(7th SEMESTER)

Course		Contact Hrs.			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Int**	**Ext.**	**Total**	
BANES1-701	Avionics	3	0	0	40	60	100	3
BANES1-702	Aircraft design	3	1	0	40	60	100	4
BANES1-703	Project-I	0	0	8	60	40	100	4
BANES1-704	Training-III***	-	-	-	40	60	100	3
BANES1-705	Rockets and Missiles (Compulsory)	3	1	0	40	60	100	4
	Departmental Elective-IV (POOL-I, Select One)	3	1	0	40	60	100	4
BANED1-711	Jet Propulsion							
BANED1-712	Rocket Propulsion							
	Departmental Elective-V (POOL-II, Select One)	3	0	0	40	60	100	3
BANED1-721	Air Transportation and Operation							
BANED1-722	Aircraft Composite Material							
BANED1-723	Aircraft Modelling and Simulation							
XXXX	**Open Elective****	3	0	0	40	60	100	3
	Flying Hour*	-	-	-	-	-	-	-
Total		**-**	**-**	**-**	**340**	**460**	**800**	**28**

Project-I: Mini Project for UG students to enable them apply knowledge to address the real-world situations/problems to find solutions. The students will carry out project under the supervision of PSAEC faculty advisor. A group of maximum two (02) can register for one project. The registered students will submit the project proposal in the prescribed format in the office of HOD within 10 days of semester registration. Faculty advisor of the group has to accept/reject proposal based on the merits and outcome of the project. The students will require to develop and present a working prototype at the end of the semester to earn the credits of project.

If the students are not able to develop the working prototype, they will not be able to earn the credits and they will have to repeat the course in the form of new project.

***Note: Students will given an opportunity to avail flying hours at Punjab State Civil Aviation Council Airstrip by paying additional charges. Minimum 02 Hrs Flying is compulsory for each student. However students are interested in more flying hours can avail maximum 04 Hrs Flying by paying additional charges and as per availability of Aircraft and Pilot with Punjab State Civil Aviation Council.**

****Open Elective Subjects may also be chosen from the list of Open Electives-I, II and III offered by other departments of university.**

*****Internship will be imparted at the end of 6th semester as per AICTE Internship Policy.**

60 marks external (40 to be given by external training agency and 20 to be given by class incharge against their submission of reports, daily diary, power presentation in the institution etc) and
40 internal marks (to be allotted by the external examiner at the time of Viva Voce).

(8th SEMESTER)

Course		Contact Hrs.			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Int**	**Ext.**	**Total**	
	Departmental Elective-VI (POOL-I, Select One)	3	0	0	40	60	100	3
BANED1-811	**Internet of Things (IoT)**							
BANED1-812	**Carbon Fiber Reinforced Polymer(CFRP)**							
	Departmental Elective-VII (POOL-II, Select One)	3	1	0	40	60	100	4
BANED1-821	Boundary Layer Theory							
BANED1-822	Advanced Aerodynamics							
BANED1-823	Experimental Aerodynamics							
BANES1-801	Project-II	0	0	8	60	40	100	4
XXXX	**Open Elective****	3	0	0	40	60	100	3
XXXX	**Open Elective****	3	0	0	40	60	100	3
	Flying Hour*	-	-	-	-	-	-	-
Total		**12**	**1**	**08**	**220**	**280**	**500**	**17**

Project-II: Students can do Project-II either outside the institute or within the institute under a supervision of PSAEC Faculty advisor. A group of maximum two (02) students can register for the project-II. The registered students will submit the project proposal in the prescribed format in the office of HOD within 10 days of semester registration. Faculty advisor of the group has to accept/reject proposals based on the merits and outcome of the project.

***Note: Students will given an opportunity to avail flying hours at Punjab State Civil Aviation Council Airstrip by paying additional charges. Minimum 02 Hrs Flying is compulsory for each student. However students are interested in more flying hours can avail maximum 04 Hrs Flying by paying additional charges and as per availability of Aircraft and Pilot with Punjab State Civil Aviation Council.**

****Open Elective Subjects may also be chosen from the list of Open Electives-I, II and III offered by other departments of university.**

7th Semester

AVIONICS

Subject Code –BANES1-701 **L T P Cr 3 0 0 3** **Duration:45 Hours**

COURSE OBJECTIVES

- To enable the student to describe different types avionics systems of aircraft.
- The student should be able to apply Avionics verification and validation techniques.
- The student should be able to understand working of Communication and Navigation of aircraft.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

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- Identify avionics System/subsystem requirements
- Compare the Military and Civil Avionics requirements
- Describe working principles of communication systems
- Describe working principles of navigation systems

UNIT –I (13 Hrs.)

Role of avionics: Role for Avionics in Civil and Military Aircraft systems, Avionics sub-systems and design, defining avionics System/subsystem requirements-importance of facilities, Avionics system architectures

Avionics system data buses, design and integration: MIL-STD-1553B, ARINC-429, ARINC-629, CSDB, AFDX and its Elements, Avionics system design, Development and integration-Use of simulation tools, stand alone and integrated Verification and Validation

UNIT –II (10 Hrs.)

Avionics system essentials: displays, i/o devices and power: Trends in display technology, Alphanumeric displays, character displays etc., Civil and Military aircraft cockpits, MFDs, MFK, HUD, HDD, HMD, DVI, HOTAS, Synthetic and enhanced vision, situation awareness, Panoramic/big picture display, virtual cockpit-Civil and Military Electrical Power requirement standards, comparing the Military and Civil Requirements and Tips for Power System Design

UNIT –III (10 Hrs.)

Communication systems: Fundamentals of radio wave propagation, antennas, transmission lines, communication, receiver and transmitter; Working principles of following systems: Very High Frequency (VHF) communication, High Frequency (HF) communication, Audio, Emergency Locator Transmitters, Cockpit Voice Recorder, ARINC communication and reporting

UNIT –IV (12 Hrs.)

Navigation systems: Fundamentals of Very High Frequency omnidirectional range (VOR); Automatic Direction Finding (ADF); Instrument Landing System (ILS); Microwave Landing System (MLS); Distance Measuring Equipment (DME);Radio altimeter, Very Low

Frequency and hyperbolic navigation(VLF/Omega); Doppler navigation; Area navigation, RNAV systems; Flight Management Systems; Global Positioning System (GPS), Global Navigation Satellite Systems (GNSS); Inertial Navigation System; Air Traffic Control transponder, secondary surveillance radar; Traffic Alert and Collision Avoidance System(TCAS),Weather avoidance radar.

RECOMMENDED BOOKS

1. Digital Avionics Handbook, 3rd Edition, CRC Press, 2012
2. R P G Collinson, "Introduction to Avionics Systems", 3rd Edition, Springer, 2011
3. E.H.J. Pallett, "Micro Electronics Aircraft System", FT Prentice Hall,1984
4. Ian Moir and Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics subsystem integration", 3rd edition, Wiley,2008.
5. Thomas K Eismin, "Aircraft Electricity and Electronics",7th Edition, McGraw-Hill Education,2019.

AIRCRAFT DESIGN

Subject Code –BANES1-702	L T P Cr 3 1 0 4	Duration:60 Hours

COURSE OBJECTIVES

- The course enables students to understand and apply various concepts related to aircraft design.
- The course enables students to conceptually design various types of aircrafts.

LEARNING OUTCOME

After undergoing the subject, the student will be able to:

- Analyze various concepts related to aircraft design.
- Estimate weight & geometrical parameters of different types of aircrafts.
- Analyze aerodynamic and stability characteristics during design of different types of aircrafts.
- Analyze and estimate performance parameters during aircraft design.
- Analyze and estimate structural aspects and apply in aircraft design.

UNIT – I (16 Hrs.)

Introduction: Aircraft design, Requirements and specifications, Airworthiness requirements, Importance of weight, Aerodynamic and structural design considerations, Classifications of airplane, Concept of configuration, Features of special purpose airplanes, unmanned aerial vehicles and their features, Control configured vehicles.

Weight Estimation and Wing Design: Estimation of airplane weight based on airplane type / mission and material used, Trends in wing loading and thrust loading, Iterative approach, Estimation of Horizontal and vertical tail volume ratios.

UNIT – II (14 Hrs.)

Symmetrical Maneuvering Loads: Classical methods of estimating symmetrical maneuvering loads on a wing in flight, Basic flight loading conditions, Load factor, V-n diagram, Gust loads, Estimation of gust loads, Gust envelope, Use of panel methods to estimate air load distribution on a wing.

Wing Design: Factors influencing selection of airfoil and plan form, Span wise air loads variation, Super critical wing, Stalling, take-off and landing considerations, BM and SF diagrams, Design principles of all metal, stressed skin wing (Civil & Military airplane), Estimation of wing drag.

UNIT – III (16 Hrs.)

Structural Integration: Structural layout of straight, tapered and swept (forward and aft) wings, Cockpit and passenger cabin layout, Layout of flight and engine controls, Wing-fuselage joining methods, All metal airplane considerations, Use of composite materials, Preparation of 3-views, CG location.

Undercarriage and Inlets: Requirement of undercarriage, Different arrangements, Mechanism for retraction into fuselage and wing, Absorption of landing loads, Calculations of loads, Number of engines, Types and location for inlets, Variable geometry inlets, Revised CG location.

UNIT – IV (14 Hrs.)

Complete Design Problem: Preparation of conceptual design of an airplane from given specifications, Use and analysis of existing designs for this purpose, Design of airframe for the specifications, Prediction of performance, stability and control, Relaxed stability, Selection of engines from all considerations with all details, Freezing the design, Preparation of preliminary drawings including 3 views and layout.

RECOMMENDED BOOKS

1. D. P. Raymer, “Aircraft Design: A Conceptual Approach”, 5th Edition, AIAA Publication, 2012.
2. Darrol Stinton D., “The Design of the Aeroplane”, 2nd Edition, Black Well Science, 2001.
3. J. D. Anderson Jr., “Aircraft Performance and Design”, 3rd Edition, Tata McGraw-Hill, 2010.
4. L.M.Nikolai, “Fundamentals of Aircraft Design”, Illustrated edition , American Institute of Aeronautics & Astronautics; 2010
5. John J. Bertin and Russell M. Cummings , “Aerodynamics for Engineers”, 5th Edition, Pearson Prentice Hall;

ROCKETS & MISSILES

Subject Code –BANES1-705 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

Main objectives of this course are:

- Basic knowledge of rockets / missiles
- Guidance & navigation systems for missiles.
- Performance, stability & control of rockets and missiles including maneuvering flights
- Launch operations & Re-entry of space vehicles.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Describe different types of rockets and missiles.
- Differentiate between rockets and missiles.
- Calculate various stability aspects of various control configuration of space vehicles.
- Analyze problems related to launch and recovery of space vehicles.
- Predict various types of trajectories of space vehicles.

UNIT – I (14 Hrs.)

Introduction: Introduction to rockets and missiles, Difference between Rocket and missiles, Type of Rockets and missiles, satellites, satellite launch vehicles.

Aerodynamic Characteristics of Airframe Components: Bodies of revolution, Different fore-body shapes, Summary of characteristics of bodies of revolution, Base pressure, Aerodynamic control, Jet control, various subsystems of missile & rockets

UNIT – II (18 Hrs.)

Performance and Propulsion of Missiles and Rockets Introduction of drag, various types of drags, Boost glide trajectory, Graphical solution, Boost sustainer trajectory, staging & stage separation, long range cruise trajectory, long range ballistic trajectory, Powered and un-powered flight, Brief description of Fin Stabilized, spin stabilized Rockets and their force systems, ramjet, scramjet, rocket (liquid/solid fuel based) engines, Thrust misalignment.

Guidance, Control & Navigation of Missiles and Rockets Introduction to guidance and navigation, various types of guidance schemes & their application. Types of Control and actuation systems, navigation systems for high accuracy & its suitability

UNIT –III (16 Hrs.)

Stability and Control Longitudinal: Two degrees of freedom Analysis, Complete Missile Aerodynamics with forward and rear control, Static stability margin.

Directional: Introduction, cruciform configuration, Body wing and Tail contribution on directional control.

Lateral: Induced roll, internal control and design consideration for cruciform and Monowing, Damping in roll.

Maneuvering Flight: Introduction to maneuvering of missiles and rockets, Flat turn for cruciform and mono-wing, Pull-ups, Relationship of maneuverability and static stability margin.

UNIT IV (12 Hrs.)

Dynamic Stability: Equation of motion, longitudinal dynamic degree of freedom, classical solution, lateral dynamics.

Advanced topics: Launching problems, Re-entry and recovery of space vehicles, Modern Concepts, Manned Missions.

RECOMMENDED BOOKS

1. Howard S. Seifert, Ed. Wiley, "Space Technology", Chapman and Hall, London, 1959.
2. SR Mohan, "Fundamentals of Guided Missile", DRDO, 2016.
3. Design of Guidance and Control Systems for Tactical Missiles, 1st Edition, CRC Press 2019.
4. EL Fleeman, "Tactical Missile Design", 2nd Edition, AIAA Education Series, 2006.
5. EL Fleeman, "Missile Design and System Engineering", AIAA Education Series, 2013

JET PROPULSION

Subject Code –BANED1-711	L T P Cr 3 1 0 4	Duration:60 Hours

COURSE OBJECTIVES

- Make the students understand the flow dynamics of supersonic and compressible flows through compressor, combustion chamber, nozzles and turbine passages and flows involving heat transfer and frictional effects.
- The differences in the performance analysis of a turbine engine in ideal and real conditions are also discussed so that the students can appreciate the need to study both of these situations.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Describe compressible flows through compressor, combustion chamber, nozzles, and turbine passages.
- Analyze various types of engine cycles.
- Estimate the performance of centrifugal compressor and combustion chamber.
- Estimate the performance of axial flow compressor and turbine.

UNIT I (18 Hrs.)

Steady 1-Dimensional Gas Dynamics; Basics, simple flows: nozzle flow, nozzle design, nozzle operating characteristics for isentropic flow, nozzle flow and shock waves. Nozzle characteristics for some operational engines. Rayleigh flow and Fanno flow. Effect of frictional duct length in subsonic flow and supersonic flow, numerical problems in 1D flow. Principles of Supersonic Combustion and Thrust Vectoring.

Inlets and Nozzles: Subsonic inlets: pressure recovery, inlet sizing drag flow distortion. Supersonic inlets: Total and sonic state points, A/A* normal shock based internal compression inlets, design sizing and performance. Exhaust nozzle, C-D nozzle, engine back pressure control, exit area ratio, and exhaust nozzle system performance in details.

UNIT II (12 Hrs.)

Parametric Cycle Analysis of Ideal Engines and Real Engines: Ideal Engines: Steps of engine parametric cycle analysis, basic assumptions. Applications to

a) Ideal Ramjet
b) Ideal Turbojet with and without afterburner
c) Ideal Turbofan engine, optimum BPR and afterburning
d) Ideal turboprop engine
e) Ideal Turbo shaft engine.

Real Engines: Cycle analysis of turbojet, turbojet with after burner, turbofan and turboprop

UNIT III (10 Hrs.)

Combustion Chambers and centrifugal compressor: Combustion systems, burners, ignition, flame stability. After burners: System design, flame stability, pressure losses etc.
Centrifugal compressor – principle of operation, work done and pressure rise, diffuser, compressibility effects, compressor characteristics, computerized design procedures.

UNIT IV (20 Hrs.)

Axial Flow Compressor: Euler‟s Turbo-machinery equations. Axial flow compressor analysis, cascade action, flow field. Euler‟s equation, velocity diagrams, flow annulus area stage parameters. Degree of reaction, cascade airfoil nomenclature and loss coefficient, diffusion factor, stage loading and flow coefficient, stage pressure ratio, Blade Mach Number, repeating stage, repeating row, mean line design. Flow path dimensions, number of blades per stage. Radial variation, design process, performance.

Axial Flow Turbine: Turbine: Introduction to turbine analysis, mean radius stage calculations, stage parameters, stage loading and flow coefficients degree of reaction, stage temperature ratio and pressure ratio, blade spacing, radial variation, velocity ratio. Axial flow turbine, stage flow path, Dimensional stage analysis. Multistage design; steps of design: single stage and two stages. Turbine performance. Blade cooling.

RECOMMENDED BOOKS

1. J.D. Mattingly, Elements of Gas Turbine Propulsion, McGraw Hill 1st Ed. 1997.
2. Cohen, Rogers and Sarvanmottoo, Gas Turbine Theory, John Wiley.
3. P.G. Hill and C.R. Peterson, Mechanics and Thermodynamics of Propulsion, Addison-Wesley, 1970.
4. Gorden C. Oates, Aircraft Propulsion Systems, Technology and Design, AIAA Pub.
5. J.L. Kereebrock, Aircraft Engines and Gas Turbine, MIT Press 1991.

ROCKET PROPULSION

Subject Code –BANED1-712 | **L T P Cr** **3 1 0 4** | **Duration:60 Hours**

COURSE OBJECTIVE

- This course is aimed to provide knowledge of construction and working of solid, liquid and hybrid engines used in rockets and missiles.
- The student should be able to evaluate propulsive performance of the aerospace vehicle during the course**.**

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Classify and explain working of various engines used in the rockets.
- Estimate flight performance of the rocket.
- Explain various types of missile trajectories and motion through the atmosphere.

UNIT – I (16 Hrs.)

Propulsion Systems: Jet Propulsion and Rocket Propulsion – Definition, Principle, Classification, Description and Application; Electrical, Nuclear and other Advanced Propulsion Systems.

Nozzle Theory: Ideal Rocket; Isentropic Flow through Nozzles; Exhaust Velocity; Choking; Nozzle Types; Nozzle Shape; Nozzle Area Expansion Ratio; Under expansion and Overexpansion; Nozzle Configurations; Real Nozzles; Performance Correction Factors; Multiphase Flow.

UNIT – II (14 Hrs.)

Thrust and Thrust Chambers: Thrust Equation; Specific Impulse, Thrust Coefficient, Characteristic Velocity and other Performance Parameters; Thrust Chambers; Methods of Cooling of Thrust Chambers; Steady State and Transient Heat Transfer; Heat Transfer Distribution; Steady State Heat Transfer to Liquids in Cooling Jackets; Uncooled Thrust Chambers; Thermal insulation; Radiation; Exhaust Plumes.

UNIT – III (12 Hrs.)

Solid Propellant Rocket Motors Application and Classification of Solid Propellant RocketMotors; Propellants and Characteristics; Composite, Double Base and CompositeModified Double Base Propellants; Metallized Propellants; Ingredients andProcessing; Propellant Burning Rate; Erosive Burning; Propellant Grains and GrainConfigurations; Propellant Grains Stress and Strain.

UNIT-IV (18 Hrs.)

Liquid Propellant Rocket Engines: Propellant and their Properties; Monopropellants andBipropellants; Storable, Cryogenic and Gelled Propellants; Fuels and Oxidizers;Metals; Propellant Tanks; Liquid Propellant Feed Systems; Injectors; Thrust ChamberShapes and Characteristic Length; Hybrid Propellant Rocket Motors; GaseousPropellant Rocket Motors and Reaction Control Systems.

Rocket Testing: Types of Tests; Test Facilities and Safeguards; Safety and EnvironmentalConcerns; Facilities and Safeguards; Monitoring and Control of Toxic Materials andExhaust Gases; Instrumentation and Data Management; Reliability and QualityControl; Flight Testing.

RECOMMENDED BOOKS

1. Sutton, George P. and Biblarz Oscar, “Rocket Propulsion Elements”, 9th Edition, John Willey and Sons, 2017.
2. Barrere, M., “Rocket Propulsion”, 1st Edition Elsevier Publication, 1960
3. Turner, Martin J. L., “Rocket and Spacecraft Propulsion: Principle, Practice and New Developments” ,3rd Edition, Springer, 2008.
4. John D Anderson Jr., “Introduction to flight, 8th Edition., Tata Mc Graw Hill, 2015.
5. J.W.Cornelisse, H F R Schoyer, K F Wakker, “Rocket propulsion and space flight dynamics”, 4th Edition, Pitman Publishers, 2001.

AIR TRANSPORTATION AND OPERATIONS

Subject Code –BANES1-721	L T P Cr	Duration:45 Hours
	3 0 0 3	

COURSE OBJECTIVES

- Understand air traffic control, airlines, airports & its maintenance issues.
- Understand the procedures for various segments of aircraft operations and various issues involved during the airline operations.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Develop a process for designing airports and airline operations.
- Compare different communication aids used in air transportation operations.
- Infer working of air traffic control and management
- Evaluate the operational procedures and standards in air transportation industry.

UNIT – I (13Hrs.)

Air Transportation Industry: Introduction to airline industry and economics, determination of operating costs, Airline route selection and scheduling, Methods of describing peaking, planning of flight operations, special topics in airline operations, Emergence of Low Cost Carrier (LCC).

Aircraft characteristics affecting airport design, Functions of airport, Components of an airport, Airport layouts and configurations, Geometric design of the airfield, Wind Rose Diagram, Geometric design of the airfield, Design alternatives, Airport operations manual.

UNIT – II (10Hrs.)

Airspace Classification and Communication: Airspace classification, controlled versus uncontrolled airspace, Instrument Flying Rules (IFR) & Visual Flying Rules (VFR) in controlled & uncontrolled airspace, Airspace classes, Radio communication, Air Traffic Control (ATC) communication procedures, clearance, aircraft identification, destination airport, departure instructions, route of flight, altitude assignment, required reports, holding instructions.

UNIT – III(11Hrs.)

Air Traffic Control (Part I): Modeling & Simulation of ATC systems, Factors affecting Capacity & Delay, Estimation of airway Capacity & Delay, Human Factors and Controller Workload, Performance Based Navigation, Free Flight, Conflict Detection and resolution, Environmental effects of Aviation, Modeling air transport systems.

UNIT – IV (11Hrs.)

Air Traffic Control (Part II) and Procedures: Principles of Air Navigation and Air Traffic Control, Overview of CNS & ATM, Separation standards, Radar and Non-radar separation, wake turbulence longitudinal separation minima, Precision approaches for landing, Radar systems for ATC. Control towers, Delegation of responsibility,

RECOMMENDED BOOKS

1. Michael S. Nolan, "Fundamentals of Air Traffic Control", 4th Edition, Thomson Brooks/Cole, USA, 2011.
2. Robert Horonjeff & Francis X. McKelvey, "Planning and Design of Airports", 5th Edition, McGraw Hill Professional Publishing, 2010.
3. John H. H. Grover, "Airline Route Planning, Blackwell Scientific Publications, Oxford, UK, 1990.
4. John G. Wensveen, "Air Transportation: A Management Perspective", 8th Edition, Ashgate Publishing Ltd., UK, 2015.
5. Seth B. Young & Alexander T. Wells , "Airport Planning and Management", 7th Edition, McGraw Hill Education,2019.

AIRCRAFT COMPOSITE MATERIALS

Subject Code –BANES1-722	**L T P Cr**	**Duration:45 Hours**
	3 0 0 3	

COURSE OBJECTIVES

- This course will provide an understanding of the strength and stress behavior of the composite materials as explained by certain recent theories on the subject.
- The students are to be equipped with the knowledge of the composite material performance under fatigue, impact and other adverse conditions that an aircraft is subjected to.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Explain stress strain relation of composite material.
- Describe performance of composite components under fatigue, impact and other flight conditions.
- Differentiate and examine various types of aircraft composite materials

- Evaluate strength of composite materials.
- Explain composite materials, their applications to structure design, technology and calculate strength.
- Develop new solutions.

UNIT – I (11Hrs.)

Introduction: Definition, Characteristics, Classification, comparison with metallic materials, Particulate Composites, Fiber-reinforced composites, Applications of composites in Aerospace Industry.

Fibers: Glass fibers, Carbon & Graphite fibers, Aramid fibers, Boron fibers and other fibers. Properties and applications of various types of fibers. Fiber finishing, Weave pattern of fibers.

UNIT – II (11Hrs.)

Matrix Materials: Definition, Functions of a matrix, Thermosetting, thermoplastic, Carbon, Metal and Ceramic matrix materials. Curing of resins. Prepregs, characteristics, handing and storing of prepregs.

Sandwich and Laminate Composites: Sandwich construction, Face and Core material, Honeycomb structures and their properties, Honeycomb manufacturing, Fabrication of sandwich structures, Laminate lay-up, importance of ply orientation, lay-up code, Joining of laminate structures, Tooling required.

UNIT – III (12 Hrs.)

Manufacturing Processes: Open mold processes, Closed mold processes, Continuous processes. Their merits and demerits.

Fabrication of thermosetting resin matrix composites – Hand lay-up techniques, Bag molding processes, Resin transfer molding, Filament winding, Pultrusion, preformed molding compounds. Fabrication of thermoplastic resin matrix composites short fiber composites), Fabrication of metal matrix composites, Fabrication of ceramic matrix composites

UNIT – IV (13 Hrs.)

Repair of Composites: Defects in composites, Non-destructive inspection techniques, Damage assessment, evaluation and classification, Repair of composites.

Advanced Composites: Introduction to Carbon Nanotube (CNT) and Graphene, Graphenated Carbon Nanotubes (g-CNT), Categories of CNT based on structures, Properties, characterization, fabrication and applications of these materials.

RECOMMENDED BOOKS

1. Lalit Gupta , "Advanced Composite Materials" , Himalayan Books Publication,1998.
2. B. D. Aggarwal, L. J. Broutman and K. Chandrashekhar, "Analysis and Performance of Fiber Composites", 3rd Edition, John Wiley & Sons, 2012.
3. R.M. Jones ,Mechanics of Composite Materials , Taylor & Francis, 2015.
4. Sabodh K. Garg, "Analysis of Structural Composite Materials".
5. Daniel, "Engineering Mechanics of composite material", Oxford University Press, 2013.

AIRCRAFT MODELLING AND SIMULATION

Subject Code –BANES1-723 **L T P Cr** **Duration:45 Hours**
3 0 0 3

COURSE OBJECTIVES

- To enable the student to describe process of Mathematical modelling for solving engineering problems.
- The student should be able to build mathematical models of aircraft dynamics.
- The student should be able to carry out simulation of aircraft dynamics in professional software.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Do mathematical modeling for solving engineering problems
- Develop aircraft mathematical models using standard techniques
- Execute computational simulation of aircraft dynamic models using professional softwa

UNIT – I (13 Hrs.)

Mathematical Modelling: Mathematical concepts in Modelling, why modelling, Goals of modelling studies, Process of Mathematical modeling, Real world problem, falling rock modeling, Computational problem, Basics of curve fittings, Engineering simulations and process of solving engineering problems, Analytical and numerical problem solutions with example.

UNIT –II (12 Hrs.)

Aircraft Modeling: Aircraft modeling, Aircraft state-space vectors, body-fixed coordinate systems, rotation matrix for wind and stability axes, Aircraft Equation of motion, kinetic equations for translation, kinematic equations for attitude, rigid-body kinetics, sensors and measurement systems, Introduction to Perturbation, Perturbation theory, nominal and perturbation values, Linearization of rigid body kinetics, Linear state-space model based on using wind and stability axes.

UNIT –III (11 Hrs.)

Dynamic Models: Decoupling: longitudinal and lateral modes: Longitudinal and lateral equations, Aerodynamic Forces and Moments, longitudinal and lateral forces and moments, standard aircraft maneuvers, bank to turn, altitude control dynamic models, longitudinal and lateral stability analysis, Satellite modelling, Attitude model

UNIT –IV (11 Hrs.)

Simulation models : Software Simulation of Aircraft dynamics models, 767 longitudinal and lateral model, F-16 Longitudinal and Lateral Mode, F2B Bristol Lateral model

RECOMMENDED BOOKS:

1. Dominic J.Diston, “Computational Modelling and Simulation of Aircraft and the Environment”, John Wiley & Sons, Ltd., 2009
2. R. C. Nelson, “Flight Stability and Automatic Control”, McGraw-Hill Book, 1989
3. Brian L. Stevens, “Aircraft Control and Simulation, 2nd Edition, John Wiley & Sons, 2003.
4. David Allerton, “Principles of Flight Simulation”, John Wiley and Sons, 2009.
5. John P. Fielding, “Introduction to Aircraft Design, 2nd Edition ,Cambridge University Press, 2017.

8th Semester

INTERNET OF THINGS

Subject Code –BANED1-811 **L T P Cr** **Duration:45 Hours**
3 0 0 3

COURSE OBJECTIVES

In this course, student will explore various components of Internet of things such as Sensors, internetworking and cyber space. In the end they will also be able to design and implement IoT circuits and solutions.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Understand general concepts of Internet of Things (IoT)
- Recognize various devices, sensors and applications
- Apply design concept to IoT solutions
- Analyze various M2M and IoT architectures
- Evaluate design issues in IoT applications
- Create IoT solutions using sensors, actuators and Devices

UNIT – I (12 Hrs.)

Introduction to IoT: Sensing, Actuation, Networking basics, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, IoT Definition, Characteristics. IoT Functional Blocks, Physical design of IoT, Logical design of IoT, Communication models & APIs.

M2M to IoT-The Vision-Introduction, From M2M to IoT, M2M towards IoT-the global context, A use case example, Differing Characteristics. Definitions, M2M Value Chains, IoT Value Chains, An emerging industrial structure for IoT

UNIT – II (11 Hrs.)

M2M vs IoT An Architectural Overview–Building architecture, Main design principles and needed capabilities, An IoT architecture outline, standards considerations. Reference Architecture and Reference Model of IoT.

UNIT – III (11 Hrs.)

IoT Reference Architecture- Getting Familiar with IoT Architecture, Various architectural views of IoT such as Functional, Information, Operational and Deployment. Constraints affecting design in IoT world- Introduction, Technical design Constraints.

Domain specific applications of IoT: Home automation, Industry applications, Surveillance applications, Other IoT application.

UNIT – IV(11 Hrs.)

Developing IoT solutions: Introduction to Python, Introduction to different IoT tools, Introduction to Arduino and Raspberry Pi Implementation of IoT with Arduino and Raspberry, Cloud Computing, Fog Computing, Connected Vehicles, Data Aggregation for the IoT in Smart Cities, Privacy and Security Issues in IoT.

RECOMMENDED BOOKS

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st Edition, Academic Press, 2014.
2. Vijay Madisetti and ArshdeepBahga, "Internet of Things (A Hands-on Approach)", 1st Edition, VPT, 2014
3. Francis da Costa, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st Edition, Apress Publications, 2013
4. Cuno Pfister, "Getting Started with the Internet of Things", O‟Reilly Media, 2011

CARBON FIBRE REINFORCED POLYMER

Subject Code –BANED1-812	L T P Cr 3 0 0 3	Duration:45 Hours

COURSE OBJECTIVES

The course on Carbon fibre reinforced has become very essential for a Aeronautical/ aerospace engineer to meet the demand of the today‟s world applications, where advances in Technological needs demands High strength, corrosion resistance, fatigue / creep resistant & stiff structure with very lesser densities such as in making of automobiles, aircrafts, space crafts, etc.

After learning the course the students should be able to: -

- Understand the significance of advanced materials.
- Compare the set of technological properties of the advanced materials with the conventional materials.
- Distinguish the construction, constituent‟s phases & characteristics of the composite materials.
- Calculate the strength of the carbon fibre reinforced polymer under transverse & longitudinal loading applications.
- Identify the strengthening mechanics adopted in a carbon fibre reinforced polymer
- Explain the fabrication techniques of different types of composite materials.

UNIT-I (12 Hrs.)

Introduction: Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential

UNIT-II (11 Hrs.)

Various types of composites: Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-

Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites

UNIT-III (13 Hrs.)

Fabrication methods: Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes like filament welding, compression molding, resin-transplant method, pltrusion, pre-peg layer, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films

UNIT-IV (09 Hrs.)

Testing of Composites: Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.

Books:

1. K.K. Chawla, "Composite Materials – Science & Engg.", Springer, New York, 1988.
2. Mel M. Schwartz, "Composite Materials: Properties, Non-destructive testing and Repair", Prentice Hall, New Jersey ,1996.
3. L.J. Broutman and R.M. Krock, "Modern Composite Materials", Addison-Wesley, 1967.
4. David A Colling & Thomas Vasilos, "Industrial Materials: Polymers, Ceramics and Composites, Vol. 2", Prentice Hall, N. Jersey, 1995.

BOUNDARY LAYER THEORY

Subject Code –BANED1-821 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

- This course will provide knowledge of basic concepts of momentum and thermal boundary layers, formulation of equations and solutions given by different investigators in case of flat surface and axi-symmetric bodies.
- The study involves the analysis and understanding of empirical results for laminar boundary layer, transition and turbulent boundary layer.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Describe and formulate momentum and thermal boundary layers equations in respect of flat surface and axi-symmetric bodies.
- Analyze empirical results obtained for laminar, transition and turbulent boundary layers.

UNIT – I (16Hrs.)

Review of Basic Concepts and Formulation of Equation: Descriptors/Topics: Boundary layer thickness, Momentum thickness, Energy thickness, Shape Factor, separation equations of Motion and energy equation for compressible viscous fluid-derivation and discussion, boundary layer equation and their general properties.

UNIT – II (16 Hrs.)

Exact and Approximate Methods and Axially Symmetrical Body: Descriptors/Topics: Flat plate at zero incidence, Flows with pressure gradient, von Karman and Polhausen Methods. Rotation near ground, Circular jet, Boundary layer on a body of revolution, flow in the entrance section of pipe.

UNIT – III (16 Hrs.)

Thermal Boundary Layer, Transition and Boundary Layer Control: Descriptors/Topics: Heat transfer from heated surface. Incompressible and compressible laminar flow over a flat plate, Plate thermometer problem. Pipe flow and flow over a flat plate, Critical Reynolds number, Turbulent spots, Principles of theory of stability of Laminar flows, Sommer-field equation, factors affecting transition, Laminar airfoils.

Methods of control, Fundamental equations and exact solution for a flat plate with uniform suction, Compressible Boundary Layers with suction, Approximate solution for a flat plate with uniform suction, compressible boundary layers with suction approximate solutions, theoretical and experimental results.

UNIT – IV (12Hrs.)

Turbulent Boundary Layer and pipe flows: Descriptors/Topics: Fundamentals of Turbulent flow, Mean motion and fluctuations, Reynolds, stresses, wind tunnel Turbulence, Prandtls mixing Length theory, Von Karman‟s similarity Hypothesis, Velocity distribution laws. Experimental results through smooth pipes, Relation between laws of friction and velocity distribution, Universal Resistance law for smooth pipe at large Reynolds number, Rough pipe and equivalent roughness.

RECOMMENDED BOOKS

1. John D. Anderson (Jr.), „Fundamentals of Aerodynamics‟, 2^{nd} Edition., McGraw Hill.
2. Gupta and Gupta, „Fluid Mechanics and its Applications‟, Wiley Eastern, **1960**
3. H. Schlichting, ‟Boundary Layer Theory‟, 6^{th} Edition., McGraw Hill, **1986.**
4. Frank M. White, „Fluid Mechanics‟, 2^{nd} Edition, McGraw Hill, **1986**
5. John Bertin , Aerodynamics for Engineers, 4th Ed. , Pearson Publishers 2004

ADVANCED AERODYNAMICS

Subject Code –BANED1-822	**L T P Cr**	**Duration:60 Hours**
	3 1 0 4	

COURSE OBJECTIVES

- Analyze supersonic flows by applying different techniques.
- Calculate boundary layer thickness by applying different methods.
- Analyze complete supersonic and hypersonic configurations.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:
- Analyze flow properties in compressible medium.
- Design supersonic nozzle by method of characteristics
- Evaluate aerodynamic characteristics of supersonic airfoils theoretically.
- Analyze and design supersonic and hypersonic aircraft configurations

UNIT – I (16 Hrs.)

Non Linear Supersonic Flows: Numerical techniques, method of characteristics, supersonic nozzle design, finite difference method, time dependent technique for supersonic blunt bodies, numerical problems

Laminar and Turbulent Boundary Layer:
Laminar :Compressible flow over a flat plate, reference temperature method, stagnation point aerodynamic heating, boundary layer over arbitrary bodies using finite difference method, Turbulent: reference temperature method for flat plate, Meador-Smart reference temperature method, prediction of airfoil drag ,turbulence modeling, numerical problems

UNIT – II (16 Hrs.)

Flow With Small Perturbations: One dimensional wave equation, D‟‟ Alembert‟‟s solution,2-D Subsonic and supersonic flow past a wavy wall, method of characteristics to unsteady 1-D homentropic flow, uniform flow regions, simple wave regions and non simple wave regions, simple compression and expansion waves

UNIT – III (16 Hrs.)

Bodies of Revolution: Introduction, cylindrical coordinates, axially symmetric flow, subsonic flow, supersonic flow, solution for cone, and slender cone, yawed body of revolution in supersonic flow, cross flow solutions for slender body of revolution, lift of slender body of revolution, Rayleigh formula

UNIT – IV(12 Hrs.)

Supersonic Airplane Configurations And Hypersonic Flow
Governing equations and boundary conditions, consequences of linearity, conical flow method for rectangular, swept, delta and arrow wings, singularity distribution method, design consideration for supersonic aircraft, aerodynamic interaction, supersonic analysis for complete configurations. Qualitative aspects, Newtonian theory, lift and drag of wings at hypersonic speeds, hypersonic shock wave relations, mach no. independence, hypersonic and CFD, high L/D hypersonic configurations, Aerodynamic heating, ground test data and flight test data

RECOMMENDED BOOKS

1. John D Anderson Jr., "Introduction to flight, 8th Edition., Tata Mc Graw Hill, 2015
2. John J Bertin, "Aerodynamics for Engineers" , 6th Edition, Pearson Publishers, 2013.
3. Liepmann, H W and A. Roshk, "Elements of Gas dynamics", Dover Publications Inc., 2002.
4. Anderson J. D, "Modern Compressible Flow with Historical Perspective", 3rd Edition, McGraw-Hill, 2017.
5. Zucrow, M J and J D Hoffman, "Gas Dynamics - Vol. 1" , Wiley India Pvt Ltd, 2013

EXPERIMENTAL AERODYNAMICS

Subject Code –BANED1-823	L T P Cr	Duration:60 Hours
	3 1 0 4	

COURSE OBJECTIVES

- Gain insight on the problem associated with design, setup and execution of experimental methods pertinent to aerodynamics/fluid mechanics and the most important and up-to-date measurement techniques.
- Develop a practical knowledge and capability to perform measurements in dedicated facilities aimed at studying fundamental problems in aerodynamics/fluid mechanics.

LEARNING OUTCOME

At the end of the subject, the student will be able to:

- Differentiate between different types tunnels
- Select an appropriate technique to perform an experiment to study aerodynamic characteristics of a body
- Acquire and interpret data using different data acquisition techniques.
- Integrate experimental equipment with data acquisition system using graphical programming.

UNIT – I (16 Hrs.)

Introduction: Types of wind tunnels – Open and closed wind tunnels; wind tunnels with open and closed test sections; variable density wind tunnels; smoke tunnels; vertical wind tunnels; sub-sonic, super-sonic, trans-sonic wind tunnel; water tunnels. Wind tunnel calibration, Measurements techniques in wind tunnels: forces and moments, pressure, velocity, temperature, aero-acoustic measurements.

UNIT – II(16 Hrs.)

Qualitative and Quantitative Measurements: Low speed flow visualization techniques, Schlieren, shadowgraph, interferometry, introduction to laser diagnostic techniques.

Measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals, Steady and unsteady pressure measurements and various types of pressure probes and transducers, errors in pressure measurements, thermocouples, thermography, velocity measurement using hot wire anemometry , Laser Doppler Velocimetry and Particle Image Velocimetry

UNIT – III(16 Hrs.)

Data Acquisition and Processing: Data acquisition and digital signal processing techniques, wind tunnel data acquisition, measurement of steady and unsteady pressure, velocity, temperature, turbulence intensity, calibration of force, pressure and acoustic sensors. Calibration of single and two wire probes.

Data validation techniques: verifying experimental data with theoretical and computational results.

UNIT – IV(12 Hrs.)

Virtual Instrumentation: Introduction to VI (virtual instrumentation) and its typical applications, functional systems, graphical programming, data flow techniques, advantages of VI techniques. VI programming techniques; VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, string and file I/O, DAQ methods, code interface nodes.

RECOMMENDED BOOKS

1. Jewel B. Barlow, “Low speed wind tunnel testing”, 3rd Edition, John Wiley & sons, 2010.
2. Bruno Chanetz, “Experimental Aerodynamics: An Introductory Guide”, 1st Edition, Springer Nature Switzerland AG, 2020.
3. Justin D. Pereira , “Wind Tunnels: Aerodynamics Models & Experiments (Engineering Tools, Techniques and Tables)”, U.K. Edition, Nova Science Publishers Inc, 2011.
4. Sanjay Gupta “Virtual instrumentation using Lab VIEW ”,2nd Edition, McGraw Hill Education, 2017.
5. Helmut Krakowski, “Wind Tunnel Designs And Their Diverse Engineering Applications”, 1st Edition, Scitus Academics”, 2017.