PhD Programme in Engineering/Sciences

Prospectus

2019

Academy of Scientific & Innovative Research (AcSIR)

CSIR-National Aerospace Laboratories, Bangalore

Contents

Sl. No.	Topic	Page No.
1.	Introduction	3
2.	Eligibility for admission	3
3.	Summary of the Courses offered at CSIR-NAL	5
4.	Syllabus of the Courses offered at CSIR-NAL	9

Academy of Scientific and Innovative Research (AcSIR)

PhD Programme in Engineering/Sciences

at

CSIR-National Aerospace Laboratories (CSIR-NAL), Bangalore

1.0 Introduction:

Academy of Scientific & Innovative Research (AcSIR) has been established in 2011, by an Act of Parliament, as an 'Institution of National Importance' with the mandate to create and train some of the best of tomorrow's Science & Technology leaders through a combination of innovative and novel curricula, pedagogy and evaluation. National Aerospace Laboratories (NAL), Bangalore is a constituent Institution under the Council of Scientific and Industrial Research (CSIR) of India. NAL is a high technology oriented institution concentrating on advanced topics in the aerospace and related disciplines. Aerospace technology encompasses the trans-disciplinary areas of science and engineering and is in the forefront of modern developments and achievements in the fields of aeronautics, space and defence. It involves study of various disciplines namely aerodynamics, propulsion, flight mechanics, avionics, materials and structures. The Integrated PhD (Engineering)/ PhD (Engineering)/ PhD (Sciences) programme being offered at CSIR-NAL, Bangalore through AcSIR aims to provide in-depth exposure to the engineering concepts, scientific principles, research methodology and hands on experience on advanced real life R&D projects in different disciplines of flight vehicle engineering. Students completing this program are expected to be fully research – enabled and industry ready. This helps in meeting the severe shortage of the highly skilled manpower required for developing technologies for the future generation flight vehicles.

The first few semesters of the program focuses on the coursework required for equipping the students with the fundamentals of the subjects related to their research problem. In the subsequent semester/s the students work towards preparing a research proposal before taking a comprehensive examination by selecting topics of high relevance and novelty, and will have state-of-the art review, methodologies, recommendations etc. After successfully completing the comprehensive examination the students will be utilizing their knowledge acquired through the coursework and literature review to solve real-world design challenges by working on advanced R&D topics and for a thesis on the chosen topic. Simultaneously, they will also be involved in a Six–Eight weeks project concerned with societal/rural issues under the 'CSIR-800 Programs' which needs to be completed before submission of the thesis.

2.0 Eligibility for Admission:

Integrated PhD (Engineering):

A Bachelor's degree in Engineering/Technology with exceptionally good academic record and eligibility to apply for a fellowship* such as CSIR-GATE-JRF or equivalent. The candidate should have specialization in Aeronautical/Aerospace engineering/technology and keen interest in carrying out research on topics relevant to flight vehicles. The candidate will be admitted to Integrated Dual Degree PhD (IDDP) programme. On completion of IDDP programme the candidate will be awarded both M.Tech (Flight Vehicles) & PhD (Engineering) degrees.

PhD (Engineering):

A Master's degree in Engineering/Technology with exceptionally good academic record and eligibility to apply for a fellowship* such as CSIR-SRF or INSPIRE or equivalent. The candidate should have specialization in Aeronautical/Aerospace/Mechanical/Structures/Materials/Metallurgy/ Chemical/Polymers/Electronics/Communications/Computer engineering/technology and keen interest in carrying out research on topics relevant to flight vehicles.

PhD (Sciences):

A Master's degree in Sciences with exceptionally good academic record and eligibility to apply for a fellowship* such as CSIR-NET-JRF or INSPIRE or equivalent. The candidate should have specialization in Physical/Chemical/Material Sciences and keen interest in carrying out research on topics relevant to flight vehicles.

*After enrolment to the PhD program, the candidate should separately apply to the funding agency and get the fellowship awarded.

Note: Existing Project Staff (Research Fellows/Project Assistants working on research projects at CSIR-NAL for a minimum period of one year and meeting the guidelines of CSIR-NAL Academic Cell)/CSIR Scientists/Industry Sponsored Candidates who fulfil the qualifications as per AcSIR are eligible to apply for the PhD programme.

Before applying, Project Staff/CSIR Scientists/Industry Sponsored Candidates should have identified and established contacts with a scientist from CSIR-NAL who is willing to supervise the thesis work.

For other details (such as Admission Process, Eligibility, Important Dates, Fee Structure, Mode of Payment, Online Application, Academic requirements etc.) please visit the AcSIR website http://acsir.res.in. For details on fellowships please visit the respective websites such as http://www.csirhrdg.res.in, http://www.inspire-dst.gov.in, etc.

3.0 Summary of the Courses offered at CSIR-NAL:

Foundation Courses (Level 1)

Sl. No.	Code	Name of the Course	L-T-P-C	Course Coordinator	Division
1.	ENG(NAL)-1-3501	Applied Mathematical Methods	3-0-0-3	**Dr AK Onkar**	STTD
2.	ENG(NAL)-1-3502	Applied Numerical Methods	3-0-0-3	**Dr M Manjuprasad**	STTD
3.	ENG(NAL)-1-3503	Aircrafts and Systems	3-0-0-3	**Mr. Vineet Kumar**	CCADD
4.	ENG(NAL)-1-3504	Aerodynamics	2-0-0-2	**Dr V Ramesh**	CTFD
5.	ENG(NAL)-1-3505	Aerospace Propulsion	2-0-0-2	**Mr. P Manjunath**	PR
6.	ENG(NAL)-1-3506	Flight Mechanics	2-0-0-2	**Dr C Kamali**	FMCD
7.	ENG(NAL)-1-3507	Avionics	2-0-0-2	**Dr CM Ananda**	ALD
8.	ENG(NAL)-1-3508	Aerospace Materials	2-0-0-2	**Dr M Sujata**	MT
9.	ENG(NAL)-1-3509	Structural Mechanics	2-0-0-2	**Dr DVTG Pavan Kumar**	STTD
10.	ENG(NAL)-1-3510	Aviation Meteorology	3-0-0-3	**Dr Mrudula G**	CEM
11.	ENG(NAL)-1-3511	Research Methodology	2-0-1-3	**Dr Mrudula G**	
12.	ENG(NAL)-1-3512	Computer Programming for Research	2-0-1-3	**Dr Mrudula G**	

Core Courses (Level 2)

Sl. No.	Code	Name of the Course	L-T-P-C	Course Coordinator	Division
13.	ENG(NAL)-2-3501	Fluid Dynamics	3-0-0-3	**Dr V Ramesh**	CTFD
14.	ENG(NAL)-2-3502	Computational Fluid Dynamics	3-0-0-3	**Dr JS Mathur**	
15.	ENG(NAL)-2-3503	Gas dynamics	3-0-0-3	**Dr V Ramesh**	
16.	ENG(NAL)-2-3504	Low speed aerodynamics	3-0-0-3	**Dr L Venkatakrishnan**	EAD
17.	ENG(NAL)-2-3505	Boundary layer theory	3-0-0-3	**Dr R Mukund**	
18.	ENG(NAL)-2-3506	Gas Turbine Propulsion	3-0-0-3	**Dr B Dileepkumar Alone**	PR
19.	ENG(NAL)-2-3507	Heat Transfer in Propulsion Systems	3-0-0-3	**Mr. R Senthil Kumaran**	
20.	ENG(NAL)-2-3508	Aircraft Stability and Control	3-0-0-3	**Dr GK Singh**	FMCD
21.	ENG(NAL)-2-3509	Systems Engineering	3-0-0-3	**Dr CM Ananda**	ALD
22.	ENG(NAL)-2-3510	Advanced Avionics	3-0-0-3	**Dr CM Ananda**	
23.	ENG(NAL)-2-3511	Advanced Embedded Systems and Software Engineering	3-0-0-3	**Ms. J Jayanthi**	
24.	ENG(NAL)-2-3512	Mechanical behaviour of Materials	3-0-0-3	**Dr M Sujata**	MT
25.	ENG(NAL)-2-3513	Processing and Characterization of Metals	3-0-0-3	**Dr Venkatswarulu**	
26.	ENG(NAL)-2-3514	Advanced Ceramics Materials	3-0-0-3	**Dr PK Panda**	
27.	ENG(NAL)-2-3515	Piezoelectric Materials and Devices	3-0-0-3	**Dr Soma Dutta**	
28.	ENG(NAL)-2-3516	Corrosion Engineering	3-0-0-3	**Dr JN Balaraju**	SED
29.	ENG(NAL)-2-3517	Surface Modification Technologies	3-0-0-3	**Dr ST Aruna**	
30.	ENG(NAL)-2-3518	Nanostructured Coatings and	3-0-0-3	**Dr Harish C. Barshilia**	

		Materials			
31.	ENG(NAL)-2-3519	Advanced Structural Mechanics	3-0-0-3	**Dr DVTG Pavan Kumar**	STTD
32.	ENG(NAL)-2-3520	Finite Element Methods	3-0-0-3	**Dr M Manjuprasad**	
33.	ENG(NAL)-2-3521	Structural Dynamics	3-0-0-3	**Dr S Raja**	
34.	ENG(NAL)-2-3522	Stability of Structures	3-0-0-3	**Dr AK Onkar**	
35.	ENG(NAL)-2-3523	Mechanics of Composites	3-0-0-3	**Dr SR Viswamurthy**	ACD
36.	ENG(NAL)-2-3524	Design of Composite Structures	3-0-0-3	**Dr Byji Varughese**	
37.	ENG(NAL)-2-3525	Analysis of Composite Structures	3-0-0-3	**Dr VL Sateesh**	CSMST
38.	ENG(NAL)-2-3526	Processing & Characterization of Composite Materials	3-0-0-3	**Dr Shylaja Srihari**	
39.	ENG(NAL)-2-3527	Engineering Electromagnetics	3-0-0-3	**Dr Hema Singh**	CEM
40.	ENG(NAL)-2-3528	Computational Electromagnetics	3-0-0-3	**Dr Shiv Narayan**	
41.	ENG(NAL)-2-3529	Atmospheric Electromagnetics	3-0-0-3	**Dr Mrudula G**	
42.	ENG(NAL)-2-3530	Advances in Computational Intelligence and Applications	2-0-1-3	**Dr Balamati Choudhury**	

Specialization Courses (Level 3)

Sl. No.	Code	Name of the Course	L-T-P-C	Course Coordinator	Division
43.	ENG(NAL)-3-3501	Grid generation techniques for CFD	2-0-2-3	**Dr JS Mathur**	CTFD
44.	ENG(NAL)-3-3502	Kinetic schemes for the computation of compressible flows	2-0-2-3	**Dr JS Mathur**	
45.	ENG(NAL)-3-3503	Turbulent Flows	3-0-0-3	**Dr L Venkatakrishnan**	EAD
46.	ENG(NAL)-3-3504	Experimental Aerodynamics	3-0-0-3	**Dr R Mukund**	
47.	ENG(NAL)-3-3505	Mechanical aspects of Turbo Machinery	3-0-0-3	**Dr S Jana**	PR
48.	ENG(NAL)-3-3506	Propulsion Systems for Light Aero Vehicles	3-0-0-3	**Mr. K Monickavasagom pillai**	
49.	ENG(NAL)-3-3507	Experimental techniques in Propulsion	2-0-2-3	**Mr. P Manjunath**	
50.	ENG(NAL)-3-3508	Flight Vehicle Identification – Tools & Techniques	3-0-0-3	**Mr. Basappa**	FMCD
51.	ENG(NAL)-3-3509	Digital Image Processing and Applications	3-0-0-3	**Dr VPS Naidu**	
52.	ENG(NAL)-3-3510	Multi Sensor Data Fusion	3-0-0-3	**Dr VPS Naidu**	
53.	ENG(NAL)-3-3511	INS/GPS Multi-sensor Kalman Filter for Navigation	3-0-0-3	**Mr. N Shantha Kumar**	
54.	ENG(NAL)-3-3512	Vision based Guidance and Control	3-0-0-3	**Dr SM Vaitheeshwaran**	ALD
55.	ENG(NAL)-3-3513	Advanced Experimental Techniques in Materials Science	2-0-2-3	**Dr Anjana Jain**	SED
56.	ENG(NAL)-3-3514	Materials for Energy Conversion	3-0-0-3	**Dr ST Aruna**	
57.	ENG(NAL)-3-3515	Nano-Dimensional Magnetic Thin Films	2-0-2-3	**Dr Prasanta Chowdhury**	
58.	ENG(NAL)-3-3516	Computational Structural Dynamics and Aeroelasticity	2-0-2-3	**Dr M Manjuprasad**	STTD

59.	ENG(NAL)-3-3517	Computational Nonlinear Structural Mechanics and Vulnerability	2-0-2-3	**Dr M Manjuprasad**	
60.	ENG(NAL)-3-3518	Computational Stochastic Structural Mechanics and Reliability	2-0-2-3	**Dr M Manjuprasad**	
61.	ENG(NAL)-3-3519	Applied Aeroelasticity	3-0-0-3	**Dr S Raja**	
62.	ENG(NAL)-3-3520	Smart Materials and Structures	3-0-0-3	**Dr S Raja**	
63.	ENG(NAL)-3-3521	Vibration Control Techniques for Aerospace Structures	3-0-0-3	**Dr S Raja**	
64.	ENG(NAL)-3-3522	Finite Element Methods for Aircraft Structures	3-0-0-3	**Dr S Raja**	
65.	ENG(NAL)-3-3523	Fatigue and Fracture Mechanics	3-0-0-3	**Dr CM Manjunatha**	
66.	ENG(NAL)-3-3524	Mechanical Design and CAD/CAM	3-0-0-3	**Dr G Balamurugan**	
67.	ENG(NAL)-3-3525	Mechanical Systems Design and Aircraft Systems	3-0-0-3	**Dr G Balamurugan**	
68.	ENG(NAL)-3-3526	Optimization Techniques in Engineering Design	3-0-0-3	**Dr DVTG Pavan Kumar**	
69.	ENG(NAL)-3-3527	Impact and Crashworthiness	3-0-0-3	**Dr S Sathiyanarayan**	
70.	ENG(NAL)-3-3528	Finite Element Methods for Composites	3-0-0-3	**Dr AK Onkar**	
71.	ENG(NAL)-3-3529	Digital Signal Processing and Applications	2-0-2-3	**Mr. PS Vijayakumar**	
72.	ENG(NAL)-3-3530	Manufacturing Techniques for Composites	2-0-2-3	**Dr Ramesh Sundaram**	ACD
73.	ENG(NAL)-3-3531	Repair Technology for Aircraft Structures using Composites	2-0-2-3	**Dr D Saji**	
74.	ENG(NAL)-3-3532	Experimental Techniques for Composites	2-0-2-3	**Dr D Saji**	
75.	ENG(NAL)-3-3533	Non-Destructive Testing and Evaluation	2-0-2-3	**Dr M Ramesh Kumar**	
76.	ENG(NAL)-3-3534	Introduction to Continuum mechanics	3-0-0-3	**Dr VL Sateesh**	CSMST
77.	ENG(NAL)-3-3535	Textile Reinforcements for Composites	2-0-2-3	**Dr BS Sugun**	
78.	ENG(NAL)-3-3536	Electromagnetic Design and Analysis of Radomes	3-0-0-3	**Dr Raveendranath U. Nair**	CEM
79.	ENG(NAL)-3-3537	Adaptive Antenna Algorithms	3-0-0-3	**Dr Hema Singh**	
80.	ENG(NAL)-3-3538	Frequency Selective Surfaces: Design and Analysis	3-0-0-3	**Dr Shiv Narayan**	
81.	ENG(NAL)-3-3539	Design and Analysis of Radar absorbing Materials and Structures	3-0-0-3	**Dr Balamati Choudhury**	
82.	ENG(NAL)-3-3540	Atmospheric Dynamics And Numerical Weather Prediction	3-0-0-3	**Dr Mrudula G**	

Level 4 Courses

Sl. No.	Code	Name of the Course	L-T-P-C	Course Coordinator	Division
83.	ENG(NAL)-4-3501	Review Article	0-0-0-2	**Thesis Supervisor**	All
84.	ENG(NAL)-4-3502	Research Proposal	0-0-0-2	**Thesis Supervisor**	
85.	ENG(NAL)-4-3503	CSIR-800 Project	0-0-0-4	**Thesis Supervisor**	

4.0 Syllabus of the Courses offered at CSIR-NAL

Foundation Courses (Level 1)

ENG(NAL)-1-3501: Applied Mathematical Methods: 3-0-0-3

Course Coordinator: Dr AK Onkar

Associated Faculty: Dr VL Sateesh

Linear Algebra: Matrices and matrix algebra, system of linear equations, LU decomposition, introduction to vector spaces, linear transformation, orthogonalization, eigensystems, diagonalization, singular value decomposition, introduction to tensor and tensor calculus. Ordinary Differential Equations: Introduction to first order ODEs, method of separation of variables, exact solutions, introduction to second order ODEs, homogeneous linear equations, equations with constant and variable coefficients, nonhomogeneous equations, series solutions of ODEs, Legendre and Bessel functions, Strum Louville problems, Laplace transform and its application to ODEs. Partial Differential Equations: Introduction to first order PDEs, method of characteristics, method of separation of variables, classification of second order PDEs, reduction to standard form, heat and wave equations in one and two dimensions, two dimensional Laplace equation, PDEs in infinite and semi-infinite spatial domain, integral transform, Fourier transform, solving PDEs using Fourier and Laplace transforms, non-homogeneous PDEs

ENG(NAL)-1-3502: Applied Numerical Methods: 3-0-0-3

Course Coordinator: Dr M. Manjuprasad

Associated Faculty: Ms. S Manju, Mr. PS Vijayakumar, Dr G Mrudula

Modeling and Error Analysis: Mathematical Modeling and Engineering Problem Solving, Approximations and Round-off Errors, Truncation Errors and the Taylor Series. Interpolation and Approximation: Lagrange and Newton Interpolations, Interpolating Polynomials using Finite Differences, Hermite Interpolation, Piecewise and Spline Interpolation; Least Squares Approximation, Gram-Schmidt Orthogonalizing Process, Legendre Polynomials, Chebyshev Polynomials; Uniform Polynomial Approximation. Linear Algebraic Equations: *Direct Methods:* Cramer's Rule, Gauss Elimination Method, Gauss Jordan Elimination Method, Triangularization Method, Cholesky Method, Partition Method; Error Analysis and System Condition for Direct Methods; *Iteration Methods:* Jacobi Iteration Method, Gauss-Seidal Iteration Method, Successive Over Relaxation Method; Convergence Analysis of Iterative Methods. Eigenvalues and Eigenvectors: Bounds on Eigenvalues, Jacobi Method for Symmetric Matrices, Givens method for Symmetric Matrices, Householder's Method for Symmetric Matrices, Rutishauser Method for Arbitrary Matrices, Power Method, Inverse Power Method. Differentiation and Integration: *Numerical Differentiation:* Methods Based on Interpolation, Non-Uniform Nodal Points, Uniform Nodal Points; Methods Based on Finite Differences; Methods Based on Undetermined Coefficients; Optimum Choice of Step-Length; Extrapolation Methods; Partial Differentiation; *Numerical Integration:* Methods Based on Interpolation, Newton-Cotes Methods, Trapezoidal and Simpson's Rules; Open Type Integration Rules, Methods Based on Undetermined Coefficients, Newton-Cotes Methods, Trapezoidal and Simpson's Methods, Gauss Quadrature Methods, Radau Integration Methods, Composite Integration Methods, Romberg Integration, Double Integration. Roots of Equations: *Bracketing Methods:* Graphical, Bisection and False-Position Methods; *Open*

Methods: Simple Fixed Point Iteration, The Newton-Raphson and Secant Methods, Multiple Roots, Systems of Nonlinear Equations; *Roots of Polynomials:* Polynomials in Engineering and Science, Computing with Polynomials, Conventional Methods, Muller's and Bairstow's Methods. Ordinary Differential Equations- Initial and Boundary Value Problems: Single-Step and Multi-Step Methods, Convergence and Stability, Euler Method, Backward Euler Method, Mid-point Method, Taylor Series Method, Runge-Kutta Methods, Finite Difference Methods, Finite Element Methods. Partial Differential Equations: Method of Finite Differences, Elliptic and Parabolic Equations. *Signals and signal processing:* Characterization and classification of signals, signal processing operations and applications. Transform –domain representation of Signals: Fast Fourier Transform its applications and properties, z-Transform. Introduction to Analog and Digital Filters and its applications, basics of filter design procedures and design examples. Introduction to time_frequency methods. *Seminars on advanced/special topics in Numerical Methods.*

ENG(NAL)-1-3503: Aircrafts and Systems: 3-0-0-3

Course Coordinator: Mr. Vineet Kumar

Associated Faculty: Mr. Lakshminarayana and Mr. Bhaskar Chakravarthy

Evolution of heavier-than air aircraft for several applications: passenger, transport, freight, military applications. Configurations of various types of aircraft: Fixed wing aircraft, various types of aircraft, identification of various structural parts, materials used and their functions. Interplay of aerodynamics, structural mechanics, propulsion, avionics and controls in their conceptualization and performance. Introduction to aircraft specifications: Standards for both Military and Civil aircraft, Airworthiness certification aspects aircraft introduction to flight-testing: Purpose and Scope of Flight Testing; introduction to general flying and handling characteristics of aircraft. Flight test plans and procedures, Flight test data acquisition, analysis and interpretation. Aircraft systems: Mechanical, Electrical and Avionics subsystems integration.

ENG(NAL)-1-3504: Aerodynamics: 2-0-0-2

Course Coordinator: Dr V Ramesh

Associated Faculty: Dr TN Venkatesh

Introduction, relevant properties of a fluid, pressure, temperature, density, viscosity, bulk elasticity, Thermodynamic properties. Hydrostatics, aerostatics and the atmosphere. Aeronautical definitions: Wing geometry, airfoil geometry, aerodynamic force, force and moment coefficients, pressure distribution on an airfoil, estimation of the lift, drag and pitching moment coefficients, Trailing vortex drag, lift dependent drag, airfoil characteristics. Basic Fluid mechanics: One dimensional flow: The basic equations of conservation, measurement of air speed, compressible one-dimensional flow, speed of sound, one-dimensional normal shock waves.

ENG(NAL)-1-3505: Aerospace Propulsion: 2-0-0-2

Course Coordinator: Mr. P Manjunath

Associated Faculty: Dr S Jana, Mr. R Senthil Kumaran, Mr. Ashfaque Ahmad Khan

Introduction to Aerospace Propulsion, Basics of Aerospace Flight and Propulsion, Standard Atmosphere & Operational Envelopes, Basics of Aircraft Engines and Rocket Engines. Thermodynamics & Gas Dynamics: Basics of Fluid Mechanics and Thermodynamics, Laws of thermodynamics, Isentropic Flow, Flow with Shocks, Fanno Flow, Rayleigh Flow, Multidimensional Flow. Combustion & Heat Transfer: Chemistry & Stoichiometry, Premixed Fames, Diffusion Flames, Ignition, Subsonic Combustion, Supersonic Combustion, Heat transfer basics, Heat transfer challenges of propulsion systems. Aircraft Propulsion: History & Classification, Propellers, Gas Turbine Engines, Cycle Analyses, Components (Inlets, Compressor, Combustion Chamber, Turbine, Afterburner & Nozzle) Analyses, Engine Performance Analyses. Turbomachinery Mechanical: Components (Compressor, turbine, rotor etc.), Materials (Conventional & Advanced), Failure Theories, Structural Vibrations, Rotor dynamics, Bearings. Rocket Propulsion: History & Classification of Rockets (Solid, Liquid, Hybrid, Cryo, Electric & Nuclear), Nozzle Theory, Basics of Rocket Flight & Orbital Mechanics, Solid Rocket Propulsion, Liquid Rocket Propulsion.

ENG(NAL)-1-3506: Flight Mechanics: 2-0-0-2

Course Coordinator: Dr C Kamali

Associated Faculty: Dr GK Singh, Mr. PVS Murthy, Dr P Lathasree

Systems of Axes, Euler Angles and quaternions, Axes Transformation, Static Equilibrium and Trim, Aircraft Static Stability, Contributions of Wing and Tail, Neutral Point and Static Margin, Longitudinal Stability and Control, Directional Stability and Control, Roll Stability and Control, Equations of Motion and their alternative forms, Solution of Equations of Motion, elastic airplane equations of motion, Transfer function and response characteristics, State Space Method, Aerodynamic stability and control derivatives, Aircraft modes of motion, Longitudinal and Lateral dynamic stability modes, mathematical model structure, reduced order models, frequency responses and time histories, aerodynamic Modeling, flight path reconstruction techniques, aerodynamic derivative estimation.

ENG(NAL)-1-3507: Avionics: 2-0-0-2

Course Coordinator: Mr. CM Ananda

Associated Faculty: Ms. J Jayanthi, Dr SM Vaitheeswaran

Role in Aircraft, avionics environment. Avionics Systems: Equipments, Principle and operation. Communication Systems: VHF, HF, AMS, RTU. Navigation: Introduction and basic principles, Radio direction finding; Radio ranges; hyperbolic system of navigation (LORAN, DECCA). VOR/DME and TACAN; Doppler navigation; Inertial navigation: GPS; Terrain reference navigation. Aids to approach and landing. FMS, Gyros and accelerometers. Attitude and heading reference systems. Surveillance systems: EGPWS; SWS; TCAS. Data recording systems: FDAU, SSCVFDR. Data bus protocols: A429, A629, AFDX, CSDB, Mil-Std-1553. Basic Avionics Architecture, Packaging and EMI/EMC.

ENG(NAL)-1-3508: Aerospace Materials: 2-0-0-2

Course Coordinator: Dr M Sujata

Associated Faculty: Dr D Saji

Aerospace Materials: Design requirements for aerospace structural materials, general perspectives of advanced aeropace materials with regard to fuselage, propulsion and space vehicle applications. Metallic Materials: Aluminium alloys-Physical metallurgy and mechanical properties with emphasis on aeronautical requirement, temper designations, processing and properties, alloy specifications of aerospace grade Al-alloys; magnesium alloys used for aerospace applications; structural steels-various grades of steels used for landing gear, transmission systems and fatigue critical applications; Titanium alloys-Physical metallurgy, mechanical properties, processing and applications of aerospace grade alloys; Ni-base superalloys-evolution of materials for aero-engine applications, recent developments for aero-gas turbine, advanced thermal barrier coatings on superalloys used for gas turbine. Polymeric based composite (PMC) materials- Introduction, quasi-static strength of PMCs, reinforcements and matrices in PMCs, interfaces, processing and properties of composites, advantages of composites; carbon fibres, Carbon fibre-reinforced plastics (CFRP) and glass fibre reinforced plastics (GFRP), joining and repair of composites, Introduction to Damage tolerant composites, Destructive and Non-destructive testing, fracture and toughness of composites, fatigue strength of PMCs. Metal-based composite materials-Introduction, metal-ceramic composites, laminates, and applications of MMCs. Recent advances in smart materials' applications in aerospace, superplastic forming and diffusion bonding processing of aerospace alloys. Life prediction of materials and structures in aerospace-fatigue and fracture of metallic materials, random load fatigue and life prediction, physical reason for the existence of effective ΔK (ΔK_{eff}), crack growth and life prediction, special testing techniques-SCC, fracture toughness, microstructural degradation, stress rupture etc.,

ENG(NAL)-1-3509: Structural Mechanics: 2-0-0-2

Course Coordinator: Dr DVTG Pavan Kumar

Associated Faculty: Dr VL Sateesh

Basic elasticity- Stress and Strain, Equations of equilibrium, Plane stress and strain, Boundary conditions, Principal stresses and strains, Compatibility equations, Mohr's circle, Stress-strain relationships, Hooke's law; Two-dimensional elasticity problems in Rectangular and Polar coordinates: Stress functions, Bending of an end-loaded cantilever, Plate with a hole; Torsion of solid sections; Stresses in Simple Structural Members: Axially loaded members, Stresses in beams, Deflection of beams by integration, Euler column buckling, Thin-walled pressure vessels, Yield and fracture criteria, Introduction to bending of thin plates.

ENG(NAL)-1-3510: Aviation Meteorology: 3-0-0-3

Course Coordinator: Dr Mrudula G

Composition of atmosphere, vertical distribution of temperature , pressure, wind, stability and instability, development of inversions, types of inversions, surface effects, diurnal variation, International Standard Atmosphere (ISA) , Altimetry, calculation of terrain clearance, lowest usable flight level, effects of convergence and divergence, General circulation, Turbulence, gustiness, types of turbulence, origin and location of turbulence, Jet Streams, origin, description and location, heights and seasonal occurrence of jet streams, CAT, cause, location and forecasting, Standing waves, Thermodynamics of the atmosphere, thermodynamic variables, Adiabatic processes, Clouds, formation and description, cloud types, cloud classification, influence of inversions on cloud development, flying conditions in each cloud type, Fog, fog types, mist, haze, Precipitation types, methods of development, Types of air masses, properties of an air mass, Fronts, geographic differentiation, movement of fronts and pressure systems, life cycle, Different Pressure Systems, Tropical revolving

storms, development of tropical revolving storms, origin and local names, location and period of occurrence, inter Tropical convergence zones (ITCZ), weather in the ITCZ, general seasonal movement, climatic elements relative to the regions, Typical weather situations in mid-latitudes, westerly waves, high pressure area, uniform pressure pattern, Local seasonal weather and wind, Flight Hazards, Icing, Turbulence, Windshear, Thunderstorms, electricity in the atmosphere, conditions for and process of development, forecast, Thunderstorm avoidance, down bursts, micro and macro bursts, Tornadoes, Low and high level inversions, effect on aircraft and flight execution, Hazards in mountainous areas, Visibility reducing phenomena, Meteorological Observations, PIREPS, Weather Charts, surface charts, upper air charts, symbols and signs on analysed and prognostic charts, Information for Flight Planning, aeronautical codes, METAR, TAF, SPECI, SIGMET, SNOWTAM, runway report, meteorological broadcasts for aviation and use of pre-flight meteorological documents, meteorological briefing and advice, measuring and warning systems for low level windshear, inversion, special meteorological warnings, information for computer flight planning.

ENG(NAL)-1-3511: Research Methodology: 2-0-1-3

Course Coordinator: Dr Mrudula G

Introduction to The Process of Conducting Research, Research Design Introduction, Steps in the Process of Research, Identifying a hypothesis and/or research problem, specifying a purpose, creating research questions, Reviewing literature, Ethics of research and informed consent, Introduction to Qualitative Research, Essence of Qualitative Data, Sampling, Collection Techniques, Case Study, Interpreting Qualitative Data, Qualitative Data Analysis Procedures, Coding, Thematic development, Introduction to Quantitative Research, Essence of Quantitative Data, Collection and Analysis Techniques, Sampling Concepts, Defining the Target Population, Representative Sample, Design Effect, Sampling Methods (Cluster, Stratified, Simple Random), Quantitative Data Collection Instruments, Choosing a good instrument, Interval and Ratio Scales, Introduction to Applied Statistics, Identifying the dependent and independent variables, Confidence levels, Math that manipulates data, Descriptive Statistics, Summarizing and describing a collection of data, Univariate and bivariate analysis, Mean, mode and standard deviation, Percentages and Ratios, Histograms, Identifying randomness and uncertainty in data, Inferential Statistics, Drawing inference from data, Modeling assumptions, Identifying Patterns, Regression analysis, T-test, Analysis of Variance, Correlations, Chi-square, Introduction to Mixed Methods Research, Advantages, Design Components, Explanatory Mixed Methods Framework, Exploratory Mixed Methods Framework, Data Mining – Finding the Patterns and Problems in the World of Data, Writing About Quantitative Findings, Writing About Qualitative or Mixed Methods Findings, Critically Critiquing Research Reports, Applying Research in the Security Environment.

ENG(NAL)-1-3512: Computer Programming for Research: 2-0-1-3

Course Coordinator: Dr Mrudula G
Associated Faculty: Dr Hema Singh and Arun Kumar A

FORTRAN Programming: Variables, data and types, assignment statements, arithmetic statements, input and output statements, FORMAT statements, DO Loop, block IF, nested block IF, computed GOTO statements, Single and multidimensional arrays, function and subroutines, nesting of subprograms, COMMON and EQUIVALENCE statements, Problems related to areas in statistics and numerical analysis, manipulation of characters and strings. C Programming: Data types –Operators and Expressions, Control constructs—if-then-for and while, Arrays, Functions –General from arguments and return values, Dynamic and

Static variables, Advanced Programming Techniques: Control constructs –do-while, switch statements, break and continue, exit function, Functions – parameter passing calls –by-value, call – by- reference, calling functions with arrays, argc and argv, Recursion, —Basic concept, design, Dynamic date structures: Pointers, pointer, Dynamic allocation functions-malloc and calloc, Structures –Basics of structures, Referencing structure element, Array of structures, Passing structures to functions and structure pointers, Unions –Declaration and uses, File handling—file accessing functions, fopen, fclose, putc, getc and fprintf. Elements of Parallel Computing: Solving problems in parallel, temporal and data parallelism and its comparison, inter-task dependency, basic structure of parallel computers, pipelined parallel computer and array processes and software problems in parallel computing. Shell programming: Introduction: Kernel, Shell, How to use Shell, Common Linux Command Introduction, Process, Linux commands related with process, Redirection of Standard output/input, Redirectors, Pipes, Filters, Shell programming, Basics, Special Characters, Introduction to Variables and Parameters, Variable Substitution, Assignment, Special Variable Types, Quoting, Quoting Variables, Escaping, Exit and Exit Status, Tests, Test Constructs, File test operators ,Other Comparison Operators, Nested if/then Condition Tests, Operators, Numerical Constants, The Double-Parentheses Construct, Operator Precedence, Internal Variables, Typing variables: declare or typeset, Manipulating Variables, Manipulating Strings, Parameter Substitution, Loops and Branches, Nested Loops, Loop Control, Testing and Branching.

Core Courses (Level 2)

ENG(NAL)-2-3501: Fluid Dynamics: 3-0-0-3

Course Coordinator: Dr V Ramesh

Associated Faculty: Dr TN Venkatesh

Introduction: Concept of a fluid, continuum, properties of a fluid. Pressure Distribution in Fluid: Pressure and pressure gradient, equilibrium of a fluid element, hydrostatic forces. Fundamental conservation equations: Integral and differential forms of Mass, Momentum and Energy conservation , Boundary conditions, stream function, vorticity and irrotationality. Viscous flow: Reynolds Number and Geometry effects, Introduction to Boundary layer theory. Potential Flows: Elementary Plane-Flow solutions. Introduction to Compressible flows: Introduction, speed of sound, adiabatic and isentropic steady flow, converging-diverging nozzles.

ENG(NAL)-2-3502: Computational Fluid Dynamics: 3-0-0-3

Course Coordinator: Dr JS Mathur

Associated Faculty: Dr V Ramesh

Introduction to CFD, Equations governing fluid flow, Hyperbolic partial differential equations and shocks, finite difference technique and difference equations, Implicit difference formula, Time discretization and stability, Schemes for linear convective equation, Analysis of time integration schemes, Monotonicity , Schemes for Euler equations, Finite volume methodology, Introduction to unstructured mesh computations.

ENG(NAL)-2-3503: Gas Dynamics: 3-0-0-3

Course Coordinator: Dr V Ramesh

Associated Faculty: Dr TN Venkatesh, Dr Kaushik and Dr Sintoo Singha

Fundamentals of thermodynamics; propagation of small disturbances in gases; normal and oblique shock relations, nozzle flows; one-dimensional unsteady flow; small disturbance theory of supersonic speeds, generation of supersonic flows in tunnels, supersonic flow diagnostics, supersonic flow over two-dimensional bodies; shock expansion analysis, method of characteristics; one-dimensional rarefaction and compression waves; flow in shock tube. Laboratory classes for demonstrating the concepts and conducting of experiments.

ENG(NAL)-2-3504: Low speed aerodynamics: 3-0-0-3

Course Coordinator: Dr L Venkatakrishnan

Associated Faculty: Mr. P Suriyanarayanan

Elementary flows, Introduction to small perturbation theory, 2-D airfoils in subsonic flow, numerical methods for 2-D airfoils, similarity rules, Multhops method, vortex lattice and double lattice methods, aerodynamics of wing-fuselage system and aerodynamics of control

surfaces. High angle of attack aerodynamics: non-linear aerodynamics, unsteady aerodynamics. 2D numerical solutions. Thin aerofoil theory, lifting line theory.

ENG(NAL)-2-3505: Boundary Layer Theory: 3-0-0-3

Course Coordinator: Dr R Mukund

Associated Faculty: Mr. M Viji

Navier-Stokes equation and its importance, Prandtl's boundary layer approximations, Significance of scaling, 2D boundary layer equations, asymptotic theory, Blasius solutions, momentum integral methods, Axisymmetric and 3D boundary layer, thermal boundary layer, compressible boundary layer, Unsteady boundary layer, Instability, turbulent boundary layer, Reynolds stress, turbulent boundary layer on flat plate, pipe flows, introduction to perturbation techniques.

ENG(NAL)-2-3506: Gas Turbine Propulsion: 3-0-0-3

Course Coordinator: Dr B Dileepkumar Alone

Associated Faculty: Mr. Kishore Kumar, Mr. K Sathiyamoorthy, Mr. G Muthu Selvan

Introduction: History of gas turbine, Introduction to gas turbine-components, Classifications of gas turbines, Thermodynamics of aircraft jet engines, Classification of jet engines, Performance parameters, Specific thrust, Specific fuel consumption, Thermal efficiencies and Propulsive efficiency. Intakes and diffusers: Introduction, Inlet ducts geometry, Diffusers/ Classifications/ Characteristics, Methods of flow control, Subsonic inlets, Transition ducts. Compressors: *Cascade Aerodynamics* - Compressor cascades, Turbine cascades, Losses. *Axial Compressor Aerodynamics* – Introduction, Axial compressor /fan, Euler's equation, Velocity triangle/ h-s/ t-s diagrams, Performance parameters, Compressor characteristics Instabilities in compressor & their controls, Losses, Compressor design methodology, Radial equilibrium method & Stream line curvature method, Degree of reaction, Diffusion factor & Work coefficient, Multi-staging, Recent trend in turbo machinery design. *Centrifugal Compressor Aerodynamics* – Introduction, Stage dynamic, Inducer and impeller, Diffuser & its performance characteristics, Introduction to stage design, Introduction to Aero elasticity/ Optimization techniques, Measurement techniques in turbo machines. Combustion chambers: Basic considerations, Combustion fundamentals, Diffusers, Combustion aerodynamics, Swirler aerodynamics, Combustion performance, Fuel injection, Combustion noise, Heat transfer, Emissions. Turbines: Introduction, Eulers equation for turbines, Velocity triangles, Dimensionless parameters, Secondary drag/ losses, Comparison between axil compressors and turbines, Free vortex theory, Mean line design, CFD for turbines. Afterburners & nozzles: Basic principle and Components of Afterburners, Ignition, Flame stabilization and combustion in Afterburners, Heat transfer in Afterburner, Afterburner performance evaluation and test facilities, Basic principle and types of propulsive nozzles, Fixed and variable aircraft nozzles, Performance evaluation. Component matching: Introduction, Performance characteristics, Equilibrium running diagram, Procedure to find equilibrium point, Balancing. Coupling and alignment, Performance evaluation, General matching procedure, Operating line & Transient Operation

ENG(NAL)-2-3507: Heat Transfer in Propulsion Systems: 3-0-0-3

Course Coordinator: Mr. R Senthil Kumaran

Associated Faculty: Mr Y Giridhara Babu, Mr. J Felix, Mr. C Jayaprakash

Fundamentals of heat transfer: Conduction, Convection, Radiation, Concept of boundary layers - velocity / thermal. Temperature measurement techniques: Infra red thermography. Thermocouples, Heat flux gauges, Liquid crystal thermography, Temperature sensitive paints. Heat exchangers: Types, Design Factors. Turbine blade heat transfer and film cooling: Leading edge film cooling and heat transfer, Trailing Edge film cooling and heat transfer. Impingement cooling and heat transfer: Effect of geometrical parameters, Effect of flow parameters. Effusion / transpiration cooling: Flat and curved Plates, Starter films, Effect of compound angle. Anti-icing and De-icing: Theory, Application. Turbine rim seals: Types, Flow through rim seals, Ingestion, Geometrical and flow parameters. Engine Temperature and Health Monitoring: Thermal barrier coatings, Engine temperature monitoring, Engine safety and health monitoring.

ENG(NAL)-2-3508: Aircraft Stability and Control: 3-0-0-3

Course Coordinator: Dr GK Singh

Associated Faculty: Mr. PVS Murthy, Dr R Guruganesh, Mr. S Viswanathan

Introduction to open- and closed-loop control systems and examples, Differential equation models of physical systems and solution methods, choice of linear models, Laplace transforms, transfer functions, and block diagrams, State-variable system models, relative stability, gain and phase margins, Bode plots, Nyquist stability Criterion, Nichols chart, linear design process, Root locus design methods, System bandwidth, Feedback system characteristics, Design of feedback systems in the frequency- and time-domain, Pole placement method, Observability and controllability, angle-of-attack limiter, sideslip angle and sideslip rate feedback, roll rate feedback, design of command paths, nonlinear design and verification, control power requirements for unstable aircraft, control actuator rate requirements, limits on static instability, control surface sizing, center-of-gravity limits, inertia cross coupling, roll coupling, autorotation, roll reversal, Longitudinal and Lateral stability Augmentation, Fundamentals of Inertial Navigation, Basic autopilot control laws

ENG(NAL)-2-3509: Systems Engineering: 3-0-0-3

Course Coordinator: Dr CM Ananda

Associated Faculty: Mr. A Pankaj, Dr Manju Nanda

Principles and processes of Systems Engineering, Need of Systems Engineering, Meaning and Context of Safety Integrity Targets. Systems Engineering Process: Functional analysis and Specifications, Requirements Analysis and allocation, System Synthesis, Analysis and Design Optimisation, Development of the System Logical Solution, Effectiveness Evaluation and Decision Making. System Design and Integration: Design Requirements, Specifications, Architecture analysis and design, Model Based Design, UML/SysML, Model Driven Development, Integrated Model driven verification and validation, System requirements, analysis, systems integration, Systems certification, Systems Engineering Review Process. Selected Design Engineering Activities: Software Engg, Reliability Engg, Maintainability Engg, Human Factor Engg, Safety Engg, Quality Engg, Environmental Engg and Life Cycle costing Engineering. Reliability Modelling: Block Diagram Analysis, Common cause Failure, Fault Tree Analysis. Engineering Design Methods and Tools, System Reviews, Systems Engg Program planning, Integration design and test planning, Organization of Systems Engg, System Engineering Program Evaluation, System Engineering Management.

ENG(NAL)-2-3510: Advanced Avionics: 3-0-0-3

Course Coordinator: Dr CM Ananda

Associated Faculty: Ms. J Jayanthi, Mr. A Pankaj

Aircraft Architectures: Federated and Integrated modular avionics, DIMA, Avionics systems integration. Displays: Introduction to EFIS, EICAS, Head-Up displays. Advanced Visualization Concepts: Intelligent displays management, EVS/SVS, LIDAR. Advanced Navigation Concepts: Vision aided Navigation, Highway In the Sky, CNS/ATM, GNSS. Advanced Surveillance Systems: TAWS, TCAS I and II. Control Systems: PFCS, Fly-by-wire, Fly-by-light control systems, Automatic Flight Control Systems. Landing systems: ILS and MLS, IESVS. Aircraft Data Networks, Bus Architectures, Advanced bus protocols, AFDX. Avionics Health Management Techniques. Model Based Design, Model Driven Development, Tool Based Automation. Software Engineering: Life cycle management, IV&V process, planning and testing, Formal Methods, Software Quality management, Configuration management and certification. Integrated System engineering Platform, Integrated System Integration Platform, Integrated Model Driven IV&V. Standards and regulations related to Civil Aircraft: DO and FAR. Terminal guidance systems, Telemetry systems, Man-machine interface. Modular Avionics Packaging, ARINC and Mil types, system cooling, EMI/EMC requirements BIT and CFDS, Automatic Test Equipment, Speeds maintenance, ATLAS, Remote diagnostics and maintenance support-Life Cycle Costs for Military and Civil Avionics, Software costs, Establishing spares level.

ENG(NAL)-2-3511: Advanced Embedded Systems and Software Engineering: 3-0-0-3

Course Coordinator: Ms. J Jayanthi

Associated Faculty: Dr CM Ananda, Dr Manju Nanda

Embedded System Basics. System Architecture: von Neumann, Harvard and differences. Memory Architecture and their implementation. ADC and DAC. I/O Devices and Mechanisms. Instruction Set and Addressing Modes. Interfacing of Memory and Peripheral Devices. Bus Architecture: evolution and implementations. Embedded Systems Software: Issues. RTOS: Introduction, scheduling, memory, I/O, device driver. Embedded Software Development perspective. Performance Analysis and Optimization for advanced avionics system design. System Specification and Modeling. Basic Digital signal processing: wavelet and speech transformation. Embedded image processing: vision based tracking. Micro Air Vehicle systems, hardware, MEMS sensors, interfaces, software platform, development suite and hardware in loop testing.

ENG(NAL)-2-3512: Mechanical behaviour of materials: 3-0-0-3

Course Coordinator: Dr M. Sujata

Associated Faculty: Dr S.K. Bhaumik, Dr CM Manjunatha, Dr Shylaja Srihari

Structure and deformation in materials-introduction, bonding in solids, structure in crystalline materials, elastic deformation and theoretical strength, inelastic deformation, summary. A survey of engineering materials-introduction, alloying and processing of metals, irons and steels, non-ferrous metals, polymers, ceramics and glasses, composite materials, materials selection for engineering components, summary. Mechanical testing-introduction to tension test and other basic tests-engineering stress-strain properties, trends in tensile behaviour, true stress-strain interpretation of tensile test, compression test, hardness tests, notch

impact tests, bending and torsion test. Stress-strain relationships and behaviour of materials-Introduction, models for deformation behaviour, elastic deformation, anisotropic materials. Review of complex and principal states of stress and strain-Plane stress, principal stresses and maximum shear stress, 3-D states of stress, stresses on the octahedral planes, complex states of strain. Yielding and fracture under combined stresses-general form of failure criteria, maximum normal stress fracture criterion, maximum shear stress yield criterion, octahedral shear stress yield criterion, discussion of the basic failure criterion, Coulomb-Mohr fracture criterion, modified Mohr's fracture criterion. Time dependant behaviour- creep testing, physical mechanism of creep, time-temperature parameters and life estimates, creep failure and varying stress. Fatigue of materials-introduction and stress based approach-definition and concepts, sources of cyclic loading, fatigue testing, physical nature of fatigue damage, trends in S-N curves, mean stresses, multi-axial stresses, variable amplitude loading. Fracture mechanics-application of K to design and analysis, fracture toughness values and trends, plastic zone size and plasticity limitations on LEFM, fracture toughness testing, and fracture mechanics beyond linear elasticity. Fatigue crack growth-introduction, fatigue crack growth rate testing, effects of stress ratio on fatigue crack growth, trends in fatigue crack growth behaviour, life estimates for constant amplitude loading, life estimates for variable amplitude loading, design considerations, plasticity aspects and limitations of LEFM for fatigue crack growth, environmental crack growth.

ENG(NAL)-2-3513: Processing and Characterization of Metals: 3-0-0-3

Course Coordinator: Dr K Venkatswarulu

Associated Faculty: M Suresh Kumar

Preparation of metals and alloys by liquid metallurgy, powder metallurgy routes. Atomisation technique for preparation of metallic powders. Processing routes such as rolling, extrusion and forging. Advantage and limitations of processing methods. Preparation techniques for advanced composites and alloys. Elastic deformation. Plastic deformation. Interpretation of tensile stress-strain curves. Yielding under multi axial stress. Yield criteria and macroscopic aspects of plastic deformation. Importance of sever plastic deformation. Strengthening of metals by cold work, solute atoms and grain boundaries. Dislocation and their role in plastic deformation. Mechanisms of strengthening in metals. Recovery, recrystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion. Methods of deformation, conventional thermo-mechanical processing of metals and alloys. Basics of optical microscopy and SEM imaging, including instruments, signals, uncertainties, imaging (SE, BSE), diffraction, resolution, aberrations, depth of Composition analysis using EDS, capabilities & limitations. Identification of phases by metallographic and XRD studies, microstructural studies using optical, scanning and transmission electron microscopy.

ENG(NAL)-2-3514: Advanced Ceramics Materials: 3-0-0-3

Course Coordinator: Dr PK Panda

Associated Faculty: Dr R Ramachandra Rao, Dr L Rangaraj, Mr. A Udaya Kumar

Physical Ceramics: Introduction and classification of ceramics, oxide ceramics (alumina, silica, zirconia, magnesia etc.), non-oxide ceramics (SiC, Si_3N_4, SiAlON, Boron Carbide etc), chemical bonding and crystal structure, defects in crystal, x-ray diffraction, Bragg's law, phase analysis of ceramics by XRD technique, morphology and ceramic microstructure by scanning electron microscopy (SEM), phase equilibria of binary and ternary ceramic systems. Processing of Ceramics: Hydrothermal synthesis, sol-gel, co-precipitation, reaction

synthesis, colloidal processing, slip casting and tape casting, injection moulding, isostatic pressing, Gas phase synthesis: chemical vapor deposition (CVD), chemical vapor infiltration (CVI), Fabrication of ceramic components by CVI/CVD, sintering and crystallization, hot pressing, nucleation and grain growth, hot isostatic pressing, spark plasma sintering, Liquid phase synthesis: melt infiltration and polymeric derived ceramics (PDC). Characterization of Ceramics: particle size and surface area analysis, porosity and density, theoretical fracture strength, Griffith's theory of brittle fracture, toughness and fracture toughness, factors influencing the strength of ceramic materials, toughening mechanisms in ceramics, Mechanical testing of ceramic materials: modulus of rupture (MOR): 3point and 4 point bend, Tensile strength, Fracture toughness (K_{IC}) by indentation, Single Edge Notched Beam (SENB) and R curve methods, Hardness measurements, creep and fatigue, thermal properties (heat capacity, thermal onductitvity, coefficient of thermal expansion) of ceramics, thermal stress and thermal shock resistance (Kingery's and Hasselmann theory), thermal fatigue etc, Electrical properties: dielectric, ferroelectric, piezoelectric properties, barium titanate and lead zirconate titanate (PZT), sensors and actuators, magnetic properties (diamagnetic, paramagnetic and ferromagnetic). Applications of ceramic materials for aerospace applications, high temperature structural application, as sensors and actuators etc.

ENG(NAL)-2-3515: Piezoelectric Materials and Devices: 3-0-0-3

Course Coordinator: Dr Soma Dutta

Associated Faculty: Dr Anjana Jain, Dr PK Panda

Introduction: Definition, Introduction of Piezoelectricity, Different types of Piezoelectric Materials. General Principles and Theoretical Considerations: Origin of Piezoelectricity, Principles of Piezoelectricity, Dielectric and ferroelectrics, Polarisation and domain wall movement, Alternative formulation of piezoelectric theory, Secondary piezoelectric effect, Piezoelectricity in the light of atomic theory, Basic mechanics of piezoelectricity and Constitutive Constants. Nonlinear Piezoelectric Effects. Piezoelectric Materials: Natural & Synthetic Piezo Materials (Barium titanate, lead titanate, lead zirconate titanate (PZT), Effect of composition, Phase diagram, Soft and hard PZTs, Effect of dopants on piezo properties, Lead –free Piezo Materials, Piezoelectric Polymers and their Composites. Material Preparation: *Bulk Piezoceramics:* Mixed oxide route, hydrothermal, sol-gel, co-precipitation, wet-chemical method, spray drying etc., calcinations and sintering, electroding and poling. *Thin/Thick Film Piezoceramics:* Preparation Methods, Physical Vapour Deposition, Chemical Vapour Deposition, Chemical Solution Deposition, Pulsed Laser Deposition, Electron beam heating. *Piezo-Polymer:* Solvent Cast Method, Hot Press, Extrusion method and their combinations, Spin coating technique. Characterization of Piezoelectric Materials: X ray Analysis, Differential scanning calorimetry, IR, Raman, Tensile Properties, Measurement of Piezo-electric coefficients for bulk and thin films, Dielectric constant and loss factor, Hysteresis, Strain and block force measurement, IEEE standard on Piezoelectricity. Piezoelectric Devices: Fabrication of Multi-layered sensors and actuators, Different types of actuators. Low dimensional piezoelectric devices and MEMS, Flexible Sensor Devices. Applications: Vibration control, Flow control, Structural Health Monitoring, Dynamic Pressure Sensor, Noise detection/cancellation, Bio-medical applications, Electronic Applications, Piezoelectric Transducers (Acoustic, Strain gauge & Ultrasonic), etc.

ENG(NAL)-2-3516: Corrosion Engineering: 3-0-0-3

Course Coordinator: Dr JN Balaraju

Associated Faculty: Dr Meenu Srivastava, Dr Amitha Rani

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals. Exchange current density, polarization - concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviour of active/passive metals, Flade potential, theories of passivity. Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures. Susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of India, Salt Spray Test and standards. Corrosion prevention by design improvements, anodic and cathodic protection, metallic, non-metallic and inorganic coatings, mechanical and chemical methods and various corrosion inhibitors.

ENG(NAL)-2-3517: Surface Modification Technologies: 3-0-0-3

Course Coordinator: Dr ST Aruna

Associated Faculty: Dr Meenu Srivastava

Introduction to Surface Modification – Importance and Methods. Surface degradation-tribology, wear and corrosion- types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, role of friction and lubrication; overview of different forms of corrosion, Tribocorrosion. Chemical and electrochemical polishing, chemical conversion coatings- phosphating, chromating, chemical colouring, anodization; Electro/elctroless deposition - deposition of copper, zinc, nickel and chromium, alloy and composite plating by electro/electroless methods, sol-gel coatings, their properties and applications. Thermochemical and plasma chemical processes- nitriding, carburising, ion implantation etc. Vacuum deposition techniques - physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, chemical vapour deposition (CVD), plasma assisted CVD. Thermal spraying, techniques, advanced spraying techniques - plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications.

ENG(NAL)-2-3518: Nanostructured Coatings and Materials: 3-0-0-3

Course Coordinator: Dr Harish C. Barshilia

Associated Faculty: Dr ST Aruna, Dr Prasanta Chowdhury, Dr PK Panda, Dr. CM Manjunatha

Introduction: Concept of nanomaterials – scale / dimensional aspects, nano and nature, effect of size reduction on various properties, advantages and limitations at the nano level. Methods to produce nanomaterials: Plasma methods, chemical vapour deposition, sol-gel process, electro/electroless deposition, ball milling, severe plastic deformation, combustion synthesis etc. Applications: Fullerenes, carbon nano tubes, nano composites, nanosensors, nanomedicines, multilayered coatings, Superhard coatings, Magnetic materials etc. Health Issues: Understanding the toxicity of nanoparticles and fibers, exposure to quartz, asbestos, air pollution. Environmental issues: Effect on the environmental and other species. Societal implications: Implications of nanoscience and technology in society, government regulations. Introduction to characterization of nanomateials. Nanofibers, methods of preparation, electrospinning, polymer and ceramic nanofibers by electrospinning, applications of nanofibers.

ENG(NAL)-2-3519: Advanced Structural Mechanics: 3-0-0-3

Course Coordinator: Dr DVTG Pavan Kumar

Associated Faculty: Dr Amit Kr. Onkar

Thin plates: Kirchhoff theory – strain-displacement relations, stress-strain relations, stress resultants, equilibrium equations, boundary conditions; Analysis of rectangular and circular plates with different boundary conditions and loadings; Buckling of plates; Thermal stresses in plates; Membrane theories for the analysis of circular cylindrical, spherical and conical shells; Bending, shear and torsion of open and closed, thin-walled beams: Bending of open and closed section 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, Torsion of closed section beams, Torsion of open section beams, Analysis of combined open and closed sections; Stress analysis of aircraft components: Tapered Beams, Fuselage, Wing. Introduction to fatigue, fracture and damage tolerance analysis of aircraft structural components.

ENG(NAL)-2-3520: Finite Element Methods: 3-0-0-3

Course Coordinator: Dr M Manjuprasad

Associated Faculty: Ms. S Manju, Dr Amit Kr. Onkar

Introduction: Historical background, The basic concepts of the Finite Element Method, Fundamental concepts in elasticity, Potential energy and equilibrium, Raleigh-Ritz method, Galerkin's method, Solutions of linear equations. One-Dimensional Elements: Introduction, Interpolation and shape functions, Governing differential equations of bars and beams, weak form and finite element modeling; Potential energy and Galerkin approaches, classical Euler-Bernoulli and Timoshenko beam, linear and quadratic elements; Assembly of stiffness matrices and load vector, Treatment of boundary conditions, Stress computation, Temperature effects. Two-Dimensional Elements: Introduction, Finite element modeling and formulation, Plane elasticity and axisymmetric problems, Isoparametric four-noded quadrilateral element, Numerical integration, Higher order elements, Bending of Elastic Plates, Shear Deformation Plate Theory, Convergence studies. Three-Dimensional Elements: Introduction, Finite element modeling and formulation of hexahedral elements, higher order elements, Shell Elements. Introduction to FEM in Composites, Structural Dynamics and Nonlinear Mechanics. Seminars on special topics in FEM.

ENG(NAL)-2-3521: Structural Dynamics: 3-0-0-3

Course Coordinator: Dr S Raja

Associated Faculty: Mr. B Balakrishnan

Introduction to vibration and airframe structures, single and multi degrees of freedom systems, different structural models (physical, spatial, modal), vibration of beams & plates, numerical techniques in structural vibration, measurement devices & instrumentation, structural testing methodologies, structural coupling and vibration controls.

ENG(NAL)-2-3522: Stability of Structures: 3-0-0-3

Course Coordinator: Dr Amit Kr. Onkar

Concepts of stability, bifurcation and limit point instability, stability of discrete systems, linear and nonlinear behavior, stability of beams and columns, energy methods, static and dynamic formulations, axial-flexural buckling, lateral-torsion buckling, buckling of beams on elastic foundations, imperfection sensitivity analysis, stability of plates, axial-flexural buckling, shear-flexural buckling, buckling under combined loads, introduction to inelastic buckling and dynamic stability, parametric instabilities and stability under non-conservative forces, introduction to aeroelasticity, divergence and flutter.

ENG(NAL)-2-3523: Mechanics of Composites: 3-0-0-3

Course Coordinator: Dr SR Viswamurthy

Classification of composites, behaviors of unidirectional composites, prediction of elastic constants using micromechanics, Homogenization theory, Voigt and Reuss approximation, two and three phase composite cylinder models; strength of composites, failure modes, macromechanical analysis of lamina; Properties of laminates and their constitutive equations, classical laminate and shear deformation theories, analysis of laminates, interlaminar stresses, failure theories, analysis of laminates after initial failure. Analysis of laminated composite beams.

ENG(NAL)-2-3524: Design of Composite Structures : 3-0-0-3

Course Coordinator: Dr Byji Varughese

Associated Faculty: Mr. Lohith, Ms. Kumari Asha

Refresher on composite analysis: Lamina micromechanics, Lamina macromechanics, Classical lamination theory, Failure theories, Strength of laminates and examples. Vibration and stability of composite plates: Governing equations for vibration and buckling of composite plates, Vibration of simply supported composite plates, buckling of simply supported composite plates under in-plane loads and approximate methods. Introduction to structural design: Inputs for structural design, Steps in structural design, Selection of structural configuration and Structure sizing, Laminate design and carpet plots , Design principles with composites, Selection of orientation and thickness and Design examples, Stiffened composite plates. Design of joints: Introduction, Types of joints, Mechanically fastened joints, Failure modes in mechanically fastened joints, Design guidelines for mechanically fastened joints, Adhesively bonded joints, Failure modes in bonded joints, Stress distribution in adhesive joints, Types of bonded joints, Selection of type of adhesive joints, Design guidelines for adhesively bonded joints and Decision on the type of joint. Damage tolerance in composites: Introduction, Sources of damage, Types of damage, FAR requirements and advisory circulars, Building block approach, Impact damages: Damage growth under fatigue loads, Residual strength: Tests and analytical methods. Detailed design: Basics of projections, Drawing standards and conventions, Introduction to CADD, Design of composite parts and Assembly design. Optimization: Fundamentals of optimization, Mathematical concepts in optimization, Optimization of composite plates. Testing of composite structures: Factors influencing testing, Test environment, Test methods and standards, Introduction to static testing of composite structures and Examples. Repair of composite aircraft structures: Introduction to repair, Repair philosophy, Repair sequence, Repair criteria, Damage assessment, Classification of repair, Selection of repair joints, Repair procedures, Certification of repair

ENG(NAL)-2-3525: Analysis of Composite Structures: 3-0-0-3

Course Coordinator: Dr VL Sateesh

Associated Faculty: Dr L Srikanth, Dr GN Dayananda

Introduction: Definition, Classification, Tailoring composites, Mechanical properties of composite lamina, Prediction of strength and stiffness. Elements of micromechanics. Macromechanics: Analysis of lamina, Constitutive classical laminate theory, Thermal stresses. Analysis of composite plates, Analysis of composite shells, Vibration of beams and plates, Examples of applications

ENG(NAL)-2-3526: Processing & Characterization of Composite Materials: 3-0-0-3

Course Coordinator: Dr Shylaja Srihari

Associated Faculty: Dr A Vanaja, Dr Sandhya Rao

Introduction to composites, classification of composites (based on matriices-PMC, MMC &CMC, based on reinforcement – particulate,continuous reinforcements,special class of composites – hybrid, bio composites, Nano composites), PMC for aerospace application (thermoset/ thermoplastic based composites), Polymer matrix composite processing technologies, characterisation / testing of composites (physical/ thermal/ mechanical/thermomechanical/hygrothermal), hygrothermal effects on the properties of composites(hotwet degradation & certification aspects)

ENG(NAL)-2-3527: Engineering Electromagnetics: 3-0-0-3

Course Coordinator: Dr Hema Singh

Maxwell's equations in free-space and time-varying fields, plane wave in dielectric and conducting media, wave equation, Poynting vector, Wave polarization, Reflection, refraction, and diffraction, Modes of Propagation in Waveguides, Transmission lines, Antenna Fundamentals, Antenna Arrays, Radiation Characteristics, microwave source and components

ENG(NAL)-2-3528: Computational Electromagnetics: 3-0-0-3

Course Coordinator: Dr Shiv Narayan

Associated Faculty: Dr Hema Singh

Basic Electromagnetics: Maxwell's equations, interface and boundary conditions, uniform plane wave, pointing vector, polarization, image current and equivalence principle, reciprocity theorem, surface integral equations, volume integral equations, Green's function. Analytical Methods: Method of Separation of Variables, Orthogonality condition. Low-frequency Techniques: Method of Moments (MoM), Finite Difference Time Domain (FDTD), Finite Element Method (FEM).Hybrid Methods: Mode Matching-Generalized Scattering Matrix (MM-GSM) method, Transmission Line Transfer Matrix (TLTM) Method, PO-MoM method.

ENG(NAL)-2-3529: Atmospheric Electromagnetics: 3-0-0-3

Course Coordinator: Dr Mrudula G

Associated Faculty: Dr R U Nair, Dr Balamati Choudhury

Maxwell's equations and electromagnetic theory, Electromagnetic waves, polarization, spectra and Fourier transform, the Doppler effect, angular distribution of radiation, thermal radiation, diffraction Propagation through homogeneous materials, Plane boundaries, volume scattering, reflection and emission from real materials, The nature of electromagnetic radiation: source, Polarization, Stokes' parameters, Radiation laws, Blackbody emission, Brightness temperature, interactions between electromagnetic radiation and atmospheric gases, aerosols and clouds, and ocean surfaces, covering the spectrum from the ultraviolet through the microwave, Radiative transfer processes in atmosphere, Electromagnetic energy interactions, Electromagnetic radiation models (wave/particle), Atmospheric refraction, Atmospheric scattering, Atmospheric absorption ("atmospheric windows"),Radiometric quantities and reflectance, radiative transfer equation, propagation through the atmosphere, electromagnetic properties of the atmosphere and surface, atmospheric emission characteristics, electromagnetic spectrum, emission range, Introduction to Radar, basic principles, Electromagnetic Waves, Radar Hardware, Radar Equation for Point Targets, Distributed Targets, Doppler Velocity Measurements, Spectrum Width and turbulence, Meteorological Targets, Clear-Air Return, Meteorological Uses of Weather Radar, Effects of weather systems on performance of radars.

ENG(NAL)-2-3530: Advances in Computational Intelligence and Applications: 2-0-1-3

Course Coordinator: Dr Balamati Choudhury

Soft Computing: Artificial Neural Network: Neurons, Single layer and multilayer architecture, back propagation learning algorithm. Radial basis function (RBF) neural network, learning algorithm. Fuzzy Logic: Types, membership functions, fuzzification and defuzzification, rule-based fuzzy inference engine, Type-1 and Type-2 fuzzy logic, typical applications. Genetic Algorithm: Basic concept, Parameters: Reproduction, Crossover, Mutation, Types: Real coded GA, Binary GA, Mixed integer GA, Parallel GA, Hybrid GA. Swarm Intelligence: Basic Concept, parameters of PSO, Real and binary *PSO,* Boolean PSO*, Pareto Front Multi-Objective PSO.* Bacterial Foraging Optimization: Basic Concept, chemotaxis, swarming, reproduction and elimination-dispersion, algorithm of BFO. Applications of Soft Computing: Applications to Electromagnetics, Communications, Controls, Aerospace, Signal Processing.

Specialization Courses (Level 3)

ENG(NAL)-3-3501: Grid Generation Techniques for CFD: 2-0-2-3

Course Coordinator: Dr JS Mathur

Associated Faculty: Mr. K Madhu Babu

Introduction various grid generation techniques, structured grid generation, Algebraic grid generation methods, introduction to PDE based grid generation techniques, concept of grid control and grid control functions, examples of simple grid generation methods in 2D and 3D, multi-block approach for complex configurations. Introduction to unstructured grid generation, Delaunay triangulation method, 2D and 3D unstructured meshes, concept of isotropic and un-isotropic tetrahedral meshes, concept of hybrid grids. Unconventional methods, the Cartesian Grid and Mesh free approach. A brief hands-on training on the POINTWISE software for grid generation.

ENG(NAL)-3-3502: Kinetic Schemes for the Computation of Compressible Flows: 2-0-2-3

Course Coordinator: Dr JS Mathur

Associated Faculty: Dr V Ramesh and Mr. Keshav S. Malagi

An introduction to kinetic schemes for CFD, The moment method strategy for computation of in-viscid flows. Concept of up-winding at the kinetic level, introduction to 1-D FDM,FVM kinetic upwind schemes, stability and consistency studies for kinetic schemes, introduction to multi-dimensional problems, variants of kinetic schemes, the kinetic mesh free methods.

ENG(NAL)-3-3503: Turbulent Flows: 3-0-0-3

Course Coordinator: Dr L Venkatakrishnan

Associated Faculty: Mr. N Karthikeyan and Mr. Kiran Chutkey

Characteristics of turbulent flows, RANS equations, vortex dynamics, concepts of equilibrium and similarity, Free shear layers, wall bounded flows, Stability of fluid flows, laminar-turbulent transition, statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, basics of turbulence modelling, turbulent measurement techniques.

ENG(NAL)-3-3504: Experimental Aerodynamics: 3-0-0-3

Course Coordinator: Dr R Mukund

Associated Faculty: A Sathia Narayanan and P Suriyanarayanan

Introduction to aerodynamic testing in various speed regimes; requirements of aerodynamic testing; Design aspects of low speed wind tunnels; flow visualization methods; Measurement methods for flow variables. Wind tunnel balances; Elements of computer based instrumentation ; measurements and analyses methods; Model Design, Pressure, Flow, and Shear Stress measurements; Forces and moments from balance measurements, Sources of error in wind tunnel data, scale effects in data usage, general test procedures for aircraft. Introduction to advanced optic based flow diagnostics.

ENG(NAL)-3-3505: Mechanical Aspect of Turbo Machinery: 3-0-0-3

Course Coordinator: Dr S Jana

Associated Faculty: Mr. SS Kulkarni

Introduction to Mechanical Aspect of Turbo machinery: Engine Configurations, Compressor, Turbine, Combustor, Materials. Mechanical Design of Rotor Components: Compressor Blade, Turbine Blade, Disk, Blade Disk Attachment, Impeller, Bladed Disk. Rotor Systems and Dynamics: Rotor Configurations, Support System, Lubrication, Critical Speed Analysis, Unbalance Response, Balancing. Vibration aspects: Blade Vibration, Disk Vibration, Bladed Disk. Advanced Bearings: Foil Bearings, Active Magnetic Bearings.

ENG(NAL)-3-3506: Propulsion Systems for Light Aero Vehicles: 3-0-0-3

Course Coordinator: Mr. K. Monickavasagom Pillai

Associated Faculty: Mr. HS Muralidhara, Mr. AJ Steve Mithran

Introduction & IC engine basic theory: Engine types - Operating cycles of SI and CI Engines - Calculation of performance parameters - Typical Performance curves - Components of the SI and CI engines- Fuel supply system - carburettor, fuel injection - ignition system - Engine cooling and lubrication system - Turbo charging and Super charging - Effects on engine performance - Aero diesel and gasoline engines – Small gas turbines. Fuels: Introduction - Structure of petroleum, Refining process, Products of refining process. *Fuels for SI & CI engines:* Properties of fuels for S.I. and C.I. Engines - Potential alternative fuels for S.I. and CI Engines and their properties - Alcohols & Gasoline blends - Fuel additives - DEE/DME - Biodiesels - Biodiesel blends with diesel - Dual fuel systems. *Fuels for Gas Turbine engines:* Specific requirement for Gas turbine engines and standards - Properties of liquid fuels & Gaseous fuels - Fuel handling systems, safety and additives. Hydrogen - Properties - Use in C.I Engines - Use in S.I Engines - Production methods- Storage methods - Safety precautions. IC engine combustion: Combustion Chemistry - Combustion in SI engines- Initiation of combustion - Flame velocities - Normal and abnormal combustion - Combustion chambers - Combustion in CI engines - Vaporization of fuel droplets and spray formation - Air motion - swirl, squish, tumble flow - Diesel knock and engine variables, features and design considerations of combustion chambers. Engine emissions: Introduction, concerns, regulations - Mechanisms of pollution formation - Carbon monoxide, unburned hydrocarbons, oxides of nitrogen and smoke/Particulate emission - Effects of pollutions on environment – Methods of measurement - Methods of controlling emissions for SI, CI and gas turbine engines - Correlations. Wankel rotary engines: Basics - Working principle - Merits and demerits - Comparison with reciprocating engine - Applications - Engine Design aspects - Geometrical equations, P-V diagram, V-theta diagram, Torque fluctuation - Engine components - Coating requirements - Testing of engines - Airworthiness certification - Aero Wankel engines. Recent trends: Homogenous charge compression ignition (HCCI) - CRDI in CI engines - VVTi - Lean burn engines - Stratified combustion engines - Fuel cell - Use of light weight materials for engine components - Flexible fuel vehicles, Small UAV & MAVs power plants - Introduction - Electric motors with high specific energy batteries - Mini I.C.Engines - Merits and demerits.

ENG(NAL)-3-3507: Experimental Techniques in Propulsion: 2-0-2-3

Course Coordinator: Mr. P Manjunath

Associated Faculty: Mr C Jayaprakash, Mr. G Muthuselvan, Mr. Y Giridhara Babu, Mr. SS Kulkarni, Mr. R Senthil Kumaran

Introduction: Introduction to Propulsion Systems, High Speed Combustor Test Facility, Combustion and Gas Dynamics, Heat Transfer in Propulsion Systems, Turbo machinery, Mechanical Aspects of propulsion systems Measurement Techniques: Measurement techniques in propulsion systems, The study of temperature, pressure and mass flow measurement, The study of Data acquisition & controls. High Speed Combustor Test Facility: The experimental study of Nitrogen gas command/purging system, The study of Oxygen gas system, The study of Hydrogen gas system, The experimental study of air flow system, The experimental study of kerosene fuel system, The experimental study of high pressure air compressor system, The experimental study of pre-heater01 up to 500 K temperature. Combustion and Gas Dynamics Lab: The study of lean blow out prediction in swirl stabilized combustor, The study of atomization performance prediction of simplex atomizer. Heat Transfer lab: The study of convection heat transfer coefficient measurement: Turbo machinery Lab: The study of wake flow measurement in a linear cascade. Mechanical Aspects of Propulsion Systems: Rotor dynamics analysis of typical geeffot rotor system, The study of advance bearing system.

ENG(NAL)-3-3508: Flight Vehicle Identification – Tools & Techniques: 3-0-0-3

Course Coordinator: Mr. Basappa

Associated Faculty: Dr Sachin Tharewal

Introduction: Motivation, Measurements, Methods, Models, Validation. Data gathering: Optimal Input Design, Maneuvers, Instrumentation, Calibration. Aircraft Mathematical Modeling: Reference frame, Equations of Motion, Navigation Equations, Aerodynamic Modeling. Estimation and Optimization: Properties of Estimator, State Estimation, Parameter Estimation, Optimization Methods. Regression, Ordinary Least Squares, Generalized Least Squares, Nonlinear Least Squares, Model Structure Determination, Maximum Likelihood Method, Output Error and Equation Error Methods, Kalman Filtering. Model Validation: Statistical Accuracy, Residual Analysis, and Simulation.

ENG(NAL)-3-3509: Digital Image Processing and Applications: 3-0-0-3

Course Coordinator: Dr VPS Naidu

Digital image fundamentals, intensity transformations and spatial filtering, frequency domain processing, image enhancement, image restoration, color image processing, morphological image processing, image segmentation, stereo vision and correspondence problem, image registration, image fusion, matlab examples, and case studies.

ENG(NAL)-3-3510: Multi Sensor Data Fusion: 3-0-0-3

Course Coordinator: Dr VPS Naidu

Multi sensor data fusion introduction, algorithms for data fusion, Multi sensor estimation, Decentralized data fusion, Multi sensor multi target tracking, Fundamentals of image processing, Image registration, Image fusion, Flight vision, Matlab examples and case studies.

ENG(NAL)-3-3511: INS/GPS Multi-sensor Kalman Filter for Navigation: 3-0-0-3

Course Coordinator: Mr. N Shantha Kumar

Associated Faculty: Dr Sudesh K Kashyap, Dr C Kamali

Inertial sensing principles and technology, Simple low cost INS implementations, Inertial mechanization / Error models, GPS principles, signals, receivers, Simple multi-sensor Kalman Filter, Error modeling applications, INS/ GPS multi-sensor integration.

ENG(NAL)-3-3512: Vision based Guidance and Control: 3-0-0-3

Course Coordinator: Dr SM Vaitheeswaran

Associated Faculty: Ms. Veena Shantaram, Mr. H Lokesha

Introduction: Background, requirements and issues, human vision. Image formation: geometry and photometry: Geometry, brightness, quantization, camera calibration, photometry (brightness and color). Image segmentation: Region segmentation, Edge and line finding. Multi-view Geometry: Shape from stereo and motion, feature matching, surface fitting, Active ranging. Image classification: Pixel classifications, region classification, face detection and identification. Object Recognition: Alignment methods, Shape descriptions. Motion Analysis: Motion detection and tracking, Inference of human activity from image sequences. Applications survey, Review: Industrial, navigation, mapping, multimedia. Course Intro and Demos of Working Computer and Robot Vision Systems, World 2D: Representing and Manipulating Points, Lines And Conics Using Homogeneous Coordinates. World 2D: Projective Transformations and Transformation Groups. Characterization of Distortions Caused by Projective Imaging and the Principle of Point/Line Duality, Estimating a Plane-to-Plane Homography with Angle-to-Angle and Point-to-Point Correspondences, World 3D: Representing Points, Planes, and Lines. World 3D: Quadrics, Transformation Groups, and the Absolute Conic. Visual Perception and Edge Detection (Sobel, LoG, Canny), Extracting Interest Points and Their Descriptors (with Harris, SIFT, and SURF) in Image Pairs and Establishing Point-to-Point Correspondences Between the Images. Estimating Homographies with Linear Least-Squares Minimization, Robust Homography Estimation with the RANSAC Algorithm, Refining Homographies with Nonlinear Least-Squares Minimization (Gradient-Descent, Levenberg-Marquardt, and DogLeg), Image Segmentation. Binary Image Processing Algorithms, Measuring Texture and Color, Camera Models: The Pinhole Model. Camera Models: The Finite Projective and the General Projective Cameras. Image of the Absolute Conic (or How to Make a Camera Figure Out Its Internal Parameters from a Couple of Images). Camera Calibration (Zhang's Algorithm), Extracting Features by Bin Counting in Parameter Space -- The Hough Transform. Epipolar Geometry and the Fundamental Matrix, PCA for Dimensionality Reduction and Data Decorrelation, LDA (Linear Discriminant Analysis) for Image Recognition, Face Recognition Studies with PCA, LDA, etc., and Nearest-Neighbor Classification, Automatically Learning the Most Discriminating Features through Class Entropy Minimization, Image Segmentation using Graph Partitioning Algorithms.

ENG(NAL)-3-3513: Advanced Experimental Techniques in Materials Science: 2-0-2-3

Course Coordinator: Dr Anjana Jain

Associated Faculty: Dr Venkateswarlu, Dr M Sujata

Metallographic techniques: Resolution, depth of focus, polarized light, phase contrast, interference microscopy, quantitative metallographic techniques and Image Analysis. X-ray diffraction techniques: Bragg's law, Diffraction methods, Stereographic projection. Cameras-Laue,Debye-Scherer cameras, Seeman- Bohlin focusing cameras, GIXRD. Application of x-ray diffraction: Indexing space group identification, intensity calculation, lattice parameter measurement, stress analysis, phase analysis. Electron microscopy: Construction and operation of electron microscope –specimen preparation techniques. Image formation methods in scanning electron microscope, composition analysis, EDX, WDX. Basics of TEM and STEM. Scanning probe microscopes: Scanning Tunneling Microscope, Atomic Force Microscope etc. Advanced chemical and thermal analysis: Basic principles, practice and applications of surface analytical techniques such as X-ray spectrometry, XPS, AES, SIMS, Thermal analysis methods – DTA, DSC, TGA. Nanomechanical characterization: Dynamic Indentation Technqiues, NHT, Tribology at Nanoscale, Nanotribology and Nanoscratch Testing. Spectroscopic techniques: IR, FTIR and Raman spectroscopies.

ENG(NAL)-3-3514: Materials for Energy Conversion: 3-0-0-3

Course Coordinator: Dr ST Aruna

Associated Faculty: Dr Parthasarathi Bera, Dr B Shri Prakash

Fundamental of electrochemical energy conversion – Thermo dynamical and kinetic aspects– Relevance in aerospace applications- Principles of Batteries and Fuel cell operations – Types of batteries and fuel cells - Components of batteries and fuel cells and their material aspects - Experimental techniques. Introduction to solar radiation and heat transfer, various types of solar collectors, solar water heating, solar cooling, solar industrial process heat and types of solar thermal power systems, photovoltaics, Hydrogen energy - production and storage.

ENG(NAL)-3-3515: Nano-Dimensional Magnetic Thin Films: 2-0-2-3

Course Coordinator: Dr P Chowdhury

Associated Faculty: Dr Harish C. Barshilia

Introduction: Magnetism, Magnetostatics, Magnetism of electron, Ferromagnetism, Antiferromagnetism and other ferromagnetic order, Micromagnetism, domain and hysteresis, Nanoscale magnetism, Experimental methods, Application of soft magnetic materials and its application, hard magnetic materials and it's applications, Spin electronics, Magnetic sensor, Principle of magnetic sensing, Signal and noise, Different type of magnetic sensor, field mapping, Applications of magnetic sensors.

ENG(NAL)-3-3516: Computational Structural Dynamics and Aeroelasticity: 2-0-2-3

Course Coordinator: Dr M Manjuprasad

Associated Faculty: Mr. AC Pankaj, Dr Amit Kr. Onkar

Variational Principles, Hamilton's Least Action Principle, Lagrange's equations; Vibration of multi-degree of freedom systems; Finite element formulation for elasto-dynamics of continuous systems; bar, beam and plates; Normal mode expansions and direct integration; Static/dynamic condensation and sub-structuring techniques; Torsion and bending of an aircraft wing; Static aeroelasticity and divergence of a wing; Dynamic aeroelasticity and

bending-torsion flutter of a wing; Dynamic response of a wing to gust and atmospheric turbulence; Introduction to system identification based flutter prediction; Concepts of nonlinear vibrations.

ENG(NAL)-3-3517: Computational Nonlinear Structural Mechanics and Vulnerability: 2-0-2-3

Course Coordinator: Dr M Manjuprasad

Associated Faculty: Dr DVTG Pavan Kumar, Mr. J Dhayanidhi

Review of linear FEM. FEM for one one-dimensional plasticity: Perfect plasticity, Isotropic and Kinematic strain hardening, finite element formulation, Newton-Raphson solution technique, one-dimensional viscoplasticity, integration algorithms. Continuum theory of plasticity: Yield condition, Flow and hardening rules, loading and unloading conditions, stability, convexity and normality, J2 plasticity /viscoplasticity. FEM for two-dimensional and three-dimensional plasticity: Rate independent plasticity, Explicit and Implicit techniques, Return methods for J2 plasticity, finite element formulation, NR technique. FEM for large deformation elasticity: Continuum Mechanics - Description of motion of body, deformation gradient, Green-Lagrange strain, Rate of deformation, principal stresses, polar decomposition, Cauchy stress and P-K stresses, balance of mass and momentum, Principal of objectivity, Constitutive equation for hyper elasticity, New Hookerion elastic model, finite element formulation for finite strain elasticity, Total Lagrangian and updated lagrangian. Introduction to nonlinear FEM for structural dynamics, Nonlinear FEM for composites, Concepts of structural damage and vulnerability.

ENG(NAL)-3-3518: Computational Stochastic Structural Mechanics and Reliability: 2-0-2-3

Course Coordinator: Dr M Manjuprasad

Associated Faculty: Dr Amit Kr. Onkar, Mr. AC Pankaj

Introduction to probability, random variables, different probability distributions; Random process theory, stationarity, ergodicity, non-stationarity, power spectral density; Random field theory, homogeneity, non-homogeneity; Vibration of S.D.O.F. system under random inputs; Input output relation, Extension to M.D.O.F. system; Failure of randomly vibrating systems; Formulation of reliability for structural problems; Exact solution methods – first order and second order reliability methods, transformations; Simulation methods – Direct Monte Carlo and Importance sampling methods; System reliability methods; Introduction to Reliability based design concepts; Concepts of stochastic finite element methods.

ENG(NAL)-3-3519: Applied Aeroelasticity: 3-0-0-3

Course Coordinator: Dr S Raja

Associated Faculty: Mr. D Dwarakanathan

Aerodynamic-structural coupling, static aeroelasticity (divergence, control reversal etc), dynamic aeroelasticity (Flutter, Buffet, Gust), flexible loads, introduction to numerical and experimental techniques in Aeroelasticity. Aerodynamic theories (subsonic/supersonic), basics in active controls, aeroservoelasticity (modeling, analysis) & its applications: active flutter control technique, gust load alleviation etc.

ENG(NAL)-3-3520: Smart Materials & Structures: 3-0-0-3

Course Coordinator: Dr S Raja

Associated Faculty: Mr. D Dwarakanathan

Introduction to smart materials, constitutive modelling, smart & adaptive structures concepts, numerical & experimental methods for adaptive structures (sensing, actuation, monitoring), active-passive vibration controls, shape control of structures, optimal placement techniques for sensor & actuators.

ENG(NAL)-3-3521: Vibration Control Techniques for Aerospace Structures: 3-0-0-3

Course Coordinator: Dr S Raja

Introduction to vibration, sources of vibration, passive vibration control approaches, modelling different vibratory loads & structural system, system identification techniques, introduction to active control system, feedforward & feedback controls, modelling of different actuators and sensors, control system design and analysis, experimental techniques in vibration control.

ENG(NAL)-3-3522: Finite Element Methods for Aircraft Structures: 3-0-0-3

Course Coordinator: Dr S Raja

Associated Faculty: Mr. U Ashwin

Introduction to thin walled structures, Isotropic & composite materials, beam, plate & shell theories, R-R method and displacement based FE procedure, novelty in FE coding, numerical experimentation with FE analysis, static & dynamic solutions using numerical approaches.

ENG(NAL)-3-3523: Fatigue and Fracture Mechanics: 3-0-0-3

Course Coordinator: Dr CM Manjunatha

Associated Faculty: Dr PK Sahoo

Introduction to fatigue of materials; Mechanisms of fatigue failures; HCF and LCF; Fatigue design concepts; Fatigue testing; S-N curves, factors influencing S-N behavior; Strain-life approach; cyclic stress-strain behavior; Fatigue life estimation under block and spectrum loads. LEFM concepts; crack tip plastic zone; FCGR; crack growth life estimation; statistical aspects of fatigue; variable amplitude fatigue; load sequence effects. Introduction to SIF, SERR, J-integral values, Irwin's theory, 2D and 3D VCCI and MVCCI methods, MVCCI method, methods of crack growth analysis in metals/composites using FEA.

ENG(NAL)-3-3524: Mechanical Design and CAD/CAM: 3-0-0-3

Course Coordinator: Dr G Balamurugan

Associated Faculty: Mr. AC Pankaj, Mr. Mahesh Kadam, Mr. K Vinod Kumar

Fundamentals - Introduction to Design: Design, Design Process, Problem Formulation, Factor of Safety and Design codes. Load analysis: Equilibrium equations, Free-Body diagrams, Load analysis case studies. Materials and Processes: Material-property definitions, stress-strain relationships, Heat treatment, coatings and surface treatment, material selection. Stress, strain and deflection: Principal stresses, strains, Mohr's circle, types of stresses, stress concentration, combined stresses, thick and thin cylinders, columns, case studies. Static failure theories: Selection and use of failure theories, factors in the selection of safety factor, General guidelines for adopting factor of safety. Applications - Introduction to the Design of Material handling equipments winches, wire ropes, shackles, hoists, tackles etc, IS standards. Basics of Mechanical Design, Design of Gears & Power Screws, Design of Keys and Shafts, Design of Springs, Brakes, Coupling and Clutches, Design of Flexible Mechanical Elements (Belts & Chains), Selection of the Rolling Bearings & Sealing Elements, fasteners & Joints. Case studies, Geometric Dimensioning and tolerance practices, standards etc. CAD/CAM - Introduction to CAD, Solid Modeling, Feature Modeling, Parametric Modeling, Boundary Representation and Constructive Solid Geometry, Transformations and Projections, Computer Aided Manufacturing.

ENG(NAL)-3-3525: Mechanical Systems Design and Aircraft Systems: 3-0-0-3

Course Coordinator: Dr G. Balamurugan

Associated Faculty: Mr. Jaidev Vyas, Mr. Mahesh Kadam, Mr. Vinod Kumar

Introduction: Review of fundamentals of kinematics-Mobility analysis -Formation of one D.O.F. multiloop kinematics chains, Network formula - Gross motion concepts. Kinematic Analysis: Position analysis -Vectorloop equations for four bar, slider crank, inverted slider crank - Geared five bar and six bar linkages. Analytical method for velociy and acceleration analysis - Four bar linkage jerk analysis - Plane complex mechanism. Path Curvature Theory: Fixed and Moving centrodes, inflection points and inflection circle. Euler Savary equation, Graphical constructions - Cubic of stationary curvature. Synthesis Of Mechanisms: Type synthesis - Number sythesis - Assosiated linkage concept. Dimensional systhesis - Function generation , path generation, motion generation. Graphical methods. Cognate linkage - Coupler curve synthesis, design of six bar mechanisms .Algebraic methods. Application of instant centre in linkage design. Cam mechanism - Determination of optimum size of Cams. Dynamics Of Mechanisms: Static force analysis with friction - Inertia force analysis - combined static and inertia force analysis. Shaking force, Kinetostactic analysis. Introduction to force and moment balancing of linkages. Spatial Mechanism And Robotics: Kinematic analysis of spatial RSSR mechanism - Denavit - Hartenberg parameters. Forward and inverse Kinematics of robotic manipulators. Aircraft Systems: Hydraulics Systems, Hydraulics (Theory and application), a) Pumps - Different types of pumps, Pump characteristics & Theory, Aerospace applications b) Valves- Different kinds of valves, flow and pressure loss calculations,Flow through pipes, Control systems , c) Landing Gear system- Architecture, subsystems, Load calculations d) Fuel system- Architecture,design etc. e) Thermal Systems Thermal engineering (Theory) Thermodynamic principles, Refrigeration and air conditioning, Heat exchangers, Compressors & Turbines, Environmental control system-Architecture , subsystems , Load calculations d) Simulation methods applied to Systems using Bond Graph techniques etc.

ENG(NAL)-3-3526: Optimization Techniques in Engineering Design: 3-0-0-3

Course Coordinator: Dr DVTG Pavan Kumar

Associated Faculty: Dr Amit Kr. Onkar, Dr M. Manjuprasad

Introduction to Optimization, Classical Optimization Techniques, Unconstrained Optimization, Constrained Optimization, Linear Programming, Multi-objective Optimization, Finite Element Based Optimization, Structural Design Optimization, Introduction to Multidisciplinary Design Optimization, Evolutionary Optimization and Optimization of Composites.

ENG(NAL)-3-3527: Impact and Crashworthiness: 3-0-0-3

Course Coordinator: Dr S Sathiyanarayan

Associated Faculty: Mr. J Dhayanidhi, Dr Satish Chandra

Classification of Impact, High velocity and low velocity impacts, Stereo-mechanical Impact, Central Impact, Rotational Impact and Eccentric impact. Vibration aspects, Wave transmission in Elastic solids, Impact of two rods, Impact of rigid mass on a rod, Transverse impact of a mass on a beam. Contact phenomena, Forces and deformations at the contact point, the hertz law of contact, other contact deformation relations, examples. Soft body impact at high velocities, shock waves, bird hit, hail impact. Energy absorption concepts, airbags, foams, gelatine, Crashworthiness of vehicles, Calculation of energy absorbed during low velocity impact. Experimental aspects of impact, measurement of accelerations, velocities of impact, low velocity, high velocity impact, high speed photography. Computational methods for impact analysis, explicit analysis, examples.

ENG(NAL)-3-3528: Finite Element Methods for Composites: 3-0-0-3

Course Coordinator: Dr AK Onkar

Associated Faculty: Ms. S Manju

Introduction to finite element methods: Discussion on mathematical modeling, weighted integral and weighted residual methods, Rayleigh-Ritz methods, principle of minimum potential energy, weak formulation, FE solutions of one and two dimensional problems, convergence analysis. Mechanics of composite laminates: Introduction to composites, micromechanical analysis of composites, homogenization theory, macromechanical analysis of lamina, properties of laminates and their constitutive equations, classical laminate and shear deformation theories, interlaminar stresses, failure theories, environmental effects. Finite element modeling and analysis of composites: One dimensional modeling of laminated beams and plate strips by CLPT and Timoshenko beam theory, two dimensional modeling of laminated plates using CLPT, FSDT and HSDT, layerwise theories, 3D modeling of laminated plates, cutout in composites, statics, free-vibration and buckling analysis, first ply and progressive failure analysis, modeling of delamination, intra-ply and inter-ply damage, nonlinear and post-buckling response analysis.

ENG(NAL)-3-3529: Digital Signal Processing and its Applications: 3-0-0-3

Course Coordinator: Mr. PS Vijayakumar

Associated Faculty: Dr VPS Naidu

Introduction to Signals and signal processing: Characterization and classification of signals, signal processing operations and applications. Fundamentals of Discrete time systems: Introduction, Basic Definitions, Important discrete-time signals, Discrete-Time systems,

Sampling of continuous time signals, Digital filter with A/D and D/A, MATLAB Exercises. Transform –domain representation of Signals: Discrete-Time Fourier Transform, Discre Fourier Transform (DFT) and its properties, Computation of the DFT of real sequences, inverse DFT, The z-Transform, MATLAB Exercises. The Fast Fourier Transform and its applications: Introduction, Computation of FFT, Convolution of two sequences using DFT, MATLAB Exercises. Analog filter Design: Introduction, Filter types and Transformations, Implementation of second order Filters, Component requirements, Filter approximations, Filter design procedures and design examples, MATLAB Exercies. Digital Filter Design: Introduction, Filter specifications, Magnitude and phase response of Digital Filters, Filter Design considerations and Realization, MATLAB Exercises. Time-Frequency Analysis: Theoretical background, Fourier transforms short comings, interpretations difficulties, Spectrogram, Time-scale analysis, Wigner-Ville distribution, MATLAB Exercises. Digital signal processing Applications: Vibration data processing, System Fault diagnosis and Health monitoring, Case study using MATLAB simulation exercises.

ENG(NAL)-3-3530: Manufacturing Techniques for Composites: 2-0-2-3

Course Coordinator: Dr Ramesh Sundaram

Associated Faculty: Mr. Satish S Nimbal

Introduction to course/Why Composites, Health and Safety Issues, Glass / Carbon / Organic Reinforcements /Thermoset / Thermoplastic matrices, Ceramic / Metal matrix Composites, Hand layup/Wet Layup / Spray up/Vacuum Bagging, Prepreg and Autoclave moulding, Tool Design & Manufacturing, Matched die / Compression molding / SMC, Pultrusion / Filament winding, Cocuring and Integral Construction, Sandwich composites, Liquid Composite Molding, Joining Composites, Thermoplastic processing techniques, Machining of Composites, Repair of Composites, Recycling, Quality inspection / Testing, Natural Fiber Composites.

ENG(NAL)-3-3531: Repair Technology for Aircraft Structures using Composites: 2-0-2-3

Course Coordinator: Dr D Saji

Introduction to aircraft materials, classification of metallic materials, basic material structures and properties, mechanical behaviour of materials and manufacturing process, Introduction to composite materials and their processing, Mechanical testing of composites. Adhesively Bonded Joints & Mechanically Fastened Joints. General Engineering Applications of FRP composites. Introduction to repair; Repair philosophy, Repair sequence, repair criteria, sources of damages, Types of damages, Damage assessment. Classification of repair, Design of repair joints, Design of damage tolerant repair joints, Selection of repair joints, Repair procedures, Repair schemes for damaged composite aircraft parts. Why composites for repair of aged metallic structures, crack patching, repair qualification and certification procedures.

ENG(NAL)-3-3532: Experimental Techniques for Composites: 2-0-2-3

Course Coordinator: Dr D Saji

Introduction to composites, Manufacturing processes for polymer matrix composites, Micro and Macro mechanics, Classical laminate theory, Introduction to Fracture Mechanics, types

of damages in composites and damage propogation. Fundamental Strain Gage Technology, Strain Gages on Composites, Normal-Stress and Shear Stress Gages and Rosettes, Strain Gage Reinforcement Effects on Low-Modulus Materials. Experimental characterization of composites, Mechanics of materials approach to stiffness Determination of E1, E2, v12 etc, Mechanical Test Fixtures. Instrumentation Practices for Tension & Shear Testing of Composite Materials, Creep and fatigue testing of Composites. Non destructive testing of composites- Ultrasonics, Acoustic Emission, X-ray, Infra red thermography. Advances in composites testing- Digital image correlation system, laser Doppler vibrometer Vibrothermography, laser ultrasonics, Embedded Fiber Optic Strain Sensors for damage detection.

ENG(NAL)-3-3533: Non-Destructive Testing and Evaluation: 2-0-2-3

Course Coordinator: Dr M Ramesh Kumar

Introduction to NDT: Explain: Selection of NDT methods. Visual Inspection (Optical method), Liquid Penetration Inspection, its advantages and limitations. Magnetic Particle Inspection: Methods of generating magnetic field, types of magnetic particle and suspension liquids.Eddy Current Inspection: Principle, operation variable, procedure, inspection coils. Microwave Inspection: Microwave holography. Ultrasonic Inspection: Basic equipment characteristic of ultrasonic waves, variables inspection, inspection methods pulse echo A,B,C scans transmission. Radiography Inspection: Principles, radiation source – Rays and gamma rays – rays tubes, radio graphic films, scenes and filters, image intensifiers, Industrial Computer Tomography. Optical Holography: Basic of holography, recording and Acoustical Holography: system and techniques applications. Advanced Techniques: Acoustic Emission, Laser ultrasonics, Acousto ultrasonic, infrared thermography.

ENG(NAL)-3-3534: Introduction to Continuum Mechanics: 3-0-0-3

Course Coordinator: Dr VL Sateesh

Vectors and tensors: Introduction, Vectors: vector addition and scalar components. Indicial notations, finite roations. Scalar products, vector products. Change of orthogonal basis. Tensors: Rectangular Cartesian tensor components, tensor properties. Vector and tensor calculus: gradient, divergence and curl. Stress: body forces, surface forces, traction vectors, stress components. Principle axes, principle stress and invariants. Strain and deformation: small strains and rotations in two and three dimensions, kinematics of a continuous medium, rate of deformation tensor, spin tensor. Finite strain and deformation, Eulerian and Lagrangian formulation, rotation and stretch tensors. Compatability conditions. Basic principles: Integral transformation, conservation equations (mass, engergy, angular momentum and linear momentum). Entropy and the second law of thermodynamics, clausius Duhem inquality. Engergy potentials. Constitutive relations: Introduction to ideal materials, classical elasticity, visoelastic behavior, introduction to plasticity.

ENG(NAL)-3-3535: Textile Reinforcements for Composites: 2-0-2-3

Course Coordinator: Dr BS Sugun

Introduction to textile structures, weaves, knits and braids, Introduction to basic weaves and weaving machinery, yarn and fabric mechanics, woven cloth construction and design, glass and carbon weaving, 3D preforming technologies such as stitching, tufting, multilayer

weaving, orthogonal weaving and 3D weaving, woven fabric geometry, weaving calculations, testing and evaluation.

ENG(NAL)-3-3536: Electromagnetic Design and Analysis of Radomes: 3-0-0-3

Course Coordinator: Dr Raveendranath U. Nair
Associated Faculty: Dr Shiv Narayan

Basics of radome performance parameters: Power transmission, power reflection, insertion phase delay, boresight error, antenna pattern degradations; Classification of radome wall configurations: Radome types, Classes and Styles. Monolithic and multilayered structures; Radome materials: Organic radome dielectric materials, Foam materials, inorganic radome dielectric materials, Radome design techniques: Constant thickness design and variable thickness designs. Broadband radome designs; Radome analysis techniques: Geometrical Optics (GO) methods, Physical Optics (PO) methods, plane wave spectrum method, finite element method, and Hybrid methods; Novel Radomes: Frequency Selective Surfaces (FSS) radomes, metamaterial radomes; Radome performance measurements: Power transmission efficiency measurements, Insertion Phase Delay (IPD) measurements, Measurements of antenna pattern degradations.

ENG(NAL)-3-3537: Adaptive Antenna Algorithms: 3-0-0-3

Course Coordinator: Dr Hema Singh

Adaptive antenna fundamentals, Beam forming networks, Antenna beam/sidelobe control, Degrees of Freedoms, Adaptive Array Processing: Narrowband/Wideband, Sidelobe Cancellers: Conventional GSC, DF-GSC, Blind DF-GSC, Adaptive Algorithms: LMS algorithms, RLS algorithm, SMI algorithm, Weighted Least Square algorithm, Active Cancellation in adaptive arrays, Correlation/Coherence between Signals, Mutual Coupling effect, platform effect.

ENG(NAL)-3-3538: Frequency Selective Surfaces: Design and Analysis: 3-0-0-3

Course Coordinator: Dr Shiv Narayan
Associated Faculty: Dr Raveendranath U. Nair

Fundamentals of Frequency Selective Surfaces (FSS): FSS elements, Types of FSS, dielectric loading effect, grating lobe phenomena, Wood's anomalies; Single and multiplayer FSS, FSS structure with multiple periodicity; EM design of FSS structures: Dual-band, Multi-band, FSS performance parameters, Optimization of design and performance parameters; Cascading of Multi-screen FSS;FSS Materials and Fabrications; Measurement Techniques; Applications of FSS: Radomes, Antennas, Radar absorbing structures (RAS).

ENG(NAL)-3-3539: Design and Analysis of Radar absorbing Materials and Structures: 3-0-0-3

Course Coordinator: Dr Balamati Choudhury
Associated Faculty: Dr R U Nair, Dr Hema Singh

Concepts in Radar cross section (RCS), Radar range equation; Stealth techniques; Radar Absorbing Materials (RAM) and its ideal requirements; Fundamental EM concepts for RAM: Maxwell's equation, surface boundary conditions, constitutive relations, EM wave propagation through free space, homogeneous, inhomogeneous medium, EM parameters for RAM; Mathematical analysis for RAM on surfaces: Reflection at planar boundary, curved

boundary, grid-based methods, high-frequency methods; EM design of RAM and Radar Absorbing Structures (RAS): narrowband absorbers, broadband absorbers, realization of RAM in practice; Absorber Characterization Techniques: measurement of material properties, free space techniques; Identification and applications of RAM; Trends in RAM; Advanced metamaterial based RAM.

ENG(NAL)-3-3540: Atmospheric Dynamics and Numerical Weather Prediction: 3-0-0-3

Course Coordinator: Dr Mrudula G

Equations of motion in spherical and polar coordinates, isobaric coordinate and sigma co-ordinate system, scale analysis of dynamical equations, Rossby Number, Classification of flows, geostrophic wind, inertial wind, Eulerian flow and cyclostrophic wind, gradient wind-cyclonic and anticyclonic cases, horizontal accelerations and ageostrophic flow, thermal wind, backing and veering, local temperature variations, barotropic and baroclinic atmospheres, Divergence and vorticity in different co-ordinate systems, significance of the various terms, divergence and vorticity of the geostrophic wind, the vector vorticity equation and its scale analysis, the divergence equation, balance equation, Atmospheric waves , concept of wave motion, simple harmonic wave, stable, unstable and neutral waves, linear perturbation theory wave equation, Fourier series representation of wave form, Acoustic waves, shallow water gravity waves, internal gravity waves, inertial gravity waves, Rossby waves , forced topographic Rossby waves, mountain waves and Lee waves, equatorial wave theory, mixed Rossby gravity waves, Kelvin waves, vertically propagating planetary waves, Quasi geostrophic analysis, geopotential tendency equation, omega equation, Hydrodynamic instability, Kelvin Helmholtz instability, linear barotropic and baroclinic instability and cyclogenesis, available potential energy, the Raleigh Theorem, Atmospheric energetics, energy equation, internal and potential energies, NWP, Finite difference Techniques, Spectral Technique, Galerkin Methods, Staggered grid, CFL Criteria and Stability Analysis, Nonlinear Instability and Aliasing, Boundary Conditions and time integration, Different Models, Coupling, Hierarchy of Coupled models, Coupling strategies, spin up problems, Basic Concepts of Parameterization, Overview of Objective Analysis, Basic Concepts, Optimum Interpolation Technique, Static Dynamic and Normal Mode initialization.

Level 4 Courses

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