B TECH AERONAUTICAL ENGINEERING

Year	THIRD SEMESTER						FOURTH SEMESTER					
	Sub. Code	Subject Name	L	T	P	C	Sub. Code	Subject Name	L	T	P	C
II	MAT 2121	Engineering Mathematics - III	2	1	0	3	MAT 2221	Engineering Mathematics - IV	2	1	0	3
	AAE 2121	Introduction to Aircraft Structures	2	1	0	3	AAE 2221	Incompressible Aerodynamics	3	1	0	4
	AAE 2122	Materials and Processing Techniques	3	0	0	3	AAE 2222	Air-Breathing Propulsion	3	0	0	3
	AAE 2123	Engineering Thermodynamics	3	1	0	4	AAE 2223	Linear Control Theory	2	1	0	3
	AAE 2124	Fluid Dynamics	3	1	0	4	AAE 2224	Aircraft Performance	2	1	0	3
	AAE 2125	Introduction to Aerospace Engineering	3	0	0	3	AAE 2225	Advanced Aircraft Structures	3	0	0	3
	AAE 2141	Fluid and Thermal Engineering Lab	0	0	3	1	AAE 2241	Aerodynamics & Propulsion Lab	0	0	3	1
	AAE 2142	Structures Lab	0	0	3	1	AAE 2242	Numerical Computation Lab	0	0	3	1
			16	**4**	**6**	**22**			**15**	**4**	**6**	**21**
	Total Contact Hours (L+T+P)		**26**				**Total Contact Hours (L+T+P)**		**25**			
III	**FIFTH SEMESTER**						**SIXTH SEMESTER**					
	HUM 3021	Engineering Economics and Financial Management	3	0	0	3	HUM 3022	Essentials of Management	3	0	0	3
	AAE ****	Flexible Core 1:	3	0	0	3	AAE ****	Flexible Core 2:	3	0	0	3
	AAE 3121	Flight Dynamics and Control	4	1	0	4	AAE 3221	Aircraft Design	3	1	0	4
	AAE 3122	Compressible Aerodynamics	3	0	0	3	AAE ****	Program Elective I/Minor Specialization	3	0	0	3
	AAE 3123	Avionics and Navigation System	2	1	0	3	AAE ****	Program Elective II/ Minor Specialization	3	0	0	3
	IPE 4302	Open Elective-1 Creativity, Problem Solving and Innovation	3	0	0	3	*** ****	Open Elective-2	3	0	0	3
	AAE 3141	Geometric Modelling Lab	0	0	3	1	AAE 3241	Avionics Lab	0	0	3	1
	AAE 3142	Flight Dynamics and Control Lab	0	0	3	1	AAE 3242	Structural Design and Analysis Lab	0	0	3	1
			15	**2**	**6**	**21**			**18**	**1**	**6**	**21**
	Total Contact Hours (L+T+P) + OE		**25**				**Total Contact Hours (L+T+P) + OE**		**25**			
IV	**SEVENTH SEMESTER**						**EIGHTH SEMESTER**					
	AAE ****	Program Elective – III/ Minor Specialization	3	0	0	3	AAE 4291	Industrial Training				1
	AAE ****	Program Elective – IV/ Minor Specialization	3	0	0	3	AAE 4292	Project Work/Practice School				12
	AAE ****	Program Elective – V	3	0	0	3	AAE 4293	Project Work (B. Tech Honours) **				20
	AAE ****	Program Elective – VI	3	0	0	3	AAE ****	B Tech Honours (Theory 1)** (V Semester)				4
	AAE ****	Program Elective – VII	3	0	0	3	AAE ****	B Tech Honours (Theory 2)** (VI Semester)				4
	*** ****	Open Elective-3				3	AAE ****	B Tech Honours (Theory 3)** (VII Semester)				4
	AAE 4191	Mini Project (Minor specialization)*				8						
			15	**0**	**0**	**18/26**						**13/33**
	Total Contact Hours (L+T+P) + OE		**15 + 3 = 18**									

*Applicable to students who opted for minor specialization

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

Flexible Core I	Other Programme Electives	Open Electives
AAE 3124: Industrial IoT AAE 3125: Finite Element Methods AAE 3126: Rocket Propulsion **Flexible Core II** AAE 3222: Machine Learning and AI AAE 3223: Computational Fluid Dynamics AAE 3224: Theory of Vibrations **Minor Specializations** **I. Aerodynamics** AAE 4401: Applied Aerodynamics AAE 4402: Turbomachinery Aerodynamics AAE 4403: Experimental Aerodynamics AAE 4404: High Speed Aerodynamics **II. Avionics System Engineering** AAE 4405: Unmanned Aircraft Systems, Sensors, and Instrumentation AAE 4406: Antenna Design, Analysis, and its Applications AAE 4407: Aerospace Embedded Systems, Software, Safety and Security AAE 4408: Aircraft Communication and Networking	AAE 4441: Advanced Propulsion Systems AAE 4442: Aeroelasticity AAE 4443: Aircraft Electrical System Design and EMI/EMC Analysis AAE 4444: Airship Technology AAE 4445: Aviation Fuels & Combustion AAE 4446: Aviation Management AAE 4447: Composite Materials and Structures AAE 4448: Computer Integrated Manufacturing AAE 4449: Design of Fixed Wing Unmanned Aerial Vehicle AAE 4450: Digital Manufacturing AAE 4451: Electrochemical Energy Storage Systems AAE 4452: Experimental Mechanics AAE 4453: Heat Transfer AAE 4454: Helicopter Engineering AAE 4455: Industrial Automation and Robotics AAE 4456: Lean Manufacturing AAE 4457: Navigation, Guidance and Control AAE 4458: Non-linear Control Systems AAE 4459: Numerical Methods for Scientific Computing AAE 4460: Operations Research AAE 4461: Optimal Control AAE 4462: Optimization Techniques in Engineering AAE 4463 Spaceflight Dynamics AAE 4464: Spaceflight Mechanics AAE 4465: Statistical Quality Control and Reliability AAE 4466: Surrogates and Approximations in Engineering Design AAE 4467: Systems Engineering AAE 4468: Total Quality Management AAE 4469: Wind Energy Engineering	AAE 4311: Introduction to Aerospace Engineering AAE 4312: Introduction to Avionics and Navigation System

III SEMESTER

AAE 2121: INTRODUCTION TO AIRCRAFT STRUCTURES [2-1-0-3]

Loads on airframe, functions of structural components. Basic elasticity, Stresses: Tensile, Compressive and Shear, determination of stresses on inclined planes, principal stresses, strain. Elastic constants – strain energy. Numerical examples. On deformation of simple bars and Compound bars under axial loads. [6]
Euler buckling of columns, Inelastic buckling, Effect of initial imperfections, beam columns, Stability of beams under transverse and axial loads. Numerical Problems [6]

Types of beams, Supports and Loads, Shear force and Bending Moment diagrams in beams, theory of symmetrical and unsymmetrical bending of beams. Bending of open and closed thin-walled beams. Stress analysis of isotropic and composite beams, beam deflection and slope. Numerical Problems [10]

General stress, strain and displacement relationships for open and single cell closed section thin-walled beams. Shear of open and closed section beams. Numerical Problems [10]

Torsion of solid sections, open and closed section beams ,Numerical Problems [4]

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 2122: MATERIALS AND PROCESSING TECHNIQUES [3-0-0-3]

Basic concepts: Materials engineering, scope, history, Crystalline structure, FCC, BCC, HCP, APF and Density, Numerical based on FCC, BCC, HCP and APF [3]

Miller indices for planes and directions, Crystal imperfections, Plastic Deformation of Metals and Alloys, Classification of Strengthening mechanism. Schmid's law, critically resolved shear stress, deformation due to slip and twinning. X-ray diffraction of crystals and Bragg's law [9]

Solid solutions: Hume Rothery's rules, Gibbs phase rule, Phase diagrams and uses, 1-2-1 rule, Tie-line rule, Levers rule, Relationship of levers rule to microstructure and properties, isomorphous phase diagram, Iron carbon phase diagram, numerical related to Phase diagrams [8]

Introduction to Powder metallurgy and Processes, Finishing and super finishing processes. Merits and demerits, limitations and applications. Rapid Prototyping techniques; Subtractive and Additive Processes, Fused Deposition Modeling, Stereo lithography, Solid Base Curing, Ballistic Particle Manufacturing- Process principles, Process capabilities, Applications, Advantages and Limitations, Chip less machining, Internal and external thread rolling, Spline rolling, High Energy rate forming processes [8]

Non-traditional machining techniques; Abrasive jet machining, Ultrasonic Machining, Electron Beam Machining, Laser Beam Machining, Electric Discharge Machining, Wire EDM, Process principles, Process capabilities, Applications, Advantages and Limitations. Electromagnetic forming, Explosive forming, Magnetic pulse forming, shearing [8]

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. Kalpakjian S., Manufacturing Engineering and Technology, Addison Wesley Publishing, Delhi, (2000).
7. Degarmo paul, Black & Kohser, Materials and Processes in Manufacturing (8/e), Prentice Hall of India, New Delhi, (2003).
8. Dalela S., Manufacturing Science and Technology" (Vol. II & III), Umesh Publishers, Delhi, (1998).

AAE 2123: ENGINEERING THERMODYNAMICS [3 1 0 4]

Introduction to Thermodynamics Zeroth Law of Thermodynamics – Concept of quality of Temperature – Principles of Thermometry [6]

First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system – Steady Flow Energy Equation- Limitations of the First Law [8]

Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements Carnot cycle, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Availability and Irreversibility, Gibbs and Helmholtz Functions, Maxwell Relations –Third Law of Thermodynamics [8]

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. [10]

Ideal and Real gases- Perfect Gas Laws – Equation of State, Compressibility, Mixtures of perfect Gases Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Avogadro's Laws of additive volumes, Theory of psychrometry, Atmospheric Air- Specific humidity, Relative humidity, Psychrometric chart [10]

Performance evaluation of Gas power cycles, Vapor Power cycles, Refrigeration cycles [6]

References:

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

AAE 2124: Fluid Dynamics [3 1 0 4]

Fluid Properties: definition, formula and units of relevant fluid properties, Viscosity, newton's law of viscosity, variation of viscosity, Numerical problems involving viscosity [6]

Pressure definition, Pascal's law of pressure, hydrostatic law of pressure, pressure measurement using manometers, different type so manometers. [6]

Fluid Statics: Total pressure and centre of pressure on different plan object, buoyant force, stability of floating and submerged body. Numerical problems [6]

Fluid Kinematics: velocity and acceleration vector, derivation of continuity equation in 3 dimension, introduction to 3D momentum equation, stream line, streamline and path line, velocity potential function and stream function. Equation relating to it. Uniform, source and sink flow, super imposed flow. Numerical problems [8]

Fluid dynamics: Derivation of Bernoulli's equation, application of equation to venturimeter, pitot tube, orifice meter. Numerical problems. [6]

Dimensional analysis and Similitude : Dimensions, Primary and secondary quantities, dimensional analysis using Buckingham pi theorem, similarity, model studies, dimensionless numbers. Numerical problems [4]

Viscous and turbulent flow: flow of viscous fluid in circular pipe, viscous flow between flat plates, shear stress and velocity distribution in circular pipe. Numerical problems [4]

Flow through pipes: head loss in pipe, Darcy-Weisbach equation, head loss due to sudden expansion and contraction. Numerical problems. [3]

Boundary layer: development of boundary layer, displacement thickness, momentum thickness and energy thickness, flow separation, drag force on a flat plat due to boundary layer. Drag coefficient. [3]

Introduction to compressible flow, expression for velocity of sound in fluid [2]

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,7(e) McGraw Hill, (2011).
4. Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Alric P. Rothmayer, Fundamentals of Fluid Mechanics,7(e) John Wiley and Sons, New Jersey, (2013).
5. Clayton T. Crowe, Donald F Elger, Barbara C Williams,John A Roberson, Engineering Fluid Mechanics,9(e), John Wiley and Sons, New Jersey, (2009)

AAE 2125: INTRODUCTION TO AEROSPACE ENGINEERING [2-1-0-3]

Have an overview of the history of flight [3]
Ballooning, Apply basic/constitutive principles of mechanics of fluids, Bernoulli and control volume approaches, the source of all aerodynamic forces, Equation of state for a perfect gas, specific volume, anatomy of aircraft, anatomy of space vehicle [8]

Definition of Altitude, Hydrostatic equation, Relation between geopotential and geometric altitudes, Pressure, Temperature and Density altitudes [4]
Basics of Aerodynamics, Incompressible and compressible flow, elementary thermodynamics, isentropic flow, laws of conservations, speed of sound, low speed wind tunnels, measurement of airspeed, Explain flow regimes (viscous/non-viscous; compressible/incompressible aerodynamics) and to estimate viscous and thermal effects [9]
Airfoil Nomenclature, Lift, Drag and Moment co-efficient, Infinite versus finite wings, Pressure coefficient, Elements of Airplane Performance – Equation of Motions for level flight, climbing flight, gliding flight, take-off and landing, Stability and Control [5]
Introduction, Orbit equation, Space Vehicle Trajectories, Kepler's laws, Space environment, Orbital Mechanics, Attitude dynamics and control, Propulsion and launch vehicles, satellite orbits, transfer orbits and maneuvers [4]
Introduction, Types of Propulsion system [3]

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 2141: 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 2142: 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

AAE 2221: Incompressible Aerodynamics (3 – 1 – 0 – 4)

Basic of Aerodynamics: Types of Aerodynamics flows, Aerodynamic forces and moments, Force and moment components and coefficients, Flow over the body, Pressure distribution on an airfoil, Types of drag, Estimation of lift, Drag and pitching moment coefficient from the pressure distribution. Experimental methods, wake survey, Continuity, momentum and energy equations. [6]
Elementary Flows:- Incompressible flow condition, governing equation for irrotational, incompressible flow: Stream function and velocity potential. Laplace's equation, Boundary conditions. Elementary flows. Combination of uniform flow with a Source and Sink, Doublet, Non lifting flow over a circular cylinder, Vortex flow, Circulation, Kutta-Joukowski theorem, Lifting flow over a cylinder The vortex sheet. Kelvin circulation theorem and starting vortex. Numerical source panel method [10]
Introduction to Wind Tunnel Techniques:- Purpose, components and application of Wind tunnel. Different types of wind tunnels. Velocity measurements. Different types of velocity measurements in wind tunnel. Load balancing system, Design of subsonic wind tunnel. [4]
Thin airfoil theory:- Concept of Vortex sheet, Kutta Condition, Classical thin airfoil theory for symmetric and cambered airfoil sections, Comparison of theoretical and experimental results, Limitations of thin airfoil theory. Vortex panel numerical method and its application, Modern subsonic airfoils. [12]
Incompressible flow over finite wings:- Vortex filament, Biot-Savart law and Helmholtz's theorems, Prandtl's classical lifting line theory: Downwash and induced drag. Elliptical and modified elliptical lift distribution. Lift distribution on wings. Limitations of Prandtl's lifting line theory. Importance and effect of Aspect ratio, Numerical nonlinear lifting line method. Lifting surface theory and vortex lattice numerical method. [10]

Incompressible flow over airfoil:- The complex potential function and conformal transformation, The Kutta-Zhukovsky transformation, Lift on the Zhukovsky airfoil section. [6]

References:

1. Anderson, J. D., Fundamentals of Aerodynamics, (5e), McGraw-Hill International, (2011)
2. Houghton, E. L. and Carruthers N.B., Aerodynamics for Engineering Students, (5e), 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 2222: Air-Breathing Propulsion [---]

AAE 2223: Linear Control Theory [2-1-0-3]

Introduction: Brief overview of the historical development of Control system theory, Basic terminologies of the control systems, Definition of transfer function. Mathematical modeling of Mechanical and electrical systems to determine the transfer functions. Transfer functions of power amplifiers in different configurations. [04]

Reduction of multiple sub systems: - Development of block diagrams from governing differential equations, Rules for reducing the block diagrams, examples of block diagram reduction into open loop transfer functions of complex systems. Introduction to signal flow graph, Mason's gain formula for finding the transfer function. [08]

Time domain and frequency domain Analysis: - 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. Transient response of I and II order systems. Error analysis and its impact on the system output. Introduction to frequency domain analysis and its significance. Graphical techniques- Bode and Polar plots to find the Phase margin and gain margin of the system. [10]

Root locus and stability of systems: - Routh Hurwitz stability criteria and numerical examples. Analysis of control systems via Root locus technique and numerical examples. [08]

State Space analysis: - Introduction to state space techniques. Design a state-feedback controller using pole placement for systems to meet transient response specifications. Determine if a system is controllable and Design a state-feedback controller using pole placement for systems not represented in phase-variable form to meet transient response specifications. [06]

References:

1. Ogata, K., "Modern Control Engineering", Prentice Hall, V edition, 2009.
2. Norman S Nise:"Control systems Engineering:,John Wiley,2011
3. Kuo, B.C., "Automatic Control System", Prentice Hall, 10th edition, 2019
4. Gopal. M., "Control Systems: Principles and Design", Tata McGraw-Hill, 2002.
5. Nagrath & Gopal, "Modern Control Engineering", New Ages International,2021.
6. E. Bryson and Y-C Ho: Applied Optimal Control, Taylor and Francis, 2017
7. Nagoor Kani:"Control Systems Engineering",RBA Publications,2014

AAE 2224: Aircraft Performance [---]

AAE 2225: 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, structural components of aircraft, loads on structural components, function of structural components, fabrication of structural components, connections [4]

Bending stresses in beams of unsymmetrical sections. Bending of open and closed, thin-walled beams, symmetrical bending, unsymmetrical bending, deflections due to bending, calculation of section properties applicability of bending theory, temperature effects [8]

Shear of beams, general stress, strain and displacement relationships for open and single cell closed section thin-walled beams, shear of open section beams, shear of closed section beams, concept of shear flow, shear centre, bending, shear and torsion of combined open and closed section beams [8]

Structural idealization, principle, idealization of a panel, effect of idealization on the analysis of open and closed section beams, deflection of open and closed section beams, shear flow variation in idealized sections, stress analysis of aircraft components: bending, shear and torsion of fuselages, wings, fuselage frames and wing ribs [10]

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. [6]

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)
6. NPTEL Course: Aircraft structures https://nptel.ac.in/courses/101105084

AAE 2241: 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, 3rd edition (1999)
2. J.D. Anderson, Fundamental of Aerodynamics, McGraw-Hill Education; 6th edition (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.
5. Lab Manuals of Aerodynamics & Propulsion Lab

AAE 2242: 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, 2 Ed., Cambridge University Press, (2011)
3. Fausett L.V., Applied Numerical Analysis Using MATLAB, 2 Ed., Pearson Education, (2007)
4. Chapra S.C. and Canale R.P., Numerical Methods for Engineers, 5th Ed., McGraw Hill, (2006)
5. william palm, Introduction to MATLAB for Engineers , 3rd edition, 2010

V SEMESTER

AAE 3124: INDUSTRIAL IOT [2 1 0 3]

Understanding Industrial Internet of Things (IIoT): Industrial Internet of Things and Cyber Manufacturing Systems, Application map for Industrial Cyber Physical Systems, Cyber Physical Electronics production. [8]

Modelling of CPS and CMS: Modelling of Cyber Physical Engineering and manufacturing, Model based engineering of supervisory controllers for cyber physical systems, formal verification of system, components, Evaluation model for assessments of cyber physical production systems. [10]

Architectural Design Patterns for CMS and IIoT: CPS-based manufacturing and Industries 4.0., Integration of Knowledge base data base and machine vision, Interoperability in Smart Automation, Enhancing Resiliency in Production Facilities through CPS. Communication and Networking of IIoT [8]

Artificial Intelligence and Data Analytics for manufacturing: Application of CPS in Machine tools, Digital production, Cyber Physical system Intelligence, Introduction to big data and machine learning and condition Monitoring [5]

Application of IIoT: Smart Metering, e-Health Body Area Networks, City Automation, Automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector. [5]

References:

1. Ismail Butun, Industrial IoT Challenges, Design Principles, Applications, and Security(1e), 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 (1e) Taylor and Francis(2021).

4. Sabina Jeschke, Christian Brecher Houbing Song , Danda B. Rawat Editors Industrial Internet of Things Cyber Manufacturing Systems
5. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014

AAE 3125: Finite Element Method [3 0 0 3]

Introduction: Origin of FEM, application area, advantages and disadvantages, General steps of finite Element Analysis, types of elements, differential equation involved, analytical and approximate solution. Difference between FEM and FDM(Finite Difference Method), List of different commercial softwares available. [6]

Review of Matrix notation and operations, numerical problems [6]

Finite Element formulation using principle of minimum potential energy, weighted residual method, Rayleigh-Ritz methods. Numerical problems [6]

Formulation of 1 dimensional Problem: 1D bar/spring/link equation, truss equation, beam equation, numerical problems [8]

Formulation of 2 dimensional problems: plane stress plane, strain Constant strain triangular and Linear strain Triangular element FE equation. Numerical problems [6]

Practical consideration FE analysis, Introduction to contact and large deformation modelling: [4]

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 3126: ROCKET PROPULSION [2 1 0 3]

Nozzle theory: Introduction to steady 1-D flow, isentropic and normal shock relations, Area- Mach number relations, mass flow rate and exhaust velocity relation, converging and converging- diverging (C-D) nozzle performance curves, critical pressures, under and over expanded nozzles, shock-expansion cells, Mach disk and barrel shock. Nozzle efficiency, nozzle functions, nozzle applications- thrust vectoring (mechanical and fluidic), jet noise suppression, thrust reversing etc. Nozzle coefficients- Gross thrust coefficient, Discharge or flow coefficient, Velocity Coefficient, Angularity coefficient. Introduction and classification of rocket nozzles, Bell, Contoured & Conical Nozzles, performance. [10]

Rocket fundamentals: History of rockets, classification, Rocket performance parameters, total impulse, specific impulse, mass ratio, propellant mass fraction, thrust, variation of thrust with altitude and various nozzle operations, impulse to weight ratio, thrust to weight ratio, effective exhaust velocity, characteristic velocity, payload and structural coefficient, energy and efficiency- internal, propulsive and overall. Rocket masses definition, Rocket equation, rocket staging, Forces acting on vehicle. [8]

Liquid Rocket Propulsion: Chemical rocket Propulsion classification, Liquid rocket – parts, working, propellants, monopropellant, bipropellant, cold gas and cryogenic, earth storable, gelled, performance, mixture ratio, liquid oxidizers and fuels. Feed Mechanism- pressure and pump feed system. Propellant tank- arrangements, materials, filling, ullage, expulsion efficiency, sloshing and vertexing. Thrust chamber, Engine cycles- open & closed. Turbopump, injectors, classification, combustion process. [8]

Solid Rocket propulsion: Introduction, working, applications, classifications, components-propellant grain, port cavity, igniter, liner, nozzle. Propellants- composition, double base & composite. Burning rate, relation with pressure, characteristics, relation with temperature, erosion. Grains- terminology, burning time, deflagration limit, web fraction, volumetric loading fraction. Grin configuration-cartridge loaded and case-bonded. Hazards. [6]

Hybrid Rocket propulsion: Introduction, history, construction, working, parts, advantages and disadvantages over liquid and solid rockets, fuel & oxidizer combinations, hybrid ballistics, hybrid combustion theory, regression rate, comparison with solid grain combustion. Multi-port fuel grain, operation. [4]

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 3121: FLIGHT DYNAMICS AND CONTROL [3-1-0-4]

Basic Concepts of Stability and Control: Review of Static Stability – Concepts and Introduction to Dynamic Stability – Review: Body Axis, Stability Axis, Earth Axis – Euler Angles – Transformation between Axis – Advantages of Axis – Aircraft Equations of Motion – Kinematic Equations [4]

Static Longitudinal Stability and Control: Equations of equilibrium and stability – Contributions of major components – Stick-fixed stability – Control, effectiveness, hinge moments, and effect of freeing the stick – Control forces and gradients – Effect of manoeuvres – Critical condition for longitudinal stability and control – Powerplant contribution & its effect on Neutral point – Stick-fixed neutral point – Static margin – Elevator effectiveness – Elevator angle of trim – Flight measurement of Xnp – Elevator hinge moment – Stick forces (trim tab & stick force gradient) [8]

Static directional and lateral stability and control: Contributions of major components to directional stability and its desirable level – Directional control – Critical conditions for rudder design – Dihedral effect and contributions of major components to dihedral effect – Lateral control – Design of control surfaces – Roll stability and roll control – Yaw stability and yaw control [8]

Dynamic stability : Newton's second law of rigid dynamics – Axes system and relevant transforms – Angular motion equations – Aerodynamic forces – Gravitational and thrust forces – Small Perturbation Theory – Linear Equations of Motion – Stability Derivatives – Longitudinal and Lateral Modes – Concept and Physics – Characteristic Equation – Transfer Function Approach – State Space Modeling and Application to Modes – Short period approximation – Long period approximation – Pure pitching motion – Linearized Lateral dynamics – Lateral motion – Linearized coupled motion – Roll approximation – Spiral approximation – Dutch roll approximation – Pure rolling – Pure yawing – Inertia coupling – Flying and Handling Qualities – Autopilots – Stability – Augmentation System (Longitudinal and Lateral Control) – Fly-By-Wire Aircraft – Active Control System [28]

References:

1. Robert C Nelson, Introduction to Flight Stability and Automatic Control, 2nd Edition, McGraw-Hill, 1998.
2. Anderson, Jr. J.D., Introduction to Flight, McGraw Hill, 2005.
3. Perkins, C.D. and Hage, R.E., Airplane Performance, Stability, and Control, Wiley Publications, 1949.
4. Roskam, J., (a) Methods for estimating drag polars of subsonic airplanes and (b) Methods for Estimating stability and control derivatives of conventional subsonic airplanes, 1973.
5. Etkin, B., Dynamics of Atmospheric Flight, Dover Publications, 2005.
6. Pamadi, B., Performance, Stability, Dynamics, and Control of Airplanes, AIAA Education Series, 2nd Edition, 2004.
7. Phillips, W.F., Mechanics of Flight, John Wiley Publications, 2nd Edition, 2010.
8. Yechout, T.R., Introduction to Aircraft Flight Mechanics: Performance, Static Stability, Dynamic Stability, Feedback Control, and State-Space Foundations, AIAA Education Series, 2014.
9. Napolitano, Marcello R. Aircraft Dynamics, Hoboken, NJ, USA: Wiley, 2012.
10. Stengel, Robert F. Flight dynamics, Princeton university press, 2005.
11. Sinha, Nandan K., and Narayan Ananth Krishnan. Advanced flight dynamics with elements of flight control, CRC Press, 2017.
12. M. V. Cook, Flight Dynamics Principles, A Linear Systems Approach to Aircraft Stability and Control, 3rd Edition, Elsevier, 2013.

AAE 3122: COMPRESSIBLE AERODYNAMICS [2-1-0-3]

One dimensional flow: Isentropic process for closed system/flow processes. Velocity of sound, Mach number, flow regimes, Governing equations of inviscid compressible flow, Continuity, Momentum and Energy equations in Integral and Differential form, Stagnation conditions. [6]

Shock and expansion waves: Oblique shock relations. Supersonic flow over a wedge, M relations strong and weak shock solutions / Shock polar. Regular reflection from a solid boundary. Intersections of shock wave. Expansion waves. Prandtl – Meyer Expansion. [6]

Flow through nozzles, diffusers and Inlets: Isentropic flow through Convergent – Divergent nozzles. Chocked flow conditions. Normal shock. Under and Over expansion conditions. Flow through diffusers – wave reflections from a free boundary. Description of supersonic wind tunnels and rocket engine. Subsonic and supersonic inlets, Axisymmetric and 2-D inlets. [8]

Subsonic compressible flow over airfoil: Introduction, Velocity potential equation, Transonic small perturbation equation, Prandtl-Glauert compressibility corrections, Critical Mach number, Drag divergence Mach number - Area rule, Supercritical airfoil. [6]

Supersonic flow: Linearized supersonic flow, Linearized supersonic flow over airfoil and wings. Shock Expansion theory. Detached shock. Axi-symmetrical flows, flow past slender bodies of revolution, conical flows, Numerical integration procedure. [6]

Hypersonic flow: Qualitative aspects of hypersonic flow. Newtonian theory. Flat plate at an angle of attack. Hypersonic shock wave relations. Lift and drag of wings at hypersonic speeds. Recent advances in hypersonic flows and testing techniques. [4]

References:

1. Anderson, J.D., Modern Compressible Flow: With Historical Perspective, McGrawHill, (2002)
2. Elements of Gas dynamics, Liepmann and Roshko
3. Compressible-fluid Dynamics, Thompson
4. Introduction to Fluid Mechanics, Fox and McDonald
5. Thompson, P. A. Compressible Fluid Dynamics. Maple Press Company, 1984.

AAE 3123: AVIONICS AND NAVIGATION SYSTEMS [2 1 0 3]

Introduction Unmanned Air Vehicle: Basic, definition and types of UAV. UAV Avionics systems. DGCA Rules and regulation on UAV in India. [3]

Introduction to Avionics in aircraft: Analog and Glass cockpit of Different aircraft, ADS-B, Civil, Military aircraft and spacecraft avionics. Organization Framework, avionics architecture, types of payloads. [3]

System Engineering and Avionics software Tools: What is system engineering, RTCA/DO-178B, DO-178C, V model for software development, DO-330/3301/332/333, CERT, MISHRA, Software Testing Tools. **[3]**

Introduction to Navigation systems: Inertial Sensors and Inertial Navigation Systems, Multisensors Navigation Systems, Kalman filter basics & Mechanization, GPS-INS Mechanization. Point source and hyperbolic source systems, **Satellites Radio Navigation:** -Satellite Navigation Systems, Orbital Mechanics & Clock Characteristics, Atmospheric effects on satellite signals, NAVSTAR Global Positioning Systems, Global Orbiting Navigation Satellites Systems. **RADAR**: Doppler and Altimeter Radars, Mapping and Multimode Radar, Weather RADAR, FMCW Radar [8]

Essential System Display: Cockpit Design, Displays, PFD, ND, MFD, HUD, HMD, HMI, I/O Devices and Power. [4]

Essential System Aircraft Electrical Systems: Aircraft electrical systems, Electrical Power Generation, Distribution, conversion and protection Systems, aircraft lights, electrical systems of small and large aircraft.
Packaging, ARINC and DOD Types, System Cooling, EMI/EMC Requirements. [4]

Essential Systems Aircraft Databus: Digital Communication, Digital Data Bus System, ARINC-429,629, AFDX, MIL-STD-1553, Fiber Optic Comm. [3]

Flight Control Systems: Flight control, FBW, FBL, Flight management systems, Autopilot, LRU, IMA & Mission Systems. [4]

Aircraft Landing systems: Mechanics of Landing, Automatic landing systems, ILS, MLS, SLS, Carrier landing systems, Surveillance systems-radio altimeter etc. [4]

References:

1. Cary R. Spitzer: Digital Avionics Handbook-Avionics Development and Implementation (2nd Edition), 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, Sixth Edition, 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, 2nd Edition, 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.
8. https://nptel.ac.in/courses/101108056
9. https://www.aviationtoday.com/

AAE 3141: 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”, Ed. 2, Createspace Independent Publishers, (2015

AAE 3142: 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, 3rd Edition.
2. S. Hasan Saeed: Automatic Control Systems (With Matlab Programs).
3. Mathworks: Modeling, Analysis and Design of Control Systems in MATLAB and Simulink.
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

AE 3222: Machine learning and Artificial Intelligence [2 1 0 3]

Introduction to Artificial Intelligence: Definition of Artificial Intelligence, Difference between AI and Machine learning, Support Vector machines, Singular value decomposition, Principle component analysis, Linear regression, Logistic regression, Clustering, Decision tree and random forest algorithms, Classification. [6]

Probability theory: What is probability, Probability distributions, Axioms of Probability, Probability Density Estimation, Random variables, Conditional Probability, Chain rule, Bayes rule, Naive bayes, Maximum Likelihood Estimations, Maximum A Posteriori, Hypothesis testing. [8]

Artificial Neural Networks: Biological Neuron, McCulloch-Pitts Neuron Model, Feedforward Network, Hebbian learning rule, Perceptron learning rule, Activation functions, Gradient descent (batch and stochastic), Singe layer perceptron, XOR problem, Multi-layer perceptron, Bias-Variance Trade-off. [8]

Deep learning: Deep learning vs ANNs, Overfitting, Underfitting, Hyperparameter Tuning, Regularization methods, Cross validation, Data augmentation, Convolutional neural networks (CNNs), Layers in a CNN, Recurrent neural networks, Transfer learning, Evaluation metrics. [7]

Popular DI Architectures: Single Shot Detectors (SSD), You Only Look Once (ZOLO) Architecture Family, Generative Adversarial Networks (GANs), Recurrent Neural Networks (RNNs). [7]

References:

1. Stuart J. Russell and Peter Norvig: Artificial Intelligence -A Modern Approach.
2. Simon Haykin: Neural Networks - A Comprehensive Foundation (2e).
3. Daniel Graupe: Principles of Artificial Neural Networks (2e).
4. Rich and Knight: Artificial intelligence (2e).
5. Jacek M Zurada: Introduction to artificial Neural Systems.
6. Christopher M. Bishop: Neural Networks for Pattern Recognition.
7. Deep Learning Book by Aaron Courville, Ian Goodfellow, and Yoshua Bengio

AAE 3223: COMPUTATIONAL FLUID DYNAMICS [2 1 0 3]

Governing Equations of Fluid Dynamics: Models of Flow, finite control volume and infinitesimal element approaches. The substantial derivative. Divergence of velocity field and its physical meaning. The continuity equation. Momentum and Energy Equations. Energy Equation in non-conservative format. [4]

General Characteristic of the governing equations: The initial and boundary conditions. Mathematical behavior of different classes of partial differential equations. Equilibrium and Marching behavior. [3]

Discretization Process: Explicit -Taylor series expansion and Discretization of governing equations. Methods of deriving the discretised equations. [4]

The Basic Solution Techniques: Steady state conduction heat transfer. Implementation of boundary conditions and solution. Extension of the method to 1-D Conduction through fin. [4]

Unsteady conduction Heat Transfer: Explicit, Implicit and Crank Nicholson Methods. ADI Methods of solving space and time marching in 2D. [5]

Discretization using Control Volume technique: 1D Diffusion Problems. The Four basic rules in control volume formulation. Dicretization of source terms and linearization of the same. Control volume technique to 2D and 3D steady diffusion flow problems. [4]

Convective flow with diffusion: Numerical methods for steady 1D convective flow with diffusion. Properties of discretization schemes: Conservativeness, Boundedness and Transportiveness. The CDS, the Upwind, and QUICK schemes. Numerical false diffusion with physical examples. [4]

Solution of Pressure linked velocity equations: The need for staggered grid. Flow chart, discussion. The derivation of the pressure correction equation as Poisson's Pressure equation. Implications and implementation. Marker and Cell Explicit Method. [6]

Implementation of Boundary Conditions in CFD: The inlet, exit, outflow and the wall Boundary Conditions. The Constant Pressure, Symmetry and Cyclic BC's. [2]

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, Longman Scientific & Technical. England, 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, 2003.
6. Fletcher C. A. J., Computational Techniques for Fluid Dynamics, Vol I and Vol II., Springer- Verlag. Berlin, 2012.

AAE 3224: **THEORY OF VIBRATION [2 1 0 3]**

Introduction Vibrations and Single degree of freedom systems: Fundamentals, classifications of vibrations Simple harmonic motion, free vibrations, free damped vibrations. Springs in series and parallel combination, governing differential equations of different systems and computing natural frequencies. Damped free vibrations, analyzing systems with over, under and critical damping of systems with viscous damping. Coulomb damping and derivation of differential equation. [10]

Forced vibration of Single degree of freedom systems: - Forced vibrations with and without damping by considering harmonic excitation and rotating unbalance. Base excitation and concept of displacement and force transmissibility ratio and isolation. Force vibration with Coulomb damping. Determining system parameters from Frequency response curves. Deriving peak frequency from experimental curves. Concept of whirling of shafts-undamped and damped case. [12]

2 degree of freedom systems: - 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. [06]

Multi-degree of freedom systems and continuous system approach: - Analysis of MDOF system by considering spring-mass system, concept of influence coefficients. Determining natural frequency and mode shapes of MDOF systems- by direct approach and numerical methods. Concept of continuous systems and examples. [08]

References:

1. Singirisu Rao S (2004) "Mechanical Vibration" Pearson Education, Delhi
2. Dukkapatti Rao V (2016)" Text Book of Mechanical Vibration "Prentice Hall of India Ltd, 8th Edition
3. Daniel Imnan J. (2001) "Engineering Vibration" Prentice Hall, New Delhi
4. Groover G.K. (2014)" Mechanical Vibrations" Nemchand And Bros, Roorkee, 8th edition
5. Thomson W.T. (2011) "Theory of Vibrations with Applications" Chapman and Hall, 6th Edition
6. Seto W.W. (1989) "Theory and Problems in Mechanical Vibrations" MGH, Singapore
7. C Sujatha (2009)," Vibrations and Acoustics-Measurement and Signal analysis", Mc Graw Hill India

AAE 3221: **AIRCRAFT DESIGN [3 1 0 4]**

Introduction:- Purpose and scope of airplane design; stages in airplane design; classification of airplanes based on purpose, design requirements and configuration; factors affecting airplane configuration; historical background [6]

Data collection and preliminary three-view drawing:- Importance of collection of data on existing airplanes similar to the proposed design; suggested airplane data sheet; preliminary three-view drawing based on data collection [4]

Weight estimation:- Dependence of airplane performance on airplane parameters and atmospheric characteristics; steady level flight, steady climb, absolute ceiling, Range and Endurance, turning, take off distance and lading distance. Estimation of empty-weight fraction; estimation of fuel fraction; guidelines for drag polar and SFC for subsonic airplanes; iterative procedure for take-off weight calculation; trade-off studies. [8]

Estimation of Wing loading and Thrust loading:- Choice of wing loading based on considerations of landing field length, prescribed flight speed, absolute ceiling, maximum rate of climb, range, take-off balance field length, specific excess power, sustained turn rate and turbulence. Choice of engine; characteristics of piston engine, turboprop, turbofan and turbojet

engines; propeller characteristics, selection of propeller diameter. Choice of engines for different ranges of flight speeds. [14]

Wing Design and selection of wing parameters:- Considerations for choice of wing parameters – airfoil section, aspect ratio, sweep, taper ratio, twist, incidence, dihedral and vertical location [4]

Fuselage and Tail Sizing:- Features of the fuselages of general aviation aircraft and transport airplanes ; desired features of fuselage design; guidelines for
sizing of fuselages of general aviation aircraft and transport airplanes; Preliminary sizing of horizontal and vertical tails – choice of aspect ratio, taper ratio; sweep and airfoil section; engine location; landing gear. [6]

Weights and Center of Gravity:- Subdivisions of airplane weight – structures group, propulsion group, equipment group; estimation airplane weight – approximate group weight method, statistical group weight method; calculation of c.g. location; balance table; c.g. shift. [6]

References:

1. Fundamentals of aircraft and aircraft design (AIAA Educational Series) – Volume -1, Leland Nicolai, Grant Carichner,
2. Aircraft Design – A Conceptual approach – Daniel P Raymer
3. Civil Jet Aircraft Design – Lloyd R Jenkinson, Paul Simpkin, Parren Rhodes
4. Aircraft Design projects for engineering students – L. R Jenkionson, J.F. Machman
5. Introduction to Aeronautics: A Design Perspective (AIAA Education Series, Steven A. Brandt , Randall J. Stiles, John J. Bertin, Ray Whitford
6. NPTEL Airplane design (Aerodynamic), IIT Madras Prof. E.G. Tulapurkara

AAE 3241: 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, (Second Edition), McGraw Hill Education India Private Limited; Second edition (Revised on 1 July 2017, old edition, (2009)
2. C.A. Balanis: Antenna Theory - Analysis and Design (4th Edition), John Wiley, (2016)
3. Michael Barr, Anthony Massa: Programming Embedded Systems, Second Edition with C and GNU Development Tools (2nd Edition), O'Reilly Media, (2009)
4. Brian L. Stevens, Frank L. Lewis & Eric N. Johnson: Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems (3rd Edition), 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 (1st Edition), Butterworth-Heinemann: Elsevier, (2009)

AAE 3242: 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”, 2nd Edition, 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)

PROGRAM ELECTIVES

AAE 4441: ADVANCED PROPULSION SYSTEMS [3-0-0-3]

AAE 4442: AEROELASTICITY [3-0-0-3]

AAE 4443: 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 generator/engine coupling. [8]

Electrical Power conversion, Power distribution, protection theory and equipment's used, Wiring Installation, Circuit protection, shielding/screening, Aircraft Electrical Systems, Aircraft Lighting Systems. [7]

Electrical System Components, Electrical and magnetic field. Introduction to E3 Models and Techniques, Deterministic and Statistical EMC Models, HEMP, HIRF and Lightning. [7]

Techniques to Design Robust Lightning Protection Circuits, Pyrotechnic Systems, EMC Testing in aircraft, spacecraft, UAV and flight control, System level testing etc. Charging. Patterns. [7]

EMI/EMC Specifications, standards, and practices. EMI/EMC measurement problems. Electromagnetic hazards. [7]

References:

1. Mike Tooley and David Wyatt: Aircraft Electrical and Electronic Systems: Principles, Operation and Maintenance (1st Edition), 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 (3rd Edition), Aerospace Series, Wiley, (2011).
4. Thomas K. Eismin: Aircraft Electricity and Electronics (6th Edition), McGraw Hill Education (India) Private Limited, (2014).
5. EHJ Pallett: Aircraft Electrical Systems (3rd Edition), PEARSON India Education Services Pvt. Ltd, (1997).
6. Len Buckwalter: Avionics Training: Systems, Installation, and Troubleshooting, Avionics Communications Inc., (2005).

AAE 4444: AIRSHIP TECHNOLOGY [3-0-0-3]

AAE 4445: AVIATION FUELS AND COMBUSTION [3-0-0-3]

Solid, liquid and gaseous fuels, classification of solid, liquid and gaseous fuels, storage and handling of fuels. [6]

Fuel properties, aviation fuel requirements, flash and fire points, testing of fuel properties, refining, cracking, polymerization, synthetic liquid fuels. [6]

Gaseous fuels, natural gas, methane, producer gas, manufacture, cleaning and purification of gaseous fuels. [6]

Stoichiometry, correct requirement of air for combustion of fuels, flue and exhaust gas analysis, combustion in ramjets and scramjets. [6]

Adiabatic flame temperature, flame propagation, laminar and turbulent flames, flame velocities, methods of flame stabilization, premixed and non-premixed combustion. [6]

Burners for solid, liquid and gaseous fuels, burner design, recuperative and regenerative burners. [6]

References:

1. Sarkar S., Fuels and Combustion, CRC Press, 2009.
2. Joshua Philips, H., Fuels – Solids, liquids and gases, Nabu Press, 2011.
3. Turns S.R., An introduction to combustion – Concepts and applications, Tata McGraw- Hill, 2000.
4. Sharma S.P. and Mohan C., Fuels and combustion, Tata McGraw-Hill, 1984.
5. Mishra D.P., Fundamentals of Combustion, Prentice-Hall of India, 2008.

AAE 4446: Aviation Management [3 0 0 3]

AIR TRAFFIC MANAGEMENT : Introduction: Air traffic services provided to aircraft operators, Government responsibilities, Flight rules and airspace organization, Airways and procedures, Phases of flight, Subsystems of ATM system, Facilities and operation, System capacity, Airborne collision avoidance systems, Future trends, Capacity driven operational concept of ATM. [8]

ECONOMICS OF CONGESTION: Impact of ATM on airspace user economic performance, Effects of schedule disruptions on the economics of airline operations, modeling of an airline operations control center. COLLABORATIVE DECISION MAKING Effect of shared information on pilot controller and controller- controller interactions, Modeling of distributed human decision making in traffic flow management operations. [8]

AIRPORT OPERATIONS AND CONSTRAINTS: Analysis, modeling and control of ground operations at airports, Collaborative optimization of arrival and departure traffic flow management strategies at airports.AIRSPACE OPERATIONS AND CONSTRAINTS Performance measures of air traffic services,Identification of airport and airspace capacity constraints. [8]

SAFETY AND FREE FLIGHT: Accident risk assessment for advanced air traffic management, Airborne separation assurance systems. Human factors **COGNITIVE WORKLOAD ANALYSIS AND ROLE OF AIR TRAFFIC CONTROLLER:** Task load measures of air traffic controllers, Technology enabled shift in controller roles and responsibilities. [6]

AIRCRAFT SELF SEPARATION: Cooperative optimal airborne separation assurance in free flight airspace, Automatic dependent surveillance broadcast system - operational evaluation. [6]

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, 2004, ISBN-13:978-0-534-39388-5.
3. Air Transportation Systems Engineering, Donohue, G. L. et al., (Editors), AIAA, 20003, ISBN 1-56347-474-3
4. Avionics Navigation Systems, Keyton, M. and Fried, W. R., John Wiley, 2001, ISBN 0-471-54795-6
5. Introduction to Flight, John D. Anderson, Jr., Tata McGraw-Hill Publishing Company, Fifth Edition, Fifth Edition, 2007, ISBN 13: 978-0-07-066082-3

AAE 4447: COMPOSITE MATERIALS AND STRUCTURES **[2 1 0 3]**

Classification of composite materials, Characterization of composite materials, Mechanical behavior of composite materials, Basic terminologies of composites. [8]

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. [8]

Effective Modulii of a continuous fibre reinforced lamina, Models based on mechanics of materials. [8]

Force-Displacement relations for laminates, Laminate stiffness, Single general orthotropic layer, Inter-laminar stresses. [6]

Failure of continuous fiber-reinforced orthotropic lamina, Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion . [6]

References:

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

AAE 4448: 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) [6]

NC programming with interactive graphics, manual data input. Problem with conventional NC, Computer Numerical Control, Direct Numerical Control [4]

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. [9]

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, Part classification and coding, production flow analysis, machine cell design, benefits of group technology [9]

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 [8]

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).

AAE 4449: DESIGN OF FIXED WING UNMANNED AERIAL VEHICLE [3-0-0-3]

AAE 4450: DIGITAL MANUFACTURING [3-0-0-3]

Introduction: definition, features and developments of Digital Manufacturing (DM), Basic Concept and Connotation of Digital Manufacturing Science. Modeling Theory and Method of Digital Manufacturing Science: Critical Modeling Theories and Technologies in Digital Manufacturing Science, Basic Architecture Model of Digital Manufacturing System. (7)

Computing Manufacturing in DM: C-Space and Screw Space, Virtual Prototyping. Manufacturing Computational Model, Computational Geometry. Manufacturing informatics in DM: Principal Properties of Manufacturing Information, Measurement, Synthesis and Materialization of, Manufacturing Information Integration, Sharing and Security of Manufacturing Information (7)

Intelligent manufacturing in DM: Intelligent Multi Information Sensing and Fusion in the Manufacturing Process, Knowledge Engineering in the Whole Life Cycle of Manufacturing Product, Intelligent Manufacturing System. Artificial Intelligence and Intelligent Manufacturing Systems. (7)

Industry 4.0: Artificial Intelligence and intelligent manufacturing systems, smart factories: Levels of smart factories, benefit of smart factories, key principles of smart factories, Industry 4.0 and its components, Transitioning for Industry 3.0 to Industry 4.0. Industrial IoT: IoT in global context, Design Principles,
IoT in manufacturing, Cyber Physical systems in manufacturing, M2M technology: Application, key features, architecture and components (7)

Management of Technology in DM: Concept and development process, R&D System Framework and Management Mode, Human-Machine Engineering on DM Process. Rapid Manufacturing: Introduction and processes, digital Manufacturing security. Future Development of DM: The Precision of Digital Manufacturing, The Extremalization of Digital Manufacturing, The Environmental Protection of Digital Manufacturing (6)

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

AAE 4451: ELECTROCHEMICAL ENERGY STORAGE SYSTEM[3-0-0-3]

Introduction to Energy storage and battery terminology: Brief history of electrochemical energy storage, Requirement of energy storage, Definition and measuring methods. [3]

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. [6]

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. [9]

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 supercapacitors. [9]

Basic elements of in lithium-ion batteries and Fabrication: Introduction, Positive electrodes, Negative electrodes, electrolytes, Current collectors, Manufacturing and packaging. [9]

References:

1. Glaize, Christian, and Sylvie Genies. Lithium batteries and other electrochemical storage systems (1e). John Wiley and Sons, (2013).
2. Sundén, Bengt. Hydrogen, Batteries and Fuel Cells (1e). Academic Press, (2019).
3. Sterner, Michael, and Ingo Stadler, eds. Handbook of energy storage: Demand, technologies, integration (1e). Springer, (2019).
4. Newman, John, and Karen E. Thomas-Alyea. Electrochemical systems (3e). John Wiley and Sons, (2012).
5. O'hayre, Ryan, Suk-Won Cha, Whitney Colella, and Fritz B. Prinz. *Fuel cell fundamentals (3e)*. John Wiley and Sons, 2016.

AAE 4452: 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 [6]

Stress, Strain and Displacement Fields- Beam under pure bending, Analytical solution, Fringe contours from various experimental methods [8]

Physical Principle of Strain Gauges, Photoelasticity, Physical principle behind various experimental techniques, Strain Gauges, Photoelasticity, Grids for determining plastic strains [8]

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 [8]

Eigen value approach or use of Mohr's circle, Shear distribution in a three point bend specimen [6]

References:

1. Cesar A. Sciammarella, Federico M. Sciammarella : Experimental Mechanics of Solids (1e), 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)

AAE 4453: HEAT TRANSFER [2-1-0-3]

Introduction to heat transfer: Various modes of heat transfer. Governing laws and equation for different modes of heat transfer. Combined mode, conductivity and film coefficient of heat transfer. Thermal diffusivity, overall heat transfer coefficient, thermal resistance and conductance. Linear heat flow through plane wall, composite wall, cylinder, sphere. Heat transfer from fins of uniform cross section having adiabatic tip, Isothermal tip,infinitely long fins. Heat transfer from fins of uniform cross section having Convective tip, Efficiency and effectiveness of fin. Effect of variable thermal conductivity, critical thickness of insulation. [12]

Convection heat transfer: Physical mechanism of convection, Newton's law of cooling, no-slip condition, Classification of fluid flows, Dimensionless numbers – Reynolds number, Nusselt number, Prandtl number. Velocity and thermal boundary layers, surface shear stress, Advantages of dimensional analysis, dimensional homogeneity, fundamental and derived quantities Buckingham pi theorem, selection of repeating variables, Example on Buckingham pi theorem, External forced convection, flow over flat plates, boundary layer thickness, flat plate with unheated length, Internal forced convection, fully developed flow, constant surface temp and heat flux, correlations for laminar and turbulent flows, Mechanism of Natural convection, Grashof number, coefficient of volume expansion. [14]

Radiation heat transfer: Radiation, black body radiation, Planck's law, Wien's displacement law, radiation intensity, irradiation, radiosity, Spectral quantities, radiative properties, Kirchhoff's law, Shape factor, relations of shape factor, radiation heat transfer between two black surfaces, Radiation heat transfer between two non-black surfaces, radiation shield. [6]

Heat Exchanger: Types of heat exchanger, advantages and disadvantages of each type, various application of heat exchanger, LMTD derivation for parallel and counter flow heat exchanger, NTU derivation for parallel and counter flow heat exchanger, fouling factor. [4]

References:

1. P.K. Nag (2011) “Heat and Mass Transfer”, Tata McGraw Hill Education Pvt Ltd, New Delhi
2. Yunus Cengel and Afshin Ghajar (2011) “Heat and Mass Transfer”, Tata McGraw Hill Education Pvt Ltd, New Delhi.
3. R. K. Rajput. (2006) “Heat and Mass Transfer”. S Chand & Co Ltd. New Delhi.
4. S K Som (2008) “Introduction to Heat Transfer”, PHI Learning Pvt Ltd, New Delhi.
5. J P Holman. (2010) “Heat Transfer” McGraw Hill, New York.
6. M L Mathur and R P Sharma (2011), “Internal Combustion Engines”, Dhanpat Rai publications, New Delhi.
7. V Ganesan, (2012), “Internal Combustion Engines”, Tata McGraw-Hill Education, New Delhi

AAE 4454: HELICOPTER ENGINEERING [3-0-0-3]

Introduction: Fundamentals, introduction to helicopters, parts, layouts, Historical development of the helicopter, helicopter configuration. [6]

Layout of the Helicopter: control requirements, types of rotor systems, basic power requirements, qualitative requirements of power and control systems of helicopter, control plane, hub plane etc. [8]

Hovering theory: Momentum theory, blade element theory, combined blade element theory, non-uniform inflow calculation, ideal rotor vs optimum rotor. [8]

Vertical Flight: various flow states of rotor, normal state, vortex ring state, turbulent wake state, Autorotation, Autorotation in vertical descent, ground flight, performance calculation of vertical flight. [8]

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, performance calculation in forward flight, Glauert’s hypothesis, comparision with fixed wing aircraft. [6]

References:

1. Prouty, R.W., “Helicopter Performance, Stability and Control”, R.E. Krieger Pub. Co. Florida, 1990
2. Seddon, J., “Basic Helicopter Aerodynamics”, B.S.P. Professional Books, 1990
3. Gessow, A. and Meyers, G.C., “Aerodynamics of the Helicopter”, Dover Publication
4. Bramwell, A.R.S., “Helicopter Dynamics”, Edward Arnold Pub., London, 1976
5. Stepniewski, W.Z., “Rotary Wing Aerodynamics, Vol. 1 and 2”, Dover Publications, 1984.
6. Padfield, G.D., “Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modeling”, AIAA series, 1996

AAE 4455: INDUSTRIAL AUTOMATION AND ROBOTICS [3-0-0-3]

Introduction to pneumatic systems: Structure and signal flow of pneumatic systems, Compressors, Air generation and distribution, Constructional details and working of filter, lubricator, and pressure regulator, Advantages and limitations, Applications. [6]

Sensors and Actuators: Symbols of pneumatic valves, types of pneumatic actuators traverse time diagram, Design of manually operated circuits, push buttons, rollers, flow, pressure control valves, time delay, counter circuits, control of multiple actuators [10]

Electronic actuation systems: Electrically actuated direction control valves, Relay control systems, Design of electro pneumatic circuits, Limit switches, magnetic, inductive, capacitive, optical, ultrasonic, pneumatic proximity sensors, introduction to PLC. [10]
Robotics: Introduction to Robotics, Rigid-Body Kinematics, Dynamics of Robots, Trajectory Planning for Flexible Robots, Robotic Sensors, Robot End Effectors, Robot Programming, Industrial Applications. [10]

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, 2012.
3. Peter Croser, Frank Ebel, Pneumatics Basic Level TP 101, Festo Didactic GMBH & Co, Germany, 2012.
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 4456: 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. (2)

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. Just-in-time manufacturing. Toyota production systems, Ford production systems. (8)

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. (8)

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. (8)

Additional Interests: Develop VSM Current and Future state diagram using Microsoft Visio or Similar Software Package. (2)

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. (8)

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 4457: NAVIGATION, GUIDANCE AND CONTROL [3-0-0-3]

Introduction Concepts of navigation, guidance and control. Introduction to basic principles. Air data information. Radar Systems Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI). [8]

Tracking with Radar Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT). Other Guidance Systems Gyros and stabilized platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS. [8]

Transfer Functions Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop. Missile Control System Guided missile concept. Roll stabilization. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus. [10]

Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance [4]

Integrated Flight/Fire Control System, Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot. [6]

References:

1. M .I. Skolnik: Introduction to Radar Systems, Tata McGraw-Hill, 2007.
2. M. Kayton and W. Fried: Avionics Navigation System, Wiley Interscience,1997.
3. P. Zarchan: Tactical and Strategic Missile Guidance, AIAA, 2007.
4. N.S. Nise: Control Systems Engineering, Wiley-India, 2004.
5. B. Friedland: Control System Design, Dover, 2005.

AAE 4458: NON-LINEAR CONTROL SYSTEMS [3-0-0-3]

Basic concepts: Control Theory, Mechanism and machine, Kinematic pair, link, chain, and inversions, constrained and Introduction of linear and nonlinear systems, nonlinear system behavior. [5]

Mathematical preliminaries: open and closed sets, compact set, dense set, Topology, sequence, Continuity of functions, Lipschitz condition, smooth functions, Vector space, norm of a vector, normed linear space, inner product space. [6]

Linear Algebra: 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. [8]

Advance stability theory: Lyapunov stability for autonomous and non-autonomous systems, Linear Time Variant, Instability theorem, function, Barbalat's Lemma, Function analysis.
[7]

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. [10]

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 (2nd edition), MacMillan, (1996).
7. Shimkin N.: Nonlinear Control Systems. In: Binder M.D., Hirokawa N., Windhorst U. (eds) Encyclopedia of Neuroscience, (2009).

AAE 4459: NUMERICAL METHODS FOR SCIENTIFIC COMPUTING [3-0-0-3]

Chapter 1 Introduction
Background - Representation of Numbers on a Computer - Errors in Numerical Solutions - Round-Off Errors - Truncation Errors - Total Error. [02]

Chapter 2 Mathematical Background
Concepts from Pre-Calculus and Calculus – Vectors - Operations with Vectors - Matrices and Linear Algebra - Operations with Matrices - Special Matrices - Inverse of a Matrix - Properties of Matrices - Determinant of a Matrix - Cramer s Rule and Solution of a System of Simultaneous Linear Equations – Norms - Ordinary Differential Equations (ODE) - Functions of Two or More Independent Variables - Definition of the Partial Derivative - Chain Rule - The Jacobian - Taylor Series Expansion of Functions - Taylor Series for a Function of One Variable - Taylor Series for a Function of Two Variables - Inner Product and Orthogonality [08]

Chapter 3 Solving Nonlinear Equations
Estimation of Errors in Numerical Solutions - Bisection Method - Regula Falsi Method - Newton's Method - Secant Method - Fixed-Point Iteration Method - Equations with Multiple Solutions - Systems of Nonlinear Equations - Newton's Method for Solving a System of Nonlinear Equations - Fixed-Point Iteration Method for Solving a System of Nonlinear Equations. [05]

Chapter 4 Solving a System of Linear Equations
Overview of Numerical Methods for Solving a System of Linear Algebraic Equations - Gauss Elimination Method - Potential Difficulties When Applying the Gauss Elimination Method - Gauss Elimination with Pivoting - Gauss-Jordan Elimination Method - LU Decomposition Method - LU Decomposition Using the Gauss Elimination Procedure - LU Decomposition Using Crout's Method - LU Decomposition with Pivoting - Inverse of a Matrix - Calculating the Inverse with the LU Decomposition Method - Calculating the Inverse Using the Gauss-Jordan Method - Iterative Methods - Jacobi Iterative Method 133 4. 7. 2 Gauss-Seidel Iterative Method. [06]

Chapter 5 Eigenvalues and Eigenvectors
The Characteristic Equation - The Basic Power Method - The Inverse Power Method - The Shifted Power Method - The QR Factorization and Iteration Method. [02]

Chapter 6 Numerical Differentiation
Finite Difference Approximation of the Derivative - Finite Difference Formulas Using Taylor Series Expansion - Finite Difference Formulas of First Derivative - Finite Difference Formulas for the Second Derivative - Differentiation Formulas Using Lagrange Polynomials - Differentiation Using Curve Fitting - Richardson's Extrapolation - Error in Numerical Differentiation - Numerical Partial Differentiation. [04]

Chapter 7 Numerical Integration
Overview of Approaches in Numerical Integration - Rectangle and Midpoint Methods - Trapezoidal Method - Composite Trapezoidal Method - Simpson's Methods - Simpson's 1/3 Method - Simpson's 3/8 Method - Gauss Quadrature - Evaluation of Multiple Integrals - Estimation of Error in Numerical Integration - Richardson's Extrapolation - Romberg Integration - Improper Integrals. [04]

Chapter 8 Ordinary Differential Equations
Euler's Methods - Eulers Explicit Method - Analysis of Truncation Error in Euler s Explicit Method - Eulers Implicit Method - Modified Euler's Method - Midpoint Method - Runge-Kutta Methods - Second-Order Runge-Kutta Methods - Third-Order Runge-Kutta Methods - Fourth-Order Runge-Kutta Methods - The Shooting Method - Finite Difference Method - Error and Stability in Numerical Solution of Boundary Value Problems. [05]

Reference(s):

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 4460: OPERATIONS RESEARCH [3-0-0-3]

Introduction: Origin and development, Feature or OR, Methodology of OR
Linear Programming Model: Formulation of real life situations Solutions methodology: Graphical method, simplex method. Special cases:- Unbounded, In-feasible, Alternate and degenerate solution Two phase method. Duality Theory Dual simplex method Post Optimal Analysis [10]

Transportation Model: Formulation Transportation algorithm Developing initial BFS using North West corner Rule, Least cost cell method, VAM, Row/Column Minimum Method Testing the solution and improving using stepping stone method and MODI method. Resolving unbalance, degeneracy. [6]

Assignment Model: Formulation, Hungarian Algorithm Tackling Unbalance [3]

Game Theory: Two person Zero Sum game Formulation Pure strategy and Mixed strategy Solution methodology: Graphical method and LP method [4]

Dynamic Programming: Decomposition stages, Recursive equationsDeterministic Discrete state DP applications. [4]

Network Models Shortest path problem: Minimum spanning tree problem, Maximum flow problem Project Management with PERT/CPM Network construction Scheduling with CPM/PERT. Time cost trade-off. [6]

Queuing Theory: General structure of system. Analysis of M/M/1 with infinite and finite population, self service system. [3]

REFERENCES

1. Vohra N.D.: Quantitative Techniques in Management, 2nd ed. Tata McGraw Hill Publishing co. Ltd., New Delhi (2017)
2. Hamdy Taha: Operation Research, an Introduction, Pearson (2016)
3. Hiller, Liberman: Introduction to Operations Research, McGraw HIll International.(2017)
4. Gillet B.E.: Operations Research Tata McGraw Hill (2000)
5. Gupta, Hira: Operations Research S. Chand & Co. (2018)
6. Don T. Phillips, A. Ravindran And James J. Solberg: Operations research: principles and practice Wiley (2007)

AAE 4461: OPTIMAL CONTROL [3-0-0-3]

Introduction: 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.
[5]

The Calculus of Variations: The Euler-Lagrange equation, Path optimization subject to constraints, Weak and strong extrema, Calculus of variations applied to optimal control
[5]

The Minimum (Maximum) Principle and The Hamilton-Jacobi Theory: Pontryagin's minimum principle, Optimal control with state and control constraints, Time-optimal control, Singular solutions, Hamilton-Jacobi-Bellman (HJB) equation and dynamical programming.
[8]

Linear Quadratic Regulator (LQR) And Linear Quadratic Gaussian (LQG) Problems: 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.

[10]

Estimators/Observers: MIMO System and SVD, Holonomic & Nonholonomic System Optimal Control, Game Theoretic Optimal Control Design.

[4]

Signals and system norms: H_∞ synthesis, different type of optimal controller, Model predictive control.

[4]

References:

1. A.E. Bryson and Y.C. Ho: Applied Optimal Control (2nd ed.), Blaisdel., 1975.
2. Naidu D.S: Optimal Control Systems, CRC Press, 2002.
4. Sinha A.: Linear Systems: Optimal and Robust Control, CRC Press, 2007.
5. 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, (3rd edition), Athena Scientific, 2005.
7. Richard W. Cottle, Mukund N. Thap: Linear and Nonlinear Optimization, Springer Nature, 2017.
8. https://nptel.ac.in/courses/108107098

AAE 4462: OPTIMIZATION TECHNIQUES IN ENGINEERING [3-0-0-3]

Chapter 1: Introduction

Optimal Problem Formulation - Design Variables – Constraints - Objective Function - Variable Bounds - Engineering Optimization Problems - Classification of Optimization Algorithms. [04]

Chapter 2: Single-variable Optimization Algorithms

Optimality Criteria - Bracketing Methods - Exhaustive Search Method - Bounding Phase Method - Region-Elimination Methods - Interval Halving Method - Fibonacci Search Method - Golden Section Search Method - Gradient-based Methods - Newton-Raphson Method - Bisection Method - Secant Method - Cubic Search Method - Root-finding Using Optimization Techniques. [12]

Chapter 3: Multivariable Optimization Algorithms

Optimality Criteria - Unidirectional Search - Direct Search Methods - Hooke-Jeeves Pattern Search Method - Powell's Conjugate Direction Method - Gradient-based Methods - Cauchy's (Steepest Descent) Method - Newton's Method - Conjugate Gradient Method. [06]

Chapter 4: Constrained Optimization Algorithms

Kuhn-Tucker Conditions - Lagrangian Duality Theory - Penalty Function Method - Method of Multipliers - Feasible Direction Method - Quadratic Programming - Sequential Quadratic Programming. [04]

Chapter 5: Non-traditional Optimization Algorithms

Genetic Algorithms - Working Principles - Differences between GAs and Traditional Methods - Similarities between GAs and Traditional Methods - GAs for Constrained Optimization - Other GA Operators - Real-coded Gas - Multi-objective Gas - Simulated Annealing - Global Optimization - Using the Steepest Descent Method - Using Genetic Algorithms - Using Simulated Annealing. [10]

Reference(s):

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

AAE 4463: SPACEFLIGHT DYNAMICS [3-0-0-3]

AAE 4464: SPACEFLIGHT MECHANICS [2-1-0-3]

Introduction and overview, Space Technology Basic Definitions, Space Environment And Missions Vectors and kinematics basics. [7]

Relative motion, Two body problem-Introduction, Conic Sections, Types of Orbits, Kepler's Laws and proofs, Lagrange Points [7]

Orbital Elements, Orbit position as a function of time, Orbit Determination, Gibb's method [8]

Orbital Maneuvers Introduction, Hohmann Transfer, Bi elliptical Transfer, Phasing and Plane change Maneuvers, Interplanetary Trajectories, Sphere of Influence, Interplanetary Hohmann Transfer, Method of Patched Conics, Planetary Flyby [8]

Orbit Perturbations-Introduction, Sources of perturbation, Space Debris, Relative motion in orbit, Basic equations, Solution to various numerical problems. [6]

References:

1. Curtis "Orbital Mechanics for Engineering students" Elsevier,2010
2. Chobotov "Orbital Mechanics" AIAA Education series,Third Edition,2002.
3. Roger R Bate, " Fundamentals of Astrodynamics" Dover Publications, 1971Tom Logdson., "Orbital Mechanics" Wiley Publications, 1998

AAE 4465: STATISTICAL QUALITY CONTROL AND RELIABILITY [2-1-0-3]

Introduction: Definitions of the term quality, Functions of Inspection and Quality Control. Introduction to Total Quality Control, Organization for quality, General quality control engineering fundamentals: Measures of central tendency and dispersion like Average, Standard deviation, Median, Mode, Range, Variance, Concept of variation, Causes of Variation, Patterns of variation, Frequency distribution, The Normal distribution curve, Tchebyeheff's and Camp-Meidell's Inequality theorems. Shewhart's bowl drawing experiments. [5]

Modeling Process Quality: Probabbilistic relationships, Descrete and continuous proability distributions. Tolerance allocation when the means are not equal to the nominal sizes. Tolerance Allocation when the Number of Processes is Finite [4]
Methods of Statistical Process Control and Capability Analysis: ,R & s charts, Type I and Type II Errors. Process capability analysis Process capability indexes – Cp and Cpk. Control charts for attributes: p, np, c and u charts [12]

Acceptance sampling: Acceptance sampling by attributes – Single, Double and Multiple sampling plans, Operating characteristic curve, AOQ curve, AOQL, Average Total Inspection, Average Fraction Inspected, ASN curve. Producer's and Consumer's risks, Dodge-Roming & MIL-STD acceptance sampling tables. [9]

Reliability Engineering: Concepts of reliability, Statistical Models of reliability, Reliability of hazard functions, System reliability, Redundancy techniques in system design. Failure modes, effects & criticality analysis, Fault tree analysis, Event tree analysis Design review & validation, Design for reliability [6]

References:

1. Montgomery D. C., Introduction to Statistical Quality Control, (7e), John Wiley & Sons, New York, 2013
2. Amitav Mitra, Fundamentals of quality control and improvement (3e) Wiley, 2008
3. Grant E.L., Statistical Quality Control, (6e), McGraw Hill Publications, New York, 1988
4. Juran J.M., Quality Planning and Analysis, (2e) McGraw Hill Publications, Delhi, 1984
5. Rao S S., Reliability Engineering Pearson Education, 2014

AAE 4466: SURROGATES AND APPROXIMATIONS IN ENGINEERING DESIGN [2-1-0-3]

Chapter 1: Sampling Plans

The 'Curse of Dimensionality' and How to Avoid It - Physical versus Computational Experiments - Designing Preliminary Experiments (Screening) - Estimating the Distribution of Elementary Effects - Designing a Sampling Plan – Stratification - Latin Squares and Random Latin Hypercubes - Space-filling Latin Hypercubes - Space-filling Subsets. [10]

Chapter 2: Constructing a Surrogate

The Modelling Process - Stage One: Preparing the Data and Choosing a Modelling Approach - Stage Two: Parameter Estimation and Training - Stage Three: Model Testing - Polynomial Models - Radial Basis Function Models - Fitting Noise-Free Data - Radial Basis Function Models of Noisy Data – Kriging - Building the Kriging Model - Kriging Prediction - Support Vector Regression - The Support Vector Predictor - The Kernel Trick - Finding the Support Vectors. [16]

Chapter 3: Exploring and Exploiting a Surrogate

Searching the Surrogate - Infill Criteria – Prediction-Based Exploitation – Error-Based Exploration - Balanced Exploitation and Exploration - Conditional Likelihood Approaches - Other Methods. [10]

Reference(s)

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

AAE 4467: SYSTEMS ENGINEERING [3-0-0-3]

Introduction of Systems Engineering: System engineering definition, systems, subsystems, system engineer, system manager and their roles, System life cycles. V model for software and product design. Case study- Life Cycle Cost Considerations for Complex Systems

[4]

Fundamentals of Systems Engineering: Fundamentals of Systems Engineering, The Common Technical Processes and the SE Engine, An Overview of the SE Engine by Project, Example of Using the SE Engine, Distinctions between Product Verification and Product, Cost Effectiveness Considerations, Human Systems Integration (HSI) in the SE Process, Competency Model for Systems Engineers, Methodology of system engineering, 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. Case study- System Engineering Method for System Design

[8]

Project Life Cycle: Project Life Cycle, Program Formulation, Program Implementation, Project Pre-Phase A: Concept Studies, Project Phase A: Concept and Technology Development, Project Phase B: Preliminary Design and Technology Completion, Project Phase C: Final Design and Fabrication, Project Phase D: System Assembly, Integration and Test, Launch, Project Phase E: Operations and Sustainment, Project Phase F: Closeout, Funding: The Budget Cycle, Tailoring and Customization of NPR 7123.1 Requirements. Case study- Life Cycle Cost Considerations for Complex Systems

[4]

System Design Processes: Stakeholder Expectations Definition, Technical Requirements Definition, Logical Decomposition, Design Solution Definition, Product Realization, Product Implementation, Product Integration, Product Verification, Product Validation, Product Transition.

[6]

Crosscutting Technical Management: Technical Planning, Requirements Management, Interface Management, Technical Risk Management, Configuration Management, Technical Data Management, Technical Assessment, Decision Analysis.

[4]

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., The Case-Study of an Airplane and Its Subsystems.

[5]

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...

[5]

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.
7. https://nptel.ac.in/courses/110104074
8. https://ocw.mit.edu/courses/16-842-fundamentals-of-systems-engineering-fall-2015/
9. https://ocw.mit.edu/courses/esd-33-systems-engineering-summer-2010/
10. https://ocw.mit.edu/courses/16-885j-aircraft-systems-engineering-fall-2005/

AAE 4468: TOTAL QUALITY MANAGEMENT [3-0-0-3]

TOTAL QUALITY MANAGEMENT **7**

Introduction to TQM: Introduction-Definition, Basic Approach, and Contribution of Gurus-TQM framework, Historical Review, Benefits of TQM, TQM organization. Leadership, Customer Satisfaction and Employee Involvement: Characteristics of quality leaders, Customers satisfaction, Customer perception of quality, Feedback, Using customer's complaints, Employee involvement-Introduction, Teams, Cross functional teams, Quality circles, Suggestion system, Benefits of employee involvement.

PRINCIPLES AND PHILOSOPHIES OF QUALITY MANAGEMENT **4**

Overview of the contributions of Deming, Juran Crosby, Masaaki Imai, Feigenbaum, Ishikawa, Taguchi techniques – introduction, loss function, parameter and tolerance design, signal to noise ratio. Concepts of Quality circle, Japanese 5S principles and 8D methodology.

CONTINUOUS PROCESS IMPROVEMENT: **8**

Continuous Process Improvement and Tools Techniques: The Juran trilogy, improvement strategies, types of problems, the PDSA Cycle, problem-solving methods, Kaizen, reengineering, six sigma, case studies. Statistical Process Control: Pareto diagram, process flow diagram, cause and effect diagram, check sheets, histograms, statistical fundamentals, Control charts, state of control, out of control process, control charts for variables, control charts for attributes, scatter diagrams, case studies.

STATISTICAL PROCESS CONTROL AND PROCESS CAPABILITY **9**

Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed. Process capability – meaning, significance and measurement – Six sigma concepts of process capability.
Reliability concepts – definitions, reliability in series and parallel, product life characteristics curve. Total productive maintenance (TMP) – relevance to TQM, Terotechnology. Business process re-engineering (BPR) – principles, Applications, reengineering process, benefits and limitations.

TOOLS AND TECHNIQUES FOR QUALITY MANAGEMENT **8**

Quality functions development (QFD) – Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation. statistical tools, Management tools. Bench marking and POKA YOKE.

References:

1. John L. W. Beckford, "Quality: A Critical Introduction", 3rd Ed. Routledge Taylor and Frances Group, New York and London.
2. Dale H. Besterfield, Carol Besterfield - Michna, Glen H Besterfield and Mary Besterfield-Sacre, "Total Quality Management", 3rd Ed.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.

AAE 4469: WIND ENERGY ENGINEERING [3-0-0-3]

Introduction: Historical Development (BC – 20th Century), Historical Development (20th Century – 1980s), Recent Developments (1980s – present), Wind Energy Potential, Offshore Wind Energy, Modern Wind Turbines (4)

The Wind Resource, The Nature of the Wind , Geographical Variation in the Wind Resource , Long-term Wind-speed Variations , Annual and Seasonal Variations , Synoptic and Diurnal Variations , Turbulence , Gust Wind Speeds , Extreme Wind Speeds , Turbulence in Wakes and Wind Farms , Turbulence in Complex Terrain (6)

Aerodynamics of Horizontal-axis Wind Turbines, Introduction , The Actuator Disc Concept, Rotor Disc Theory , Vortex Cylinder Model of the Actuator Disc , Rotor Blade Theory , Breakdown of the Momentum Theory , Blade Geometry , The Effects of a Discrete Number of Blades , Calculated Results for an Actual Turbine (6)

Wind-turbine Performance, The Performance Curves , Constant Rotational Speed Operation , Comparison of Measured with Theoretical Performance , Variable-speed Operation , Estimation of Energy Capture , Wind-turbine Performance Measurement , Aerodynamic Performance Assessment, **Conceptual Design** of Horizontal Axis Wind Turbines, Introduction , Rotor Diameter , Machine Rating , Rotational Speed , Number of Blades , Power Control , Braking Systems , Fixed-space, Two-speed or Variable-speed Operation , Type of Generator (12)

Component Design, Blades, Pitch Bearings , Rotor Hub , Gearbox , Generator , Mechanical Brake , Yaw Drive , Tower , Foundations, **Wind-turbine Installations and Wind Farms** , Project Development , Visual and Landscape Assessment , Noise , Electromagnetic Interference , Ecological Assessment , Finance (8)

References:

1. Wind Energy Engineering, A Handbook for Onshore and Offshore Wind Turbines, Trevor M. Letcher
2. WIND ENERGY EXPLAINED Theory, Design and Application, J. F. Manwell and J. G. McGowan, A. L. Rogers
3. Wind Energy Engineering, Second Edition, Pramod Jain
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, 2nd Edition, 2012

OPEN ELECTIVES

AAE 4311: INTRODUCTION TO AEROSPACE ENGINEERING [3-0-0-3]

Have an overview of the history of flight [3]

Ballooning, Apply basic/constitutive principles of mechanics of fluids, Bernoulli and control volume approaches, the source of all aerodynamic forces, Equation of state for a perfect gas, specific volume, anatomy of aircraft, anatomy of space vehicle [[9]

Definition of Altitude, Hydrostatic equation, Relation between geopotential and geometric altitudes, Pressure, Temperature and Density altitudes [4]

Basics of Aerodynamics, Incompressible and compressible flow, elementary thermodynamics, isentropic flow, laws of conservations, speed of sound, low speed wind tunnels, measurement of airspeed, Explain flow regimes (viscous/non-viscous; compressible/incompressible aerodynamics) and to estimate viscous and thermal effect [9]

Airfoil Nomenclature, Lift, Drag and Moment co-efficient, Infinite versus finite wings, Pressure coefficient, Elements of Airplane Performance – Equation of Motions for level flight, climbing flight, gliding flight, take-off and landing, Stability and Control [5]

Introduction, Orbit equation, Space Vehicle Trajectories, Kepler's laws, Space environment, Orbital Mechanics, Attitude dynamics and control, Propulsion and launch vehicles, satellite orbits, transfer orbits and maneuvers [4]

Introduction, Types of Propulsion system [2]

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)
6. NPTEL Courses: Introduction to Aerospace Engineering https://nptel.ac.in/courses/101101079

AAE 4312: INTRODUCTION TO AVIONICS AND NAVIGATION SYSTEMS [3-0-0-3]

Introduction Aircraft: Introduction to aircraft, Introduction to flight mechanics and flight dynamics of aircraft & Unmanned Air Vehicle, UAV Instrumentations and Sensors. [3]

Introduction to Avionics in aircraft: Analog and Glass cockpit of Different aircraft, ADS-B, Civil, Military aircraft and spacecraft avionics. Organization Framework, avionics architecture, types of payloads. [3]

System Engineering and Avionics software Tools: What is system engineering, RTCA/DO-178B, DO-178C, V model for software development, DO-330/3301/332/333, CERT/MISHRA, Software Testing Tools. **[3]**

Introduction to Navigation systems: Inertial Sensors and Inertial Navigation Systems, Multisensors Navigation Systems, Kalman filter basics & Mechanization, GPS-INS Mechanization. Point source and hyperbolic source systems, **Satellites Radio Navigation:** -Satellite Navigation Systems, GPAS, Global Orbiting Navigation Satellites Systems, IRNSS. **RADAR**: Doppler and Altimeter Radars, Mapping and Multimode Radar, Weather RADAR, FMCW Radar [8]

Essential System Display: Cockpit Design, Displays, PFD, ND, MFD, HUD, HMD, HMI, I/O Devices and Power. [4]

Essential System Aircraft Electrical Systems: Aircraft electrical systems, Electrical Power Generation, Distribution, conversion and protection Systems, aircraft lights, electrical systems of small and large aircraft.
Packaging, ARINC and DOD Types, System Cooling, EMI/EMC Requirements. [4]

Essential Systems Aircraft Databus: Digital Communication, Digital Data Bus System, ARINC-429,629, AFDX, MIL-STD-1553, Fiber Optic Comm. [3]

Flight Control Systems: Flight control, FBW, FBL, Flight management systems, Autopilot, LRU, IMA & Mission Systems. [4]

Aircraft Landing systems: Mechanics of Landing, Automatic landing systems, ILS, MLS, SLS, Carrier landing systems, Surveillance systems-radio altimeter etc. [4]

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, Sixth Edition, Tata McGraw Hill Education Pvt. Ltd, 2014.
4. Cary R. Spitzer: Digital Avionics Handbook-Avionics Development and Implementation (2nd Edition), CRC Press, Taylor & Francis Group, 2007.
5. Bernard Etkin and Lloyd Duff Reid: Dynamics of Flight: Stability and Control (3rd edition), Wiley, 1995.
6. Myron Kayton & Walter R. Fried: Avionics Navigation Systems, 2nd Edition, Wiley-interscience, 1997.

7. Mohinder S Grewal: Global Navigation Satellite Systems, Inertial Navigation and Integration, John Wiley, 2013. https://archive.nptel.ac.in/courses/105/107/105107194/
8. https://nptel.ac.in/courses/101108056
9. https://www.aviationtoday.com/

MINOR SPECIALIZATION: AERODYNAMICS

AAE 4401: APPLIED AERODYNAMICS [2-1-0-3]

External Flows:- aerodynamic forces on streamlined and bluff bodies, flow separation; lift and drag on wings, including induced drag; theory of lift and circulation; vortex shedding. Automotive Aerodynamics, Drag and road load, Vortex structure, Shape optimisation (6)

Internal Flows: fully developed flow; losses and flow behaviour in pipes, ducts, pipe fittings; pipe systems and networks; flow meters calculation of energy loss, flow rates, pipe sizes etc; matching of flow systems to turbomachines. (5)

Boundary Layers: Behaviour and theory of boundary layers, Laminar and turbulent boundary layers, Von-Karman momentum integral equation, Effect of pressure gradient, Turbomachines, classification of turbomachines; selection of turbomachines. (6)

Introduction To Compressible Flow, Isentropic Processes of Ideal Gases (Review), Stagnation or Total Properties, 1-Dimensional Isentropic Wave theory, Mach Waves, Shock Waves, **Flow In A Variable-Area Duct**, Isothermal-Isentropic Flow, Isoenergetic, Isentropic Flow of an Ideal Gas, Mass Flow Relations and Choking, Flow in a Converging Nozzle, Convergent-Divergent Supersonic Diffusers, 1-DFrictional Flow in a Duct (Fanno flow), 1-D Flow with Heat Addition Rayleigh flow), Aircraft intake systems, **External Flows ,** Compression and Expansion Waves, External Flow Patterns, Lift and Drag, Linearised theory & compressibility corrections, Critical Mach number, Aerofoils in Transonic & Supersonic Flow, Design Considerations (13)

Shock - Expansion Theory, Oblique shock waves – wedge flow, Oblique shock waves – conical flow, Expansion waves, Calculation procedures, Ackeret theory, **Supersonic Boundary Layers,** Boundary layer structure, Effects of Mach number and Reynolds number, Aerodynamic heating, **Experimental Approaches,** Schlieren, Shadowgraph & Interferometry, Flow Facilities - Wind Tunnels & Shock-Tube Tunnels (6)

References:

1. Jan Roskam, Methods for Estimating Drag Polars of Subsonic Airplanes, Published by the Author, (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, any edition, McGraw Hill, (????)
5. Applied Aerodynamics: Challenges and Expectations , Victor L. Peterson and Charles A. Smith
6. Munson, B.R., Young, D.F., Okiishi, T.H., Fundamentals of Fluid Mechanics, John Wiley and Sons Inc, 3rd, 4th, 5th or 6th Edition.

AAE 4402: TURBOMACHINERY AERODYNAMICS [2-1-0-3]

Basic concepts: Understanding the importance turbomachinery components, different types of turbomachinery components, Working principle, performance parameters, velocity triangles, construction of velocity triangles and analysis. [8]

Axial flow compressors: Velocity triangles across the rotor blade, velocity triangles across the rotor and stator blades, blade geometrical details, importance towards design, parametric design of axial flow compressor stage, no of stages and its importance, subsonic and transonic flow compressor stage design calculations. [8]

Axial flow turbines: Velocity triangles across the stator blade, velocity triangles across the stator and rotor blades, blade geometrical details, importance towards design, parametric design of axial flow turbines stage, no of stages and its importance, subsonic and transonic flow turbines stage design calculations. [8]

Centrifugal compressor: Types of radial compressors, Centrifugal compressors components, functions, performance parameters, velocity triangles, design of centrifugal compressors. [6]

Radial flow turbines: Role of radial flow turbines, scope, advantages and limitations of radial flow turbines, performance parameters, design flow turbines [6]

References:

1. Hill P.G, Peterson C.R., Mechanics and thermodynamics of propulsion, 2nd ed., Addison Wesley Publishing Company, 1992.
2. Nicholas Cumpsty, Compressor Aerodynamics, Krieger Publications, USA, 2004
3. Johnson I.A., Bullock R.O., (NASA-SP-36), Axial Flow Compressors, 2002, NTIS.
4. El-Wakil, Powerplant Technology, McGraw Hill Publications, 1984.
5. J.H. Horlock, Axial Flow Compressors, Butterworths, UK, 1958

AAE 4403: EXPERIMENTAL AERODYNAMICS [3-0-0-3]

Experimental Errors, Causes and Types, Bias Errors, Random Errors, Systematic Error, Precision, Accuracy. Propagation of Error, Statistical Analysis of Experimental data. Terminology: resolution, threshold, hysteresis, non-linearity, span, dynamic range, sensitivity, response. [4]

Types of Wind Tunnels: Advantages and Disadvantages. Open and Closed-Circuit Wind tunnels; Blow down, Indraft and Pressure-vacuum facilities, Role of diffuser, Selecting wind tunnel, Storage volume and run time calculations. [4]

Shock tubes and other high-speed facilities – shock tunnel, ballistic range, Plasma Arc Tunnel, Rarefied Gas Tunnel, and Microgravity Facility. [4]

Flow Visualization Techniques –Schlieren, Shadowgraph, Interferometry. [4]

Temperature Measurements in flow: Thermostats, Thermistors, RTDs, Thermocouples, Radiation Thermometers, Pyrometers, Spectroscopy Based Measurements, Phosphorescence, Fluorescence, PLIF. [5]

Pressure Measurements in flow:
Pressure measurement methods: Manometers, Bourdon gauges, Bellows and Diaphragms, Piezoelectric, Piezo-resistive, McLeod gauge, Pirani gauge, ionization gauges. [5]

Velocity measurements in Flow: Pitot probe, Pitot correction in supersonic flows, hot wire Anemometry – constant temperature, constant current, Laser Doppler Velocimetry, Particle Image Velocimetry, Particle Tracking Velocimetry, Laser Speckle Velocimetry [6]

Force measurements: strain gauge-based measurements, balances, transducers [4]

References:

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

AAE 4404: HIGHSPEED AERODYNAMICS [2-1-0-3]

Introduction & Prediction Methods
Introduction to High Speed Flows & review of Aerodynamic forces and heating, Velocity Altitude Map, Hypersonic shock and expansion wave relations, Approximate methods, Newtonian flow, Modified Newtonian flow, Centrifugal corrections of Newtonian Busemann theory, Tangent Wedge and Tangent Cone methods, Shock expansion method [9]

Governing equations and inviscid hypersonic flow
Hypersonic Inviscid flows and its governing equations, Mach number independence, hypersonic small disturbance equations, hypersonic similarity, hypersonic equivalence principle, Blast wave theory, hypersonic inviscid flows: Exact methods, Introduction to method of characteristics, Equations used and example of methods of characteristics, Shock-Shock interactions [12]

Hypersonic Viscous flow
Governing equations for viscous flows, Similarity parameter and boundary conditions, Boundary layer equations for hypersonic flow, Introduction and fundamentals of Self Similar solutions, Self similar solution results and conclusions, Hypersonic transitions, Reference temperature method, Hypersonic aerodynamic heating, Viscous interactions, Strong and weak interactions, role if 'chi bar' in viscous interactions, Hypersonic shock wave and boundary layer interactions, Hypersonic wind tunnels and its classifications

[15]

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 4405: UNMANNED AIRCRAFT SYSTEM, SENSORS, AND INSTRUMENTATION [3-0-0-3]

Introduction to Unmanned Aircraft Systems (UAS): Unmanned Aircraft System, Some Applications of UAS, what are UAS? Why Unmanned Aircraft? The Systemic Basis of UAS, System Composition, Basic Theory and design. [4]

The Design of UAV Systems: Conceptual Phase, Preliminary Design, Detail Design, Selection of the System. Aerodynamics and Airframe Configurations, Characteristics of Aircraft Types-HALE, MALE, Tactical, Battlefield, MUAV, MAV, UCAV, NOVEL aircrafts, Design Standards, Design Standards and Regulatory Aspects-DGCA, Europe, UK, USA, Aspects of Airframe Design. [10]

Design for Stealth-Acoustic Signature, Visual Signature, Thermal Signature, Radio/Radar Signature, RCS analysis of UAV. [5]

Sensors: Payload Types-Nondispensable Payloads, Dispensable Payloads -RADAR, SAR, FLIR, EO/IR Camera Payload Control, AR/VR, RADAR Simulator etc. [5]

Instrumentations: -Communications, Antenna Types, Ground Control Stations, Autonomy, Navigations sensors and equipment's, Flight Controller, Video Communication systems and remote video terminals, Launch and Recovery Systems, Support Equipment's. [8]

Introduction to System Development and Certification, System Development, UAV System testing, system -in flight testing, Defense Application, Design for Reliability, EMC/EMI of UAS. [4]

References:

1. Reg Austin: Unmanned Aircraft Systems UAVs Design, Development and Deployment (First Edition), A John Wiley and Sons, Ltd., 2010.
2. Jay Gundlach: Designing Unmanned Aircraft Systems: A Comprehensive Approach (Second Edition), 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 (Second edition), 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.
7. https://nptel.ac.in/courses/101104073

AAE 4406: ANTENNA DESIGN ANALYSIS AND ITS APPLICATIONS [3-0-0-3]

Fundamentals of electromagnetic theory, Characteristics of Electromagnetic Waves, Boundary Conditions, Magnetostatic Field, modes of propagation-Ground wave propagation, Sky wave propagation, wave propagation mechanism, maxwell equations. [8]

Fundamentals of Antenna, Basic Antenna and Propagation Theory: Introduction, Characteristics of an Antenna. Types of Antennas. [7]

Antennas and Applications. Radiation Pattern, Radiation Pattern Lobes, Interaction between Two Wave Polarizations. Antennas Placement/Used on Aircraft, Co. and Cross Polar Radiation Patterns. [7]

Antenna Designing, Computer Modelling Techniques, Antenna Simulations Using Software, and their characteristics, Antenna Simulation for; Gain, Return Loss (S_{11}), input impedance, real impedance, imaginary impedance, parametric analysis etc. [7]

RADAR, Radar Cross Section (RCS), Radar range equations, Gain of the Radar transmitting antenna, RCS Dependency on Polarization, Radar performance factors, Types of Radar system, Stealth technology and radar absorbing materials (RAM). [7]

References:

9. Mathew N O Sadiku: Elements of Electromagnetics (3rd edition), Oxford University Press, (2001).
10. C.A. Balanis: Antenna Theory - Analysis and Design (4th Edition), John Wiley, (2016).
11. Thereza Macnamara: Introduction to Antenna Placement and Installation (1st Edition), Wiley, (2010).
12. John D Kraus, Ronald J Marhefka, Ahmad S Khan: Antennas for All Applications (3rd Edition), The McGraw Hill Companies, (2008).
13. J. E. Rhodes: Antenna Handbook, Department of The Navy, (2016).
14. Lo, Y.T., Lee, S. W.: Antenna Handbook Theory, Applications, and Design, Springer US, (1988).
15. https://nptel.ac.in/courses/117107035
16. https://ocw.mit.edu/courses/6-661-receivers-antennas-and-signals-spring-2003/

AAE 4407: AEROSPACE EMBEDDED SYSTEMS, SOFTWARE, SAFETY AND SECURITY [3-0-0-3]

Embedded Systems: Understanding the Basic Concepts, Introduction to Embedded Systems, The Typical Embedded System, Characteristics and Quality Attributes of Embedded Systems, Embedded Systems—Application- and Domain-Specific, Designing Embedded Systems with Microcontrollers, Programming and Embedded Hardware Design and Development

[6]

Design and Development of Embedded Product, Embedded Firmware Design and Development, Real-Time Operating System (RTOS) based Embedded System Design. An Introduction to Embedded System Design with VxWorks and MicroC/OS-II RTOS, Integration and Testing of Embedded Hardware and Firmware, The Embedded System Development Environment, Product Enclosure Design and Development, The Embedded Product Development Life Cycle (EDLC), Aircraft embedded systems: computer, OBC, microprocessor and microcontroller in LRUs, communication modules, databus modules.

[6]

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.

[4]

Introduction to Coding Standards and compliance: CERT C, C++ and MISRA C:2012, SEI CERT C Top 10 Secure Coding Best Practices, JAVA, CWE, Introduction to Process Standard DO-178C for Avionics.

[8]

SDLC & Fundamentals of Software Testing: Basics of Software Development Life Cycle for Safety & Security Projects: · Basics of Software Testing, Static and Dynamic Analysis, Software Quality Metrics, Structural Code Coverage including MC/DC and LCSAJ · Data Flow and Control Flow Analysis, Unit/System/Integration testing & Regression Testing.

[6]

Introduction to Functional Safety Standard – ISO 26262:2011 for Automotive, ISO 26262:2011 Road Vehicle – Functional Safety of electrical and/or electronic systems, Introduction to Process Standard – DO-178C for Avionics, DO-178C: Software Considerations in Airborne Systems and Equipment Certification,

[6]

References:

1. K.V. Shibu: Introduction to Embedded Systems, (Second Edition), McGraw Hill Education India Private Limited; Second edition (Revised on 1 July 2017, old edition, 2009.
2. E. A. Lee and S. A. Seshia: Introduction to Embedded Systems - A Cyber-Physical Systems Approach (Second Edition), 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.
7. https://nptel.ac.in/courses/108102045

AAE 4408: AIRCRAFT COMMUNICATION AND NETWORKING [3-0-0-3]

Introduction: communication systems and process, analog and digital signal, source, channel, modulation process.

[3]

Signals: Signals and Signal Space, classifications, Correlation, signal representation, Fourier series, computations, Filters, Linear systems, Spectral density, random process and noise analysis.

[4]

Analog Communication: Modulation and Demodulation: Amplitude Modulations and Demodulations, Angle Modulation and Demodulation, FM, PM, demodulators or detectors, Performance of communication systems, AM and FM Receiver,

[6]

Digital Communication: sampling theory, PCM, Waveform coding theory, digital data transmission, Cellular and mobile communication, Security in Next Generation Air Traffic Communication Network, Aircraft communication, Behavior analysis of analog and digital systems in the presence of noise, MIMO, OFDM.

[8]

Aircraft Databus: Commercial Standard Digital Bus, Data bus, ARINC, Avionics Application Software Standard Interface.

[4]

Computer: Basic functions and facilities of a computer, Computer Systems Architecture and Hardware.

[4]

Networking Essentials., Networking Computers, Communications, Data Communications and Transmission Media, RISC processors: ARM and SPARC, VLIW processors, network security.

[5]

Case study: Aircraft computers, Aircraft Networking, Aircraft Data Network (ADN).

[2]

References:

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