**BACHELOR OF TECHNOLOGY (AERONAUTICAL ENGINEERING) CREDIT BASED**

**KURUKSHETRA UNIVERSITY KURUKSHETRA**

**SCHEME OF STUDIES/EXAMINATION**

**SEMESTER-V w.e.f 2020-21 ONWARDS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **Teaching Schedule** | | | |  | **Examination Schedule (Marks)** | | | | **Duration of Exam**  **(Hrs.)** |
| **L** | **T** | **P** | **Hours/Week** | **Credit** | **Major Test** | **Minor Test** | **Practical** | **Total** |
| 1 | #HM-905A | Entrepreneurship | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 2 | AER-301A | Aircraft Structure-II | 3 | 1 | 0 | 4 | 4 | 75 | 25 | 0 | 100 | 3 |
| 3 | AER-303A | Aerodynamics-II | 3 | 1 | 0 | 4 | 4 | 75 | 25 | 0 | 100 | 3 |
| 4 | AER-305A | Propulsion-II | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 5 | AER-307A | Aircraft Materials and Manufacturing Processes | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 6 | AER-309A | Aircraft Structure Lab | 0 | 0 | 2 | 2 | 1 | 0 | 40 | 60 | 100 | 3 |
| 7 | AER-311A | Aerodynamics Lab | 0 | 0 | 2 | 2 | 1 | 0 | 40 | 60 | 100 | 3 |
| 8 | AER-313A | Project-I | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 100 | 100 | 3 |
| 9 | \*AER-315A | Industrial Training-II | 2 | 0 | 0 | 2 | - | 0 | 100 | 0 | 100 |  |
| 10 | \*\*MC-903A | Essence of Indian Traditional Knowledge | 3 | 0 | 0 | 3 | - | 100 | - | - | 100 | 3 |
|  |  | **Total** | **20** | **2** | **6** | **28** | **20** | **375** | **205** | **220** | **800** |  |

**Note:**

1. \*AER-315A is a mandatory non-credit course in which the students will be evaluated for the industrial training undergone after 4th semester and students will be

required to get passing marks to qualify.

2. \**\*MC-903A is mandatory credit-less course in which the students will be required to get passing marks in the major test.*

3. #The course is common with B.Tech. (Mechanical Engineering).

**BACHELOR OF TECHNOLOGY (AERONAUTICAL ENGINEERING) CREDIT BASED**

**KURUKSHETRA UNIVERSITY KURUKSHETRA**

**SCHEME OF STUDIES/EXAMINATION**

**SEMESTER-VI w.e.f 2020-21 ONWARDS**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S. No.** | **Course Code** | **Course Title** | **Teaching Schedule** | | | |  | **Examination Schedule (Marks)** | | | | **Duration of Exam**  **(Hrs.)** |
| **L** | **T** | **P** | **Hours/Week** | **Credit** | **Major Test** | **Minor Test** | **Practical** | **Total** |
| 1 | #HM-901A | Organizational Behaviour | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 2 | AER-302A | Aircraft Design | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 3 | AER-304A | Aircraft Stability and Control | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
| 4 | AER-306A | Aircraft Design Lab | 0 | 0 | 2 | 2 | 1 | 0 | 40 | 60 | 100 | 3 |
| 5 | AER-308A | Aircraft Structure Repair Lab | 0 | 0 | 2 | 2 | 1 | 0 | 40 | 60 | 100 | 3 |
| 6 | AER-310A | Project-II | 0 | 0 | 6 | 6 | 3 | 0 | 0 | 100 | 100 | 3 |
| 7 | AEP\* | Program Elective-I | 3 | 1 | 0 | 4 | 4 | 75 | 25 | 0 | 100 | 3 |
| 8 | AEP\* | Program Elective-II | 3 | 0 | 0 | 3 | 3 | 75 | 25 | 0 | 100 | 3 |
|  |  | **Total** | **15** | **1** | **10** | **26** | **21** | **375** | **205** | **220** | **800** |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Program Elective-I** | |  | **Program Elective-II** | |
| **Course Code** | **Course Title** |  | **Course Code** | **Course Title** |
| AEP-302A | Aeroelasticity |  | AEP-308A | Aircraft Systems |
| AEP-304A | Aircraft Composite Materials |  | AEP-310A | Aircraft Engineering Practices |
| AEP-306A | Aerospace Heat Transfer |  | AEP-312A | Airplane Performance |

***Note:***

1. \**The course of Program Elective will be offered at 1/3rd strength or 20 students (whichever is smaller) of the section.*

*2. All the students have to undergo 4 to 6 weeks industrial training after 6th semester and it will be evaluated in 7th semester.*

3. #The course is common with B.Tech. (Mechanical Engineering).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | |
| **HM-905A** | **ENTREPRENEURSHIP** | | | | | | |
| **L** | **T** | **P** | **Credit** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **-** | **3** | **75** | **25** | **100** | **3h** |
| **Purpose** | **To make the students conversant with the basics concepts in management thereby leading to nurturing their managerial skills.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able understand who the entrepreneurs are and what competences needed to become an Entrepreneur.** | | | | | | |
| **CO2** | **Students will be able understand insights into the management, opportunity search, identification of a Product; market feasibility studies; project finalization etc. required for small business enterprises.** | | | | | | |
| **CO3** | **Students can be able to write a report and do oral presentation on the topics such as product identification, business idea, export marketing etc.** | | | | | | |
| **CO4** | **Students will be able to know the different financial and other assistance available for the small industrial units.** | | | | | | |

**Unit-I**

**Entrepreneurship:** Concept and Definitions; Entrepreneurship and Economic Development; Classification and Types of Entrepreneurs; Entrepreneurial Competencies; Factor Affecting Entrepreneurial Growth – Economic, Non-Economic Factors; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs; Manager Vs. Entrepreneur, Entrepreneurial challenges.

**Unit-II**

**Opportunity / Identification and Product Selection:** Entrepreneurial Opportunity Search and Identification; Criteria to Select a Product; Conducting Feasibility Studies; Sources of business ideas, Marketing Plan : Conducting of Marketing Research, Industry Analysis, Competitor analysis, market segmentation and positioning, building a marketing plan, marketing mix, launching a new product; export marketing, Methods of Project Appraisal, Project Report Preparation; Specimen of Project Report; Project Planning and Scheduling using Networking Techniques of PERT / CPM.

**Unit–III**

**Small Enterprises and Enterprise Launching Formalities:** Definition of Small Scale; Rationale; Objective; Scope; SSI; Registration; NOC from Pollution Board; Machinery and Equipment Selection, Role of SSI in Economic Development of India; major problem faced by SSI, MSMEs – Definition and Significance in Indian Economy; MSME Schemes, Challenges and Difficulties in availing MSME Schemes.

**Unit–IV**

**Role of Support Institutions and Management of Small Business:** DIC; SIDO; SIDBI; Small Industries Development Corporation (SIDC); SISI; NSIC; NISBUD; State Financial Corporation SIC; Venture Capital: Concept, venture capital financing schemes offered by various financial institutions in India.

**Special Issues for Entrepreneurs**: Legal issues – Forming business entity, requirements for formation of a Private/Public Limited Company, Entrepreneurship and Intellectual Property Rights: IPR and their importance. (Patent, Copy Right, Trademarks), Case Studies-At least one in whole course.

**Note**

• Case studies of Entrepreneurs – successful, failed, turnaround ventures should be discussed in the class.

• Exercises / activities should be conducted on ‘generating business ideas’ and identifying problems and opportunities.

• Interactive sessions with Entrepreneurs, authorities of financial institutions, Government officials should be organized

**Text Books:**

1. “Entrepreneurship development small business enterprises”, Pearson, Poornima M Charantimath,2013.

2. Roy Rajiv, “Entrepreneurship”, Oxford University Press, 2011.

3. “Innovation and Entrepreneurship”, Harper business- Drucker.F, Peter, 2006.

**Reference Books:**

1. Enterpreneurship Development- S.Chand and Co.,Delhi- S.S.Khanka 1999

2. Small-Scale Industries and Entrepreneurship. Himalaya Publishing House, Delhi –Vasant Desai 2003.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | | | |
| **AER-301A** | **AIRCRAFT STRUCTURE-II** | | | | | | | |
| **Lecture** | **Tutorial** | | **Practical** | **Credit** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **1** | | **-** | **4** | **75** | **25** | **100** | **3 h** |
| **Purpose** | **To provide knowledge of advanced concepts related to various structures and components of aircraft under various loading conditions.** | | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO 1** | | **Students will be able to derive and calculate bending and shear stresses in thin walled sections.** | | | | | | |
| **CO 2** | | **Students will be able to evaluate shear flows in various sections of aircraft.** | | | | | | |
| **CO 3** | | **Students will be able to analyze and calculate all types of stresses in aircraft parts.** | | | | | | |
| **CO 4** | | **Students will be able to grasp the concept of vibrations and its types in different modes.** | | | | | | |

**Unit-I**

**UNSYMMETRICAL BENDING**

Bending stresses in beams of unsymmetrical sections – Bending of symmetric sections with skew loads.

**SHEAR FLOW IN OPEN SECTIONS**

Thin walled beams, Concept of shear flow, shear centre, Elastic axis. With one axis of symmetry, with wall effective and ineffective in bending, Applications of shear flow calculations, Numericals.

**Unit-II**

**SHEAR FLOW IN CLOSED SECTIONS**

Bredt – Batho formula, Single and multi – cell structures. Approximate methods. Shear flow in single &multicell structures under torsion. Shear flow in single and multicell under bending with walls effective and ineffective**,** Numericals.

**Unit-III**

**BUCKLING OF PLATES**

Rectangular sheets under compression, Local buckling stress of thin walled sections, Crippling stresses by Needham’s and Gerard’s methods, Thin walled column strength. Sheet stiffener panels. Effective width, inter rivet and sheet wrinkling failures.

**Unit-IV**

**STRESS ANALYSIS IN WING AND FUSELAGE**

Aircraft loads- classification – the V-n diagram – shear force and bending moment distribution over the aircraft wing and fuselage – shear flow in thin-webbed beams with parallel and non-parallel flanges – complete tension field beams – semi-tension field beam theory, Numericals

**INTRODUCTION TO VIBRATION:**

Free and forced vibration of single, two and multiple degrees of freedom systems, Principal modes, normal modes, static coupling and dynamic coupling.

**Text Books:**

1. Megson, T.M.G., “Aircraft Structures for Engineering Students”, Edward Arnold, 1995.

2. Perry, D.J., and Azar, J.J., “Aircraft Structures”, 2nd edition, McGraw–Hill, N.Y., 1993.

3. N G R Iyengar, Structural Stability of Columns and Plates, Affiliated East West Press (P) Ltd, New Delhi

4. W T Thomson, Vibration Theory and Application, 3rd edition, George Allen & Unwin Ltd.

**Reference Books:**

1. Rivello, R.M., “Theory and Analysis of Flight Structures”, McGraw-Hill, 1993

2. Bruhn. E.H. “Analysis and Design of Flight vehicles Structures”, Tri – state off set company, USA, 1985.

3. Michael Chun-Yung Niu, Airframe structural Design, Conmilit Press Ltd,1998

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | | |
| **AER-303A** | **AERODYNAMICS-II** | | | | | |  |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time (Hrs)** |
| **3** | **1** | **0** | **4** | **75** | **25** | **100** | **3** |
|  | | | | | | | |
| **Purpose:** | **To introduce the concepts of compressibility and make the student understand the theory behind the formation of shocks and expansion fans.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO 1** | **Students will be able to calculate the various parameters of 1-D and 2-D compressible flow.** | | | | | | |
| **CO 2** | **Students will be able to gain knowledge in shock formation phenomenon and fluid waves.** | | | | | | |
| **CO 3** | **Students will be able to characterize fluid flow in nozzles.** | | | | | | |
| **CO 4** | **Students will be able to analyze fluid flows over delta wings and its correlations.** | | | | | | |

**Unit-I**

**FUNDAMENTAL ASPECTS OF COMPRESSIBLE FLOW**

Compressibility, continuity, momentum and energy equations for steady one dimensional flow, compressible Bernoulli’s equation, area – Mach number – velocity relation, Mach cone, Mach angle, one dimensional isentropic flow through variable area duct, critical conditions, characteristic Mach number, Area-Mach number relation, maximum discharge velocity – operating characteristics of nozzles- introduction to hypersonic flows, Numericals.

**Unit-II**

**SHOCK AND EXPANSION WAVES**

Normal shock relations, Prandtl’s relation, Hugoniot equation, Rayleigh Supersonic Pitot tube equation, Moving normal shock waves, Oblique shocks,  M relation, Shock Polar, Reflection of oblique shocks, left running and right running waves, Interaction of oblique shock waves, slip line, shock-boundary layer interaction – transonic lambda shock – compression corner effect – incident shock interaction – Rayleigh flow, Fanno flow, Expansion waves, Prandtl Meyer expansion, Maximum turning angle, Simple and non-simple regions. Numericals.

**Unit-III**

**TWO-DIMENSIONAL COMPRESSIBLE FLOW**

Potential equation for 2-dimensional compressible flow, Linearization of potential equation, perturbation potential, Linearized Pressure Coefficient, Linearized subsonic flow, Linearized supersonic flow, Method of characteristics, Karman –Tsien correction, Critical Mach number, Whitcomb’s area rule, Super critical airfoil.

**Unit-IV**

**DELTA WING AERODYNAMICS**

Polhamus theory, leading edge suction analogy, calculations of lift coefficient, flow field, aspect ratio effect, leading edge extension, HAA aerodynamics

**NOZZLES**

Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions, Nozzle efficiency, Losses in nozzles, Over expanded and under, expanded nozzles, Ejector and variable area nozzles, Interaction of nozzle flow with adjacent surfaces, Thrust reversal.

**Text Books:**

1. Anderson, J. D, “Modern Compressible Flow”, McGraw-Hill & Co., 2002.

2. Rathakrishnan.,E,”Gas Dynamics”, Prentice Hall of India, 2004.

**Reference Books:**

1. Aerodynamics for engineering students; Houghton EL & Brock AE

2. Shapiro, A. H., “Dynamics and Thermodynamics of Compressible Fluid Flow”, Ronald Press, 1982.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | |
| **AER-305A** | **PROPULSION-II** | | | | | | |
| **L** | **T** | **P** | **Credit** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **-** | **3** | **75** | **25** | **100** | **3h** |
| **Purpose** | **To make students understand non-air-breathing and hypersonic propulsion methods so that they get familiarized with various propulsion technologies associated with space launch vehicles, missiles and space probes.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to evaluate the entry and exit parameters of axial flow turbine.** | | | | | | |
| **CO2** | **Students will be able to explain the characteristics of various chemical rocket propulsion systems.** | | | | | | |
| **CO3** | **Students will be able to grasp knowledge of electric rocket propulsion systems.** | | | | | | |
| **CO4** | **Students will be able to grasp knowledge of various advanced rocket propulsion systems.** | | | | | | |

**Unit–I**

**FUNDAMENTALS OF ROCKET PROPULSION:**

The development of the rocket, Classification of rocket engines and their operating principle, Multi-stage rockets, Thermal Rocket engine: Basic configuration, The development of thrust and the effect of the atmosphere, The thermodynamics of the rocket engine, The thermodynamic thrust equation, Specific impulse of rocket engine; Numerical problems.

**AXIAL FLOW TURBINE:**

Impulse and reaction blading of gas turbines – Velocity triangles and power output – Elementary theory – Vortex theory – Choice of blade profile, pitch and chord – Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – Methods of blade cooling – Matching of turbine and compressor, Numericals.

**Unit-II**

**CHEMICAL ROCKET PROPULSION SYSTEM**

Salient features of solid propellant rockets – selection criteria of solid propellants – estimation of solid propellant adiabatic flame temperature – propellant grain design considerations – erosive burning in solid propellant rockets – combustion instability – strand burner and T-burner -applications and advantages of solid propellant rockets, Numericals.

The basic configuration of the liquid propellant engine, The combustion chamber and nozzle: Injection, Ignition, Combustion instability, Thrust vector control; Liquid propellant distribution systems, Cooling of liquid-fueled rocket engines, Combustion and the choice of propellants, The performance of liquid-fueled rocket engines.

**Unit-III**

**ELECTRIC PROPULSION SYSTEM AND MEMS**

Pure Electric Thrusters – Electrostatic, Electro Magnetic and Hall- effect Thrusters; Optimum Flight Performance; Electric Power Generation in Space; Recent Micro Spacecraft Developments; Micro-propulsion Options; Primary Set of Micro-propulsion Requirements; Chemical Propulsion Options; Review of Electric Propulsion Technologies for Micro and Nanosatellites; Emerging Technologies: MEMS and MEMS- Hybrid Propulsion System

**Unit-IV**

**ADVANCED PROPULSION SYSTEMS**

**Hybrid chemical rocket propulsion system;** Ion propulsion – Nuclear rocket – comparison of performance of these propulsion systems with chemical rocket propulsion systems– Solar sail – current scenario of advanced propulsion projects worldwide.

**Text Books:**

1. Sutton, G.P., Rocket Propulsion Elements, John Wiley and Sons Inc., New York, 8th Edition, 2010.
2. Martin J.L Turner , Rocket &space craft propulsion, Springers –oraxis publishing, 2001.
3. Cornelisse, J.W., ―Rocket Propulsion and Space Dynamics‖, J.W., Freeman & Co. Ltd., London, 1982.

**Reference Books:**

1. Micropropulsion for Small Spacecraft, Paul, Z., Progress in Astronautics &Aeronautics, Vol. 187, AIAA,2000.

2. Mattingly J.D., ―Elements of Propulsion: Gas Turbines and Rocket‖, AIAA, 1991.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | |
| **AER-307A** | | **AIRCRAFT MATERIALS AND MANUFACTURING PROCESSES** | | | | | | |
| **Lecture** | | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time (Hrs.)** |
| **3** | | **0** | **0** | **3** | **75** | **25** | **100** | **3** |
| **Purpose** | **To make the student aware of various materials & production technologies generally involved in aircraft manufacturing process. As an engineer the knowledge and practical skills in different manufacturing processes are essential.** | | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO1** | **Students will be able to impart knowledge on concepts of aircraft materials properties and its applications.** | | | | | | | |
| **CO 2** | **Students will be able to interpret the properties of materials required to manufacture the aircraft.** | | | | | | | |
| **CO 3** | **Students will be able to interpret various composite materials and their manufacturing techniques.** | | | | | | | |
| **CO 4** | **Students will be able to compare various advanced manufacturing process and their applications.** | | | | | | | |

**Unit-I**

**INTRODUCTION**

Properties of flight vehicle materials, Importance of strength/weight ratio of materials for Aerospace vehicles: Structures, Importance of temperature variations, factors affecting the choice of material for different parts of an airplane.

**Unit-II**

**AIRCRAFT STEELS**

Classification of alloy steels, Effect of alloying elements, Carbon steels v/s Alloys steels, corrosion-resistant steels, Heat treatment, Corrosion prevention methods, Selection and application of steel alloys to aircraft manufacture

**LIGHT METAL ALLOYS**

Aluminium alloys, Heat treatment, High strength and high corrosion-resistant alloys, Magnesium alloys and

their properties, Heat treatment. Application to Aerospace Vehicle of these alloys.

**Unit-III**

**COMPOSITE MATERIALS AND MANUFACTURING PROCESS**

Definition- Classification of Composite Materials -Advantages and Disadvantages-Materials and its Compositions - Manufacturing Process Selection Criteria, Basic Steps in a Composites Manufacturing Process-Types of Moulding- Honey Comb Design –Methods of Making Tools; Wet Lay-Up Process, Nomex-Curing Processes-Pre-peg-Vacuum Bagging, Spray-Up Process.

**Unit-IV**

**AIRCRAFT MANUFACTURING PROCESSES**

Profiling, Hydroforming, mar forming bending rolls, Spar milling, Spark erosion and powdered metal parts, integral machining, Contour etching, High energy rate forming, Manufacturing of honeycomb structures, General methods of construction of aircraft and aero-engine parts.

**Text Books:**

1. G.F. Titterton, “Aircraft Materials and Processes”, Himalayan Books, New Delhi

2. Cindy Foreman-Advanced Composites- Jeppessen Ltd.

**Reference Books:**

1. C G K Nair, Aircraft Materials, Interline

2. Chapman WAJ, “Workshop Technology”, Vol. I, II, III.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | |
| **AER-309A** | | **AIRCRAFT STRUCTURE LAB** | | | | | | |
| **L** | | **T** | **P** | **Credit** | **Practical** | **Minor Test** | **Total** | **Time** |
| **-** | | **-** | **2** | **1** | **60** | **40** | **100** | **3h** |
| **Purpose** | | **The aircraft structures lab with enable the student to conduct experiments so that they are able to understand the theoretical concepts and principles in a better way.** | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO 1** | **Students will be able to gain basic knowledge on the mechanical behavior of materials like aluminum, mild steel and cast iron.** | | | | | | | |
| **CO 2** | **Students will be able to obtain buckling strength of both long columns using different elastic supports.** | | | | | | | |
| **CO 3** | **Students will be able to interpret the concept of locating the shear centre for open and closed section of beams** | | | | | | | |
| **CO 4** | **Students will be able to describe test procedures, synthesize and discuss the results.** | | | | | | | |

**Note: Student will be required to perform all 8 experiments out of the following list.**

1. Compute stress and deflections of beams for various end conditions, verification of Maxwell‘s theorem
2. Perform Compression tests on long columns and evaluate critical buckling loads.
3. Evaluation of Young’s modulus by bending of cantilever Beams
4. Perform unsymmetrical bending on a beam and tabulate the results.
5. Evaluate shear centres of open section beam.
6. Evaluate shear centres of closed section beam.
7. Perform inspection and non-destructive testing (NDT) on aircraft structural components.
8. Fabricate and determine the young‘s modulus of a sandwich structure.

**Text 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. |

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | | |
| **AER-311A** | | **AERODYNAMICS LAB** | | | | | | | |
| **Lecture** | | **Tutorial** | **Practical** | **Credits** | **Major**  **Test** | **Minor**  **Test** | **Practical** | **Total** | **Time**  **(Hrs.)** |
| **0** | | **0** | **2** | **1** | **0** | **40** | **60** | **100** | **3** |
|  | | | | | | | | |  |
| **Purpose** | **In this course, students will conduct experiments for a range of different applications. These experiments will involve pressure and velocity measurement techniques, uncertainty analysis and report writing.** | | | | | | | | |
| **Course Outcomes** | | | | | | | | | |
| **CO 1** | **Students will be able to analyze the applications related to experimental techniques from aerodynamics** | | | | | | | | |
| **CO 2** | **Students will be able to infer the results based on computational methods applied during analysis** | | | | | | | | |
| **CO 3** | **Students will be able to determine the aerodynamic performance parameters using wind tunnel** | | | | | | | | |
| **CO 4** | **Students will be able to determine the viscous flow and computing boundary layer thickness over a flat plate.** | | | | | | | | |

**Note: Student will be required to perform at least 8 experiments out of the following list.**

1. Identification and plotting different flow structure (wingtip vortices, downwash region, up-wash region, trailing edge wake) around finite wing using smoke at subsonic speed in the wind tunnel
2. To perform Schlieren techniques on a fluid to find the velocity.
3. Visualization of flow using smoke at subsonic speed around the delta wing in the wind tunnel.
4. To perform particle Image velocimetry (PIV) to find the velocity of the fluid.
5. Perform wind tunnel calibration and compare the results.
6. To evaluate pressure distribution parameters around a circular cylinder.
7. Determination of aerodynamic performance of airfoils by wind tunnel testing.
8. To compute flow characteristics in the wake of a low-speed airfoil at different angles of attack.
9. To evaluate Boundary layer thickness of laminar and turbulent boundary layers over a flat plate

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | | |
| **AER-313A** | | **Project-I** | | | | | | | |
| **Lecture** | | **Tutorial** | **Practical** | **Credits** | **Major**  **Test** | **Minor**  **Test** | **Practical** | **Total** | **Time**  **(Hrs.)** |
| **0** | | **0** | **2** | **1** | **--** | **--** | **100** | **100** | **3** |
|  | | | | | | | | |  |
| **Purpose** | **To be able to apply some of the techniques/principles that have been taught to carry out time and budget planning for the project.** | | | | | | | | |
| **Course Outcomes** | | | | | | | | | |
| **CO1** | **Demonstrate a thorough and systematic understanding of project contents.** | | | | | | | | |
| **CO 2** | **Understand methodologies and professional way of documentation and communication.** | | | | | | | | |
| **CO 3** | **Know the key stages in development of the project** | | | | | | | | |
| **CO 4** | **Extend or use the idea in mini project for major project.** | | | | | | | | |

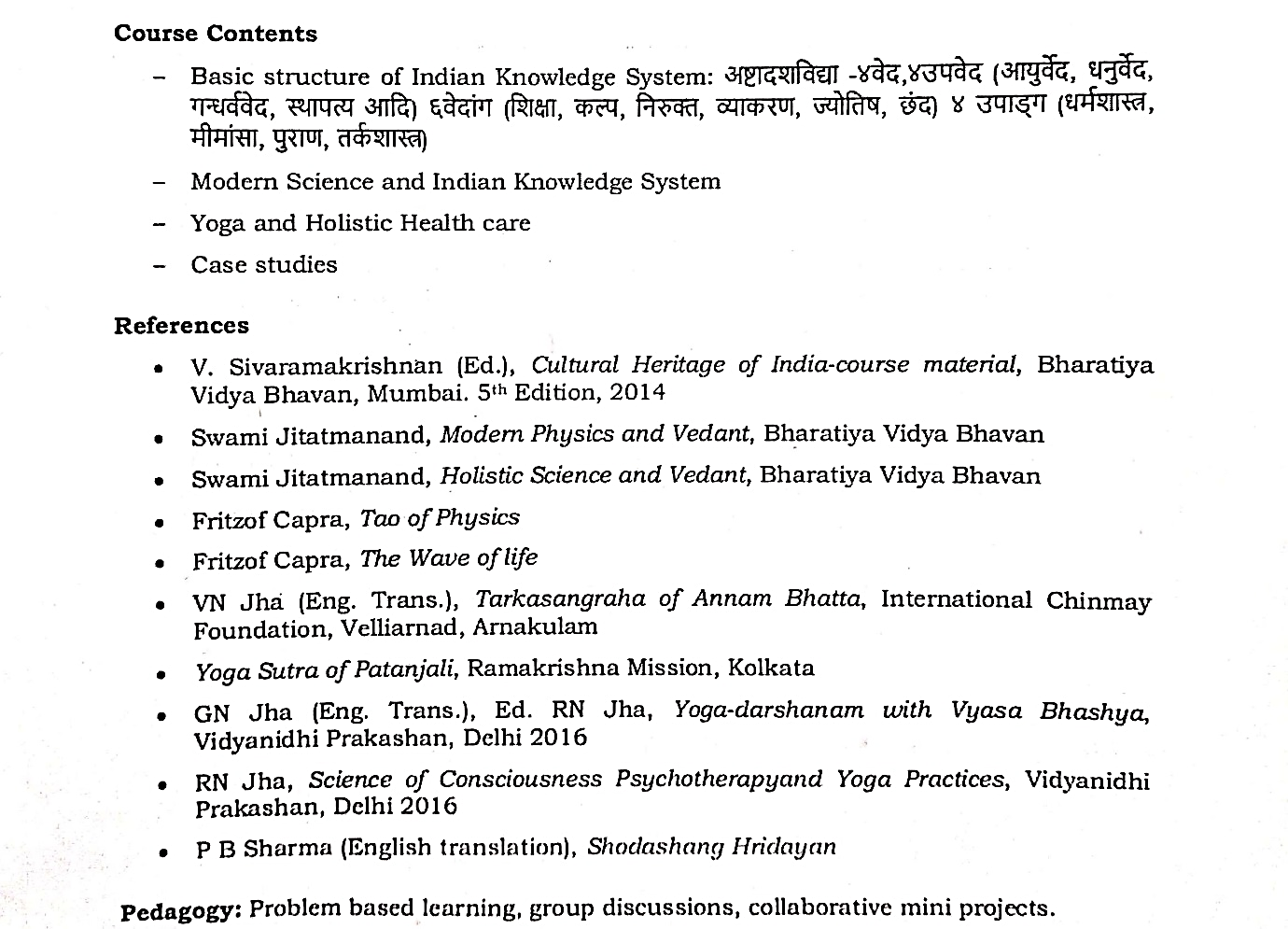
The students expected to take up a project under the guidance of teacher from the college. The project must be based on aeronautical/mechanical application-based engineering problems, which can be extended up to the full academic session. The students may be asked to work individually or in a group not more than four students in a group. Viva- voce must be based on the preliminary report submitted by students related to the project as per the format.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B. Tech (5th Semester) Aeronautical Engineering** | | | | | | | |
| **AER-315A** | | **INDUSTRIAL TRAINING-II** | | | | | | | |
| **Lecture** | | **Tutorial** | **Practical** | **Credits** | **Major**  **Test** | **Minor**  **Test** | **Practical** | **Total** | **Time**  **(Hrs.)** |
| **2** | | **0** | **0** | **--** | **--** | **100** | **--** | **100** |  |
|  | | | | | | | | |  |
| **Purpose** | **To provide comprehensive learning platform to students where they can enhance their employ ability skills and exposure to the industrial environment.** | | | | | | | | |
| **Course Outcomes** | | | | | | | | | |
| **CO1** | **Capability to acquire and apply fundamental principles of engineering.** | | | | | | | | |
| **CO 2** | **Become updated with all the latest changes in technological world.** | | | | | | | | |
| **CO 3** | **Capability and enthusiasm for self-improvement through continuous professional development and life-long learning** | | | | | | | | |
| **CO 4** | **Awareness of the social, cultural, global and environmental responsibility as an engineer.** | | | | | | | | |

**Note:** AER-315A is a mandatory non-credit course in which the students will be evaluated for the industrial training undergone after 4th semester and students will be required to get passing marks to qualify.

The candidate has to submit a training report of his/her work/project/assignment completed in the industry during the training period. The evaluation will be made on the basis of submitted training report and viva-voce/presentation.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B. Tech. (5th Semester) Aeronautical Engineering** | | | | | | | |
| **MC-903A** | **ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE** | | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Practical** | **Total** | **Time (Hrs.)** |
| **3** | **0** | **0** | **--** | **100** | **--** | **--** | **100** | **3** |
|  | | | | | | | |  |
| **Purpose** | **To impart basic principles of thought process, reasoning and inferencing.** | | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO 1** | **Students will be able to understand, connect up and explain basics of Indian traditional knowledge in modern scientific perspective.** | | | | | | | |



**Note: The paper setter will set the paper as per the question paper template provided.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **HM-901A** | **ORGANIZATIONAL BEHAVIOUR** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time (Hrs.)** |
| **3** | **0** | **0** | **3** | **75** | **25** | **100** | **3** |
| **Purpose:** | **To make the students conversant with the basic concepts of organizational culture and behavior for nurturing their managerial skills.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO 1** | **An overview about organizational behavior as a discipline and understanding the concept of individual behavior.** | | | | | | |
| **CO 2** | **Understand the concept and importance of personality, emotions and its importance in decision making and effective leadership.** | | | | | | |
| **CO 3** | **Enabling the students to know about the importance of effective motivation and its contribution in group dynamics and resolving conflicts.** | | | | | | |
| **CO 4** | **Understand how to overcome organizational stress by maintaining proper organizational culture and effective communication.** | | | | | | |

**Unit-I**

**Introduction to Organizational Behavior*:***Concept and importance of Organizational Behavior, Role of Managers in OB, Foundations or Approaches to Organizational Behavior, Challenges and Opportunities for OB.

**Foundation of individual behavior**: Biographical characteristics, concept of Abilities and Learning, Learning and Learning Cycle, Components of Learning, concept of values and attitude, types of attitude, attitude and workforce diversity

**Unit-II**

**Introduction to Personality and Emotions**: Definition and Meaning of Personality, Determinants of Personality, Personality Traits Influencing OB, Nature and Meaning of Emotions, Emotions dimensions, concept of Emotional intelligence

**Perception and individual decision making***:* Meaning of perception, factors influencing perception, Rational decision-making process, concept of bounded rationality. Leadership- Trait approaches, Behavioral approaches, Situational approaches, and emerging approaches to leadership.

**Unit-III**

**Motivation**:concept and theories of Motivation, theories of motivation-Maslow, Two Factor theory, Theory X and Y, ERG Theory, McClelland’s Theory of needs, goal setting theory, Application of theories in Organizational Scenario, linkage between MBO and goal setting theory, employee recognition and involvement program.

**Foundations of Group Behavior and conflict management: Defining** and classifying of Groups, stages of group development, Informal and Formal Groups– Group Dynamics, Managing Conflict and Negotiation, a contemporary perspective of intergroup conflict, causes of group conflicts, Managing intergroup conflict through Resolution.

**Unit-IV**

**Introduction to Organizational Communication**:Meaning and Importance of Communication process, importance of Organizational Communication, Effective Communication, Organizational Stress: Definition and Meaning, Sources and Types of Stress, Impact of Stress on Organizations, Stress Management Techniques.

**Introduction to Organization Culture**- Meaning and Nature of Organization Culture, Types of Culture, Managing Cultural Diversity, Managing Change and Innovation – Change at work, Resistance to change, A model for managing organizational change.

**Text Books:**

1. Colquitt, Jason A., Jeffery A. LePine, and Michael Wesson. Organizational Behavior: Improving Performance and Commitment in the Workplace. 5thed. New York: McGraw-Hill Education, 2017.

2. Hitt, Michael A., C. Chet Miller, and Adrienne Colella. Organizational Behavior. 4th ed. Hoboken, NJ: John Wiley

**Reference Books:**

1. Robbins, Stephen P., and Timothy Judge. Organizational Behavior. 17th ed. Harlow, UK: Pearson Education

2. Stephen P. Robins, Organisational Behavior, PHI Learning / Pearson Education, 11th edition, 2008.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AER-302A** | | **AIRCRAFT DESIGN** | | | | | | |
| **L** | | **T** | **P** | **Credit** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | | **0** | **-** | **3** | **75** | **25** | **100** | **3h** |
| **Purpose** | | **To familiarize the students with the mathematical analysis of aircraft structural design knowledge.** | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO1** | **Students will be able to evaluate the basic skills involved in weight estimation for the aircraft design process** | | | | | | | |
| **CO2** | **Students will be able to gain knowledge of theoretical design and its application for initial sizing and configuration layout of aircraft** | | | | | | | |
| **CO3** | **Students will be able to interpret basic techniques in the design of various operative systems of an aircraft.** | | | | | | | |
| **CO4** | **Students will be able to implement the cost and estimation methods for designing of aircrafts** | | | | | | | |

**Unit–I**

**OVERVIEW OF THE AIRCRAFT DESIGN PROCESS**

Phases of aircraft design, aircraft conceptual design process, project brief/request for proposal, problem definition, information retrieval, integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation, airfoil selection, airfoil design, airfoil design considerations, wing geometry and wing vertical location, wingtip shapes, tail geometry and arrangements, thrust to weight ratio, thrust matching, wing loading performance, constraint analysis.

**Unit-II**

**INITIAL SIZING AND CONFIGURATION LAYOUT**

Sizing with the fixed engine and with rubber engine. geometry sizing of fuselage, wing, tail, control surfaces, development of configuration lay out from conceptual sketch. the inboard profile drawing, lofting- definition, significance and methods, flat wrap lofting, special consideration in configuration lay out, Isobar tailoring, Sears-Haack volume distribution, structural load paths, radar, IR, visual detectability, aural signature, considerations of vulnerability, crashworthiness, producibility, maintainability, fuselage design, crew station, passengers and payload

**Unit-III**

**PROPULSION, FUEL SYSTEM INTEGRATION AND LANDING GEAR DESIGN**

Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and subsystems arrangements, guidelines and significance of design layout, report of initial specifications.

**BASELINE DESIGN ANALYSIS**

Fundamentals of Structures and Types of Loads ; Estimation of static longitudinal, lateral and directional stability control derivative; estimation of aircraft dynamical characteristics, handling qualities, Cooper – Harper scale, relation to aircraft dynamic characteristics, performance analysis and constraint analysis.

**Unit-IV**

**COST ESTIMATION, PARAMETRIC ANALYSIS, OPTIMISATION AND REFINED SIZING**

Elements of life cycle cost, cost estimating method, RDT&E and production costs, operation and maintenance costs, cost measures of merit, aircraft and airline economics, DOC and IOC, airline revenue, breakeven analysis, investment cost analysis, parametric analysis and optimization, improved conceptual sizing methods, sizing matrix plot and carpet plot, trade studies, design trades, requirement trades, growth sensitivities, multivariable design optimization methods, measures of merit, determination of final baseline design configuration, preparation of type specification report.

**Text Books:**

1. Daniel P. Raymer, ―Aircraft Design: A Conceptual Approach‖, AIAA Educational Series, USA, 4th Edition, 2006.

2. J. F. Marchman, L. R. Jenkinson, ―Aircraft Design Projects for Engineering students‖, AIAA Publishers, USA, 2003.

3. Ajoy Kumar Kunda, ―Aircraft Design‖, Cambridge University Press, UK, 2010.

**Reference Books:**

1. E. Torenbeek, ―Synthesis of Subsonic Airplane Design‖, Delft University Press, New York, 1986.

2. E. H Bruhn, ―Analysis and Design of Flight Vehicles Structures‖, Jacobs Publishing House, USA, New Edition, 1973.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AER-304A** | **AIRCRAFT STABILITY AND CONTROL** | | | | | | |
| **L** | **T** | **P** | **Credit** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **-** | **3** | **75** | **25** | **100** | **3h** |
| **Purpose** | **Learn about the mathematical modelling of an aircraft in longitudinal, lateral and directional cases.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to illustrate the concept of stability and application to dynamic systems like Aircraft, and the role of primary controls and secondary controls in longitudinal stability.** | | | | | | |
| **CO2** | **Students will be able to grasp the concept of slide slip angle, roll angle and yaw angle their concepts related to lateral directional stability** | | | | | | |
| **CO3** | **Students will be able to estimate the longitudinal and directional parameters with the help of the linearized equations of aircraft motion** | | | | | | |
| **CO4** | **Students will be able to analyze the different type of modes in longitudinal, lateral and directional motion of aircraft, and recovery from those modes.** | | | | | | |

**Unit–I**

**INTRODUCTION AND LONGITUDINAL STABILITY-I**

Aircraft axes system, Definition: Equilibrium, stability, controllability, & maneuverability. Examples from simple mechanical systems for stability. Longitudinal static stability and dynamic stability for unaccelerated flight. Criteria for longitudinal static stability and trim condition. Contribution of Principle components. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady, symmetric pull-up maneuver, elevator effectiveness, elevator hinge moment, neutral point, maneuver point, static margin for stick fixed and stick free conditions, control force and control gradient. Trim tabs and types of trim tabs, Aerodynamic and mass balancing of control surfaces, forward and aft-most limits of CG.

**Unit-II**

**LATERAL-DIRECTIONAL STATIC STABILITY**

Introduction to lateral-direction stability- aerodynamic forces and moments, aircraft side force due to side slip, aircraft rolling moment due to side slip, and aircraft yawing moment due to side slip. Aircraft component contribution, directional static stability, Aircraft component contribution for lateral-directional stability, rudder requirements.

**Unit-III**

**AIRCRAFT EQUATION 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 moment 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 (No Derivation). Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system

**Unit-IV**

**LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES**

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-linearization equations of motion. Linearized of force and moment equation of motion.

**AIRCRAFT DYNAMIC STABILITY**

Principle modes of motion characteristics, mode shapes and significance, time constant, undamped natural frequency and damping ratio- mode shapes- significance. One degree of freedom, two degree of freedom approximations- constant speed (short period), constant angle of attack (long period) approximations solutions.

**Text Books:**

1. Fundamentals of Aerodynamics, J. D. Anderson, McGraw Hill.

2. Yechout, T.R.etal.,―Introduction to Aircraft Flight Mechanics‖, AIAA education Series, 2003, ISBN 1- 56347-577-4.

3. Nelson, R.C., ―Flight Stability and Automatic Control‖, 2nd Edn., Tata McGraw Hill, 2007, ISBN 0-07- 066110-3.

**Reference Books:**

1. Schmidt, L.V., ―Introduction to Aircraft Flight Dynamics‖, AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.

2. Etkin, B and Reid, L.D., ―Dynamics of Flight‖, 3rd Edn., John Wiley, 1998, ISBN0-47103418-5.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | | |
| **AER-306A** | **AIRCRAFT DESIGN LAB** | | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Practical** | **Total** | **Time (Hrs.)** |
| **-** | **-** | **2** | **1** | **-** | **40** | **60** | **100** | **3** |
| **Purpose** | **To make the students design aircrafts on basis of theoretical and parametric studies.** | | | | | | | |
| **Course Outcomes** | | | | | | | | |
| **CO 1** | **Draw conceptual sketch of aircrafts based on client requirements such as type, role, payload, mission, aerodynamic & performance requirements.** | | | | | | | |
| **CO 2** | **Estimate total takeoff gross weight, thrust-weight ratio, wing loading parameters using data sheets.** | | | | | | | |
| **CO 3** | **Develop initial layouts for major components such as fuselage, empennage, landing gears and wings** | | | | | | | |
| **CO 4** | **To prepare comparative case study for various aircrafts** | | | | | | | |

**List of Experiments:**

1. Conceptual sketch and weight estimation

2. Airfoil design and constraint analysis

3. Initial sizing-I [rubber engine & fixed engine sizing]

4. Initial sizing-II [ configuration layout, crew station, passengers and payload]

5. Performance estimations [performance constraint analysis]

6. Load estimations-I [ landing gear loads]

7. Load estimations-II [propulsion system load.]

8. Design case study-I

A. Design study of A-380

B. Design study B-747

9. Design case study-II

a. Dynamics of F-16

B. Dynamics of SR-71

**Note:** At least eight experiments are required to be performed by students from the above list and two may be performed from the experiments developed by the institute.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AER-308A** | **AIRCRAFT STRUCTURE REPAIR LAB** | | | | | | |
| **L** | **T** | **P** | **Credit** | **Practical** | **Minor Test** | **Total** | **Time** |
| **-** | **-** | **2** | **1** | **60** | **40** | **100** | **3h** |
| **Purpose** | **To give the practical knowledge of handling and operating various repairing techniques with deformation studies in aircraft structures.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to apply various ways of structural repair system using various methods.** | | | | | | |
| **CO2** | **Students will be able to conduct welding patch repair process and compare with riveted repair process.** | | | | | | |
| **CO3** | **Students will be able to execute sheet metal forming on aircraft structural components.** | | | | | | |
| **CO4** | **Students will be able to perform hands-on work on composite Sections** | | | | | | |

**List of Experiments:**

1. To perform aircraft wood glueing process for understanding the manual fabrication.

2. To perform welded patch repair by plasma arc welding process.

3. To perform welded patch repair by TIG, MIG welding techniques.

4. To perform welded patch repair by beam welding techniques

5. To perform fabric patch repair technique to understand surface preservation.

6. To perform riveted patch repair technique and compare with conventional welding process.

7. To perform repair of composite laminate.

8. To perform repair of composite sandwich panels.

9. To perform sheet metal forming for understanding machined fabrication.

For better understanding of the experiments, the department is also required to utilize the resources available on various websites, digital media & industrial visits etc.

**Note: Student will be required to perform at least 8 experiments out of the following list.**

**Program Electives I and II [6thSemester]**

**(Aeronautical Engineering)**

|  |  |
| --- | --- |
| **Program Elective-II** | |
| **Course Code** | **Course Title** |
| AEP-302A | Aeroelasticity |
| AEP-304A | Aircraft Composite Materials |
| AEP-306A | Aerospace Heat Transfer |

|  |  |
| --- | --- |
| **Program Elective-II** | |
| **Course Code** | **Course Title** |
| AEP-308A | Aircraft Systems |
| AEP-310A | Aircraft Engineering Practices |
| AEP-312A | Airplane Performance |

**Elective - I & II will be offered as departmental elective for Aeronautical Engineering Students**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-302A** | **AEROELASTICITY** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **0** | **-** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To study basic aeroelastic problems that occur in an aircraft during the operational condition.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to outline the importance of aeroelasticity in flight vehicle design and classify static and dynamic aeroelastic problems.** | | | | | | |
| **CO2** | **Students will be able to describe structural dynamic and steady and unsteady aerodynamics aspects of the airframe and its components and their role in aeroelasticity.** | | | | | | |
| **CO3** | **Students will be able to construct a theoretical basis for the solution of static aeroelastic problems an estimate loads and other critical speeds.** | | | | | | |
| **CO4** | **Students will be able to construct a theoretical basis for the solution of flutter problems and estimate of flutter speeds.** | | | | | | |

**Unit-I**

**AEROELASTIC PHENOMENA:**

Stability versus response problems; The aeroelastic triangle of forces; Aeroelasticity in aircraft design; Prevention of aeroelastic instabilities; Influence and stiffness coefficients; Coupled oscillations.

**Unit-II**

**DIVERGENCE OF A LIFTING SURFACE:**

Simple two-dimensional idealizations; Strip theory, integral equation of the second kind exact solutions for simple rectangular wings, semi-rigid assumption and approximate solutions; Generalized coordinates, successive approximations, numerical approximations using matrix equations.

**Unit-III**

Loss and reversal of aileron control, critical aileron reversal speed, aileron efficiency, semi rigid theory and successive approximations. Lift distribution, rigid and elastic wings; Tail efficiency, effect of elastic deformation on static longitudinal stability.

**Unit-IV**

Non-dimensional parameters, stiffness criteria, dynamic mass balancing, dimensional similarity; Flutter analysis, two dimensional thin airfoils in steady incompressible flow, quasi-steady aerodynamic derivatives; Galerkin method for critical flutter speed, stability of disturbed motion, solution of the flutter determinant, methods of determining the critical flutter speeds, flutter prevention and control.

**Text Books:**

1. Y.C. Fung, ―An Introduction to the Theory of Aeroelasticity‖, John Wiley & Sons Inc., New York, 2008.

2. E.G. Broadbent, ―Elementary Theory of Aeroelasticity‖, Bun Hill Publications Ltd., 1986**.**

**Reference Books:**

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, ―Aeroelasticity‖, Edition Addison Wesley Publishing Co., Inc., 2 nd Edition, 1996.

2. R.H. Scanlan and R. Rosenbaum, ―Introduction to the study of Aircraft Vibration and Flutter‖, Macmillan Co., New York, 1981.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-304A** | **AIRCRAFT COMPOSITE MATERIALS** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **1** | **0** | **4** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To study composite materials properties used in an aircraft and its applications.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to grasp the concepts of fabrication, analysis and design of composite materials & structures.** | | | | | | |
| **CO2** | **Students will be able to explain basic composites technology, including methods of analysis and material properties.** | | | | | | |
| **CO3** | **Students will be able to identify the static testing procedure and repairing methodology of composite structural members and joints.** | | | | | | |
| **CO4** | **Students will be able to develop structural designs using composite materials.** | | | | | | |

**Unit-I**

**STRESS STRAIN RELATION:**

Introduction- Advantages and application of composite materials, reinforcements and matrices; Generalized Hooke ‘s Law; Elastic constants for anisotropic, orthotropic and isotropic materials.

**Unit-II**

**METHODS OF ANALYSIS**

Micromechanics: Mechanics of materials approach, elasticity approach to determine material properties; Macro Mechanics; Stress-strain relations with respect to neutral axis, arbitrary axis; Determination of material properties; Experimental characterization of lamina.

**Unit-III**

**LAMINATED PLATES, SANDWICH CONSTRUCTIONS AND FABRICATION PROCESS**

Governing differential equation for a general laminate, angle ply and cross-ply laminates; Failure criteria for composites. Basic design concepts of sandwich construction; Materials used for sandwich construction; Failure modes of sandwich panels; Various open and closed mould processes; Manufacture of fibers; Types of resins and properties and applications; Netting analysis.

**Unit-IV**

**DAMAGE TOLERANCE IN COMPOSITES**

Introduction, sources of damage, types of damage, FAR requirements and advisory circulars, building-block approach; Impact damages: Damage growth under fatigue loads; residual strength: Tests and analytical methods; Design of composite parts and assembly design; Optimization: Fundamentals of optimization, mathematical concepts in optimization, Optimization of composite plates.

**Text Books:**

1. Gibson, R.F, ―Principles of Composite Material Mechanics‖, CRC Press, 2nd Edition, 2007.

2. Jones, R.M, Taylor & Francis, ―Mechanics of Composite Materials‖, 2nd Edition, 2010 (Indian Print).

3. Reddy, J.N., ―Mechanics of Laminated Composite Plates and Shells – Theory and Analysis‖, CRC Press, 2 nd Edition, 2004.

**Reference Books:**

1. Agarwal, B.D., and Broutman, L.J., ―Analysis and Performance of Fibre Composites‖, John Wiley and sons. Inc., New York, 1995.

2. Lubin, G., ―Handbook on Advanced Plastics and Fibre Glass‖, Von Nostrand Reinhold Co., New York, 1989.

3. AutarK.Kaw ―Mechanics of Composite Materials‖, 2nd Edition, CRC Press, 2005.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-306A** | **AEROSPACE HEAT TRANSFER** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **1** | **0** | **4** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To study methods and process of heat transfer that takes place in aerodynamic bodies.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Understand the basic modes of heat transfer like conduction, convection radiation with and without phase change in solid liquids and gases.** | | | | | | |
| **CO2** | **Design and analyze thermal fluidic components in engineering systems to energy mechanisms (in the form of heat transfer) for steady and unsteady state.** | | | | | | |
| **CO3** | **Conduct experiments in laboratories and analyze the results with theoretical ones to evolve research-oriented projects in the field of heat transfer as well as propulsion** | | | | | | |
| **CO4** | **Apply the concepts of heat transfer with convective mode in internal and external flows involved in engineering components and work in real time problems in Industry.** | | | | | | |

**Unit-I**

**INTRODUCTION TO HEAT TRANSFER & CONDUCTION**

Modes and mechanisms of heat transfer, Basic laws of heat transfer. Conduction heat transfer: Fourier rate equation, Steady and unsteady and periodic heat transfer -Initial and boundary conditions, Overall heat transfer coefficient, Electrical analogy, Critical radius of insulation, Extended surfaces (Fins) Long, Short and insulated tips. Application to error measurement of temperature. Significance of Biot and Fourier numbers, Chart solutions of transient conduction systems –concept of Functional Body.

**Unit-II**

**CONVECTION & FORCED CONVECTION**

Buckingham Pi Theorem, application for developing semi-empirical non-dimensional correlation for convection heat transfer-significance of non-dimensional numbers-Concepts of Continuity, Momentum and Energy Equations. Concepts of hydrodynamic and thermal boundary layer -Flat plates and Cylinders. Concepts about Hydrodynamic and Thermal Entry Lengths-division of internal flows based on this- use of empirical correlations for Horizontal Pipe Flow and annulus flow.

**Unit-III**

**FREE CONVECTION & CONDENSATION**

Development of Hydrodynamic and thermal boundary layer along a vertical plate - Use of empirical relations for Vertical plates and pipes. Film boiling. Film-wise and dropwise condensation, Nusselt‘s theory of condensation on a vertical plate. Film condensation on vertical and horizontal cylinders using empirical correlations. Application in Aero engines.

**Unit-IV**

**INTRODUCTION TO RADIATION**

Laws of radiation, Heat exchangers, Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU Methods, Application in Aero engines.

**RADIATION HEAT TRANSFER**

Heat exchange between two black bodies, concepts of shape factor, Emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks. Application in Space Engineering.

**Text Books:**

1. Yunus A. Cengel, ―Heat Transfer- A Practical Approach‖, Tata McGraw hill Education (P) Ltd, New Delhi, India. 4th Edition, 2012.

2. P.K .Nag- Heat and Mass Transfer, Tata McGraw hill Education (P) Ltd, New Delhi, India. 3rd Edition, 2011.

**Reference Books:**

1. Holman, ―Heat Transfer ‖ Tata McGraw Hill education (P) Ltd, New Delhi, India. 10th Edition, 2012.

2. Ghoshdastidar, P. S. ―Heat Transfer‖, Oxford University Press, New Delhi, India. 2nd Edition, 2012.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-308A** | **AIRCRAFT SYSTEMS** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **0** | **3** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To enable the student to describe control systems of aircraft and working principle of flight instruments.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to grasp the concept and meaning of system and classify the various systems required for aircraft and their contribution to fulfilling the aircraft tasks.** | | | | | | |
| **CO2** | **Students will be able to describe the various types of electrical power generation and distribution systems in aircraft.** | | | | | | |
| **CO3** | **Students will be able to interpret the concepts of pneumatic, hydraulic and environmental control system.** | | | | | | |
| **CO4** | **Students will be able to explain the working principles of engine control and fuel systems.** | | | | | | |

**Unit-I**

**INTRODUCTION TO AIRCRAFT SYSTEMS**

System concepts, sub-systems; Generic system definition, inputs, outputs, feedback, external influence. Aircraft systems- airframe systems, vehicle systems, avionics systems, mission systems and their sub-systems; Specification of requirements, mission requirements, performance requirements.

**Unit-II**

**ELECTRICAL SYSTEMS AND AIR CONDITIONING, PRESSURIZING SYSTEMS**

Electrical loads in aircraft. Electrical power generation and control- DC, AC- types. Power distribution- primary, secondary. Power conversion and energy storage; Load protection; Electrical load management systems, 270 V DC systems; Basic air cycle systems; Vapour cycle systems, boost-strap air cycle system; Evaporative Vapour cycle systems; Evaporative air cycle systems; Oxygen systems; deicing and anti-icing systems**.**

**Unit-III**

**HYDRAULIC SYSTEMS AND PNEUMATIC SYSTEMS**

Hydraulic systems: function, merits, application, system loads, design requirements; Principal components; Hydraulic fluid: required properties; Hydraulic piping, pumps, reservoir, accumulator; Pneumatic systems; Advantages;- Working principles; Typical air pressure system; Brake system; Typical pneumatic power system; Components, landing gear systems; Landing gear and brake management systems.

**Unit-IV**

**ENGINE CONTROL AND FUEL SYSTEMS**

Principle of operation of aircraft gas turbine engines; Engine - airframe interfaces; Control of fuel flow, air flow, Limited authority control systems, full authority control systems- examples; Power off takes- need, types; Fuel systems- characteristics, components, operating modes; Fuel tank safety- fuel inserting system

**Text Books:**

1. Moir, I. and Sea bridge, A, ―Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration‖, John Wiley, 3rd Edition 2008.

2. Moir, I. and Sea bridge, A, ―Design and Development of Aircraft Systems- An Introduction‖, AIAA Education Series‖, AIAA, 2004.

**Reference Books:**

1. Pallett, E.H.J., ―Aircraft Instruments and Integrated Systems‖, Longman Scientific &Technical 10th Edition, 1992.

2. Harris, D, ―Flight Instruments and Automatic Flight Control Systems‖, 6th Edition, 2004.

3. Bolton, W., ―Pneumatic and Hydraulic Systems‖, Butterworth-Heinemann.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-310A** | **AIRCRAFT ENGINEERING PRACTICES** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **0** | **3** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To study the basics of maintenance activities that are performed during aircraft landing and takeoff operations.** | | | | | | |
| **Course Outcomes** | | | | | | | |
| **CO1** | **Students will be able to explain the ground maintenance operations of aircraft.** | | | | | | |
| **CO2** | **Students will be able to apply the concepts of various engineering practices in real-life application.** | | | | | | |
| **CO3** | **Students will be able to design and analyze the hand tools methods** | | | | | | |
| **CO4** | **Students will be able to categorize transmission methods, pipes and union, flexible hoses used in aviation types of springs used in an aircraft.** | | | | | | |

**Unit-I**

Mooring, jacking, leveling and towing operations - Preparation - Equipment and precautions – Engine starting procedures - Piston engine, turboprops and turbojets - Engine fire extinguishing - Ground power units.

**Unit-II**

Air conditioning and pressurization - Oxygen and oil systems - Ground units and their maintenance. Shop safety - Environmental cleanliness - Precautions. Process - Purpose - Types - Inspection intervals - Techniques - Checklist - Special inspection - Publications, Bulletins, various manuals - FAR Airworthiness directives - Type certificate Data Sheets – ATA specifications.

**Unit-III**

Hand tools - Precision instruments - Special tools and equipment in an airplane maintenance shop -Identification terminology - Specification and correct use of various aircraft hardware (i.e. nuts, bolts, rivets, screws, etc.) - American and British systems of specifications - Threads, gears, bearings, etc. -Drills, tapes & reamers - identification of all types of fluid line fittings. Materials, metallic and nonmetallic.

**Unit-IV**

**Springs**: Types of springs, materials, characteristics and applications. Inspection and testing of springs. Pipes and Hoses: Bending and belling/flaring aircraft pipes; Inspection and testing of aircraft pipes and hoses; Installation and clamping of pipes.

**Pipes and Unions**:

(a) Identification of, and types of rigid and flexible pipes and their connectors used in aircraft;

(b) Standard unions for aircraft hydraulic, fuel, oil, pneumatic and air system pipes.

**Text Books:**

1. KROES WATKINS DELP. “Aircraft Maintenance and Repair ", McGraw Hill, New York 1993.

2. A & P MECHANICS, “Aircraft hand Book - F.A.A. Himalayan Book House ", New Delhi, 1996.

**Reference Books:**

1. A & P MECHANICS, “General hand Book - F.A.A. Himalayan Book House ", New Delhi, 1996.

2. ATA SPECFICATIONS - F.A.A. Himalayan Book House ", New Delhi, 1996**.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **B.Tech. (6th Semester) Aeronautical Engineering** | | | | | | |
| **AEP-312A** | **AIRPLANE PERFORMANCE** | | | | | | |
| **Lecture** | **Tutorial** | **Practical** | **Credits** | **Major Test** | **Minor Test** | **Total** | **Time** |
| **3** | **0** | **0** | **3** | **75** | **25** | **100** | **3 Hrs.** |
| **Purpose** | **To study the airplane performance which includes range and endurance estimation in accordance with fuel systems.** | | | | | | |
|  | **Course Outcomes** | | | | | | |
| **CO1** | **Students will be able to learn the different regimes of aircraft and performance requirements at different atmospheric conditions.** | | | | | | |
| **CO2** | **Students will be able to understand the different type of velocities and gives differences between stall velocity and maximum and minimum velocities** | | | | | | |
| **CO3** | **Students will be able to estimate the time to climb and descent and gives the relation between the rate of climb and descent and time to climb and descent at different altitudes.** | | | | | | |
| **CO4** | **Students will be able to illustrate the velocity and radius required for a different type of maneuvers like pull-up, pull down and steady turn.** | | | | | | |

**Unit-I**

**INTRODUCTION TO AIRCRAFT PERFORMANCE:**

The role and design mission of an aircraft; Performance requirements and mission profile; Aircraft design performance, the standard atmosphere; Off-standard and design atmosphere; Measurement of air data; Air data computers; Equations of motion for performance - the aircraft force system; Total airplane drag- estimation, drag reduction methods; The propulsive forces, the thrust production engines, power-producing engines, variation of thrust, propulsive power and specific fuel consumption with altitude and flight speed; The minimum drag speed, minimum power speed; Aerodynamic relationships for a parabolic drag polar.

**Unit-II**

**CRUISE PERFORMANCE:**

Maximum and minimum speeds in level flight; Range and endurance with thrust production, and power-producing engines; Cruise techniques: constant angle of attack, constant mach number; constant altitude, methods- comparison of performance. The effect of weight, altitude and temperature on cruise performance; Cruise performance with mixed power-Plants.

**Unit-III**

**CLIMB AND DECENT PERFORMANCE**

Importance of Climb and descent performance, Climb and descent technique generalized performance analysis for thrust producing, power-producing and mixed power plants, maximum climb gradient, and climb rate. Energy height and specific excess power, energy methods for optimal climbs - minimum time, minimum fuel climbs. Measurement of best climb performance. Descent performance in Aircraft operations. Effect of wind on climb and decent performance.

**Unit-IV**

**AIRCRAFT MANOEUVRE PERFORMANCE**

Lateral maneuvers- turn performance- turn rates, turn radius- limiting factors for turning performance. Instantaneous turn and sustained turns, specific excess power, energy turns. Longitudinal aircraft maneuvers, the pull-up, maneuvers. The maneuver envelope (V-n diagram), Significance. Maneuver boundaries and limitations, Maneuver performance of military Aircraft, transport Aircraft.

**SAFETY REQUIREMENTS -TAKEOFF AND LANDING PERFORMANCE AND FLIGHT PLANNING**

Estimation of takeoff distances. The effect on the takeoff distance of weight wind, runway conditions, ground effect. Takeoff performance safety factors. Estimation of landing distances. The discontinued landing, Baulk landing, air safety procedures and requirements on performance. Fuel planning fuel requirement, trip fuel, Environment effects, reserve, and tinkering.

**Text Books:**

1. Anderson, J.D. Jr., ―Aircraft Performance and Design‖, International edition McGraw Hill, 1st Edition, 1999, ISBN: 0-07-001971-1.

2. Aerodynamics for Engineering Students: E.L. Houghton and N.B. Carruthers, Butterworth Heinemann, 1982

**Reference Book:**

1. Eshelby, M.E., ―Aircraft Performance theory and Practice‖, AIAA Education Series, AIAA, 2nd Edition, 2000, ISBN: 1-56347-398-4.