U.P. TECHNICAL UNIVERSITY, LUCKNOW

STUDY & EVALUATION SCHEME

B. Tech. Aeronautical Engineering
[Effective from Session 20016-17]

YEAR IV, SEMESTER-VII

S. No.	Subject Code	Name of the Subject	Periods			Evaluation Scheme				Subject Total	Credit
			L	T	P	Sessional Assessment			ESE		
						CT	TA	Total			
THEORY SUBJECT											
1	NOE-071-NOE074	Open Elective -I	3	1	0	30	20	50	100	150	4
2	NAE-031-NAE-034	Departmental Elective – III	3	1	0	30	20	50	100	150	4
3	NAE-041-NAE-044	Departmental Elective – IV	3	1	0	30	20	50	100	150	4
4	NAE-701-	Aircraft Structure	3	1	0	30	20	50	100	150	4
5	NAE-702	Aero Engine Maintenance System	3	1	0	30	20	50	100	150	4
PRACTICAL/DESIGN/DRAWING											
5	NAE-751	Aircraft System Lab	0	0	3	10	10	20	30	50	1
6	NAE-752	Aero Engine Lab	0	0	3	10	10	20	30	50	1
7	NAE-753	Industrial Training**.	0	0	2	-	-	50	-	50	1
8	NAE-754	PROJECT	0	0	3	-	-	50	-	50	2
	NGP-701	General Proficiency	-	-	-	-	-	50	-	50	-
		TOTAL	14	5	11					1000	25

Note- **Practical Training-1 & 2 (4-weeks each) done after 4th & 6th Semesters would be evaluated in 7th semester through report and viva voice etc.
Project should be initiated in 7th semester beginning **(End Semester Examination to be conducted for evaluation for 7th sem),** and should be complete by the end of 8th semester with good Report and power-point Presentation etc.

Departmental Elective III

NAE-031Propulsion-II
NAE-032 Aircraft Materials& Non-Destructive Testing
NAE-033 Avionics-I
NAE-034 Aircraft Maintenance & repair system

Departmental Elective IV

NAE-041Aerodynamics II
NAE-042 Aircraft System
NAE-043 Aircraft Evaluation
NAE-044 Finite Element Methods

U.P. TECHNICAL UNIVERSITY, LUCKNOW

STUDY & EVALUATION SCHEME

B. Tech. Aeronautical Engineering
[Effective from Session 20016-17]

YEAR IV, SEMESTER-VIII

S. No.	Subject Code	Name of the Subject	Periods			Evaluation Scheme				Subject Total	Credit
			L	T	P	Sessional Assessment			ESE		
						CT	TA	Total			
THEORY SUBJECT											
1	NOE-081-NOE084	Open Elective -II	3	1	0	30	20	50	100	150	4
2	NAE-801	Aircraft Rules & Regulation	3	1	0	30	20	50	100	150	4
3	NAE-051 - NAE-054	Departmental Elective -V	3	1	0	30	20	50	100	150	4
4	NAE-061 NAE-064	Departmental Elective -VI	3	1	0	30	20	50	100	150	4
PRACTICAL/DESIGN/DRAWING											
5	NAE-851	SEMINAR	0	0	3	-	50	50	-	50	2
6	NAE-852	PROJECT	0	0	12	-	100	100	200	300	7
7	NGP-801	General Proficiency	-	-	-	-	-	50	-	50	-
		TOTAL	12	4	15					1000	25

Departmental Elective -V

NAE-051 Rocket & Missiles
NAE-052 Helicopter Aerodynamics
NAE-053 Avionics-II
NAE-054 Space Craft Technology

Departmental Elective -VI

NAE-061 Aircraft Design & Testing
NAE-062 Vibration & Aero Elasticity
NAE-063 Computational Fluid Dynamics
NAE-064 Ground Handling and Supporting System

Open Electives – I

NOE-071 Entrepreneurship Development
NOE-072 Quality Management
NOE-073 Operations Research
NOE-074 Introduction to Biotechnology

Open Electives – II

NOE-081 Non Conventional Energy Resources
NOE-082 Nonlinear Dynamic Systems
NOE-083 Product Development
NOE-084 Automation and Robotics

NAE-701
AIRCRAFT STRUCTURE

L T P
3 1 0

UNIT –I 8

Introduction to Aircraft Structure-Aircraft materials-properties, Safelight vehicle materials importance of strength to weight ratio, temperature variations factors affecting choice of materials for different part of airplane.V-n diagram, the loads acting on the aircraft and salient features of the V-n diagram.Flight envelope for different flying conditions as Guest loads Inertia forces. Analysis of Fuselage and Wings of Aircrafts and Array function.

Basic Equilibrium of non coplanar statically force System basic elasticity or Hooke's law, stresses and strains, equations of equilibrium, plane stress and plane strain problems, compatibility equations, stress - strain relations.Stress analysis of aircraft components as fuselages, wings, fuselage frames, wing ribs.

UNIT- II8

Deflection of Beams- Area moment Method, slope-deflection method, moment distribution method, principle of virtual work. Application to deflection problems. Shear and bending moment distribution for semi-cantilever and other types of (wings and fuselage,) beam.Deflection of open and close section beams. Factor of safety and load factor Fatigue loads, Fluctuating stress,all theories of failure.

UNIT -III 8

Bending or Twisting–Bending of open and closed section thin walled beams, Bending of thin plates; pure bending, plate subjected to bending and twisting, plates subjected to distributed load,Bending stresses in beams of unsymmetrical sections-bending of symmetric sections with skew loads.Various loading and end conditions combined bending and in-plane loading of a thin rectangular.thin webbed beam with parallel and non-parallel flanges- Shear resistant web beams- Torsion field web beams (Wagner's. shear centre and centre of twist,

UNIT- IV8

Sear Flow in Open Sections-Thin walled beams, concept of shear flow, the shear centre and its determination – shear flow distribution in symmetrical and unsymmetrical thinwalled sections structural idealization and shear flow variation in idealized sectionsTorsion of closed and open section beams and membrane analogy.

Sear Flow inClosed Sections- Bredt-Batho theory – single-cell and multi-cell tubes subject to torsion – shear flow distribution in thin-walled single & multi-cell structures subject to combined bending torsion – with walls effective and ineffective in bending – shear centre of closed sections.

UNIT –V8

Bucking in Beam And Plates-Euler buckling of columns and beams inelastic stability of columns, effect of initial imperfections, energy method for the calculation of buckling loads in columns, flexural and tensional buckling of the thin walled columns,- local buckling stress of thin walled sections – crippling strength estimation – thin-walled column strength –load carrying capacity of sheet stiffener panels – effective width.Buckling of stiffened plates, rectangular sheets under compression,energy method forbending of thin plates.

Text and Reference Books

1. Megson T M G, 'Aircraft Structures for Engineering Students', Edward Arnold,1995.
2. Bruhn. E.H., 'Analysis and Design of Flight Vehicles Structures', Tri-state offset company, USA, 1985.
3. Howard D Curtis, 'Fundamentals of Aircraft Structural Analysis', WCBMcGraw Hill, 1997.
4. Rivello, R.M., Theory and Analysis of Flight Structures, McGraw Hill, 1993.
5. Peery, D.J., and Azar, J.J., Aircraft Structures, 2nd edition, McGraw – Hill, N.Y., 1999.
6. D.J.Perry, Aircraft Structures, Mc Graw Hill 1950
7. E.E. Sechler & L,G, Dunn, Airplane Structural Analysis & Design , Wiley & Sons Ltd,
8. F.E. Bruhn Analysis & Design of ?Flight Vehicle Structures , Tristate offset Co, 1965
9. A.S. Niles & J,S, Newel , Airplane Structural Analysis and Design, Vol & II Wiley & Sons ltd,
10. F.R. Shanley , Weight Strength Analysis of Aircraft Structures , Dover Publication , 1960
11. S. Timoshenko and J,N, Goodier , Theory of Elasticity , Mc Graw Hill , 1951
12. J.P. Den Hartog, Advanced Strength of materials, McGraw Hill , 1952
13. S. Timoshenko and J,M, Gere , Theory of Elasti Stability , Mc Graw Hill 1961
14. S. Timoshenko and K,S, Woenowsky , Theory of Plates & Shells , Mc, Graw Hill , 1959
15. M.F. Rubinstein , Matrix computer Analysis of Structures , Prentice Hall 1966
16. B. Venkatraman and S,A> Patel , Structural Mechanics with Introduction to Elasticity and Plasticity , Mc Graw Hill 1965
17. J. W Dallyand , W,F Riley Experimental Stress Analysis, Mc Graw Hill 1965
18. F.R. Shanley, Weight Strength Analysis of Aircraft Structures, Dover Publications, 1960.

NAE-702

AERO ENGNES MAINTENANCE SYSTEM

L T P
3 1 0

UNIT -I **8**

Types of piston and gas turbine engines and their relative merits and demerits, principle of operation of piston and gas turbine engines, general constructional details and functions of each part, Principles, arrangement, operation and inspection of complete fuel, lubrication, ignition and staring system as applicable to piston and gas turbine engines, Principles and operation of accessories such as fuel pump, oil pump, barometric pressure control and air fuel ratio control etc. As applicable to gas turbine and piston engines.

UNIT-II **8**

Knowledge of material used in piston and gas turbine engines. Methods of checking of components prior to and during subassembly and subsequent assembly of the engine of both piston and gas turbine type for correct alignment, Weight and balance Knowledge of various gauges and precision instruments used. Inspection procedures for crack detection Such as die-penitent, magnetic particle Inspection, X-Ray, ultra sonic and eddy Current etc.

UNIT- III **8**

Engine controls and performance instruments, General principles of operation and methods of checking for correct functioning. Testing of piston and gas turbine engines, various test rigs/instruments and equipment used. Fault diagnosis and rectification during testing. Engine installation checks of aircraft engines, precautions and procedures prior to, during and after ground running checks with particular reference to operating limitation, priming bleeding, etc, Trouble shooting and rectification.

UNIT-IV **8**

Procedure for short term and long term storage of engines. Accessories priming and inhibition procedures. Periodical servicing, procedures, reporting and rectification of defects and inspection after shock landings. Maintenance of inspection records and clearance procedure for flights. Types of stores, maintenance of stores. Inspection of documents and procedures for storage of components.

UNIT-V **8**

Types of propellers and their mechanisms, variable pitch, feathering propellers and associated control system components. Knowledge of lubricants, hydraulic fluids and fuels used in piston and gas turbine engines. Maintenance objectives and legal requirements as related to power plants and systems. Accident reporting and investigation. Power augmentation devices, thrust reversers and auxiliary power unit.

Text and Reference Books

1. Jet Engine Manual by E. Mangham and A Peace
2. Carburetors and Fuel Injection System by A. W. Judge
3. Jet Engine by Rolls Royce Ltd,
4. Fundamentals of Internal Combustion Engines by P.W. Gill, J.H. Smith & E.J. Ziurys.
5. Gas Turbine for Aircraft by A.W. Judge,
6. Gas Turbine Materials by G, Lueas and J.F. Pollock.
7. Aircraft Rules, Published by Govt, of India.
8. Jet Aircraft Power Systems by Casamassa and Bent.
9. Gas Turbine Engineering Handbook by J.W. Sawyer.
10. Internal Combustion engines Vol, n by D.R. Pye.

Departmental Elective – III

NAE-031
PROPULSION II

L T P
3 1 0

UNIT- I 8

Introduction of Jet Engines- Various types of gas turbine engines, construction details and their merits and demerits, cycle analysis of gas turbine engines. Calculation of thrust, Specific thrust, Specific fuel Consumption and efficiencies of gas turbine engines.

P**erformance-**Effect of forward speed and altitude, variation of propulsive and overall efficiency with forward speed, propeller thrust and jet thrust, effect of forward speed on propeller, shaft and thrust horse-powers.

UNIT-II 8

Energy transfer in compressor and turbine- Euler turbine equation and its different forms,velocity triangles for a generalized turbo- machine degree of reaction in turbo machines, methods of representing velocity diagrams. velocity triangle for a stage , radial equilibrium, free vortex, forced vortex and constant reaction designs; variation of blade height for the above types of blades, allowable temperature and pressure rise per stage; blade nomenclature, pressure loss coefficient , lift and drag, losses in blade passages, stall and surge, simple design examples.

UNIT-III 8

Axial flow and Centrifugal flow compressors- Types of compressors, comparison between centrifugal and axial flow compressor, adiabatic compression and efficiency of compressor cooled compressor and isothermal efficiency, poly-tropic efficiency and overall efficiency, Working of a centrifugal compressor, velocity triangles at impeller eye and tip, Effect of vane less space and function of a diffuser, worked examples, Characteristics of centrifugal compressors, surging.

UNIT- IV 8

Radial and axial flow turbines- impulse and reaction blades, velocity triangles and power output static pressure and reaction variations along blade height, negative reaction. Types of losses in turbine blades, introduction to cooled blades. Elementary aerodynamic design of centrifugal and axial compressor and turbines, Three- dimensional flow in compressors and turbine stages, Calculation of losses, Stage efficiency and characteristics, Cascade testing, cooling of turbine blades.

UNIT–V 8

Combustion Chamber- Types of Combustion chambers, desirable features of combustion chambers, process of combustion, temperature rise, combustion efficiency, Requirement of a combustion chamber, Aerodynamic and chemical performance of combustion chambers, Effect of operating conditions of the performance of combustion chambers, Cooling of Flame tubes and Fuel injection and control systems.Gas turbine engine fuels, atomization in simplex and duplex burners.

Intake and Exhaust Nozzles- All type of C-D Nozzles, their operations characteristics at various altitudes and speeds and all Types of Nozzle according to Speed.

Text and Reference Books-

1. Mechanics and Thermodynamics of Propulsion by Hill and Peterson,
2. Jet Propulsion for Aerospace Application by Hesse and Mumford,
3. Aircraft and Missile Propulsion by M,J, Zucrow, Vols, I and it,
4. The theory and Design of Gas Turbines and Jet Engines by E,T, Vincent,
5. Gas Turbine Theory by H, Cohen and G,F,C, Rogers,
6. Aircraft Propulsion by A,W, Morley,
7. Gas Turbines for Aircraft by A,W, judge.

NAE -032
AIRCRAFT MATERIALS &NON DESTRUCTIVE TESTING

L T P
3 1 0

UNIT- I **8**

Board classification of aircraft materials. Ferrous materials, nonferrous materials and alloys, ceramic materials and fiber reinforced composite materials, polymers, metal matrix particulate.Engineering Materials, Structural properties of materials, Atomic and lattice structure, Bonding in Solids, Imperfections in crystals, Solid phase and phase diagrams.

Furnishing Materials: Plastic, wood, plywood, glue, dopes and rubber used in aircraft manufacture. Paints, surface finishes and materials

UNIT- II **8**

Mechanical properties and testing, Isotropy, Orthotropic, True stress and strain, Strength and elasticity, Stiffness, Resistance, Plasticity, Ductility, Toughness and Hardness of materials. Concept of Fatigue and Creep. Mechanical Testing. Factors Affecting Strength. Deformation, Plasticity and Viscouselasticity, Fracture. Heat treatment, Chemical, thermal and Technological Properties. Methods of testing and storage.

UNIT- III **8**

Specifications: Indian Standard, British, American, French, German, and International specifications. Corrosion of material, its detection and prevention. Protective finishes. Testing Destructive and non-destructive testing techniques. Crack detection, inspection of parts by hot oil and chalk, dye-penetrate, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods.the methods of NDT and highlight its role in quality assurance. The emphasis should also be on its application during the process of design, manufacturing and maintenance.

UNIT IV **8**

Importance of NDT in quality assurance. Different types of non destructive techniques to obtain information regarding size, location and orientation of damage or cracks. Visual inspection techniques coin tapping technique for composite structures and adhesive bonds. Ultrasonic testing: Pulse echo technique, pitch-catch technique, through transmission technique, A-scan B-Scan, C-scan.Acoustic

emission: Sources of acoustic emission in composites, peak amplitude rise time during events, ring-down counts duration of events.

UNIT V **8**

X-ray radiography: Absorption spectra, short wave length, X-ray for detection of voids. Die penetration technique. Magnetic particle testing.

In each of the above techniques-

(i)theory and basic principles, (ii) advantages/disadvantages, (iii) material of parts that can be inspected, (iv) physical size and shape limitation, (v) economics of process, (vi) types of defects that can be detected,(vii) environment limitation are to be discussed along with equipment used for each of the techniques.

Text and References Books:

1. S K Hajra Chowdhary, Materials, Science and Engineering Processes, Media Promoters
2. George E. F. Titterton, Aircraft Materials, English Book Stores, Delhi
3. M L Begman, Manufacturing Processes, Asia Publishing House, Bombay.
4. Non destructive Testing, Edword Arnold U.K.
5. Introduction of Nondestructive testing - A training guide, John Wiley & Sons.
6. Donglas C Lalia, NDT for Aircraft, Jeppesen.
7. NDT and Ultrasonic Testing for Aircraft, FAA-AC 43-3

NAE -033
AVIONICS-I

LTP

310

UNIT-I 8

Information : Communication system, signals, analogue, digital and coded forms, time and frequency representation signal spectra, types of distortion.

Information: Nature and measure, influence of band width and signal /noise ratio on channel capacity, elements of Shannon's theorem and its implication. Problem of communication in presence of noise.

Modulation: Amplitude, angle and phase modulation single and vestigial sideband forms demodulation, Super heterodyne principle automatic gain and frequency control typical circuit arrangements.

Pulse modulation: sampling principle sampling criterion, quantization and quantization noise selection of number and distribution of quantization levels, bandwidth requirements, examples of coding and decoding circuits.

Transmission: Transmission lines and their circuit representation, characteristic impedance, complex propagation constant, standing wave radio matching and impedance charts

UNIT-II 8

Channel Performance: Amplitude and phase distortion, phase and group delay distortion caused by multiple effects, Noise , origin measurements, noise figure and noise temperature effect on channel performance , Frequency and time division multiplexing.

Radiation: Principle: application of basic formulae for unipole and dipole aerials, effective height directional, properties, gain impedance, linear arrays traveling –wave aerials rhombic as parasitic elements.

Propagation: Principles: influence of ionosphere and troposphere reflection from earth's surface, field strength calculation, fading diversity reception.

UNIT-III 8

Circuits: Circuits for Communication transmitters and receivers, block diagrams and examples of typical circuits, television receivers, Camera and display tubes.

Systems: Description of typical point-to-point and broadcast radio systems, choice of typical parameters (e,g, operating frequency , type of modulation, transmitter power level, bandwidth. Special Systems (Principles) : V.H.F., D.H.F. Satellite communication and related equipment, electronic counter measure, low- level TV and Head down display, CRT displays, Direction finding Air borne Telemetry Systems, Laser and infrared systems, Air data and flight recording systems.

Television Wave forms: Scanning, Interlacing, Horizontal and vertical resolution, bandwidth requirements, Color television principles, chrominance and luminance singles, basic definitions of photometry and colorimetric dichromatic systems.

UNIT-IV 8

Aircraft maintainability : Evolution of maintenance philosophy, Periodic maintenance system based on checks at specific intervals and continuous maintenance system, Daily inspection and Trip inspection system , On Condition maintenance techniques, their evolution and effect on design of aircraft systems.

Accessibility: Reparability, interchangeability, structural inspection program and sampling criteria. System redundancy, back up, dispatch reliability and goals, T.B.O. and M.T.B.F.concepts and criteria. Determination of labour requirements for maintenance and overhaul, Component removal and replacement criteria on overhaul costs. Engine life development techniques and effect on overhaul costs.

UNIT-V 8

Operating Cost: Direct operating cost-Depreciation of airframes and engine Insurance (Hull Insurance, passenger liability third party liability etc.) Housing and Parking Charges.

Indirect. operating cost-their breakdown and criteria for estimation of payload, range and Block speed, Characteristics of aircraft and their effect on operating cost.

Unit operation costs: Cost per ton kilometer and cost per seat kilometer- Break- even load factor both in terms of passengers as well as total available payload.

Other Costs: Introductory Costs, (Crew training, Technical personnel training, ferry flights, additional building and workshop facilities costs, route, proving etc,) Financing Charges, Aircraft suitability for Traffic and Route system.

Text and Reference Books

1. Communication Systems by B.P. Lathi (John Wiley and Sons 1968),
2. Communication System and Techniques by Schwartz, M.W.R. Benett and S. Stein (McGraw Hill, New York, 1966)
3. Systems – An introduction to Signals and Noise in Electrical Communication by Carlson A.N.(McGrawHill, New York 1968)

NAE -034
AIRFRAME MAINTENANCE AND REPEAR

L T P
3 1 0

UNIT- I 8

REGULATION AND LEGISTATION

Terms used and their definitions, Registration procedure, Requirements of Nationality and Registration markings, The Certificate of Airworthiness conditions of issue and validity, categories of Aircraft Maintenance Engineer's Licenses, Scope and Functions.Minimum equipment and instruments of flight

over land and sea at night and by day. Log books requirements, entry and certification, daily Certificate of Safety and alternative conditions of issue and validity.**1**nizations, Condition and procedure for grant of approval-layouts and personnel, functions and responsibilities.

UNIT -II **8**

Approved material functions, description and scope of receipt, quarantine and bonded stores, description of approved material and categorization, Precautions regarding inflammable stores, Forms and Procedure (release notes, affidavits etc.). Procedure for storage, accounting and issue of materials and overhauled components and parts.

Basic Principles of Inspection : Standard inspection technique and procedures, Attribute Inspection and Variable Inspection Limitations, Guage surveillance system inventory, guage cards, Gauge calibration and gauge maintenance, Use and care of tools, Gauges jigs and fixtures.

UNIT-III **8**

Workshop Gauges' and Inspection Gauges

(a) Blue print reading reading–interpretation of drawings, Conventional signs and sysmbols- Reading and interpretation of aircraft wiring diagram.
(b) General principles of aircraft hydraulics and hydraulic machinery.
(c) General Principles of aircraft pneumatics and applications.
(d) General principles of electricity and magnetism.

UNIT -IV **8**

Features of design, methods and processes of construction, assembly, principle of operation and checking of

(a) Landplanes, seaplanes, flying boats, amphibians, helicopter and autogyros, gliders and hovercraft.
(b) Airframe structural components braced monologue, semi monocoque and geodetic construction for all types of airplanes , Longerons, stringers, formers, bulkheads, spars and ribs, Honeycomb construction.

UNIT -V **8**

(a) Airplane landing primary secondary , lab and stabilizers, Ailerons, elevators, rudders, leading and trailing edge laps, spoilers and speed brakes, trimming and control tabs, tail planes and fins.

(b) Airplane lading gears, Types and variations –braced divided and chassis , Shock struts spring, rubber, olco-spring, oleo-pneumatic, Wheels , single piece hub and split hub, Tires with tube and tubeless, Brakes expanded shoe, Single disc and multi disc.
(c) Mechanical, hydraulic and pneumatic Systems

Text and Reference Books:

1. Aircraft Manual , Government of India.
2. Civil Airworthiness requirements CAA, UK.
3. Far's faa, u.s.a.
4. Technical electricity by davidge and hutchinson, university technical press.
5. Workshop technology vols i and ii, chapman arnold and sons.
6. Engineering inspection by parkinson, pitman & sons.
7. Engineering workshop drawing by parkinson, pitman and sons.
8. Mechanics of flight by kermode, pitman and sons.
9. Principles of engineering inspection by king and butler, clever humes press.

10. Engineering inspection measurement and testing by town and colbourne, odhams.
11. Aircraft mechanic's pocket manual by ashkouti , pitman and sons.
12. Aircraft maintenance by brimm and boggess, pitman and sons.
13. Aviation mechanic's aircraft manual by vale, mcgraw hill.
14. Aircraft basic science by northrop aeronautical institute.
15. Aircraft maintenance and repair, northop aeronautical institute.
16. Aircraft weight and balance control by henri g,d, esout, aerk publishers lne.aircraft instruments by c.a.williams, odhams.

Departmental Elective – IV

NAE-041

AERODYNAMICS-II

L	T	P
3	1	0

UNIT –I **8**

Vortex System- Vortex on the wing, complex potential function, conformal Transformation, Blasius theorem, principles of conformal transformation, Kutta Joukowski Transformation.

2-D thin Airfoils : Circulation and the generation of Lift, Bound vortex and starting vortex, Kutta condition, Glauert's thin airfoil, theory, thin symmetric flat plate airfoil, Circular arc foil, general thin airfoil section, the flapped airfoil. Determination of mean camber line, shapes for uniform and linear distribution of circulation, flow about multi element airfoils.

UNIT –II **8**

3-D Wings Theory-Downwash and induced drag, BiotSavart's law and Helormholtz's theorems. Vortex system around a lifting wing. Induced velocity of infinite and semi-infinite filaments. Prandtl's classical lifting line theory, unswept wings, fundamental equations, elliptic lift distribution, influence of aspect ratio on lift and drag, drag polar and lift correlation to aspect ratio. Techniques for general spanwise distribution, calculation of lift and vortex induced drag, numerical problems based on above. Panel methods: General description of the panel methods.

UNIT- III **8**

Differential Equation of motion- Steady compressible flows,Small perturbation potential equations solution for subsonicandsupersonic flow. Prandtl Glauert of transformation relation for subsonic flows. Linearised and exact 2-d supersonic flows theory and its application for calculation of lift, drag and pitching moments centre of pressure.Method of characteristics Prandtl-Glauert correction and Goethert rules. Ackeret's linearised supersonic airfoil theory. Compressibility effects on aerodynamic coefficients.

UNIT –V **8**

Special Performance problem- Accelerated and asymmetric flights, Take off and landing, steady and accelerated turn, drives and other maneuvers such as turning, banking, gliding, pull-up and pull down.

Propellers momentum and blade theories- use of propeller charts, Selection and performance of fixed and variable pitch propellers, elementary concept of helicopter hovering and climbing, configurations based on torque reaction-Jet rotors and compound helicopters Methods of control collective and cyclic pitch changes - Lead - Lag and flapping hinges.

UNIT-IV **8**

Stick Fixed and free Static Longitudinal Stability-Static stability of airplane, stick fixed longitudinal stability, effect of power, Neutral point, Centre of gravity limits. In flight measurement of stick fixed neutral point.Effect of free elevator on airplane stability, elevator control force, stick force gradients. In flight measurement of stick free neutral point.

Lateral Stability and Control- Dihedral effect. Contribution of different parts of airplane controls in Roll, Aileron control power, cross coupling of lateral and directional effects.

Directional Stability And Controls-Asymmetric flight, Weather cock stability, contribution of different parts of Airplane, Rudder Fixed and Rudder free static directional stability, rudder lock.

Dynamic Stability- Introduction to dynamics, spring-mass system. Equations of motion without derivation and stability derivatives.

Longitudinal Dynamic Stability- Approximate analysis of short period and phugoid modes, stick fixed and stick-free.

Lateral and Directional Dynamic Stability- Approximate analysis of roll subsidence spiral mode and dutch roll.

Text and Reference Books :

1. John D Anderson Jr., Fundamentals of Aerodynamics, 2nd Ed., Mc Graw Hill.
2. J J Bertin and M L Smith, Aerodynamics for Engineers, 2nd Ed., Prentice Hall.
3. E. Rathakrishnan, Gas Dynamics, Prentice Hall of India.
4. R S Shevell, Fundamentals of Flight, 2nd Ed., Prentice Hall.
5. E L Houghton and N B Carruthers, Aerodynamics for Engineering Students, Arnold, 2nd Ed
6. John D Anderson Jr., Computational Fluid Dynamics, The basics with Applications, McGraw Hill, Indian Edition.
7. E.L. Houghton and A,E, Brock, Aerodynamics for Engineering students, Edward Arnold (Publishers).
8. W.F. Durand (Editor) , Aerodynamic Theory, vol, I to VI, Dover Publication , 1963 A.H. Shapiro, Dynamics and Thermodynamics od Compressible Fluid Flow, vol, I & II Ronald Press,
9. A. Ferri, Elements of Aerodynamics of Supersonic Flow, Memillan , 1949
10. C.D. Perkins and R.E. Hage, Aircraft Performance , Stability, And Control, John Wiley and Sons, 1949.
11. I.H. Abott and A.E. Von Doen hoff, Theory of Wing Sections, Dover Publication, 1959.
12. A.W. Babister, Aircraft Stability and Control, Pergamon Press, 1961.

NAE-042
AIRCRAFT SYSTEMS

L T P
3 1 0

UNIT-I8

Flight Control Systems-Principles of flight control, flight control surfaces, control surface actuation, flight control linkage systems, trim and feel. Power control, mechanical, direct drive, electromechanical, electro-hydrostatic actuation ,multiple redundancy. The fly by wire system. Airbus and Boeing implementations. Inter-relationship of flight control, guidance and vehicle management systems.

Air conditioning and Cabin pressurization- Air Supply – Sources including engine bleed, APU and ground Cart - Air-conditioning System component layout, functioning of individual components & routine checks on the system - Distribution System - Flow temperature and humidity control.

UNIT-II **8**

Fire protection system-Fire and smoke detection and warning system, Fire Extinguishers system, Portable fire extinguisher type of Fire detectors, standard operating procedures for fire on ground.

Fuel System –Characteristics of aircraft fuel systems, System layout, checks during routine servicing, and common problems in the system components. fuel system components, fuel transfer pumps, fuel booster pumps, fuel transfer valves, non return valves. Fuel quantity measurement systems, level sensors, fuel gauging probes. Fuel system operation, fuel pressurization, engine feed, fuel transfer, use of fuel as heat sink, external fuel tanks, fuel jettison, in-flight refueling. Integrated civil aircraft fuel systems.

UNIT-III **8**

Hydraulic and Pneumatic System– System layout, hydraulic reservoirs and accumulators, pressure Generation , pressure control, indication and warning system functioning of hydraulic pump. Checks on hydraulic oil. Pneumatic layout System. Pneumatic reservoirs and accumulators. pressure Generation , pressure control, indication and warning system functioning of Air Pump of Pneumatic Systems. Use of pneumatic power in aircraft. Sources of pneumatic power, the engine bleed air, engine bleed air control. Users of pneumatic power,

UNIT-IV **8**

Ice protection system– Ice formation classification and detection, anti icing system, deicing system, and working of system in general. Effect of ice formation on functioning on various systems. **Oxygen system–** system layout, supply regulation, sources, storage charging and distribution. Indications and warning Engine oxygen system, procedures for carrying out oxygen leak check, precaution while working on oxygen system.

UNIT-V8

ELECTRICAL SYSTEMS-Aircraft electrical system characteristics, power (AC and DC) generation. Power generation control, voltage regulation, parallel operation, supervisory and protection functions. Modern electrical power generation types, constant frequency, variable frequency, variable speed constant frequency types. Primary power distribution, power conversion and energy storage. Secondary power distribution, power switching, load protection. Electrical loads, motors and actuators, lighting, heating, subsystem controllers, ground power. Emergency power generation. Electrical load management system.

Text and Reference Books

1. Airframe and Power plant mechanics – Airframe hand book Civil Aircraft Injection Procedure
2. Aircraft repair manual – Lary Rethmaier.
3. Light Aircraft Inspection – J E Heywrod.
4. J V Casamassa and RD Bent, Jet Aircraft Power Systems, McGraw Hill.
5. E H J Pallet, Automatic Flight Control, BSP Profession Books.1993
6. Civil Aircraft Inspection Procedures (CAP 459), Himalayan Books.
7. W Thomson, Thrust for Flight, Sir Issac Pitman.1992
8. Michacl J. Kroes Thomas W.Wild, Aircraft Power Plants, McGraw Hill
9. Michacl J. Kroes, William A Watkins and Frank Delp, Aircraft Maintenance and Repair, McGraw Hill 1993.

NAE -043
AIRCRAFT EVALUATION

LTP

310

UNIT–I 8

Aerodynamics & performance- International Standard Atmosphere and its significance pressure and density altitudes. Compressibility effect, Mach number and its variation with altitude and temperature Take-off and landing, single engine performance at altitude, climb and descent performance at altitude, Effect of horizontal speed during climb and decent on performance and economics , Cruise performance cruise at constant speed (or Mach No.) Constant altitude, constant angle of attack and their effect on block

speed and economics Noise criteria regulatory requirements regarding noise inside the passenger cabin and at near aircraft.

UNIT-II8

Aircraft Equipment-Cockpit layout and instrumentation, automatic landing system, Air Data Computer, ICAO Landing Categories, Communication and navigation equipment and their functions in general. Flight Recorder and Cockpit Voice Recorder and related regulatory requirements. Other passenger amenities like passenger address system, crew intercom; music reproducer etc, Emergency facilities/ equipment and related regulation. Weather radar and its uses. Environmental control, air conditioning and pressurization their significance and necessity.

Service Support Equipment- Airframe spares- insurance parts and consumable, Spare engine and the criteria for their proportion to installed engines-engine spares their relation to fleet size and utilization, Accessories – Rotables and consumable items. Ground support equipment.

UNIT-III 8

AircraftScheduling-Factor affecting airlines schedules, Commercial operation, Technical Metro logical, Airport Facilitation- run –way Strength and related requirements, Load Classification. Criteria for runaway and aircraft , Air Traffic Control and other number and other ground Communication /navigation facilities-their relationship and effect on related aircraft equipment Airport emergency Facilities – Fire fighting , First Aid etc.

Total take-f weight Balance diagram, calculation of c.g., and it's variation due to variation pay load and consumables.

UNIT-IV 8

Performance Estimation: Power / Thrust availed and required Effect of altitude and forward speed on engine performance and power / thrust required, Level Flight performance, maximum minimum and optimum speeds, maximum range and endurance, Maximum rate of climb and its variation with altitude, Absolute and service ceilings, take off and landing distances, Effect of ambient temperature and wind on landing and takeoff distances, One engine take off for multi-engine civil air planes.

Longitudinal Stability- Preliminary calculations of horizontal tail setting , Static stability and static margin, V-N Diagram: Gust and maneuverability envelope.

UNIT-V 8

Principles of Aerodynamic Testing : Brief history of the development of different types of Aerodynamic testing facilities, Drop tests, Rotating f tests, Wind tunnel; types of low speeds high sub-sonic speed transonic , supersonic and hyper – sonic wind tunnels.

Description , principle of operation , types of mode tests possible areas of application and limitations of each of the facilities , Basic principles of flight testing and performance reduction.

Text and Reference Books

1. G. Corning , Supersonic and Subsonic Airplane Design, Boz No, 14 , College park , Maryland, 196,
2. K.D Wood Aerospace Vehicle Design Vol, –I Aircraft design, Johnson Publishing Co, Boulder, Colarodo

3. A. Lebedinski, Lecture notes on Aircraft Design Department of Aeronautical Engineering, Indian Institute of Science, Bangalore
4. F.K. Teichman, Air plane Design Manual , Sir Issac Pitman & sons Ltd, 1950
5. C.D. Perkins and R,E, Hage, Airplane Performance Stability and Control, John Wily and Sons inc, 1963
6. D.O. Dommasch, S,S, Sherby & T,F, Connolly, Airplane Aerodynamics , Sir Issac Pitman & sons Ltd,1961
7. I.H. Abott & A,F, Von Doenhoff, Theory of Wing Section, Dover Publication Inc, 1959,
8. S.F. Hoerner, Fluid Dynamic Drag Published by the Author, 148, Busteed Drive, MidIand Park, New Jersey 1965,
9. Royal Aeronautical Society Daa Sheets on Aerodynamics , Vol, I to V and on Performance,
10. AGARD Flight Test Manual ,
11. A.F. Donovan , H,R, Lawrence , F,E, Goddard and R,R, Gilruth (Editors) , High Speed problems of Aircraft and Experimental Methods, High Speed Aerodynamics and Jet Propulsion Series Nol, VIII, Princeton University Press, 1957,
12. A. Pope and J,J Harper , Low Speed Wind tunnel Testing , John Wiley & Sons, 1966,
13. A. Pope and L,K, Goun , High Sped Wind Tunnel Testing , John Wiley & Sons, 1965

NAE-044
INTRODUCTIONTOFINITEELEMENTMETHODS

L T P
3 1 0

UNIT-I 8

Introduction to differential equations and numerical methods for solution of differential equations; finite difference, collocation, weighted residual methods. Introduction to a second order ordinary differential equation, e.g. stretching of a bar under axial loads or the onedimensional steady-state heat conduction problem, introduction to the principle of virtual work weak formulation for differential equation, definition of energy-norm, admissible functions for approximation.

UNIT- II8

Introduction to the finite element method for given weak form, essential and natural boundary conditions, construction of basis and shape functions (Lagrangian shape functions), definition of stiffness matrix and load vector, mapping to the master domain, numerical integration, element stiffness matrix and load vector, assembly, characteristics of the matrix problem, choice of solvers for the matrix problem (skyline, banded or frontal), development of a working one dimensional finite element code.

UNIT- III8

Introduction to Euler-Bernoulli beam theory, weak formulation, smoothness requirements and Hermits shape functions, solution of problem, quality of computed quantities (e.g.displacement, shear force, bending moment), introduction to Timoshenko beam theory, shear locking, shear correction factor, reduced integration. Steady-state heat conduction problem in two-dimensions, weak formulation, boundary conditions, mesh generation, triangular or quadrilateral elements, connectivity information, linear mapping construction of shape functions (e.g. for triangles, tensor product or serendipity for quadrilaterals),

UNIT- IV 8

Introduction to plane stress and plane strain problems. Weak formulation. Essential and natural boundary conditions, construction of element stiffness matrix and load vector, solution of problem, quality of finite element stresses, post processing for better stresses. Convergence characteristics of solution, a-priori error estimates, characteristics of finite element strains and stresses (Flux); postprocessing of finite element solution for recovery of "better" stresses (nodal averaging or extrapolation from Gauss points development of a two-dimensional finite element code for the plane stress/strain problems.

UNIT- V 8

Introduction to plate theory; Kirchhoff plate theory, weak formulation; Hermite shape functions in two-dimensions, Rcissner-Mindlin plate theory, higher order plate theories.numerical integration; element stiffness matrix, element load vector, assembly, imposition of essential boundary conditions; solution, convergence characteristics of finite element solution, postprocessing of finite element fluxes. Sub parametric, isoperimetric and super parametric mappings, transformation from master to physical element; Jacobian calculation.

Text and Reference Books:

1. J.N. Reddy, An Introduction to the Finite Element Method, Mc Graw Hill International.
2. I.H. Shames and S. L. Dyin, Energy and Finite Element Methods in Structural Mechanics, New Age International Publishers Ltd.
3. O.C. Zienkiewicz and R.L. Taylor, Finite Element Methods: Vol I&II, McGraw Hill, NY.

NAE-751
Aircraft System Lab

LTP
0 0 3

Say minimum 10 out of following (or such Experiments)

- Familiarization with various avionics systems
    1. High Frequency receiver.
    2. Very High Frequency receiver.
    3. Automatic Direction Finding system
    4. VHF Omni Rang/Instrument Landing systems.
- Familiarization with pressure measuring devices and system
    1. Pitot static system
    2. Altimeters
    3. Vertical speed indicator
    4. Air speed indicator /Mach meter

5. Altitude reporting / alerting system

- Familiarization with direct reading temperature and fuel quantity gauges
    1. Temperature indicating system.
    2. Fuel quantity indicating system.
- Familiarization with gyroscopic principals
    1. Artificial horizons.
    2. Slip indicators.
    3. Direction gyros.
- Familiarization with compass systems.
    1. Magnetic compass
    2. Direct reading compass.

NAE-752
Aero Engine Lab

LTP
0 0 2

Say minimum 10 out of following (or such Experiments)

1. To demonstrate the constructional arrangement and operation of turbojet and turbo-fan.
2. To demonstrate the constructional arrangement and operation of turboprop and turbo-fan shaft.
3. Recognition of visual defects of jet engines.
4. To demonstrate the operating principal 2-stroke and 4-strock CI engines.
5. To demonstrate the operating principal 2-stroke and 4-strock SI engines.
6. To demonstrate the operatingprincipal of air cooled and water cooled piston engines.
7. To demonstrate the engine configuration and firing order.
8. To demonstrate the working of engine starting systems.
9. Installation and removal procedure of propellers.
10. Demonstrate operation of fixed and variable pitch propellers.
11. Demonstrate operation of reverse pitch propellers.
12. Attachments of turbine blades to turbine disc.
13. To demonstrate the working of exhaust gas temperature measurement system.

NAE-801
AIRCRAFT RULES AND REGULATION

L T P
3 1 0

UNIT- I 8

Rules and Regulation of Aircrafts

- Need for Rules and Regulations as they relate to registration of aircraft in India.
- Aircraft Manual, The Aircraft Act 1934, The Aircraft Rules 1937.
- Airworthiness Advisory Circulars issued by DGCA.

CAR Series A- Procedure for issue of CAR and Responsibility of operator

- Responsibility of operator/owners.
- Procedure for CAR issues.

CAR Series B- Approval of cockpit check list, MEL & CDL

- Minimum Equipment List Configuration Deviation List etc, Use of such documents.
- Preparation and use of cockpit and emergency check list.

UNIT- II 8

CAR Series C-Defect Recording, Monitoring, Investigation and Reporting.

- Defect recording, reporting, investigation, rectification and analysis.

CAR Series E- Approval of Organization.

- Requirements and procedure for issue/ extension in scope/renewal of organization in various categories: Layouts, Contents and requirements for quality control/ maintenance system/Quality Assurance/ Procedures Manuals.

UNIT -III 8

CAR Series F- Airworthiness and Continued Airworthiness,

- General requirements for maintenance and certification of aircraft including gliders, micro-light aircraft, hot air balloons and Rebuilding of Aircraft.
- Documents associated with continued airworthiness of aircraft such as certificate of airworthiness, issue Revalidation and Suspensioncertificate of airworthiness , certificate of registration, Type certificate, certificate of maintenance, certificate of flight release etc Procedures and requirements for issuance, renewal and restoration of validity of such documents, Conditions for suspension/cancellation of C of R, C of A, etc.
- Documents related with maintenance of aircraft and its components such as inspection schedules, special inspection schedules, TBO/COSL, Maintenance Planning Documents, manufacturers Literatures, Procedures for preparation and approval of such documents.
- Requirements for maintenance of aging aircraft.
- Requirements procedures and conditions for issuance of Special flight permits.

UNIT- IV 8

CAR Series H-Requirement of Aircraft fuel, Refueling of Aircraft and calibration of aircraft fuels.

- Aircraft fuelling procedures.
- Unusable fuel supply-calibration of fuel quantity gauge of aircraft.
- Aviation fuel at airport Storage, Handling and quality controls.

CAR Series I – Aircraft instrument, equipment and accessories

- General requirement for installation and maintenance of various instruments and systems installed on aircraft.
- Minimum instrument required and additional equipment as per requirement.
- Requirements for installation and maintenance of various mandatory equipments on aircraft such as CVR, DFDR, ACAS, GPWS/ EGPWSetc.
- Requirements for maintenance of test equipments.
- Airworthiness procedure for cleaned room and environment for aircraft system/ accessories shop.

UNIT -V 8

CAR Series R- Airbornecommunication, navigation & Radar Equipment.

- Installation of communication, Navigation and Radar equipment.
- Maintenance of Airborne Communication, Navigation and RadarEquipment
- Installation of mode 'a', 'c' and mode 's'transponders.
- Control of electromagnetic interference of aircraft.

CAR Series S- Storage of Aircraft parts.

- Storage condition and storage/ service life of rubber part and aircraft components containing rubber parts
- Fixation of Calendar period, for determining overhaul life of reciprocating engines.

CAR Series T-Flight Testing of aircraft.

- Flight Testing of aircraft for which a Certificate of Airworthiness haspreviously been issued.

CAR Series X-Miscellaneous requirements.

- Weight and Balance Control of Aircraft.
- Provision of medical supplies in aircraft
- Use of furniture material in aircraft.
- Aircraft Log Books.
- Documents to be carried on board by Indian Registered Aircraft.
- Procedure for issue of taxi permit.

Text and Reference Books

1. Aircraft Act. 1934 & Aircraft rules 1937 by DGCA
2. Civil Aviation Requirement Section-2 by DGCA
3. www.dgca.nic.in.

Departmental Elective-V

NAE 051

Rockets and Missiles

L T P
3 1 0

UNIT-I **8**

Rocket Propulsion Elements- Classification of propulsion systems, classification of rockets motors. Principles of chemical , electrical and nuclear rockets. General characteristics of solid and liquid propellant rockets.

Definitions and fundamentals-Total impulse, specific impulse and impulse to weight ratio. Thrust and thrust coefficient, thrust and use full power. Exhaust velocity and propulsive efficiency of a rocket motors. Mass ratio, power of the jet, combustion efficiency and internal efficiency of a rocket propulsion systems.

UNIT- II **8**

Solid propellants- Propellants characteristics, grain and grain configuration. Classifications of grains, fundamental properties of burning grain surface. Basic chemicals of solid propellants and oxidizers, fuels, binders, burning rate modifiers and plasticizers. Manufacturing of solid propellants. Propellants burning rate, burning enhancement by erosion. Thrust time trace of solid propellants rockets.

Strand burner method of temperature measurement and end burning. Grain design, tubular grain design, design principals of eternal burring starts. Elements of combustion instability. Auxiliary uses of solid propellants, gas generators.

UNIT-III8

Liquid propellants-Propellants properties specifications in view economic factors, performance of propellants, common physical hazards. Desirable physical and combustion properties. Various liquid propellants. Propellants feed systems, gas pressure feed system and turbo pump feed system

Chemical propellants-Propellant formula and mixture ratio, general expression with reactant ants initially at 298.15 K or 25 ℃ . Effects of initial speed of reactants on the adiabatic flame temperature. Calculation of equilibriums compositions, systems containing only hydrogen and oxygen and system containing hydrogen, carbon, oxygen and nitrogen. Applicability of Dalton's law to chemical rocket motors

.

UNIT-IV8

Thrust chambers- Thrust chamber for liquid propellants, injector, types of injectors. Combustion instabilities, cooling of thrust chambers, steady state methods and unsteady state method of cooling, regenerating of cooling, ablative cooling, and film cooling etc. ignition devices.

Nozzle theory and characteristics- nozzle configurations, under and over expanded nozzles, mass flow through a nozzle. Theory of isentropic convergent divergent nozzles, fundamental

equations, nozzle flow separation, effects of friction and heat transfer, effect of back pressure on nozzle flow, divergent factors. Classification of nozzles used for solid propellants rockets motors.

UNIT –V 8

Thrust vector controls and Engines controls- Thrust vector control with single nozzle and with multiple thrust chambers or nozzles. Testing of thrust vector control system. Forces acting on a vehicle in the atmosphere, effect of propulsion system on vehicle performance. Control of engine starting and thrust buildups.

Hybrids and electric propulsion- Applications of hybrid propellants. Electro thermal, electro static and electromagnetic propulsion systems.

Text and References Books

1. Barrers, M, Jaumolte, A, De Vaubeke, B,F, and Vandenkerchove, J, Rocket Propulsion, Elsevier Publishing Company 1960,
2. Hill, P,G, and Peterson, C,R,, Mechanics and Thermodynamics of Propulsion, Addison-Wesely Publishing Company 1965,
3. Penner, S,S,, Chemistry Problem in Jet Propulsion , Macmillan Company , 1957,
4. Koelle, H,H,, (Edr,) Handbook of Astronautically Engineering , McGraw – Hill Book .
5. Sulton, G,P,, Rocket Propulsion Elements, John Wiley and Sons 1963
6. Zucrow , M,J,, Aircraft and Missile Propulsion – Vol, I and II , John wiley and Sons, 1958,
7. Williams , FA, Barrere, M,, and Huang, N,C, Fundamental Aspects of Solid Propellant Rockets,
8. Lancaster, O,e, (Edr,) Jet Propulsion Engines Vol, XII High Speed Aerodynamics and jet Propulsion, Princeton University Press 1959,

NAE 052
HELICOPTER AERODYNAMICS

L T P
3 1 0

UNIT- I 8

Introduction-Helicopter as an aircraft, Basic features, Layout, Generation of lift, Main rotor, Gearbox, tail rotor, power plant, drive to main and tail rotor, considerations on blade, flapping and feathering, Rotor controls various types of rotor, Geometry of the rotor, Blade loading, Effect of solidity, profile drag, compressibility etc., Blade area required, number of Blades, Blade form, Power losses, Rotor efficiency.

UNIT –II 8

Aerodynamics of Rotor Blade- Aerofoil characteristics in forward flight, Hovering and vortex ring state, Blade stall, maximum lift of the helicopter calculation of Induced Power, high speed limitations; parasite drag, power loading, ground effect. Configurations based on torque reaction-Jet rotors and compound helicopters.Hovering performance - momentum and simple blade element theories, Figure of merit - Profile and induced power estimation - Constant chord and ideal twist rotors. Methods of control Collective and cyclic pitch changes - Lead - Lag and flapping hinges.

UNIT –III 8

Induced drags and velocity, profile and parasite power requirements in forward flight-Performance. Curves with effects of altitude- Preliminary ideas on helicopter stability.Horsepower required, Range and Endurance, Rate of Climb, Best Climbing speed, Ceiling in vertical climb, Autorotation.Various configuration - Propeller, rotor, ducted fan and jet lift - Tilt wing and vectored thrust - Performance of VTOL and STOL aircraft in hover, transition and forward motion.

UNIT –IV **8**

Types Hover height- Lift augmentation and power calculations for plenum chamber and peripheral jet machine - Drag of hovercraft on land and water. Dynamic Stability and Control : Physical description of effects of disturbances, Longitudinal dynamic stability, longitudinal stabilitycharacteristics, lateral dynamic stability, lateral stability characteristics, control responseApplications of hovercraft.Differences between stability and control of airplane and helicopter.

UNIT- V **8**

Rotor Vibrations- Dynamic model of the rotor, Motion of the rigid blades, flapping motion, lagging motion, feathering motion, Properties of vibrating system, phenomenon of vibration, fuselage response, vibration absorbers, Measurement of vibration in flight. Rotor Blade Design: General considerations, Airfoil selection, Blade construction, Materials, Factors affecting weight and cost, Design conditions, Stress analysis.

Text and Reference Books

1. Gessow, A., and Myers, G,C., “Aerodynamics of Helicopter”, Macmillan &Co., N.Y. 1987.
2. McCormick, B,W., “Aerodynamics of V/STOL Flight”, Academic Press, 1987.
3. John Fay, The Helicopter and How It Flies, Himalayan Books 1995.
4. Lalit Gupta, Helicopter Engineering; Himalayan Books New Delhi 1996.
5. Joseph Schafer, Basic Helicopter Maintenance, Jeppesen 1980.
6. R W Prouty, Helicopter Aerodynamics
7. . Johnson, W., “Helicopter Theory,” Princeton University Press, 1980.
8. M cCormick, B,W., “Aerodynamics, Aeronautics and Flight Mechanics” John Wiley, 1995.
9. Gupta, L., “Helicopter Engineering”, Himalayan Books, 1996.

NAE -053
AVIONCS II

L T P
3 1 0

UNIT -I **8**

Radar Engineering - Radar definition, Radar range equation, pulsed, CW and Doppler Radars, MTI, Noise Figure Consideration, various types of radar displays, Detection of radar signals in Noise. **Microwave Engineering** -Various types of radar transmission Lines, Rectangular and circular waveguides, coaxial lines, field patterns, modes (high order and evanescent), passive components (eg. Directional couplers, filters, isolators and circulators.).

UNIT- II **8**

Guided Transmission- Rectangular and Circular waveguides, coaxial lines, field patterns, high order and evanescent modes, passive components (e.g. directional couplers, filters, isolators, circulators).

Devices and Generators: Characteristics of magnetron, klystron, back ward wave oscillator, solid –state sources, Amplifiers, characteristics of traveling wave tubes and parametric amplifiers, Diode detectors and mixers.Diode detectors and mixers. Aerials and Propagation : Antenna theory, various types of antenna for medium wave, short wave, VHF and UHF frequencies, propagation at microwave frequencies, atmospheric attemptation, effects of precipitation, reflection, Refraction and Diffraction phenomenon, clutter signals.

UNIT- III **8**

Aerials & Propagation- Antenna theory, Medium wave, short wave, VHF and UHF antennas Microwave antennas, Waveguide techniques, Properties of open ended wave guides, horns reflectors and slotted arrays, Propagation at microwave frequencies, atmospheric attenuation, effects of precipitation, effects of diffraction by hills – and buildings, clutter signals.

UNIT- IV **8**

Systems- Description and relevant theory for point –to –point and satellite links, pulse, Doppler and frequency modulated radars, block diagrams of transmitters and receivers.

Special Systems (Principles)- Analog and Digital Computers for aeronautical application , Head –up displays.

UNIT- V **8**

Electronic Navigation- maps and charts, classification of navigation systems, pilot age, viz dead rocking celestial and radio navigation, Radio direction finding at medium, high and very high frequencies, The radio compass and automatic direction finders, Radio ranges-medium frequency and VHF Omni directional ranges, Hyperbolic navigation systems, Loran and Decca, TACAN, Aids to approach and landing, The standard ILS and Ground Control Approach Systems, Dead reckoning navigation systems, Doppler navigational and inertial navigation, The technology of navigational instruments.

References:

1. M.I. SkoInik: Introduction to Radar Systems, (McGraw Hill).
2. G.J. Sonnenberg: Radar and Electronic Navigation.
3. B.S. Walker: Introduction to Computer Engineering.
4. M. Kayton and W, Fried: Avionic Navigation Systems (Wiley, New York).
5. Povessil Rayen and Waterman: Airborne Radar (Van Nostrand 1961).

NAE -054
SPACECRAFT TECHNOLOGY

L T P
3 1 0

UNIT- I **8**

BASIC CONCEPTS-The Solar System – References Frames and Coordinate Systems – The celestial Sphere , The Ecliptic Motion of Vernal Equinox – Sidereal Time – Solar Time –Standard Time – The Earth's Atmosphere.Study the basic concepts of orbital Mechanics with particular emphasis on interplanetary trajectories

UNIT- II **8**

THE GENERAL N-BODY PROBLEM-The many body Problem – Langrange, Jacobian identity The Circular Restricted Three Body Problem – Libration Points – Relative Motion in the N-body Problem – Two – Body Problem – Satellite Orbits – Relations Between Position and Time – Orbital Elements.

UNIT- III **8**

SATELLITE INJECTION AND SATELLITE ORBIT PERTURBATIONS-General Aspects of satellite Injections – Satellite Orbit Transfer – Various Cases – Orbit Deviations Due to Injection – Errors – Special and General Perturbations – Cowell's Method – Encke's Method – Method of vibrations of Orbital Elements – General Perturbations Approach.

UNIT –IV **8**

INTERPLANETARY TRAJECTORIES-Two Dimensional Interplanetary Trajectories – Fast Interplanetary Trajectories – Three Dimensional Interplanetary Trajectories – 3-Dimensional Interplanetary Trajectories – Launch if Interplanetary Spacecraft – Trajectory about the Target Planet.

UNIT- V **8**

BALLISTIC MISSILE TRAJECTORIES AND MATERIALS-The Boost Phase – The Ballistic Phase – Trajectory Geometry – Optimal Flights – Time of Flight – Re-entry Phase – The Position of the Impact Point – Influence Coefficients. Space Environment - Peculiarities - Effect of Space Environment, the Selection of Spacecraft Material.

Text and Reference Books.

1. Cornelisse, J.W. "Rocket Propulsion and Space Dynamic", W.H. Freeman & Co., 1984.
2. Sutton, G.P., "Rocket Propulsion Elements", John Wiley, 1993.
3. Van de Kamp, P., "Elements of Astromechanics", Pitman, 1979.
4. Parker E.R., "Material for Missiles and Spacecraft", McGraw – Hill Book Co., Inc., 1982.

Departmental Elective –VI

NAE -061

AIRCRAFTDESIGN& TESTING

L T P
3 1 0

UNIT- I 8

Preliminaries-Historical Developments of AirplanesAircraft Design Requirements, specifications, role of users, Aerodynamicand Structural Consideration, Importance of weight. Airworthiness requirements and standards. classifications of airplanes. Special features of modern airplane. Air Loads in Flight, symmetrical measuring loads in flight, Basic flight loading conditions, Load factor, Velocity - Load factor diagram, gust load and its estimation V-N diagram and Inertial loads Structural limits. Manufacturing procedures.

UNIT- II 8

Structural Design- Cockpit and aircraft passenger cabin layout for different categories, types of associated structure, features of light airplanes using advanced composite materials. Structural aspects of design of airplane, Bending moment and shear force diagram. Design principles of all metal stressed skin wing for civil and military applicationsLanding Gears : Different kinds of landing gears, Preliminary calculations for locating main and nose landing gears. Integration of structure and Power Plant.

UNIT- III 8

Airplane Weight Estimation- Weight estimation based on type of airplane, trends in wing loading, weight-estimation based on mission requirements, iterative approach.Basics of Wing Design, Selection of airfoil selection, influencing factors. Span wise load distribution and planform shapes of airplane wing. Stalling, take off and landing considerations. Wing dragsestimation. High lift devices. Estimation of Horizontal and Vertical tail volume ratios. Choice of power plant and various options of locations, considerations of appropriate air-intakes. Integration of wing, fuselage, empennage and power plant. Estimation of centre of gravity.

UNIT- IV 8

Aircraft Testing-Aerodynamic testing facilities for different speed regimes, low speed wind tunnels, main features of supersonic, transonic and hypersonic tunnels, shock tunnels, closed and open circuit tunnels. Design of contraction and diffuser and other components. Instrumentation and calibration of test section. Testing procedure, data reduction, blockage effects and boundary layer corrections, correction to lift drag, moment coefficient due to wind tunnel wall interference.

UNIT –V 8

Measuring devices in test Section- Pitot tube static tube, yaw probes, five hole probe, hot wire anemo-meters, scan valve system. Flow visualization techniques oil flow, tuft survey and smoke. Flow field pressure measurements, Schlieren, shadowgraph and interferometer technique, laser Doppler, hot wire PIV technique , Wind tunnel balances, mechanical and strain gauge balances and their design. Scale effects. Non - aeronautical use of wind tunnels.

Text and Reference Books.

1. Daniel P Raymer, Aircraft Design: A conceptual approach, AIAA Series, 1992.
2. D Stinton, The Design of Airplane, GRANADA, UK 1983.
3. John D Anderson (Jr.), Airplane Performance and Design, McGraw Hill 1999.
4. E Torenbeek, Synthesis of Airplane Design.
5. L M Nicholai, Fundamentals of airplane Design, Univ. of Dayton DHIO, 1975.

NAE -062
VIBRATION AND AEROELASTICITY

L T P
3 1 0

UNIT I **8**

Rectilinear motion of a particle- Differential equation of motion in resisting medium , Free vibrations with viscous damping, Forced ration with harmonic disturbing force and general disturbing force , plane harmonic motion , Motion of a projectile with and without damp , motion of a particle subjected to a central force: planetary motion.

UNIT II **8**

Dynamics of a System of Particles: Principle of Linear momentum and regular momentum, Rectilinear motion of a variable mass: Rockets, Kinetic energy and work, Law of conservation of energy.
Dynamics of a System with Constraints: Equations of constraints , generalized coordinates, Generalized forces, Equations of equilibrium, Generalized co-ordinates, Application of generalized coordinates in bending of beams, D' Alembert's principle, Lagrange's equation and applications, Hamilton's principle and application.

UNIT III **8**

Small Oscillations of Conservative Systems: Free vibrations of servative systems, Linear oscillations of two coupled masses , Free variation of system with two degrees of freedom and system "with several degrees of freedom, Principal modes and their orthogonal property, Normal modes static coupling and dynamic coupling, Approximate methods of calculating principal frequencies.

UNIT IV **8**

Dynamics of Elastic Bodies: Vibration of a string under tension , Free vibration of beams with various end condition and the determination of the various modes of vibrations and their natural frequencies, variation of beams with concentrated masses , Critical speed of a rotating Forced vibration of beams, Tensional vibration of a shaft and –shaft combination , Approximate methods of calculating natural frequencies.

UNIT V **8**

Aero elasticity- Elements of aero elasticity , General nature of acrostic problems, Nature of static aeroelastic phenomenon , Wing diver, Gene and control system reversal for an idealized tow dimensional wing and approximate solution for a finite wing , Flutter phenomena and flutter analysis Difference

between flutter instability and resonance , Simplified expressions for aerodynamic forced and moments for an oscillating airfoil, Determination of flutter speed and frequency for an idealized two dimensional wing as well as for a finite wing, Methods of flutter control and prevention, Elementary theory of buffeting.

References:

1. S. Timoshenko, Vibration Problems in Engineering , Van Nonstrand 1959.
2. W.T. Thomson, Vibration Theory and Application, Allen and Unwin 1966.
3. S. Timoshenko & D,H Young; Engineering Mechanics.
4. S. Timoshenko and D,H, Young, Advanced Dynamics , McGraw Hill , 1948.
5. Y.C. Fung, Introduction to the Theory of Aeroelasticity, Addison Wesley , 1965.

NAE -063
COMPUTATIONALFLUIDDYNAMICS(CFD)

L T P
3 1 0

UNIT –I **8**

Introduction to Computational Fluid Dynamics-Principles of Conservation-Continuity Equation, Nervier Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behavior, Approximate Solutions of Differential Equations- Error Minimization Principles, Variation Principles and Weighted Residual Approach, Fundamentals of equation.

UNIT –II **8**

Fundamentals of Discretization- Finite Element Method, Finite Difference and Finite Volume Method, Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and discretization of unsteady state Problems**.** Equations of fluiddynamics and their classification. Boundary conditions.

Finite difference schemes- Projection and truncation error, Stability, consistency, accuracy and convergence of numerical schemes.

UNIT-III **8**

Basics of Finite Volume Method - Equations in integral form, numerical flux at cell faces, upwind methods, flux - vector splitting, flux- difference splitting, shock capturing methods. Introduction to CFD CFD as a design tool; explicit and implicit methods; O,C,H types of grids, various space discretization methods such as FDM, FVM, FEM; concept of state. update formula. meshes.ImportantConsequences of discretization of time dependent diffusion type problems and stability analysis.

UNIT –III **8**

Basics of Finite Element Method - Isoperimetric elements, bilinear and tri-linear elements. Numerical Integration, space function, Petrov- Galerkin method. Grid generation: algebraic and PDEbased methods, O-, C-, H-type topologies, unstructured meshes, hybridTime marching methods. FDM applied to linear advection - diffusion equation, MacCormack scheme and its application to Euler and N-S equations.

UNIT –IV **8**

LAX Equivalence theorem, Grid independent and time independent study, Stability analysis of parabolic equations (1-D unsteady state diffusion problems):FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dufort-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Finite Volume Discretization of 2-D unsteady State Diffusion type Problems.

UNIT- V **8**

Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Gradient Search Methods, Discretization ofConvection-Diffusion Equations: A Finite Volume Approach, Discretization of Navier Stokes Equations- Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation.

Text and Reference Books:

1. T J R Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice Hall
2. O C Zicnkievicz and RL Taylor, The Finite Element Method, Vol I&II, McGraw Hill, Indian Ed.
3. John D Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill, Indian Edition
4. Charles Hirsch, Numerical Computation of Internal and External Flows, Wiley Series in Numerical Methods in Engineering, Indian Edition.

NAE -064
GROUNDHANDLING AND SUPPORTSYSTEMS

L T P
3 1 0

UNIT –I **8**

General knowledge of ground handling of Aircraft, Aircraft Safety; Mooring, Jacking, Leveling, Hoisting of aircraft, Towing, Mooring of an a/c during adverse conditions. Aircraft cleaning and maintaining. Ground signaling/marshalling of aircraft in day & night time, Brief knowledge of the signals given by the control tower.

UNIT- II **8**

Knowledge of Airfield lighting system, Aircraft Rescue & Fire Fighting. Maintenance and handling of ground equipments used in maintenance of aircraft. Compressors, Portable hydraulic test stands, Electrical power supply equipment, charging trolley. Air-conditioning and Heating unit, Ground support air start unit. Pressure oil unit, Fire extinguishers, jacks, Hoisting cranes/gantry, Ladders, Platforms, Trestles, Chocks.

UNIT –III **8**

Knowledge of safety and fire precautions to be observed duringrefueling, defueling. Maintenance including refueling, defueling & engine start. Maintenance of hydraulic accumulators, reservoirs and filters: Maintenance of landing gear (L/G), Shock strut charging and bleeding, Maintenance of L/G brakes i.e., Dragging, Grabbing, Fading, Brakes and excessive brake pedal travel.

UNIT –IV **8**

Maintenance on wheels, tires and tubes i.e dismantling, inspection, assembling, inflating, inspection and installation Rigging of flight control surfaces and duplicate inspection; Rigging checks-Angular alignment checks and symmetry checks, Knowledge and use of Tension meters, Protractors etc. Storage of ratable.

UNIT –V **8**

Reliability and Maintainability -Definition Probabilistic nature of failures - Mean failure rate - Meantime between failures - Hazard rate - Hazard models, Waybill model - System reliability improvement - Redundancy - Series - Parallel and Mixed configurations.

Introduction - Choice of maintenance strategy - Mean time- to repair (MTTR) - Factors contributing to Mean Down Time (MDT) - Fault diagnosis, and routine testing for unrevealed faults - Factors contributing to Mean Maintenance Time - (MMT) on condition maintenance - Periodic condition monitoring – Continuous condition monitoring - Economics of maintenance.

Text and Reference Books.

1. Airframe &Power plant Mechanics, General Handbook AC65-9A By US Department of Transpiration, FAA.
2. Airframe &Power plantMechanics, Airframe Handbook AC 65-15A By US Dept. of Transportation, FAA.
3. Civil Aircraft Inspection Procedure, Part - II- Aircraft.
   a) AL/3-6 - Landing Gear (b) AL/3-7- Control Systems
   c) AL/3-8 to AL/3-10 – Fire (d) AL/3-18 to AL/3-20 - Tyres, Wheels & Brakes
   e) Al/3-21 - Hydraulic systems (f) GOL/1-1 & GOL/1-2 - Ground Operations
4. Michacl J Kroes and William A Watkins, Aircraft Maintenance and Repair, McGraw Hill.
5. Civil Aviation Requirement - Section - 2- Airworthiness Series H for Saftey & Fire Precautions in Fuelling &Defueling issued by DGCA.