Systems: Optimal and Robust Control, CRC Press, (2007).*
4. *D. E. Kirk: Optimal Control Theory: An Introduction, Prentice-Hall, (1970). (former textbook on deterministic control, Dover reprinted 2004), (2004).*
5. *R. F. Stengel: Optimal Control and Estimation, Dover, (1994).*
6. *Dimitri P. Bertsekas: Dynamic Programming and Optimal Control, Volume I, Athena Scientific, (2005).*
7. *Richard W. Cottle, Mukund N. Thap: Linear and Nonlinear Optimization, Springer Nature, (2017).*

AAE **: OPTIMIZATION TECHNIQUES IN ENGINEERING [3-0-0-3]**

Introduction to optimization – linear programming – duality and sensitivity analysis – integer programming – non-linear programming – unconstrained optimization – constrained optimization: equality and inequality constraints – optimality conditions and optimization approaches – non-traditional optimization approaches – applications in aerospace engineering.

References:

1. *Ravindran, A., Phillips, D. T., and Solberg, J. J., Operations Research: Principles and Practice, Wiley-India (2006).*
2. *Rao, S. S., Engineering Optimization: Theory and Practices, John Wiley (2009).*
3. *Winston, W. L., Operations Research: Applications and Algorithms, Cengage Learning (2010).*
4. *Ravindran, A., Ragsdell, K. M., and Reklaitis, G. V., Engineering Optimization: Methods and Applications, Wiley-India (2006).*
5. *Deb, K., Optimization for Engineering Design: Algorithms and Examples,PHI Learning (2012).*
6. *Deb, K., Multi-Objective Optimization Using Evolutionary Algorithms, Wiley-India (2010).*

AAE **: SPACEFLIGHT DYNAMICS [3-0-0-3]**

Basics of System Modeling and Dynamics, Rotational Kinematics and Rigid Body Dynamics, Orbital Determination, Relative motion and Rendezvous, Spacecraft/satellite Attitude, Dynamics and Control, Robust Optimal Maneuvers, Orbital Perturbations, restricted three-body motion, launch vehicle dynamics, Re-entry dynamics, description of the motion and rates of motion of rigid bodies (Kinematics), developing the equations of motion that prediction the movement of rigid bodies taking into account mass, torque, and inertia (Kinetics), non-linear controls to program specific orientations and achieve precise aiming goals in three-dimensional space (Control).

Self-Study topics recommended:

References:

1. *William E Wiesel, Spaceflight Dynamics, Mc Graw Hill (2010).*
2. *Craig A. Kluever, Spaceflight Dynamics, Wiley, (2018)*
3. *Roger R. Bate, Donald D. Mueller, Jerry E. White, Fundamentals of Astrodynamics, Dover Publications (1971)*
4. *Bong Wie, Space Vehicle Dynamics and Control, American Institute of Aeronautics and Astronautics, (2008)*
5. *H Curtis, Orbital Mechanics for Engineering students, Elsevier, (2012).*
6. *Goldstein, Classical Mechanics, Third Edition, Pearson, (2001).*
7. *Anton H. de Ruiter, Christopher Damaren James R. Forbes, Spacecraft Dynamics and Control: An Introduction, Wiley, (2013).*

AAE **: SPACEFLIGHT MECHANICS [2-1-0-3]**

Dynamics of Particles: reference frames and rotations – energy, angular momentum; Two Body Motion: equations of motion – Kepler laws – solution to two-body problem – conics and relations – Kepler equation – orbital elements – orbit determination – Lambert Problem – satellite tracking – different methods of solution to Lambert Problem; Non-Keplerian Motion: perturbing acceleration – earth aspherical potential – oblateness – third body effects – atmospheric drag effects – applications of perturbations; Orbit Maneuvers: Hohmann transfer – inclination change maneuvers, combined maneuvers, bi-elliptic maneuvers; Lunar/Interplanetary Trajectories: sphere of influence – methods of trajectory design – restricted three body problem – Lagrangian points.

Self-Study topics recommended

References:

1. *Curtis, H, D., Orbital Mechanics for Engineering Students, Elsevier (2009).*
2. *Chobotov, V.A., Orbital Mechanics, AIAA Education Series (2002).*
3. *Tewari, A., Atmospheric and Space Flight Dynamics: Modelling and Simulation with MATLAB and Simulink, Birkhuser (2007).*
4. *Brown, C.D., Spacecraft Mission Design, AIAA Education Series (1998)*
5. *Wiesel, W.E., Spaceflight Dynamics, McGraw-Hill (1996).*
6. *Escobal, P.R., Methods of Orbit Determination, Krieger Publication Co. (1976).*

AAE **: STATISTICAL QUALITY CONTROL AND RELIABILITY [2-1-0-3]**

Fundamentals of quality and quality control. Measure of central tendencies. Probability distributions. Tolerance allocation. Control chart for variables and attributes. Process capability analysis and process capability index. Acceptance sampling. Operating characteristic curves. Dodge romig and MIL-STD acceptance sampling tables. Concept of reliability, Reliability systems, maintainability and availability.

References:

1. *Montgomery D. C., Introduction to Statistical Quality Control, John Wiley & Sons, New York (2013)*
2. *Amitav Mitra, Fundamentals of quality control and improvement,Wiley (2008)*
3. *Grant E.L., Statistical Quality Control, McGraw Hill Publications, New York (1988)*
4. *Juran J.M., Quality Planning and Analysis, McGraw Hill Publications, Delhi (1984)*
5. *Rao S S., Reliability Engineering Pearson Education (2014)*

AAE **: SURROGATES AND APPROXIMATIONS IN ENGINEERING DESIGN [2-1-0-3]**

Introduction: physical versus computational experiments – introduction to engineering optimization – need for surrogates in optimization; Design of Experiments: Sampling plans – Latin squares – Latin hypercubes sampling – stratification – Orthogonal arrays – Hammersley sequences; Surrogates: Polynomial Regression – Radial basis function – Kriging; Using surrogates in design space exploration and exploitation – infill criteria –adaptive sampling.

References:

1. *Forrester, A., & Keane, A, Engineering design via surrogate modelling: a practical guide. John Wiley & Sons(2008).*
2. *Jiang, P., Zhou, Q., & Shao, X. Surrogate model-based engineering design and optimization. Springer(2020)*

AAE **: SYSTEMS ENGINEERING [3-0-0-3]**

Introduction of Systems Engineering, Methodology of system engineering, systems, customer needs and requirements, operational analysis, functional analysis, logical analysis, physical analysis, Heterogeneous solution, system verification and validation, system engineering and product life cycle management, system project management and software system engineering. system engineering principle to avionics system, Existing avionics systems and their functions, new avionics subsystem and their base, project management of avionics engineering, software design, development and integration to system., Avionics Systems Essentials, Design areas of concern to system engineers, FARs, and certification requirements, identify design evaluation criteria and assign weighting values to the evaluation criteria, System requirements System engineering concepts, functional design, trade studies for the best system design...

References:

1. *Eugenio Brusa, Ambra Calà, Davide Ferretto: Systems Engineering and Its Application to Industrial Product Development, Part of the Studies in Systems, Decision and Control book series (SSDC, volume 134) (2018).*
2. *Mo Jamshidi: Systems of Systems Engineering Principles and Applications (1st Edition), CRC Press [First Published 2009, eBook Published 2017] (2017).*
3. *Boris Cogan: Systems Engineering - Practice and Theory, IN-TECH (March 2012).*
4. *Blanchard, Benjamin S., and Fabrycky, Wolter J., Englewood Cliffs, N.J: System Engineering and Analysis, Prentice-Hall, (1990).*
5. *Cary R. Spitzer, Digital Avionics Handbook: -Avionics Development and Implementation (2nd Edition), CRC Press, Taylor & Francis Group, (2007).*
6. *Defense Systems Management College, Systems Engineering Management Guide, U.S. Government Printing Office, December (1989).*

AAE **: TOTAL QUALITY MANAGEMENT [3-0-0-3]**

Connotations of Quality, Quality Dimensions: Product and Service. The Concept of TQM, Evolution of TQM, Inspection, SQC, QA and TQM. Conventional Quality Management versus TQM. Customer Supplier Focus in TQM, Benefits and Costs of TQM, Historical Perspectives of TQM, Measurement Tools: Check Sheets, Histograms, Run Charts, Scatter Diagrams, Cause and Effect Diagrams, Pareto's Chart, Process Capability Measurement. Analytical Tools: Process Mapping, Regression Analysis, Resource Utilization and Customer Service Analysis, The Five Why's, Overall Equipment Effectiveness. Improvement Tools and Techniques: Kaizen, JIT, Quality Circles, Force Field Analysis, Five S's, Quantitative Techniques: Failure Mode Effect Analysis (FMEA), Statistical Process Control (SPC), Quality Function Deployment (QFD), Design of Experiments (DOE), Kanban and Activity Based Costing (ABC). Taguchi Methods: Quality Loss Function, Orthogonal Arrays, The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma Programme, Six Sigma Organization: Roles and Responsibilities, Six Sigma Problem Solving Approach, Implementation of TQM in Service Organization: Framework for Improving Service Quality, Model to Measure Service Quality Programs.

References:

1. *John L. W. Beckford,Quality: A Critical Introduction, Routledge Taylor and Frances Group, New York and London(1998)*
2. *Dale H. Besterfield, Carol Besterfield - Michna, Glen H Besterfield and Mary Besterfield-Sacre, Total Quality Management,PHI, (2006)*
3. *Ron Basu, Implementing Quality: A Practical Guide to Tools and Techniques, THOMPSON, (2006).*
4. *Greg Brue, Six Sigma for Managers, TMH, (2002).*
5. *R. P. Mohanty & R. R. Lakhe, TQM in the Service Sector, Jaico Books(2013)*

AAE **: WIND ENERGY ENGINEERING [3-0-0-3]**

Introduction to wind energy, the wind resource and its characteristics, Wind turbine types, configurations, components, design of machines and wind farms, Wind turbine aerodynamics, Dynamics, aero-servo-elasticity and control of wind turbines, Introduction to off-shore wind, the off-shore environment, support structures, dynamics, Introduction to electrical systems and grid integration. Winds: physical background, energy content, variation in time and in space, geographical resource distribution, influence of terrain, measurement methods, statistical analysis. Turbines: free flow, principles of drag and lift, aerodynamics, design of turbine blades, horizontal and vertical axis wind turbines, Betz' and Glauert's turbine theories, the BEM method, Mechanics: static and dynamic loads (oscillations), rotor dynamics, solid mechanics, mechanical, modelling, aeroelasticity, Design: horizontal and vertical axis wind turbines, blades, control mechanisms, drive train, tower, nacelle, foundation, choice of materials, manufacture, adaptation to different climates, Economy: financing, investment, costs during the lifetime of a wind turbine, value of wind energy, business and market overview, small scale wind power: technology, economy, paths of development

References:

1. *Trevor M. Letcher , Wind Energy Engineering, A Handbook for Onshore and Offshore Wind Turbines, Academic Press(2017)*
2. *J. F. Manwell and J. G. McGowan, A. L. Rogers, WIND ENERGY EXPLAINED Theory, Design and Application, Wiley(2009)*
3. *Pramod Jain, Wind Energy Engineering, Mc Graw Hill Education(2016)*
4. *T. Burton, N. Jenkins, D. Sharpe, E. Bossanyi, Wind Energy Handbook, Wiley, (2011).*
5. *R. Gasch and J. Twele, Wind Power Plants: Fundamentals, Design, Construction and Operation. Springer, (2012)*

OPEN ELECTIVES

AAE ****: INTRODUCTION TO AEROSPACE ENGINEERING [3-0-0-3]

Introduction and Overview of The History of Flight, Fundamental Thoughts, Ballooning, Basic/Constructive Principles of Fluid Mechanics-Bernoulli's Theorem and Control Volume Approaches, The Sources of all Aerodynamic Forces, Standard Atmosphere, Hydrostatic Equation, Incompressible and Compressible Flows, Elementary Thermodynamics and Isentropic flow, Flow Regimes and Estimation of Viscous, Thermal Effects, Basics of Aerodynamics, Airfoil Nomenclature, Lift, Drag and Moment Coefficient, Infinite vs Finite Wings, Pressure Coefficients, Elements of Airplane Performance, Astronautics, Basics of Propulsion. Orbital Mechanics.

References:

1. *Anderson Jr. JD, Introduction to Flight, McGraw Hill International Edition, (2012).*
2. *Dava Newman, Interactive Aerospace Engineering and Design, McGraw Hill International Edition, (2002).*
3. *A.C.Kermode, Flight without Formulae, Pearson Education (United Kingdom), (1990).*
4. *Howard D Curtis., Orbital mechanics for Engineering Students, Butterworth Heinemann, (2013).*
5. *Anderson Jr. JD, Fundamental of Aerodynamics, McGraw Hill International Edition, (2017).*

AAE ****: INTRODUCTION TO AVIONICS AND NAVIGATION SYSTEMS [3-0-0-3]

Introduction to aircraft, Introduction to flight mechanics and flight dynamics of aircraft & Unmanned Air Vehicle, UAV Instrumentations and Sensors, Introduction to Avionics in aircraft, Organization framework, avionics architectures generation, types of payloads, Cockpit Layout of old and modern aircrafts, Displays, Packaging, ARINC and DOD Types, System Cooling, EMI/EMC Requirements; Aircraft Power Systems, Communication, Satellite Communication, Flight control laws, FBW, Autopilot, FMS, LRU, IMA & Mission Systems, Warning systems, Engine Control. Inertial Sensors and Inertial Navigation Systems, Elements of Navigation Systems, Ground based and celestial systems-based navigation systems, Satellite Navigation Systems, Augmentation, Radar & Mechanics of landing and types Landing Systems. Software Standards-CERT, MISRA, DO178B/C etc and avionics system engineering and systems life cycle.

References:

1. *R.P.G. Collinson: Introduction to Avionics Systems, Springer, (2002).*
2. *Arjun Singh: Airport Ground Navigation Systems, Tata McGraw Hill Education Pvt. Ltd, (2012).*
3. *Thomas K. Eismin, Aircraft Electricity and Electronics, Tata McGraw Hill Education Pvt. Ltd, (2014).*
4. *Cary R. Spitzer: Digital Avionics Handbook-Avionics Development and Implementation , CRC Press, Taylor & Francis Group, (2007).*
5. *Bernard Etkin and Lloyd Duff Reid: Dynamics of Flight: Stability and Control, Wiley, (1995).*
6. *Myron Kayton & Walter R. Fried: Avionics Navigation Systems, Wiley-interscience, (1997).*
7. *Mohinder S Grewal: Global Navigation Satellite Systems, Inertial Navigation and Integration, John Wiley, (2013).*

MINOR SPECIALIZATION: AERODYNAMICS

AAE ****: APPLIED AERODYNAMICS [2-1-0-3]

Internal flows, boundary layers , turbomachines, external flows, automotive aerodynamics, introduction to compressible flow, flow in a variable-area duct, external flows, shock – expansion theory, supersonic boundary layers, experimental approach, Aerodynamics and prediction of lift, drag, and moments, Effect of aerodynamics on system performance using examples such as projectile motion, aircraft flight, race-car performance, sailboats, and wind turbines, Simulation of system dynamics including aerodynamic effects using examples such air and ground vehicles.

References:

1. *Jan Roskam, Methods for Estimating Drag Polars of Subsonic Airplanes, University of Kansa (1973)*
2. *Hoerner, Fluid Dynamic Drag, Published by the author, (1993)*
3. *Hoerner and Boerst, Fluid-Dynamic Lift, Published by the author, (1992)*
4. *Anderson, J. D., Fundamentals of Aerodynamics, McGraw Hill, (2017)*

5. *Victor L. Peterson and Charles A. Smith ,Applied Aerodynamics: Challenges and Expectations ,NASA(1993)*
6. *Munson, B.R., Young, D.F., Okiishi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc(2018)*

AAE **: TURBOMACHINERY AERODYNAMICS [2-1-0-3]**

Classification and applications of turbomachines, ideal and real performance cycles, Construction features of compressor, principle of operation, enthalpy-entropy diagram, velocity triangles, compressor design parameters, compressor cascade, different losses in compressors, work done factor, 3D flow analysis, vortex energy equation, 2D blade section design, axial flow tracks, compressor characteristics, instabilities in axial compressors, construction and working of axial flow turbines, velocity triangle, different efficiencies, impulse and reaction turbines, losses, turbine cooling, principle of operation of centrifugal compressors, enthalpy-entropy diagram, velocity triangle, losses, construction of radial flow turbines, enthalpy-entropy diagram, velocity triangle, turbine losses.

References:

1. *Cohen, H., Rogers, G.F.C., Straznicky, P., Saravanamuttoo, H.I.H. and Nix, A., Gas Turbine Theory, Pearson, (2017).*
2. *Yahya, S.M., Turbines, compressors and fans, McGraw Hill Education, (2017).*
3. *Hill P.G, Peterson C.R., Mechanics and thermodynamics of propulsion, Addison Wesley Publishing Company, (1992)*
4. *Nicholas Cumpsty, Compressor Aerodynamics, Krieger Publications, USA, (2004)*
5. *Johnson I.A., Bullock R.O., (NASA-SP-36), Axial Flow Compressors, NTIS, (2002)*
6. *El-Wakil, Powerplant Technology, McGraw Hill Publications, (1984)*
7. *J.H. Horlock, Axial Flow Compressors: Fluid Mechanics and Thermodynamics, Krieger, (1982)*

AAE **: EXPERIMENTAL AERODYNAMICS [3-0-0-3]**

Experimental Errors, Causes and Types, Statistical Analysis of Experimental data. Wind Tunnels: Types of wind tunnel, components, operation. Shock tubes and other high-speed facilities: shock tunnel, ballistic range, Plasma Arc Tunnel, Rarefied Gas Tunnel. Flow Visualization Techniques –Schlieren, Shadowgraph, Interferometry. Temperature measurement in flow: Thermometry, Thermostats, Thermistors, RTDs, Thermocouples, spectroscopy-based measurements, PLIF. Pressure measurement methods: Manometers, Bourdon gauges, Bellows and Diaphragms, Piezoelectric, Piezo-resistive. Velocity measurements in Flow: Pitot probe, Pitot correction in supersonic flows, hot wire Anemometry. Laser Doppler Velocimetry, Particle Image Velocimetry.

References:

1. *G. S. Settles: Schlieren and Shadowgraph Techniques - Visualizing Phenomena in Transparent Media, Springer, (2001)*
2. *Alan Pope, Kennith L Goin: High speed wind tunnel testing, John Wiley & Sons, New York, (1965)*
3. *Stefano Discetti and Andrea Ianiro, Experimental Aerodynamics, CRC Press, (2017)*
4. *Jewel B. Barlow, William H. Rae, Alan Pope: Low-Speed Wind Tunnel Testing, Wiley, (1999)*
5. *S.P. Venkateshan: Mechanical Measurements , John Wiley & Sons Ltd, (2015)*
6. *Irvine I Glass, J P Sislian: Non-stationary flows and shock waves, Clarendon Press, Oxford. (1994)*

AAE **: HIGHSPEED AERODYNAMICS [2-1-0-3]**

Mach number regimes, Velocity-Altitude Map, Inclination methods, Inviscid hypersonic flow equations, Approximate methods, , Exact methods, Method of characteristics, Viscous Hypersonic flow, Similarity parameters, Self-similar solutions, Applications of self-similar solutions, Reference temperature method, High temperature flows, Hypersonic viscous interactions, Shock-shock/boundary layer interactions, Hypersonic governing equations, Viscous shock layer techniques, Parabolized Navier-Stokes equations, Full Navier-Stokes equations, Hypersonic wind tunnels.

References:

1. *John D. Anderson Jr, Hypersonic and High Temperature Gas Dynamics, McGrawHill, (1989)*
2. *John J Bertin, Hypersonic Aerothermodynamics, AIAA Education Series., Washington DC, (1994)*
3. *Wallace D. Hayes and Ronald F. Probstein, Hypersonic Flow theory, Academic Press, New York, (1959)*
4. *Ernst Heinrich Hirschel, Basics of Aerothermodynamics, Springer Verlag Berlin, (2005)*
5. *Wilbur L. Hankey, Reentry Aerodynamics, AIAA Education series, Washington DC, (1988)*

MINOR SPECIALIZATION: AVIONICS SYSTEM ENGINEERING

AAE **: UNMANNED AIRCRAFT SYSTEM, SENSORS, AND INSTRUMENTATION [3-0-0-3]**

Introduction to Unmanned Aircraft Systems (UAS) and Applications of UAS, Introduction to Design and Selection of the System, Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types, Design Standards, Design for Stealth, PAYLOADS, Communications, Control and Stability, Navigation, Launch and Recovery, Control Stations, Support Equipment, Transportation, Design for Reliability, EMC/EMI of UAS. Introduction to System Development and Certification, System Development, UAV System testing, system -in flight testing, Defence Application.

References:

1. *Reg Austin: Unmanned Aircraft Systems UAVs Design, Development and Deployment , A John Wiley and Sons, Ltd., (2010).*
2. *Jay Gundlach: Designing Unmanned Aircraft Systems: A Comprehensive Approach , AIAA Education Series, (2014).*
3. *Jay Gundlach: Civil and Commercial Unmanned Aircraft Systems, AIAA Education Series, (2016).*
4. *Dr David C. Ison: Small Unmanned Aircraft Systems Guide: Exploring Designs, Operations, Regulations, and Economics, Aviation Supplies & Academics Inc, (2017).*
5. *Douglas M. Marshall et al.: Introduction to Unmanned Aircraft Systems , Taylor & Francis, (2016).*
6. *F.B. da Silva S.D. Scott M.L. Cummings: Design Methodology for Unmanned Aerial Vehicle (UAV) Team Coordination, MIT Department of Aeronautics and Astronautics, Cambridge, MA 0213, (2007).*

AAE **: ANTENNA DESIGN ANALYSIS AND ITS APPLICATIONS [3-0-0-3]**

Fundamentals of electromagnetic theory.Boundary value problem, Magnetostatic Field, maxwell equations, Fundamentals of Antenna, Basic Antenna and Propagation Theory: Introduction, Characteristics of Electromagnetic Waves, Interaction between Two Wave Polarizations. Characteristics of an Antenna. Propagation. Antennas and Applications. Antennas Placement/Used on Aircraft, Polar Radiation Patterns., Computer Modelling Techniques, Method of Moments, FDTD, UTD, Physical Optics, Hybrid Methods, Radar Cross Section (RCS), RCS Dependency on Polarization, Stealth technology and radar absorbing materials (RAM).

References:

1. *Mathew N O Sadiku: Elements of Electromagnetics , Oxford University Press, (2001).*
2. *C.A. Balanis: Antenna Theory - Analysis and Design , John Wiley, (2016).*
3. *Thereza Macnamara: Introduction to Antenna Placement and Installation , Wiley, (2010).*
4. *John D Kraus, Ronald J Marhefka, Ahmad S Khan: Antennas for All Applications , The McGraw Hill Companies, (2008).*
5. *J. E. Rhodes: Antenna Handbook, Department of The Navy, (2016).*
6. *Lo, Y.T., Lee, S. W.: Antenna Handbook Theory, Applications, and Design, Springer US, (1988).*

AAE **: AEROSPACE EMBEDDED SYSTEMS, SOFTWARE, SAFETY AND SECURITY [3-0-0-3]**

Introduction to embedded systems, classification, major application, typical embedded systems architecture, systems components, designing embedded system with microcontroller and microprocessor, embedded hardware and firmware design and development-Tools, IDE, Development Tools, Control Systems: Tortoise SVN, etc. Effective software development for aerospace safety and critical application, software development and testing, requirement analysis, SDLC & Fundamentals of Software Testing /Embedded System, Introduction to Coding Standards i.e., CERT C and MISRA C:2012, Top 10 Secure Coding Best Practices, Introduction to Process Standard DO-178C for Avionics, Embedded System, Aircraft embedded systems: computer, OBC, microprocessor and microcontroller in LRUs, communication modules, databus modules..

References:

1. *K.V. Shibu: Introduction to Embedded Systems, McGraw Hill Education India Private Limited(2017)*
2. *E. A. Lee and S. A. Seshia: Introduction to Embedded Systems - A Cyber-Physical Systems Approach, MIT Press, (2017).*
3. *Kai Qian, David den Haring and Li Cao: Embedded Software Development with C, Springer Science and Business Media, LLC, (2009).*
4. *Michael Barr, Anthony Massa, Programming Embedded Systems, Second Edition with C and GNU Development Tools 2nd Edition, O'Reilly Media, (2009).*
5. *Renu Rajani, Pradeep Oak: Software Testing Effective Methods Tools & Techniques, Tata Mcgraw Hill Publishing Co Ltd, (2017).*
6. *MISRA C and SEI CERT C secure coding standards.*

AAE **: AIRCRAFT COMMUNICATION AND NETWORKING [3-0-0-3]**

Introduction, communication process, source, channel, modulation process, Signals and Signal Space, Amplitude Modulations and Demodulations, Angle Modulation and Demodulation, demodulators or detectors, Performance of communication systems, AM and FM Receiver, sampling theory, Cellular and mobile communication, Security in Next Generation Air Traffic Communication Network, Aircraft communication,

Commercial Standard Digital Bus, Data bus, ARINC, Avionics Application Software Standard Interface.Basic functions and facilities of a computer, Computer Systems Hardware, Networking Essentials., Networking Computers, Communications, Data Communications and Transmission Media, RISC processors: ARM and SPARC, VLIW processors, Case study : Aircraft computers, Aircraft Networking, Aircraft Data Network (ADN).

References:

1. *B. P. Lathi, Z. Ding: Modern Digital and Analog Communication Systems, Oxford University Press, (2010).*
2. *Sanjay Sharma: Communication system (Analog and Digital), S.K. Kataria & Sons, (2013).*
3. *Commercial Standard Digital Bus , Collins General Aviation Division, Rockwell International Corporation, Cedar Rapids, IA, (1991).*
4. *Dale Stacey: Aeronautical Radio Communication Systems and Networks, John Wiley & Sons, Ltd, (2008).*
5. *Rob Williams: Computer Systems Architecture - A Networking Approach (2nd Edition), PEARSON Prentice Hall, (2006).*
6. *Philipp Goedeking: Networks in Aviation: Strategies and Structures,Springer, (2010).*