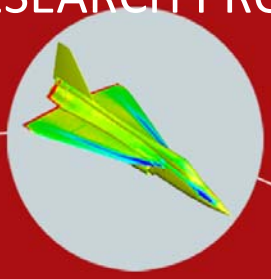
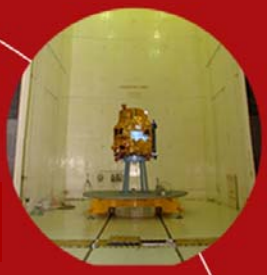
TWO YEAR
POST GRADUATE RESEARCH PROGRAMME





Fluid sciences and acoustics

ENGINEERING OF FLIGHT VEHICLES

Propulsion

Societal missions

Prospectus 2010

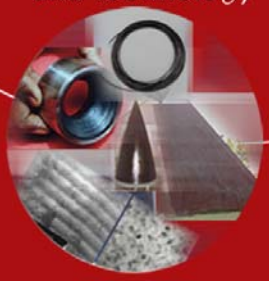
Aerospace electronics

Structural technologies

Flight mechanics and control

High-performance computing

Materials science and technology



National Aerospace Laboratories
Bangalore

About the Course :

1. Introduction
2. Eligibility for admission
3. Mode of payment
4. Summary of total credits
5. Summary of course details – Subject wise
6. Summary of course details – Semester wise
7. Syllabus of course subjects
8. Evaluation Procedure and Grading Scheme
9. List of faculty

Two Year

Post Graduate Research Program in Engineering in

Engineering of Flight Vehicles

at

National Aerospace Laboratories, Bangalore

(2010 -12)

Configuration design of an aerospace vehicle is important from the consideration of building an efficient vehicle. The efficiency of the vehicle is defined in terms of its stability (for better control), minimum drag at cruise (to reduce the fuel consumption), higher maneuverability (to have air superiority), better engine integration with airframe (to provide higher thrust), better fatigue life (for longer life) etc. All these encompass study in various disciplines of aeronautics namely aerodynamics, propulsion, structures and flight mechanics. A program is designed with the aim to get better understanding of these areas with reference to their application to configure the aerospace vehicle and addressing the R&D challenges associated with it to improve the effeiciency of the vehicle.

The program covers broadly, the areas of aerodynamics including computational fluid dynamics and experimental techniques, flight vehicle structures, aircraft propulsion, flight mechanics and control, aerospace vehicles and systems.

The two year Post Graduate Research Training Program 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 areas related to flight vehicles. Students completing this two years program are expected to be fully research – enabled and industry ready.

The first semester of the program focuses on core subjects covering the basics in each of the area mentioned above and associated practical work in the laboratories. The second semester offers courses which provides further an in-depth understanding of these areas related to their application to flight vehicles. The third semester offers advanced courses which lead to understanding of R&D challenges in the respective areas. In fourth semester students will be utilizing their knowledge acquired through the courses to solve real-world design challenges by working on advanced R&D projects work and for a dissertation in their specialization areas.

Eligibility for Admission

Candidates having BE/BTech or equivalent in Aeronautical/Aerospace/Mechanical Engg, completed in 2009 or graduating during 2010, with minimum 70% marks (Aggregate of all Semester/Year) or 7.0 CGPA (Aggregate of all Semester/Year) are eligible to apply.

Candidates who have passed BE/BTech or equivalent in relevant discipline before 2009 are not eligible to apply.

Desirable Qualification: A valid GATE score will be an added advantage.

Mode of Payment

Tuition fee need to be deposited the fee at NAL, Bangalore before the start of every semester by making payment either by cash at NAL cash counter or through Demand Draft drawn in favour of 'Director, NAL' payable at Bangalore. The Demand draft to be sent by speed post or registered letter to 'Director, National Aerospace Laboratories Bangalore 560 017' with the name of the student written in pencil on the reverse ride of the demand draft.

For other details (Admission Process, Eligibility, Fellowship, Important Dates, fee structure and online application)

Please visit the CSIR website http://www.csir.res.in/

COURSE DETAILS FOR CSIR PGRPE PROGRAM 2010 ON

'ENGINEERING OF FLIGHT VEHICLES'

From: CSIR National Aerospace Laboratories

PROGRAMME DURATION: 2 years

Summary of Total Subjects / Total Credits for PGRPE Course on
"Engineering of Flight Vehicles"
to be conducted at CSIR-National Aerospace Laboratory in the year 2010

Semester	No. of Subjects	No. of Credits	Place
1	**5**	**17**	**NAL**
2	**5**	**17**	**NAL**
3	**5**	**15**	**NAL**
4	**1***	**15***	**NAL**
Total :	**16**	**49 + 15 = 64**	

*** Project Work**

Summary of Course details – Subject Wise

Semester					
I	Aerodynamics	Applied Mathematics	Atmospheric Flight Mechanics	Aerospace Vehicles and Systems	Aircraft Propulsion
II	Gas Dynamics	Flight Dynamics and Control	Navigation, Guidance & Control	Aircraft Performance	Flight Vehicle Structures
III	Computational Fluid Dynamics & Experimental Techniques	Exp. Flight Tech & Data Handling	Flight Vehicle Design	Advanced Control	Structural Dynamics & Aeroelasticity
IV	**PROJECT WORK**				

Semester wise subjects

I SEMESTER

(All Courses are Compulsory)

Course	Credits	Course Title
NALEF101	3:0	Applied Mathematics
NALEF102	4:0	Aerodynamics *
NALEF103	3:0	Aerospace Vehicles and Systems
NALEF104	3:0	Atmospheric Flight Mechanics
NALEF105	4:0	Aircraft Propulsion*

* Includes practical classes

II SEMESTER

(All Courses are Compulsory)

Course	Credits	Course Title
NALEF201	3:0	Navigation Guidance and Control
NALEF202	4:0	Gas Dynamics*
NALEF203	3:0	Flight Dynamics and Control
NALEF204	4:0	Flight Vehicle Structures*
NALEF205	3:0	Aircraft Performance Evaluation

* Includes practical classes

III SEMESTER

(All Courses Compulsory)

Course	Credits	Course Title
NALEF301	3:0	Flight Vehicle Design*
NALEF302	3:0	Experimental Flight Techniques and Data Handling *
NALEF303	3:0	Advanced Control
NALEF304	3:0	Structural Dynamics & Aeroelasticity
NALEF305	3:0	Computation Fluid Dynamics and Experimental Techniques*

* Includes practical classes

IV SEMESTER

(Project Compulsory)

Course	Credits	Course Title
NALEF401	15	Project work-Thesis

Course Details – I Semester

NALEF101 3:0 Methods of Applied Mathematics

Linear Algebra (Matrices, vectors, determinants, linear systems, matrix eigenvalue problems,notion of vector spaces), Vector Calculus (grad,div,curl,integral theorems of Green, Stokes and Gauss and applications), ODEs (First order ODEs, higher order linear ODEs, notion of fundamental solutions and boundary conditions, systems of ODEs, series solutions of ODEs - special functions). Fourier analysis (series,integrals,transforms,applications), PDEs (basic types – elliptic, parabolic, hyperbolic), complex analysis (complex numbers and functions, complex integration, Cauchy residue theorem, power series, conformal mapping, potential theory), numerical methods (general numerics, basic numerical linear algebra like Gauss method / LU decomposition, basic numerics for ODEs / PDEs).

Kreyzig, E, Advanced Engineering Mathematics, John Wiley and Sons Inc, 2006

NALEF102 4:0 Aerodynamics

Concept of a velocity field, vorticity, Eulerian and Lagrangian coordinates, streamlines, streaklines and pathlines, concept of a substantial derivative, laws of conservation, elementary applications of continuity and the momentum theorem control volume analysis and its application, inviscid flows and the Bernoulli equations, elements of aerofoil theory. lift and drag and their coefficients, small perturbation theory; 2-D airfoils in subsonic and supersonic flow, Numerical methods for 2-D airfoils; similarity rules, Multhop's method, vortex lattice and double lattice methods, effects of sweep and AR, Aerodynamics of wing - fuselage system and aerodynamics of control surfaces. High angle of attack aerodynamics: non-linear aero -dynamics, Unsteady aerodynamics. Five laboratory classes to demonstrate the concepts and measurements of some aerodynamics parameters.

Houghton E L and Basewell R P, Further Aerodynamics for Engineers, Edward Arnold Publishing Company Holt Ashley and Landhall M, Aerodynamics of Wings and Bodies, Addison-Wesley, 1965 R T Jones, Wing Theory, Princeton University Press,1990.

NALEF103 3:0 Aerospace Vehicles and Systems

Evolution of heavier-than 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.

Kermode, A C, Flight without formulae, Sterling Book House, 1970
Padfield, R R Flying in Adverse Conditions, Tab Books, 1994
Mair W.A. and Brasail, D L , Aircraft Performance, Cambridge Aerospace Series, 1996
McCormick, B W Aerodynamics, Aeronautics and Flight Mechanics, 1995
Gorffin M D, and J R French, Space Vehicle Design, AIAA Education Series
Janes, All the world Aircrafts series.
Anderson J D: "Introduction to Flight"- McGraw Hill, 1987.

NALEF104 3:0 Atmospheric Flight Mechanics

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, modal analysis, eigenvalues, eigenvectors and mode shapes, maneuverability, Steady and accelerated flight

RC Nelson, Flight Stability and Automatic Control
Babistor A.H., Aircraft Stability and Control, Pergamon Press,
Elkin B., Dynamics of Atmospheric Flight, John Wiley and Sons
Perkins, C. D., and Hage, R. E., Airplane Performance, Stability, and Control, John Wiley and Sons, New York

NALEF105 4:0 Aircraft Propulsion

Introduction to propulsive devices; Air-breathing and Non-airbreathing systems. Performance parameters, cycle analysis of ramjet, turbo-jet, turbofan and turboprop engines; Afterburners. Rotating Components: centrifugal and axial compressors, axial turbines; Non-rotating components: combustion chambers, intakes and nozzles. Five laboratory classes for showing the concepts and conducting of experiments.

Hill P G and Peterson C R , Mechanics and Thermodynamics of Propulsion, Addison Wesley, 1965. Kerrebrock, J L , Aircraft Engines and Gas Turbines, MIT Press, 1977
Mattongly, J D, Elements of Gas Turbine Propulsion, McGraw Hill 1996
Mukunda H S, Understanding Combustion.

Course Details – II Semester

NALEF201 3:0 Navigation, Guidance and Control

Inertial Navigation Sensors and Systems, WGS-84 system, Concept of Uncertainty in Navigation, Kalman Filter Inertial Navigation System Flight Applications, Global Positioning System, High Accuracy Navigation Using Global Positioning System, Flight Testing Navigation Systems.

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, Observability and controllability, angle-of-attack limiter, sideslip angle and sideslip rate feedback, roll rate feedback, design of command paths, nonlinear design and verification, basic autopilot control laws.

Daniel J. Biezad, Integrated Navigation and Guidance Systems, AIAA Education Series

NALEF202 4:0 Gas Dynamics

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. Five laboratory classes for demonstrating the concepts and conducting of experiments.

Liepmann H W and Roshko A, Elements of Gas Dynamics, John Wiley, 1957
Becker E, Gas Dynamics Academic Press, New York, 1968.
John D Anderson, Modern Compressible Flow, McGraw Hill 1990

NALEF203 3:0 Flight Dynamics and Control

Flight Mechanics parameters, aerodynamic database, principles of simulation, sensor dynamics, high-order actuator dynamics, engine model, landing gear model, integration into 6-DOF simulation model, Aerodynamic Modeling, flight path reconstruction techniques, aerodynamic derivative estimation, aerodynamic database validation and update procedures, Statically unstable aircraft, control power requirements for unstable aircraft, control actuator rate requirements, limits on static instability, control surface sizing, center-of-gravity limits, Routh-Hurwitz

stability criterion, root locus plot, inertia cross coupling, roll coupling, autorotation, roll reversal, Longitudinal and Lateral stability Augmentation, Pole placement method,

Schmidt, L.V., Introduction to Aircraft Flight Dynamics, AIAA Education Series.
McRuer, D., et al, Aircraft Dynamics and Automatic Control, Princeton University Press.
Stengel, R. F. Flight Dynamics, Princeton University Press, Princeton, NJ 2004 (ISBN: 0-691-11407-2)

NALEF204 4:0 Flight Vehicle Structures

Introduction to Aerospace vehicle structures, Aircraft structural components & loads, Aircraft Materials with specific reference to composites, Airworthiness, certification and standards related to aero-structures, Finite element structural analysis, Analysis & design of composites structures, Engineering fracture mechanics & damage tolerance, Impact and Crashworthiness, Introduction to Computer aided design (CAD) and product life cycle, management (PLM), Structural optimization : Size, shape and topology optimization, Smart structures and materials, Active structural control. Five laboratory classes showing the materials, and involvement of students in conducting of experiments.

C.T. Sun, 2006, Mechanics of Aircraft Structures, John Wiley and Sons, New York
T.H.G. Megson, 1999, Aircraft Structures for Engineering Students, Butterworth-Heinemann, Oxford
D.V. Wallerstein, Variational Approach to Structural Analysis, John Wiley and Sons, 2001
I.H. Shames, C.L. Dym, Energy and Finite Element Methods in Structural Mechanics, 1991,

NALEF205 3:0 Aircraft Performance Evaluation

Estimation of the performance: Power requirements and engine choice and size, minimum to fly level, power to climb and maneuver with typical power plants

Stability characteristics of the airplane: Longitudinal and Lateral stability analysis, static margin and stabilizer sizing; Sizing and trade studies.

Donald Layton, Aircraft Performance,Matrix Publishers, 1988
Mair W.A. and Brasail, D L , Aircraft Performance, Cambridge Aerospace Series, 1996

Course Details – III Semester

NALEF301 3:0 Flight Vehicle Design

Survey of various types of Airplanes, Overview of the design process; preliminary aerodynamic design, take-off weight estimation, selection of wing loading, thrust loading, engine and geometrical parameters of major components Conceptual design of a flight vehicle, Airplane Layout (Three view drawings : Arrangement of surfaces, Mass and Moment of Inertia properties and balance diagram) Design of structural components (fuselage, wing, horizontal and vertical tail). Design aspects of subsystems: Flight control system, Landing Gear and subsystem, Propulsion and Fuel system integration, Air pressurization and air conditioning system, Electrical & Avionic system

Tomas C Corke., “Design of Aircraft,” Person Education, LPE, 2003.
Stinton D.,"The Design of the Aeroplane", Granada, England 1983.
D. P. Raymer, "Aircraft Design, A Conceptual approach", AIAA Education Services, 1992.
J Roskam, Vol 1 to 9 Aeroplane Design
Nicolai L., "Fundamentals of Aircraft Design", University of Dayton Ohio, 1975.
John P Fielding, Introduction to Aircraft Design Cambridge University Press, 1999

NALEF302 3:0 Experimental Flight Techniques and Data Handling

Flight test planning and execution, flight test configurations, maneuver design, data acquisition methods, MIL-F-8785C, MIL-STD-1797, and FAR Part 23 requirements, Pilot opinion rating, Control Anticipation parameters, Flying qualities requirement on s-plane, handling qualities testing and analysis, handling qualities criteria, handling qualities ratings, pilot induced oscillations (PIO).

NALEF303 3:0 Advanced Control

Optimal Control, Robust Control, Modern Linear Control, Back-stepping Design, Feedback Linearization (Dynamic Inversion), Adaptive Control Design, Neuro-adaptive Control Design, High angle-of-attack (AOA) aerodynamics (both upright and inverted), post stall gyrations, spins, deep stall, departure susceptibility, departure criteria, directional departure parameter, lateral control departure parameter, continuation and equilibrium solution.

K.Ogata: Modern Control Engineering, Third Ed., Prentice Hall, 1999.
H.J.Marquez: Nonlinear Control Systems Analysis and Design, Wiley, 2003.
J-J E.Slotine and W.Li: Applied Nonlinear Control, Prentice Hall, 1991.
H.K.Khalil: Nonlinear Systems, Prentice Hall, 1996.Current literature

NALEF304 3:0 Structural Dynamics and Aeroelasticity

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 integrations; 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 nonlinear vibrations.

Meirowitch L , Computational methods in Structural Dynamics 1980.
Clough R W and Penzein J, Dynamics of Structures McGraw Hill, 1993
Y C Fung, 2002, An Introduction to the Theory of Aeroelasticity Dover Publications.
R L Bisplinghoff, H Ashley, and R L Halfman, 1996, Aeroelasticity, Dover Publications.
Johnson, W, Helicopter Theory, Dover, 1994 Bramwell, Done, Balmford, Bramwell's Helicopter Dynamics, Butterworth-Heineman, 2001.

NALEF305 3:0 Computation Fluid Dynamics and Experimental Techniques

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.

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.

Charles Hirch: Numerical Computation of internal and external flows, Vol.l&2, Wiley-interscience publication, 1990.
Experimental Methods for Engineers, Holman
William H Roe Jr , Alan Pope, Low Speed Wind Tunnel Testing Wiley and Sons (1984)
Pankhrust R C and Holder D W Wind-Tunnel technique, Sir Issac Sons Ltd.,London,
Goldstein R J: Fluid Mechanics Measurements, Elseveier, 2003

IV Semester

NALEF401-Project work-Thesis

The project work is aimed at providing the students to work on practical problem and carryout the work either through analytical/experimental/CFD.

Evaluation Procedure and Grading Scheme

The two-year programme is made up of 4 semesters with continuous internal evaluation and a semester-end examination for all courses.

Letter grades will be awarded for each course reflecting the student's proficiency and instructor's expectation. The grades and their description along with their equivalent numerical values, where applicable, are as follows:

A	10	Outstanding
B+	9	Excellent
B	8	Very Good
C+	7	Good
C	6	Satisfactory
D	5	Fair

Performance of the student will be evaluated by two indices, semester grade point average (SGPA) and cumulative grade point average (CGPA). These will be calculated as follows:

SGPA = {Sum of (Course credit $\times$ Numerical value of course grade)} / Total course credits earned in the semester
CGPA = Cumulative points scored in all passed courses / Cumulative credits earned

A student needs to have a SGPA of over 6.0 (in each of the first and second semesters) and a CGPA of over 6.5 (at the end of the second semester) for continuing beyond the first year.

For distinction, the student need to have CGPA = 8.0 or above.

Students getting E or F grades in a course need to re-appear for the final course examination before the start of the next semester.

I grade indicates the student has not been able to complete the course requirements and needs to take necessary actions as prescribed by the CSIR laboratory.

For more details please visit www.csir.res.in.

List of Faculty

No	Name	Designation	Discipline
1	Dr Sajeer Ahmed	Scientist G	Aerodynamics
1	Dr L Venkatakrishnan	Scientist E2	Aerodynamics, Measurement Techniques
2	Dr S B Verma	Scientist E1	Aerodynamics, Gas Dynamics
3	Dr Channa Raju	Scientist E2	Aerodynamics, Gas Dynamics
4	Dr R Mukund	Scientist E2	Low Speed Flows
6	Dr V Mudkavi	Scientist F	Vorticity Dynamics
7	Dr Usha Srinivasan	Scientist E1	Fluid Mechanics, Mathematics
8	Dr K R Srilatha	Scientist E2	Panel Methods
9	Dr J S Mathur	Scientist F	CFD
10	Dr Rajani	Scientist E1	Turbulent Flows
11	Dr V Ramesh	Scientist E2	Grid free Methods
12	Dr. S. Raja	Scientist E2	Aeroelasticity
13	Mr. S.C. Lakshminarayana	Scientist E2	Airframe Design and Testing
14	Dr. S. Sridhara Murthy	Scientist G	Aircraft Structures
15	Mr. Shyam Chetty	Scientist G	Flight Mechanics and Control
16	Dr. G. Gopalaratnam	Scientist G	Flight Mechanics and Control
17	Dr. Jatinder Singh	Scientist F	Flight Mechanics and Control
18	Dr. A. A. Pashilkar	Scientist E2	Flight Mechanics and Control
19	Dr. H N V Dutt	Scientist G	Mathematics, Flight Vehicle Design
20	Mr. Bhaskar Chakravarthy	Scientist E2	Aircraft Performance
21	Mr. Manjunath P	Scientist E2	Aircraft Propulsion