Course Structure and syllabus for 3rd year I Semester (2009 Regulations)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

B.TECH. AERONAUTICAL ENGINEERING

III YEAR I SEMESTER **COURSE STRUCTURE**

Code	Subject	L	T/P/D	C
	Management Science	3	1	3
	Flight Mechanics- II	4	1	4
	Aerodynamics– II	4	1	4
	Aerospace Vehicle Structures– II	3	1	3
	Aerospace Propulsion- I	4	1	4
	Air Transportation Systems	3	1	3
	Aerospace Structures Lab	0	3	2
	Aerodynamics and Propulsion Lab	0	3	2
	Total	**21**	**12**	**25**

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MANAGEMENT SCIENCE

Unit I

***Introduction to Management*:** Entrepreneurship and organization - Nature and Importance of Management, Functions of Management, Taylor's Scientific Management Theory, Fayol's Principles of Management, Maslow's Theory of Human Needs, Douglas McGregor's Theory X and Theory Y, Herzberg's Two-Factor Theory of Motivation, Systems Approach to Management, Leadership Styles, Social responsibilities of Management.

Unit II

***Designing Organisational Structures*:** Departmentation and Decentralisation, Types of Organisation structures - Line organization, Line and staff organization, functional organization, Committee organization, matrix organization, Virtual Organisation, Cellular Organisation, team structure, boundaryless organization, inverted pyramid structure, lean and flat organization structure and their merits, demerits and suitability.

Unit III

***Operations Management*:** Principles and Types of Plant Layout-Methods of production (Job, batch and Mass Production), Work Study -Basic procedure involved in Method Study and Work Measurement-Statistical Quality Control: $\overline{X}$ chart, R chart, *c* chart, *p* chart, (simple Problems), Acceptance Sampling, Deming's contribution to quality.

Unit IV

***A) Materials Management*:** Objectives, Need for Inventory control, EOQ, ABC Analysis, Purchase Procedure, Stores Management and Stores Records - Supply Chain Management

***B) Marketing*:** Functions of Marketing, Marketing Mix, Marketing Strategies based on Product Life Cycle., Channels of distribution.

Unit V

Human Resources Management (HRM): Evolution of HRM, Concepts of HRM, Basic functions of HR Manager: Manpower planning, Recruitment, Selection, Training and Development, Placement, Wage and Salary Administration, Promotion, Transfer, Separation, Performance Appraisal, Grievance Handling and Welfare Administration, Job Evaluation and Merit Rating.

Unit VI

***Project Management (PERT/CPM*):** Network Analysis, Programme Evaluation and Review Technique (PERT), Critical Path Method (CPM), Identifying critical path, Probability of Completing the project within given time, Project Cost Analysis, Project Crashing. (simple problems)

Unit VII

***Strategic Management*:** Mission, Goals, Objectives, Policy, Strategy, Programmes, Elements of Corporate Planning Process, Environmental Scanning, SWOT Analysis, Steps in Strategy Formulation and Implementation, Generic Strategy alternatives.

Unit VIII

***Contemporary Management Practices*:** Basic concepts of Just-In-Time (JIT) System, Total Quality Management (TQM), Six sigma and Capability Maturity Model (CMM) Levels, Value Chain Analysis,Enterprise Resource Planning (ERP), Performance Management, Business Process outsourcing (BPO), Business Process Re-engineering 5S Model, Deming's PDCA, Kaizen, Poka-Yoke, Muda, Benchmarking, Balanced Score Card.

TEXT BOOK:

1. Aryasri: *Management Science*, TMH, New Delhi, 2009

REFERENCE BOOKS:

1. Stoner, Management, Pearson, 2009
2. Kotler Philip & Keller Kevin Lane: Marketing Management PHI, 2009.
3. Koontz, Weihrich, & Aryasri: Principles *of Management*, TMH, 2009.
4. Thomas N.Duening & John M.Ivancevich *Management—Principles and Guidelines,* Cengage, 2009.
5. Kanishka Bedi, *Production and Operations Management*, Oxford University Press, 2009.

6. Memoria & S.V.Ganker, *Personnel Management*, Himalaya, 2009
7. Schermerhorn: *Management*, Wiley, 2009.
8. Parnell: Strategic Management, Biztantra, 2009.
9. L.S.Srinath: PERT/CPM,Affiliated East-West Press, 2009.
10. William J. Stevenson & Ceyhun Ozgur: Introduction to Management Science, TMH, 2007.

Pre-requisites: Managerial Economics

***Objective*:** To familiarize with the process of management and to provide basic insights into select contemporary management practices.

Codes/Tables: Normal Distribution Function Table need to be permitted into the examination Hall.
Question Paper Pattern: 5 Questions to be answered out of 8 questions. The question paper should contain atleast 2 practical problems, one each from units –III & VI
Each question should not have more than 3 bits.
Unit VIII will have only short questions, not essay questions.

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FLIGHT MECHANICS – II

UNIT- I

AIRCRAFT IN EQUILIBRIUM FLIGHT- ELEVATOR ANGLE AND STICK FORCES TO TRIM- LONGITUDINAL STATIC AND MANEUVER STABILITY- I

Need for controlled flight- aircraft mission profile- means of control- task of pilot, aircraft handling qualities.

Equilibrium, stability, control, trim- definitions- examples from simple mechanical systems. Longitudinal forces and moments on aircraft in unaccelerated flight- contribution of principal components. Equations of equilibrium- thrust, angle of attack, elevator angle required to trim. Control gradient, airplane lift curve slope and pitch stiffness. Tailless aircraft and aircraft with foreplanes.

Effect of flaps and flight speed on force and moment coefficients, velocity derivatives. Longitudinal static stability- definition, relation to control gradient, pitch stiffness. Stick fixed neutral point- static margin. Equivalence of neutral point and aircraft aerodynamic centre- validity.

UNIT- II

AIRCRAFT IN EQUILIBRIUM FLIGHT- ELEVATOR ANGLE AND STICK FORCES TO TRIM- LONGITUDINAL STATIC AND MANEUVER STABILITY- II

Equations of motion in steady, symmetric pull-up maneuvers and coordinated turns- pitch rate, pitch damping. Control to trim, control gradient- maneuver point, maneuver margin- relation to static margin.

Trim curves- trim and control of highly stable, marginally stable and unstable aircraft- safety implications. Effect on pilot's task. Statutory limits on forward-most and aft-most positions of centre of gravity. Determination of neutral and maneuver points by flight testing.

Elevator hinge moments, coefficients- relation to control stick forces. Hinge moment derivatives. Stick force to trim in symmetric unaccelerated flight, maneuvering flight. Stick force gradients- effect of trim speed- role of trim tab. Effect of freeing elevator on tail effectiveness, static and maneuver stability. Elevator-free factor. Stick-free neutral and maneuver points, stability margins- relation with stick force gradients. Aerodynamic and mass balancing of control surfaces. Control tabs- types, function, construction.

UNIT- III

LATERAL-DIRECTIONAL STATIC STABILITY AND TRIM

Lateral-directional motions, aerodynamic forces and moments, coupling- aircraft side force, rolling moment and yawing moment, due to side slip, aileron and rudder- static aerodynamic derivatives. Contribution of vertical tail, side wash rate, wing dihedral, sweep, position on fuselage- high angle of attack operations. Lateral-directional stability requirements, aileron, rudder control powers, adverse aileron yaw. Gravity forces.

Equilibrium of forces and moments. Aileron, rudder, elevator and thrust required to trim aircraft in steady sideslip, roll, coordinated turn, engine out condition. Cross wind landings.

UNIT- IV

ESTIMATION OF AERODYNAMIC FORCE AND MOMENT DERIVATIVES OF AIRCRAFT

Significance of aerodynamic derivatives. Derivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle. Derivatives of side force, rolling and yawing moments with respect to the angle of sideslip, rate of sideslip, roll rate, yaw rate, aileron, rudder deflections- dependence on vehicle geometry, flight configuration- estimation- the strip theory method. Lateral and directional stability, roll and yaw damping, aileron and rudder power, the cross derivatives. Relation between dimension-less and dimensional aerodynamic derivatives.

UNIT- V

AIRCRAFT EQUATIONS OF MOTION

Description of motion of flight vehicle- systems of reference frames- earth, body, wind, stability axes- relative merits. Euler angles, angles of attack and sideslip– definitions- earth to body axis transformation, stability axis to body axis transformation. Rotating axis system- expressions for linear and angular momenta of rigid body, time derivatives- inertia tensor, components of linear and angular velocities, accelerations. Components of aerodynamic, gravity forces, moments applied on flight vehicle. Equations of motion- longitudinal and lateral-directional. Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system. Determination of vehicle trajectory- outline of method.

UNIT- VI

PERTURBED MOTION- LINEARISED, DECOUPLED EQUATIONS OF MOTION OF AIRCRAFT

Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition. Equation of motion in perturbation variables. Assumption of small perturbations, first order approximations- linearised equations of motion. Decoupling- conditions for validity, role of symmetry. Linearised longitudinal and lateral-directional equations of perturbed motion.

UNIT- VII

AIRCRAFT DYNAMIC STABILITY- LONGITUDINAL

Review of solutions of first and second order ordinary differential equations. - time constant, undamped natural frequency and damping ratio. Linearised longitudinal equations of motion of aircraft - three degree of freedom analysis- solutions- principal modes of motion- characteristics. Mode shapes- significance. Two degree of freedom constant speed approximation, constant angle of attack approximation, one degree of freedom approximations- solutions- comparison with three degree of freedom solutions- justification of approximations.

UNIT- VIII

AIRCRAFT DYNAMIC STABILITY- LATERAL-DIRECTIOAL

Lateral directional equations- three degree of freedom analysis, principal modes- characteristics- mode shapes- significance, lower order analysis- approximate solutions. Determination of longitudinal and lateral stability from coefficients of characteristic equation- stability criteria, approximate roots. Special problems in aircraft dynamics- roll coupling, high angle of attack operation. Aircraft spin- entry, balance of forces in steady spin, recovery, pilot techniques.

TEXT BOOKS

1. Yechout, T.R. et al., *Introduction to Aircraft Flight Mechanics*, AIAA education Series, 2003, ISBN 1-56347-577-4.
2. Nelson, R.C., *Flight Stability and Automatic Control*, 2nd edn., Tata McGraw Hill, 2007, ISBN 0-07-066110-3.

REFERENCES

1. Etkin, B. and Reid, L.D., *Dynamics of Flight*, 3rd edn., John Wiley, 1998, ISBN 0-47103418-5.
2. Schmidt, L.V., *Introduction to Aircraft Flight Dynamics*, AIAA Education Series, 1998, ISBN A-56347-226-0.
3. McCormick, B.W., *Aerodynamics, Aeronautics, and Flight Mechanics*, 2nd edn., Wiley India, 1995, ISBN 978-

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AERODYNAMICS – II

Tables and charts required to be supplied to candidates for reference during examination:

- *Tables:*
  - *1. Isentropic Flow Properties, 2. Normal Shock Properties, 3. Prandtl – Meyer Function and Mach Angle, 4. One Dimensional Flow with Heat Addition, 5. One Dimensional Flow with Friction, 6. Properties of International Standard atmosphere and*
- *Chart:*
  - *7. Oblique Shock Properties.*

UNIT– I COMPRESSIBLE FLOWS

Definition of compressibility of flow, measure, flow regimes. Review of thermodynamics - internal energy and enthalpy, first law of thermodynamics, entropy and second law, isentropic relations. Governing equations for inviscid compressible flow- speed of sound, stagnation conditions. Special forms of energy equation.

UNIT– II ONE-DIMENSIONAL FLOWS

Governing equations, speed of sound and Mach number, forms of energy equation, Normal shock waves, basic equations, Hugoniot equation, calculation of normal shock wave properties, measurement of air speed in compressible subsonic and supersonic flows. One-dimensional flow with heat addition, friction- thermal and friction choking.

UNIT– III OBLIQUE SHOCK AND EXPANSION WAVES

Oblique shock relations, supersonic flow over wedges and cones, shock polar, regular reflections from solid boundary, pressure deflection diagrams, intersection of shocks, Mach reflection, detached shock wave in front of a bluff body, three dimensional shock waves, Prandtl-Meyer expansion waves, shock expansion theory- application to supersonic airfoils. Viscous boundary layer - effects of compressibility, shock-boundary layer interactions.

UNIT– IV QUASI-ONE DIMENSIONAL COMPRESSIBLE FLOWS

Adiabatic flow in straight, variable area channels- nozzles, diffusers. Governing equations, area-velocity relation. Mass flow rate, effect of stagnation conditions, back pressure. Choked flow- isentropic flow, ideally expanded, over-expanded, under-expanded flows- appearance of normal shock- flow losses. Wave reflection from free boundary, Operation of supersonic wind tunnels.

UNIT– V SUBSONIC AND TRANSONIC COMPRESSIBLE FLOWS

The velocity potential, perturbation potential, governing equation of flow- linearization. The pressure coefficient- Prandtl-Glauert compressibility correction, application to swept wings, improved compressibility corrections, second order theory, critical Mach no., drag divergence Mach no., the sound barrier. Supercritical airfoils, swept wings at transonic speeds, wing-body interactions, area rule, forward swept wings, transonic aircraft.

UNIT– VI LINEARISED SUPERSONIC FLOWS

Linearised supersonic flow- governing equations, boundary conditions. Pressure coefficient, application to supersonic airfoils. Lift, drag, pitching moment, symmetric and asymmetric double wedge and biconvex airfoils. General airfoil section. Second order theory, shock expansion technique. Supersonic airfoils. Flow, airloads over wings of finite span- supersonic leading edge and subsonic leading edge, delta wings. Method of characteristics- application to supersonic nozzle design.

UNIT- VII SUPERSONIC FLOW OVER WINGS AND AIRPLANE CONFIGURATIONS

Three dimensional supersonic flow- governing equation and boundary conditions, consequences of linearity, solution methods- conical flow method – rectangular, swept, delta and arrow wings. Singularity distribution method. Design considerations for supersonic aircraft, aerodynamic interaction. Aerodynamic analysis of complete aircraft configurations in supersonic stream. Effect of Mach number on zero lift drag of two and three dimensional shapes.

UNIT– VIII HYPERSONIC FLOWS

Qualitative aspects of hypersonic flow, hypersonic shock wave relations, Newtonian flow model, stagnation region flow properties, modified Newtonian flow. Lift and drag of flat plate wings at hypersonic speeds. Hypersonic shockwave relations- Mach no. independence, law of hypersonic similarity. High L/D hypersonic configurations – wave riders. Aerodynamic heating.

TEXT BOOKS

1. Bertin, J.J., *Aerodynamics for Engineers*, 4th edn., Indian reprint, Pearson Education, 2004, ISBN: 81-297-0486-2
2. Anderson, J.D., *Modern Compressible Flow with Historical Perspective*, 3rd edn., McGraw-Hill, 2003, ISBN: 0-07-112161-7.
3. Kroo I.,*Applied Aerodynamics: A Digital Textbook*, Desktop Aeronautics Inc., http://www.desktopaero.com/appliedaero/preface/welcome.html

REFERENCES

1. Liepmann, H.W., and Roshko, A., *Elements of Gas Dynamics*, John Wiley, 1957.
2. McCormick, B.W., *Aerodynamics, Aeronautics & Flight Mechanics*, 2nd edn., John Wiley, 1995, ISBN: 0-471-57506-2.
3. Shapiro, A.H., *The Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I and II*, John Wiley, 1953.
4. Landau, L.D., & Lifshitz, E.M., *Fluid Mechanics*, 2nd edn., Course of Theoretical Physics, vol. 6, Maxwell Macmillan International Edition, Pergamon, 1989, ISBN: 0-02-946234-7.

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AEROSPACE VEHICLE STRUCTURES- II

UNIT- I THIN PLATE THEORY- THIN PLATES SUBJECTED TO BENDING, TORSION, TRANSVERSE AND IN-PLANE LOADING

Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading- thin plates having small initial curvature, energy methods of analysis.

UNIT- II STRUCTURAL INSTABILITY- BUCKLING OF THIN PLATES AND STIFFENED PANELS

Buckling of thin plates- elastic, inelastic, experimental determination of critical load for a flat plate, local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams- complete diagonal tension, incomplete diagonal tension, post buckling behaviour.

UNIT- III BENDING AND SHEAR OF THIN WALLED BEAMS

Review of symmetrical bending of beams, unsymmetrical bending- resolution of bending moments, direct stress distribution, position of neutral axis. Deflections due to bending- approximations for thin walled sections, temperature effects.

Shear loaded thin walled beams- general stress, strain and displacement relationships- direct stress and shear flow system- shear centre, twist and warping.

UNIT- IV TORSION OF THIN WALLED BEAMS

Torsion of beams of closed section- displacements associated with Bredt-Batho shear flow. Torsion of open section beams. Warping of cross section- conditions for zero warping. Bending, shear, torsion of combined open and closed section beams.

UNIT- V STRUCTURAL IDEALISATION OF THIN WALLED BEAMS

Structural idealization- principal assumptions, idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading- application to determining deflection.

UNIT- VI STRUCTURAL AND LOADING DISCONTINUITIES IN THIN WALLED BEAMS

Closed section beams- shear stress distribution of a closed section beam built in at one end under bending, shear and torsion loads.

Open section beams- I section beam subjected to torsion, torsion of beam of arbitrary section, torsion bending constant, distributed torque loading- extension of theory for general systems of loading.

Shear lag- effect of shearing strains in beams- redistribution of bending stresses due to restraining of warping, limitation of elementary bending theory, effect of accounting for shear lag on the estimated strength.

UNIT- VII STRESS ANALYSIS OF AIRCRAFT COMPONENTS- WING

Wing spars and box beams- tapered wing spar, open and closed section beams, beams having variable stringer areas. Wings- Three-boom shell in bending, torsion, shear, tapered wings, deflections, cut-outs in wings.

UNIT- VIII STRESS ANALYSIS OF AIRCRAFT COMPONENTS- FUSELAGE

Bending, shear, torsion, cut-outs in fuselages. Fuselage frames and wing ribs- principles of stiffener/ web construction, fuselage frames, wing ribs.

TEXT BOOKS

1. Megson, T.H.G., *Aircraft Structures for Engineering Students*, 4th edn., Elsevier, 2007, ISBN 0-750-667397.
2. Peery, D.J. and Azar, J.J., *Aircraft Structures*, 2nd edn., McGra-Hill, 1982, ISBN 0-07-049196-8.

REFERENCES

1. Allen, D.H. and Haisler, W.E., *Introduction to Aerospace Structural Analysis*, John Wiley, 2010.
2. Niu, M.C., *Airframe Analysis and Sizing*, 2nd edn., Hongkong Conmilit Press, 1999, ISBN 962-7128-08-2.
3. Niu, M.C., *Airframe Structural Design*, 2nd edn., Hongkong Conmilit Press, 2002, ISBN 962-7128-09-0.
4. Bruhn. E.H, *Analysis and Design of Flight Vehicles Structures*, Tri-state Off-set Company, USA, 1965.
5. Lakshmi Narasaiah, G., *Aircraft Structures*, BS Publications, 2010.
6. Rivello, R.M., *Theory and Analysis of Flight Structures*, McGraw Hill, 1993.
7. Sechler.E.E. and Dunn, L.G., *Airplane Structural Analysis and Design*, John Wiley & Sons.

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AEROSPACE PROPULSION- I

UNIT-I FLIGHT PROPULSION- AIRCRAFT GAS TURBINE ENGINES- GENERATION OF THRUST- ENGINE PERFORMANCE PARAMETERS

History of flight propulsion. Role of reciprocating engines. Operating envelope of flight vehicles. Engine operational limits. Air breathing engines- types. Aircraft gas turbine engines- types, operating principles, distinguishing features- schematic diagrams, relative merits, applications. Engine components- function, schematic diagram, layout, engine station numbering. Thrust generation- momentum equations. Gross, net, uninstalled, installed thrust, propulsive efficiency. Engine performance parameters- specific thrust, specific fuel consumption, total efficiency- performance trends. Effect of flight conditions, jet exit speed, exit pressure. Role of propulsion in aircraft performance. Criteria for engine selection, airframe-engine matching.

UNIT- II AEROTHERMODYNAMIC MODELING OF ENGINE AND COMPONENTS

Engine components- performance requirements, thermodynamic processes- change of state- representation by T-s and p-v diagrams - pressure ratios, temperature ratios. Energy transfer, losses- entropy generation- mechanisms. Performance- polytropic, stage and component efficiencies, burning efficiency, under and over expansion- interrelations- effect of variable specific heats, figures of merit- significance- ideal component characteristics.

Aircraft gas turbine engines- cycle representation- turbojet, turbojet with reheat, turbofan- identification of engine components in the cycle. Computation of net work, thermal efficiency- application to thrust equation- expression of engine performance parameters in terms temperature and pressure ratios- degeneration for ideal engine- significance.

Engine design choice parameters- compressor pressure ratio, bypass ratio, fan pressure ratio, split ratio, jet velocity ratio; design constraints- turbine inlet temperature, engine speed; flight conditions- ambient pressure and temperature, flight Mach number; engine operating parameters- mass flow rate, burner total temperature ratio – significance, interrelations.

UNIT- III PARAMETRIC CYCLE ANALYSIS OF ENGINES

Parametric cycle analysis- definition, purpose- determination of engine performance parameters- effect of component performance, engine design choices, design constraints, flight conditions, operating parameters- performance trends, optimization, optimized performance, determination of engine design point, design point performance.

Parametric cycle analysis of ideal engines- need, assumptions, procedure for ideal turbojet, turbofan- optimal compressor pressure ratio, bypass ratio, fan pressure ratio. Real turbojet engine with component losses, performance trends- comparison with ideal cycle analysis.

UNIT- IV AIRCRAFT ENGINE COMPONENTS- NON-ROTATING- INLETS AND EXHAUST NOZZLES

Subsonic inlets- function, performance requirements, geometry, operating conditions, flow field, capture area, sizing. Flow distortion, inlet drag, nacelle and interference drag, diffuser losses- methods for mitigation. Performance- pressure ratio, total pressure ratio, isentropic efficiency. Supersonic inlets- compression process, types, construction, losses, performance characteristics.

Exhaust nozzles- primary nozzle, fan nozzle- governing equations of flow- choking, engine back pressure control, nozzle-area ratio, thrust reversing, vectoring- mechanisms. Performance- gross thrust coefficient, discharge coefficient, velocity coefficient, angularity coefficient, performance maps.

UNIT- V NON-ROTATING COMPONENTS- COMBUSTION SYSTEMS- COMBUSTORS, AFTERBURNERS, DUCTS AND MIXERS

Combustors- desirable properties. Combustion process- reaction rate, flammability characteristics, stability- effects of fuel-air mixture ratio, mass flow rate, combustor volume, pressure. Combustion loading parameter, sizing of combustor. Combustion system total pressure ratio- 1-D modeling of flow.

Burners- types, components- function, schematic diagram, airflow distribution, cooling- types, cooling effectiveness. Combustor performance parameters- combustion efficiency, overall total pressure loss, exit temperature profile, ignition relight envelope- effect of combustor design. Fuel injection, atomisation, vaporisation, recirculation- flame stabilisation, flame holders. Afterburners, function, components, design requirements, design parameters. The bypass duct- total pressure losses. Mixing process- pressure losses. Aircraft gas turbine engine fuels- composition, specifications of commonly used fuels.

UNIT- VI ROTATING MACHINERY- AXIAL FLOW COMPESSORS

Operating principle, description of flow field. Construction- stages, stators, rotors, cascades of blades, repeating stages- geometry, layout, cascade-blade geometry- solidity, stagger angle, airfoil angle settings, angle of incidence, exit deviation angles, flow angles, hub-tip ratio- interrelations, design considerations.

Flow analysis- Euler's turbo-machinery equations, use of absolute and cascade relative coordinate system. Velocity diagram analysis. Stage parameters- degree of reaction, stage loading and flow coefficients, pressure and temperature ratios, blade Mach number- significance, interrelations. Flow losses- causes- diffusion, polytropic efficiency, stage efficiency- relation to total pressure loss coefficient.

Computation of stage and component parameters for compressor of given cascade-blade geometry, inlet flow conditions and engine speed- procedure. Operation at off design speeds, compressor maps - flow problems- surge, separation, rotating stall, windmilling- solutions. Estimation of flow annulus area. Significance of 50% reaction design. Variable stators, multi-spool design- need, constraints. Limits on achievable compressor performance- losses, blade stresses. Range of axial flow compressor design parameters. Typical compressor blade profiles.

UNIT- VII ROTATING MACHINERY- AXIAL FLOW TURBINES

Axial flow turbines- similarities and differences with compressors. Velocity diagram analysis- no exit swirl condition, flow losses- causes- tangential stresses, repeating stages. Computation of stage parameters for ideal and real turbine of given cascade–blade geometry and initial flow conditions and turbine speed- procedure. Typical turbine blade profiles, turbine performance maps. Thermal limits of blades- cooling, materials, construction, methods of production. Limits on stage pressure ratio of turbines- multistage, multi-spooled turbines. Range of axial flow turbine design parameters. Typical turbine blade profiles.

UNIT- VIII PERFORMANCE ANALYSIS- COMPONENT MATCHING

Nondimensionalisation and correction of engine and component characteristic parameters- merits- corrected performance. Performance analysis of compressor, fan, burner, turbine, exhaust nozzle. Relation between compressor pressure ratio, mass flow rate, efficiency, engine speed. Engine control- throttle lever setting, fuel flow, burner temperature ratio, turbine speed, flow coefficient, mass flow rate- relations. Off design performance of compressor- compressor operating line- significance, application to engine performance analysis. Engine thrust ratings.

Component matching- significance, requirements, simplifying assumptions- choked turbine and exhaust nozzle flow, constant component efficiencies. Turbine inlet temperature as control parameter. Engine working lines. Effect of exhaust nozzle area, turbine inlet vane. Component matching for gas generator, turbo jet engine. Engine performance maps. Use of matching data to second stage design. Review of aircraft-engine matching.

TEXT BOOKS

1. Mattingly, J.D., *Elements of Gas Turbine Propulsion*, McGraw-Hill, 1996, ISBN0-07-912196-9.
2. Flack, R.D., *Fundamentals of Jet Propulsion with Applications*, Cambridge University Press, 2005, ISBN 0-521-81983-0.
3. Oates, G.C., ed., *Aerothermodynamics of Aircraft Engine Components,* AIAA, 1985, ISBN 0-915928-97-3.
4. *The Jet Engine*, Rolls Royce plc, 1986, ISBN 0-902121-2-5.

REFERENCES

1. Cumpsty, N., *Jet Propulsion*, 2nd edn., Cambridge University Press, 2005, ISBN 0-521-54144-1.
2. Kerrebrock, J.L., *Aircraft Engines and Gas Turbines*, 2nd edn. , MIT Press, 1992, ISBN 0-262-11162-4.
3. Hill, P.G. and Peterson, C.R., *Mechanics and Thermodynamics of Propulsion*, 2nd edn. , Addison Wesley, 1992.
4. Saravanamuttoo, H.I.H., Rogers, G.F.C. and Cohen, H., *Gas Turbine Theory*, 5th edn., Prentice Hall, 2001.
5. El-Sayed, A.F., *Aircraft Propulsion and Gas Turbine Engines*, CRC Press, 2008, ISBN 978-0-8493-9196-5.
6. Boyce, M.P., *Gas Turbine Engineering Handbook*, 2nd edn., Gulf Professional Publishing, 2002, ISBN 0-88415-732-6.
7. *The Aircraft Gas Turbine Engine and Operation*, Pratt& Whitney, 1988.

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AIR TRANSPORTATION SYSTEMS

UNIT- I AVIATION INDUSTRY

Introduction, history of aviation- evolution, development, growth, challenges. Aerospace industry, air transportation industry- economic impact- types and causes. Airline Industry- structure and economic characteristics. Airlines as oligopolists- other unique economic characteristics. Significance of airline passenger load factors.

UNIT- II NATURAL ENVIRONMENT

The earth as a habitat, The Earth: physical issues affecting demand- surface, core, continents. Shape of demand. Demand forecasting- based on historical data, comparative analysis, theoretical demand models. Reliability of forecasts, Atmosphere of earth- gaseous properties, distance and speed, weather- weather effects on navigation.

UNIT- III REGULATORY ENVIRONMENT

The breadth of regulation- ICAO, IATA, national authorities (DGCA, FAA). Service properties- service volumes, international air service agreements, deregulation, privatization. Safety regulations- risk assessment- human factors and safety, security regulations, environmental regulations.

UNIT- IV OPERATIONAL ENVIRONMENT

Introduction. Evolution- communication, navigation and surveillance systems (CNSS). Radio communications- VHF, HF, ACARS, SSR, ADS. Navigation- NDB, VOR, DME, area-navigation systems(R-Nav), ILS, MLS, GPS, INS, laser-INS. Surveillance- SSR, ADS . Airborne elements- AFCS, PMS, electronic control and monitoring /engine instrumentation and central automated systems, EFIS, FMS, GPWS, TCAS- future trends.

UNIT- V AIRCRAFT

Costs- project cash-flow, aircraft price. Compatibility with the operational infrastructure. Direct and indirect operating costs. Balancing efficiency and effectiveness- payload-range, fuel efficiency, technical contribution to performance, operating speed and altitude, aircraft field length performance. typical operating costs. Effectiveness- wake-vortices, cabin dimensions, flight deck.

UNIT-VI AIRLINES

Setting up an airline- modern airline objectives. Route selection and development, airline fleet planning, annual utilization and aircraft size, seating arrangements. Indirect operating costs. Aircraft- buy or lease. Revenue generation, Computerized reservation systems, yield management. Integrating service quality into the revenue-generation process. Marketing the seats. Airline scheduling. Evaluating success- financial viability, regulatory compliance, efficient use of resources, effective service.

UNIT-VII AIRPORTS

Setting up an airport- airport demand, airport siting, runway characteristics- length, declared distances, aerodrome areas, obstacle safeguarding. Runway capacity- evaluating runway capacity- sustainable runway capacity. Runway pavement length, Manoeuvring area- airfield lighting, aprons, Passenger terminals-terminal sizing and configuration. Airport demand, capacity and delay.

UNIT-VIII AIRSPACE

Categories of airspace- separation minima, airspace sectors- capacity, demand and delay. Evolution of air traffic control system- procedural ATC system, procedural ATC with radar assistance, first generation 'automated' ATC system, current generation radar and computer-based ATC systems. Aerodrome air traffic control equipment and operation - ICAO future air-navigation systems (FANS). Air-navigation service providers as businesses.

TEXT BOOK

1. Hirst, M., *The Air Transport System*, Woodhead Publishing Ltd, Cambridge, England, 2008.

REFERENCES

1. Wensven, J.G., *Air Transportation: A Management Perspective*, Ashgate, 2007.
2. Belobaba, P., Odoni, A. and Barnhart, C., *Global Airline Industry*, Wiley, 2009.
3. M. Bazargan, M., *Airline Operations and Scheduling*, Ashgate, 2004.
4. Nolan, M.S., *Fundamentals of Air Traffic Control*, 4th edn., Thomson Learning, 2004.
5. Wells, A. and Young, S., *Airport Planning and Management*, 5th edn., McGraw-Hill, 1986.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

III Year B. Tech. AE– I Semester	**L**	**T/P/D**	**C**
	-	**-/ 3/ -**	**2**

AEROSPACE STRUCTURES LAB

EXERCISES

1. Study of construction and use of Universal Testing Machine, mechanical and optical extensometers- application to determine stress-strain curves and tensile and compressive strength of various engineering materials.
2. Bending tests- deflection of slender and short beams for various loading and end conditions- determination of influence coefficients- verification of Maxwell's and Castigliano's theorems.
3. Compression tests on long and short columns- determination of buckling loads– Southwell plot.
4. Determination of the strength and deformation of riveted and bolted joints.
5. Methods of inspection and non-destructive testing (NDT) of aircraft structural components.
6. Strain gauge techniques- measurement of strain in beams, thin and thick walled cylinders subjected to internal pressure, shaft subjected to combined loading.
7. Shear Centres of open and closed sections- determination of the elastic axis of beams.
8. Post buckling behavior of shear panels- measurements on semi-tension field webs of beams.
9. Determination of elastic constants of composite materials- flexural test on composites.
10. Study and calibration of photo and magnetic speed pickups for the measurement of speed.
11. Study and use of seismic pickups for the measurement of amplitude and frequency of vibration of structural components.
12. Determination of critical fracture toughness of aerospace materials.

REFERENCE BOOKS

1. Megson, T.H.G., *Aircraft Structures for Engineering Students*, 4th edn., Elsevier, 2007, ISBN 0-750-667397.
2. Bruhn. E.H, *Analysis and Design of Flight Vehicles Structures*, Tri-state Off-set Company, USA, 1965.

EQUIPMENT REQUIRED

1. UTM- 20/ 40 tonnes- with requisite jigs and fixtures for compression and tensile tests and precision extensometers.
2. Beam deflection test rigs with requisite precision dial gages.
3. Test rig for determination of shear centre.
4. NDT equipment for a) Ultrasonic testing, b) Magnetic particle testing, c) Dye penetration test.
5. Strain measuring equipment: a) various electrical resistance strain gages and rosettes, b) Multi-channel strain measuring equipment.
6. Experimental rigs and set-ups required for conducting specific tests.

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III Year B. Tech. AE– I Sem	**L**	**T/P/D**	**C**
	-	**-/ 3/ -**	**2**

AERODYNAMICS AND PROPULSION LAB

AERODYNAMICS LAB

1. Fluid flow studies using blower
2. Calibration of low speed wind tunnel
3. Drag of different bodies
4. Pressure distribution studies on two-dimensional models
5. Pressure distribution over an airfoil at different angles of attack
6. Aerodynamic characterization of NACA - 0012 airfoil
7. Axial Flow Compressor
8. Centrifugal Flow Compressor
9. Flow visualization techniques

PROPULSION LAB

1. Study of piston engine (Valve timing and port timing diagram)
2. Stripping of a piston engine, visual inspection and reasoning for common troubles and trouble-shooting
3. Performance of piston engine
4. Heat balancetest on piston engine
5. Engine balancing
6. Characterization of aviation fuels

EQUIPMENT REQUIRED

1. Low Speed Wind-Tunnel Test Rig with a test section of 1 meter X 1 meter with necessary accessories.
2. Test Rig for Axial Flow Compressor
3. Test Rig for Centrifugal Flow compressor.
4. Heat Engine Test Rig.
5. Balancing Test Rig
6. Calorimeter Apparatus
7. Piston Engine