B.Tech. Aerospace Engineering (5th SEMESTER)

		Contact Hrs.			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BASES1-501	Space Flight Mechanics	3	1	0	40	60	100	4
BASES1-502	Automatic Flight Control	3	1	0	40	60	100	4
BASES1-503	Aerospace Structure Analysis	3	0	0	40	60	100	3
BASES1-504	Flight Controls lab	0	0	2	60	40	100	1
BASES1-505	Training-II	-	-	-	60	40	100	3
	Humanities Course* (Select Any One)	3	0	0	40	60	100	3
BHSMC0-005	*Effective Technical Communication*							
BHSMC0-016	*Organizational Behavior*							
	Departmental Elective-I (Select One)	3	1	0	40	60	100	4
BASED1-511	Aerospace Materials and Processes							
BASED1-512	Viscous Flow Theory							
BASED1-513	Wind Turbines							
	Mandatory Courses (Any One)	2	0	0	100	0	100	0
BMNCC0-001	*Constitution of India*							
BMNCC0-006	*Essence of Indian Knowledge Tradition*							
Total		**-**	**-**	**-**	**420**	**380**	**800**	**22**

***Detailed syllabus of Humanities/Management subjects may be seen on the UG Open Electives Page of University website by clicking on "<u>MRSPTU List of Humanities, Social Science and Management Subjects_BHSMC0-XXX</u>"**

SPACE FLIGHT MECHANICS

Subject Code – BASES1-501 | **L T P Cr** | **Duration:60 Hrs**
3 1 0 4

COURSE OBJECTIVES

- To acquaint the students with the concepts of space flight, time derivatives of moving vectors, equation of motions in inertial frame, Orbit Maneuvers, Lunar/ Interplanetary Trajectories

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. To apply the concepts of numerical integration.
2. Analyze equation of motion in inertial frame
3. Solve the problems of orbital tracking
4. Carry out design of Orbit Maneuvers.
5. Understand the concepts of Lunar/ Interplanetary Trajectories.

UNIT-I (20 hrs)

Dynamics of Particles: Introduction, Vectors, Kinematics, Mass, force, and Newton's law of gravitation Newton's law of motion, Time derivatives of moving vectors Relative motion Numerical integration, RK method, RK1 (Euler's method), RK2 (Heun's method), RK3, RK4, Heun's predictor–corrector method, RK with variable step size

Reference frames and rotations: Equations of motion in an inertial frame, Equations of relative motion, Angular momentum and the orbit formulas, The energy law, Circular orbits ($e = 0$), Elliptical orbits ($0 < e < 1$), Parabolic trajectories ($e = 1$), Hyperbolic trajectories ($e > 1$)

UNIT-II (18 hrs)

Two Body Motion: equations of motion – Kepler laws – solution to two-body problem – conics and relations – vis-viva equation – Kepler equation – orbital elements – orbit determination – Lambert problem – satellite tracking – different methods of solution to Lambert problem.

UNIT-III (12 hrs)

Non-Keplerian Motion: perturbing acceleration – earth aspherical potential – oblateness – third body effects – atmospheric drag effects – application of perturbations.

Orbit Maneuvers: Hohmann transfer – inclination change maneuvers, combined maneuvers, bi-elliptic maneuvers.

UNIT-IV (10 hrs)

Lunar/ Interplanetary Trajectories: Introduction, Interplanetary Hohmann transfers, Rendezvous opportunities, Sphere of influence, Method of patched conics, Planetary departure, Sensitivity analysis, Planetary rendezvous, Planetary flyby, Planetary ephemeris, non-Hohmann interplanetary trajectories

RECOMMENDED BOOKS

1. Curtis, H. D., “Orbital Mechanics for Engineering Students”, 2nd ed., Elsevier (2009).
2. Chobotov, V. A., “Orbital Mechanics, 3rd ed.”, AIAA Edu. Series (2002).
3. Wiesel, W. E., “Spaceflight Dynamics”, 2nd ed., McGraw-Hill (1996).
4. Brown, C. D., “Spacecraft Mission Design, 2nd ed.”, AIAA Edu. Series (1998).
5. Escobal, P. R., “Methods of Orbit Determination”, 2nd ed., Krieger Pub. Co. (1976).

AUTOMATIC FLIGHT CONTROL

Subject Code – BASES1-502	L	T	P	Cr	Duration 60 Hrs
	3	1	0	4	

COURSE OBJECTIVES

- To acquaint the students with the concepts of stability derivatives, automatic flight control, design of autopilot systems, transfer functions and control design, to design longitudinal and lateral-directional controls for various types of aircrafts.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. To identify open and closed loop control systems.
2. Analyze linear feedback control systems and acquaint with block diagram algebra
3. Carry out the system stability analysis
4. Analyze feedback control systems including steady state and frequency response.
5. Carry out design of control systems.

UNIT-I (18 Hrs)

Introduction: Classical and modern control theory, Open loop and closed loop (feedback) control systems, Types of feedback control systems.

Feedback control system: Transfer function of linear systems. Impulse response of linear systems, Block diagrams of feedback control systems, Multivariable systems, and Block diagram algebra.

UNIT-II (12 Hrs)

System stability; Routh-hurwitz criterion, the root locus Method, Governing rules for plotting root locus, Effect of addition of Zeroes and Poles, Gain and phase margin from root locus.

Analysis of Feedback Control Systems: Typical test input signals, Frequency domain techniques, Time domain performance characteristics of feedback control systems. Effects of derivative and integral control. Steady state response of feedback control system, Steady state error, Frequency response.

UNIT-III (18 Hrs)

Control System Design: Control system design, Compensation, Forward-path compensation, Feedback-path compensation, Proportional, proportional-integral and proportional-integral-derivative (P, PI and PID) controller.

Longitudinal Auto-Pilots: Short period and phugoid dynamics, Longitudinal auto pilots: Brief description through block diagrams and root locus, Displacement autopilot, pitch-displacement autopilot, Acceleration control system, Fly-By-Wire control system, Stability augmentation system, Instrument Landing System.

UNIT-IV (12 Hrs)

Lateral Auto-Pilots: Introduction, Roll dynamics, Dutch roll approximation, Damping of Dutch Roll, Roll attitude autopilot, Methods of obtaining coordination, Yaw orientation control system.

RECOMMENDED BOOKS:

1. R. C. Nelson, "Flight Stability and Automatic Control", 2nd Ed., McGraw Hill Education(2017).
2. E. H. J. Pallett, Shawn Coyle, "Automatic Flight Control", 4th Ed., Wiley-Blackwell(1993).
3. Donald McLean, "Automatic Flight Control Systems", 1st Ed., Prentice Hall(1969).
4. C. D. Perkins & R. E. Hage, "Airplane Performance Stability and Control", Wiley India Pvt. Ltd(2011).
5. R.V. Jategaonkar, "Flight Vehicle System Identification: A Time Domain Methodology", 2nd Ed., AIAA Series(2015).

AEROSPACE STRUCTURAL ANALYSIS

Subject Code – BASES1-503	L T P Cr	Duration 45 Hrs
	3 0 0 3	

COURSE OBJECTIVES

- To equip the student with the knowledge about the mechanics of different aircraft structural members, and their design and analysis. The student should also be able to know the basic concepts of the advanced material utilized in the aerospace structures.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. Have an understanding of aerospace materials along with the skills to analyze the basic elements of aircraft structures, and to calculate loads acting on the aircraft. Analyze linear feedback control systems and acquaint with block diagram algebra.
2. Apply the concept of structural idealization for stress analysis of open and closed section beams, and understand the concept of shear flow in cell-structures. Analyze feedback control systems including steady state and frequency response.
3. Do stress analysis of aircraft wing including the tapered wing and wings with variable stringer area. Design various autopilots (longitudinal/ lateral) for various types of aircrafts.
4. Evaluate stresses in various aircraft components like fuselage, wing ribs, etc., and understand the wing-fuselage interaction and fuselage detailed design.
5. Understand the basic concept of static and dynamic aeroelasticity including the flutter and buffeting.

UNIT-I (11Hrs)

Introduction to Aircraft Structure And Materials: Aerospace Materials, Composite materials: Classifications and characteristics of composite materials, Types of Fibres, Matrix materials, Sandwich and Laminate Composite, Basic structural elements in aircraft structures, wing and fuselage, aircraft materials. Airworthiness, Factor of safety, Flight envelope, Airframe loads: Inertial loads, Maneuver loads, Gust loads, Fatigue: Fail safe and safe life

UNIT-II (12 hrs)

Thin-walled Beams: Bending of open and closed thin walled beams, Shear of beams, Torsion of beams, Combined open and closed section of beams, Structural idealization.

Single and multi – cell structures, Approximate methods, Shear flow in single & multi-cell structures under torsion. Shear flow in single and multi-cell under bending with walls effective and ineffective.

UNIT-III (10Hrs)

Design and analysis of Aircraft Wings: Wing spars and box beams, tapered wing spars, open and closed section beams, wings with variable stringer area, Three boom shell, Bending torsion, shear center, tapered wings, Deflections, Cut-outs.

UNIT-IV (12 Hrs)

Design and analysis of Fuselage: Bending, shear, torsion, cut-outs in fuselage, Principles of stiffener web construction, Fuselage frames, wing ribs, Fuselage detail design, Wing fuselage interaction, Landing gears, Engine mounts.

Aero elasticity: Static and dynamic aero elastic phenomenon, Critical speeds, Divergence of 2-D wing section and an idealized cantilever wing, Loss and reversal of aileron control, flutter and buffeting.

RECOMMENDED BOOKS:

1. C.T.Sun , “Mechanics of aircraft structures” , 3rd Ed , John Wiley publishers(1998).
2. Allen, David H., Haisler, Walter, “Introduction to Aerospace Structural Analysis” (1985).
3. T.H.G.Megson, “Aircraft Structures for Engineering Students”, 4th Ed. Elsevier Ltd(2012).
4. D.J.Peery, “Aircraft structures”, McGraw Hill(1950)
5. R.L.Bisplinghoff Holt Ashley R.L.Halfman, “Aeroelasticity”, Addison Wesley Publishing Co. Reading, Mass(1965).

FLIGHT CONTROLS LAB

Subject Code – BASES1-504	L	T	P	Cr	Duration 30 Hrs
	0	0	2	1	

COURSE OBJECTIVES

- The objective of this lab is to teach students and give knowledge about the simulation of aircraft performance in the flight simulator and access the parameters that are affecting the performance of the flight with different boundary conditions. This lab also enables the students to write the MATLAB scripts for the analysis of problems like evaluating equations of motion with one DOF, two DOF and three DOF and also the dynamics of the aircraft. This laboratory also enhances experimental skills to the students to assess the performance and static stability of an aircraft.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. Learn the basic MATLAB simulation of un-accelerated flight for takeoff, cruise and landing conditions by solving equations of motions.
2. Understand the concept behind the conventional and unconventional airfoil performance and stability conditions.
3. Identify the functions of the basic controls like ailerons, elevators and rudders used in typical airplanes.
4. Understand the dynamics of the aircraft flight simulator and it's functioning in different flight conditions like takeoff, landing and cruise condition.

LIST OF EXPERIMENTS

1. To solve basic mathematical equations related to pressure and density used in aircraft performance with basic loops using MATLAB Software.
2. To extract data of atmospheric conditions at different altitudes for aircraft equation of motion using MATLAB Software.
3. To solve the equation of motion governed by one DOF using MATLAB tools.
4. Carryout aerodynamic performance study of a symmetrical airfoil and draw a plot for C_L/C_D verses angles of attack.
5. Carryout aerodynamic performance study of a symmetrical corrugated airfoil and draw a plot for C_L/C_D verses angles of attack.
6. Carryout aerodynamic performance study of a Delta Wing aircraft model and draw a plot for C_L/C_D verses angles of attack.
7. Carryout aerodynamic static stability study of a symmetrical airfoil and draw a plot for Cm verses angles of attack.
8. Carryout aerodynamic static stability analysis of a corrugated airfoil and draw a plot for Cm verses angles of attack and ascertain its stability at given Speed and Reynolds number.
9. Carryout aerodynamic longitudinal static stability study of a delta wing aircraft and draw a plot for Coefficient of Moment verses angles of attack.
10. To perform take off, cruise, co-ordinate turn and landing with aircraft in the flight simulator in the normal weather conditions, the flight is from 'Begumpet airport' to 'Hakimpet airport'

11. To perform take off, cruise, co-ordinate turn and landing with aircraft in the flight simulator in the gusty weather conditions, the flight is from 'Begumpet airport' to 'Hakimpet airport'.

TRAINING-II

Subject Code – BASES1-505

L	T	P	Cr
0	0	0	3

EFFECTIVE TECHNICAL COMMUNICATION

Subject Code – BHSMC0-005

L	T	P	Cr
3	0	0	3

ORGANIZATIONAL BEHAVIOUR

Subject Code – BHSMC0-016

L	T	P	Cr
3	0	0	3

AEROSPACE MATERIALS AND PROCESSES

Subject Code – BASED1-511 **Duration 60 Hrs**

L	T	P	Cr
3	1	0	4

COURSE OBJECTIVES

- At the end of this course, the student should be able to describe the concepts related to composite materials and matrix materials, and apply the knowledge during fabrication of composites in aircraft and allied industry.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. Gain the knowledge of various types of composites materials in Aerospace Industry.
2. Have an understanding on various types of fibers, its advantage and its application in aerospace industry.
3. Have the knowledge of various types of matrix along its properties and usage.
4. Have an understanding of sandwich and laminated composite materials and its mechanics and applications.
5. Learn the knowledge of manufacturing processes of composite materials and be able to fabricate composite based on their own requirements.

UNIT-I (15 Hrs)

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 (14 hrs)

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 (15 Hrs)

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

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

UNIT-IV (16 Hrs)

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. Autar K Kaw, "Mechanics of Composite Materials", CRC Press
2. Lalit Gupta, "Advanced Composite Materials", Himalayan Books Publication
3. B. D. Aggarwal, L. J. Broutman and K. Chandrashekhara, "Analysis and Performance of Fiber Composites", John Wiley & Sons
4. R.M. Jones, "Mechanics of Composite Materials", Taylor & Francis

VISCOUS FLOW THEORY

Subject Code – BASED1-512 **L T P Cr** **Duration 60 Hrs**
3 1 0 4

COURSE OBJECTIVES

- To enable the students to understand the characteristics of viscous flows, the Navier-Stokes equations and its properties and determine laminar and turbulent boundary layer thickness over flat plate and in pipes.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. Calculate the boundary layer thickness, displacement thickness, momentum and energy thickness for two dimensional flows..
2. Solve and analyze various two and three dimensional flow problems. Have the knowledge of various types of matrix along its properties and usage.
3. Analyze the Navier-Stokes Equation and its properties for various two dimensional flow problems.
4. To understand the concept of laminar boundary layer and analyze the stability of laminar flows.
5. To understand the concept of turbulent boundary layer and determine the turbulent boundary layer thickness in pipes and flat plate.

UNIT-I (15 Hrs)

Viscous Flow Properties: Viscous fluid flow with historical outlines of viscous flow, Boundary conditions for viscous flow problems, Development of boundary layer- Prandtl's hypothesis, Estimation of boundary layer thickness- Displacement thickness, momentum and energy thickness for two-dimensional flows. Viscosity and thermal conductivity, thermodynamic properties

Slow Viscous Flow: Introduction, Stokes Flows, Two – Dimensional Flows, Three – dimensional Stokes Flows, analysis of Stokes's Solution, The Oseen Equations, Three-Dimensional Oseen Flows, Hele Shaw flow, Problems

UNIT-II (14 hrs)

Navier-stokes Equations And Solution: General stress system in a deformable body, the rate at which the fluid element is strained in a flow, Relation between stress and rate of deformation, Stoke's hypothesis, bulk viscosity and thermodynamic properties, The Navier – Stokes Equation (N-S) , General properties of Navier – Stokes Equation.

Two dimensional flow through a straight channel. Hagen- Poiseuille flow, Suddenly accelerated plane wall, Stagnation in plane flow (Hiemenz problem), Flow near a rotating disk, Very slow motion, Parallel flow past a sphere.

UNIT-III (15 Hrs)

Laminar Boundary Layer: Analysis of Boundary layer temperature profiles for constant wall temperature, Falkner-Skan Wedge flows, Free shear flows- plane laminar jet, plane laminar wake. Integral equation of Boundary layer, Karman-Pohlhausen method. Thermal boundary layer calculations- One parameter (U_o) and two parameters (U_0 and ΔT) integral methods. Stability of laminar flows.

UNIT-IV (16 Hrs)

Turbulent Boundary Layer: Two dimensional turbulent boundary layer equations, Integral relations, Eddy-Viscosity theories, Velocity profiles; The law of the wall, The law of the wake. Turbulent flow in pipes and channels. Turbulent boundary layer on a flat pate, Boundary layers with pressure gradient.

RECOMMENDED BOOKS:

1. Joseph A. Schetz, "Boundary Layer Analysis", 2nd Ed., Prentice Hall (1993).
2. H. Schlichting, "Boundary Layer theory", 6th Ed., McGraw Hill (1968).
3. John Bertin, "Aerodynamics for Engineers", 4th Ed., Pearson (2004).
4. Frank M White, "Viscous Fluid Flow", 3rd Ed., McGraw Hill (2006).
5. A. J. Reynolds, "Turbulent Flow in Engineering", 1st Ed., Wiley–Blackwell (1974).

WIND TURBINES

Subject Code – BASED1-513	**L T P Cr**	**Duration 60 Hrs**
	3 1 0 4	

COURSE OBJECTIVES

- To acquaint students with working principles, analysis, design and applications of wind turbines and its parts.

COURSE OUTCOMES

By the end of this course, the student will be able to:

1. Understand different wind turbine concepts and its configuration.

2. Select wind turbine and its parts according to given operating conditions using scientific methods and procedures.
3. Understand various applications and characteristics of wind turbines.
4. Analyze and estimate parameters related to performance of wind turbines.
5. Integrate the fundamental knowledge to design wind turbine with optimum performance.

UNIT-I (15 Hrs)

Introduction and Classification of Wind Turbines: History of wind power technology, wind resources, economic viability, experience in Europe and America, The Indian experience, factors in favor of wind energy, environmental effects. Types of wind energy collectors: horizontal axis rotors; Head on, fixed pitch and variable pitch blade rotors, cross wind. Vertical axis rotors; Savonius type and its variants, Darrieus type .lift based devices and drag devices.

UNIT-II (14 hrs)

Design Features: Description of various types of wind energy conversion systems (WECS) in use through their design features from 1kW range onwards. Considerations of complexities getting into the design and operation with increase in size and power output.

Applications and Characteristics of Wind Turbines: Standalone system; water pumping, direct heating and electric generation applications. Wind energy farms; Grid connected mode, hybrid mode. Wind histories, wind characteristics, power in wind stream, recording wind streams, wind rose, and choice of site.

UNIT-III (15 Hrs)

Performance of Wind Turbines: Power extraction from the wind stream, Ideal power coefficient, typical performance curves for various types, maximum power coefficients, speed-torque curves, power density of a wind stream, ducted system, vortex generator.

UNIT-IV (16 Hrs)

Complete System Design: Objectives, power requirements, wind availability, type and size of WECS required, cost of energy delivered, WECS viability, system characteristics, system requirements, system evaluation, design optimization, wind system design synthesis. Independent design project.

RECOMMENDED BOOKS:

1. Frank R. Eldridge, "Wind Machines", 2nd Ed., Van Nostrand Reinhold(1982).
2. Martin O. L. Hansen, "Aerodynamics of Wind turbines" 3rd Ed., Routledge(1980).
3. Hau, Erich, "Wind Turbines: Fundamentals, Technologies, Application, Economics", 3rd Ed., Springer(2013).
4. Paul Gipe, "Wind Power", 1st Ed., Chelsea Green(2004).

CONSTITUTION OF INDIA

Subject Code: BMNCC0-001	L	T	P	C	Duration: 30 Hrs.
	2	0	0	0	

Course Contents:

1. Meaning of the constitution law and constitutionalism
2. Historical perspective of the Constitution of India.
3. Salient features and characteristics of Constitution of India.
4. Scheme of the fundamental rights.
5. The scheme of the fundamental Duties and its legal status.
6. The directive Principles of State Policy – its importance and implementation.
7. Federal structure and distribution of legislative and financial powers between the Union and the States.
8. Parliamentary Form of Government in India – The constitution powers and the status of the president of India.
9. Amendment of the constitutional Powers and Procedure.
10. The historical perspectives of the constitutional amendments in India.
11. Emergency Provisions: National emergency, President Rule, Financial Emergency.
12. Local Self Government – Constitutional Scheme in India.
13. Scheme of the Fundamental Right to Equality.
14. Scheme of the Fundamental Right to certain Freedom under Article 19.
15. Scope of the Right to Life and Personal Liberty under Article 21.

ESSENCE OF INDIAN KNOWLEDGE TRADITION

Subject Code- BMNCC0-006 **L T P C** **Duration: 30 Hrs.**

2 0 0 0

COURSE OBJECTIVE:

The course is introduced

1. To get a knowledge in Indian Philosophical Foundations.
2. To Know Indian Languages and Literature and the fine arts in India & Their Philosophy.
3. To explore the Science and Scientists of Medieval and Modern India

COURSE OUTCOMES:

After successful completion of the course the students will be able to

1. Understand philosophy of Indian culture.
2. Distinguish the Indian languages and literature among difference traditions.
3. Learn the philosophy of ancient, medieval and modern India.
4. Acquire the information about the fine arts in India.
5. Know the contribution of scientists of different eras.
6. The essence of Yogic Science for Inclusiveness of society.

COURSE CONTENTS:

UNIT – I

Introduction to Indian Philosophy: Basics of Indian Philosophy, culture, civilization, culture and heritage, general characteristics of culture, importance of culture in human literature, Indian culture, Ancient Indian, Medieval India, Modern India.

Indian Philosophy & Literature: Vedas Upanishads, schools of Vedanta, and other religion Philosophical Literature. Philosophical Ideas the role of Sanskrit, significance of scriptures to current society, Indian Philosophies, literature of south India.

UNIT – II

Religion and Philosophy: Religion and Philosophy in ancient India, Religion and Philosophy in Medieval India, Religious Reform Movements in Modern India (selected movements only)

UNIT – III

Indian Fine Arts & Its Philosophy(Art, Technology & Engineering): Indian Painting, Indian handicrafts, Music, divisions of Indian classic music, modern Indian music, Dance and Drama, Indian Architecture (ancient, medieval and modern), Science and Technology in Indian, development of science in ancient, medieval and modern Indian.

UNIT – IV

Education System in India: Education in ancient, medieval and modern India, aims of education, subjects, languages, Science and Scientists of Ancient India, Scientists of Medieval India, Scientists of Modern India. The role Gurukulas in Education System, Value based Education.

RECOMMENDED BOOKS:

1. Kapil Kapoor, "Text and Interpretation: The India Tradition'', ISBN: 81246033375, 2005
2. "Science in Samskrit", Samskrita Bharti Publisher, ISBN-13:978-8187276333,2007

3. NCERT, “Position paper on Arts, Music, Dance and Theatre’’, ISBN 81-7450-494-X, 2006
4. S. Narain, “Examination in Ancient India”, Arya Book Depot, 1993
5. Satya Prakash, “Founders of Sciences in Ancient India”, Vijay Kumar Publisher, 1989
6. M.Hiriyanna, “Essentials of Indian Philosophy”, Motilal Banarsidass Publishers, ISBN-13: 978- 8120810990,2014
7. Chatterjee. S & Dutta “An Introduction to Indian Philosophy”.

B. Tech. Aerospace Engineering (6th SEMESTER)

		Contact Hrs.			Marks			Credits
Code	**Name**	**L**	**T**	**P**	**Int.**	**Ext.**	**Total**	
BASES1-601	Computational Fluid Dynamics	3	1	0	40	60	100	4
BASES1-602	Aerospace Vehicle Design	3	1	0	40	60	100	4
BASES1-603	Advanced Aerospace structures	3	1	0	40	60	100	4
BASES1-604	Computational Fluid Dynamics Lab	0	0	2	60	40	100	1
	Departmental Elective-II (Select One)	3	0	0	40	60	100	3
BASED1-611	Space Mission design and Optimization							
BASED1-612	Avionics							
BASED1-613	Helicopter Dynamics							
	Departmental Elective-III (Select One)	3	0	0	40	60	100	3
BASED1-621	Unmanned Aerial Vehicles							
BASED1-622	Missile Engineering							
XXXX	**Open Elective***	3	0	0	40	60	100	3
Total		**-**	**-**	**-**	**300**	**400**	**700**	**22**

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

COMPUTATIONAL FLUID DYNAMICS

Subject Code –BASES1-601	L T P Cr	Duration:60 Hours
	3 1 0 4	

COURSE OBJECTIVE

- The course will introduce the discretization techniques to solve the essential flow equations like N-S equation and RANS which are in complex partial differential forms.
- The course will enable students to acquire techniques to model the entire flow domain into regular and irregular grid system and adopting the suitable boundary condition to solve them.
- The course will also teach the common errors and solution instabilities in numerical analysis of any flow problem.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Explain partial differential, Navier strokes and Euler equations of the flow over the body.
- Describe Discretization techniques, equation transformation and grid generation.
- Apply different CFD techniques to assess pressure, pressure coefficient, forces and moments over different aerodynamic shapes**.**

UNIT –I (15 Hrs.)

Governing Equations and Boundary Conditions: General introduction about the scope of the subject, Models of flow, Concept of substantial derivative and divergence of velocity, Different Types of Flows, Integral form of conservation equations, Differential form of conservation equations, Navier-Stokes and Euler Equations, Classification of partial differential equations using Cramer's Rule, General behaviour of different classes of PDEs and their impact on physical computational fluid dynamics.

UNIT –II (14 Hrs.)

Discretization, Transformation and Grid Generation: Basic discretization techniques, Introduction to Finite Differences, Difference Equations, Explicit and Implicit approaches, concept of stability. General transformation of equations, Metrics and Jacobians, Form of governing equations suited for CFD, Stretched grids, Boundary-fitted coordinate systems-Elliptic grid generation, Adaptive grids, Some modern developments in grid generation.

UNIT –III (15 Hrs.)

Simple CFD Technique : Lax-Wendorff technique, Maccormack's technique, Relaxation technique, Pressure correction technique, Philosophy of pressure correction method. Numerical procedure for SIMPLE algorithm, Boundary conditions for pressure-correction method. Brief discussion of some computer graphic techniques used in CFD.

UNIT –IV (16 Hrs.)

Finite Volume Method: The finite volume method for one-dimensional steady state diffusion problems and for two-dimensional steady state diffusion problems, The finite volume method for one-dimensional convection and diffusion, The central differencing scheme, The upwind differencing scheme. The pressure-velocity coupling.

RECOMMENDED BOOKS

1. John D. Anderson, Computational Fluid Dynamics: The Basics with Applications, Mc Graw Hill, 1995.
2. H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics – The Finite Volume Method, Pearson Education. 2007.
3. D.C. Wilcox, Turbulence Modelling for CFD, 1993.
4. S.V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill,1981.
5. Patrick Knupp and Stanly Steinberg, Fundamentals of Grid Generation, CRC Press, 1994.

AEROSPACE VEHICLE DESIGN

Subject Code –BASES1-602 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVE

- Comprehend the flight vehicle design process.
- Acquire the knowledge of vehicle configuration and structural components.
- Understand the stability & control and subsystems.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Calculate the thrust to weight ratio and wing loading.
- Compute the flight vehicle performance.
- Select the subsystems as per vehicle design.

UNIT –I (15 Hrs.)

Overview of Design Process: Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation.

Thrust to Weight Ratio & Wing Loading: Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.

UNIT –II (14 Hrs.)

Configuration Layout & loft:Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Detect ability. Crew station, Passenger, and Payload arrangements.

UNIT –III (15 Hrs.)

Design of Structural Components: Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.

Engine Selection & Flight Vehicle Performance

Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices:- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking, Spread Sheet for Take-off and Landing. Enhanced lift design -Passive & Active. Spread Sheet

UNIT –IV (16 Hrs.)

Static Stability & Control: Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Spread Sheets. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.

Design Aspects of Subsystems: Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.

RECOMENDED BOOKS

1. Sadraey, M. H., Aircraft Design: A Systems Engineering Approach, Wiley (2012).
2. Griffin, M. D. and French, J. R., Space Vehicle Design,
3. Raymer, D. P., Aircraft Design: A Conceptual Approach, 4thed., AIAA Edu. Series (2004).
4. Anderson, J. D., Aircraft Performance and Design, McGraw-Hill (1999).
5. Corke, T. C., Design of Aircraft, Prentice Hall (2002).

ADVANCED AEROSPACE STRUCTURES

Subject Code –BASES1-603	L T P Cr	Duration:60 Hours
	3 1 0 4	

COURSE OBJECTIVE

Appreciate the roles that structures and structural materials play in aerospace vehicles.

Understand general design concepts for aerospace structures, components, vehicles, and materials.

Develop the analysis tools and skills needed to analyse the static and dynamic performance of aerospace structures.

Gain experience in identifying, formulating, and solving aerospace structural engineering problems.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Recognize phenomena such as deformation, stress and strain in simple aerospace structural elements
- Solve the simple1 Daxial deformation, torsion and bending problems.
- Compute shear stresses and twist angles in torsion for solid sections, closed thin-walled sections and open thin-walled sections.
- Understand the shear centre of abeamandan ability to predictits location.
- Evaluate the suitability of composite materials for the simple structural elements for specific aerospace applications.

UNIT –I (15 Hrs.)

Introduction: Semi-monocoque aerospace structures – Loads and Design considerations – construction concepts – layout – nomenclature and structural function of parts – strength vs stiffness-based design – Energy Method – Beam bending.

Bending, Shear And Torsion Of Thin-Walled Beams (TWB):Bending and shear of open, closed, and thin-walled beams – torsion on single-cell thin-walled beams – torsion on multiple-cell thin-walled beams.

UNIT –II (14 Hrs.)

Buckling Of Thin-Walled Beams: Concept of structural instability – flexural buckling analysis – bending of beams under combined axial and lateral loads – short column and inelastic buckling – Pure torsional buckling and coupled flexural-torsional buckling of open TWBs – concept of buckling of plates, local buckling of TWBs – buckling and post-buckling of stiffened skin panels – ultimate load carrying capacity of a typical semi-monocoque TW box section – tension-field beams.

UNIT –III (15 Hrs.)

Plate Theory: Two Dimensional and Three-Dimensional Transformation of Stresses and strains – Thin Plate Theory – Stress Resultants and Kinematics – Thin Plate Governing Equations and Boundary Conditions.

UNIT –IV (16 Hrs.)

Composite and Sandwich Structures: Introduction to Advanced Fibre Composites – Analysis of Orthotropic Composite Plies – Laminate theory – Analysis of Composite Laminates: Stiffness Matrix – Stress and Strain – Thermal Expansion – Failure Mechanisms and Analysis – failure criteria – composite beams – sandwich structures.

RECOMENDED BOOKS:

1. Megson, T. H. G., Aircraft Structures for Engineering Students, 4th ed., Butterworth-Heinemann (2007).
2. Timoshenko, S. P. and Goodier, J. N., Theory of Elasticity, 3rded., McGraw-Hill (1970).
3. Timoshenko, S. P. and Woinowsky-Krieger, S., Theory of Plates and Shells, 2nd ed., McGraw-Hill (1964).
4. Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, 2nd ed., Jacobs Publishing NC. (1973).

COMPTATIONAL FLUID DYNAMICA LAB

Subject Code –BASES1-604	L	T	P	Cr	Duration:30 Hours
	0	0	2	1	

COURSE OBJECTIVES

- The course will enable the student to develop modeling techniques.

DETAILED CONTENTS

- Modeling a 2-D object with structured mesh using GAMBIT software.
- Modeling a 2-D object with unstructured mesh using GAMBIT software.
- Modeling a 3-D object with structured mesh using GAMBIT software.
- Solving a simple 2-D flow problem using Fluent software.
- Solving a simple axisymmetric flow problem using FLUENT software.

SPACE MISSION AND DESIGN OPTIMIZATION

Subject Code –BASED1-611	L	T	P	Cr	Duration:45 Hours
	3	0	0	3	

UNIT-I (10 Hrs)

Orbital Maneuvers and Control: Launch Vehicle Trajectories, Orbit Injection, Single-Impulse Maneuvers, Hohmann Transfer, Interplanetary Flight, Orbital Rendezvous, Halo Orbit Determination and Control

UNIT-II (12 Hrs)

Launch vehicle ascent trajectory design – reentry trajectory design – low thrust trajectory design – satellite constellation design – rendezvous mission design – ballistic lunar and interplanetary trajectory design

UNIT-III (13 Hrs)

Basics of optimal control theory – mission design elements for various missions – space flight trajectory optimization – direct and indirect optimization techniques –
Restricted.

UNIT-IV (10 Hrs)

3-body problem – Lagrangian points – mission design to Lagrangian point.

RECOMENDED BOOKS

1. Osborne, G. F. and Ball, K. J., Space Vehicle Dynamics, Oxford Univ. Press (1967).
2. Hale, F. J., Introduction to Space Flight, Prentice Hall (1994).
3. Naidu, D. S., Optimal Control Systems, CRC Press (2003).
4. Chobotov, V., Orbital Mechanics, AIAA Edu. Series (2002).
5. Griffin, M. D. and French, J. R., Space Vehicle Design, 2nd ed., AIAA (2004).

AVIONICS

Subject Code –BASED1-612	L	T	P	Cr	Duration:45 Hours
	3	0	0	3	

COURSE OBJECTIVE

The course enables the student to understand the role of avionic systems and their architecture. Introduction to the various avionic systems such as display systems, air-data sensors, communication, and navigation systems will be discussed thoroughly. It also focuses on the fundamental principles and their functioning in detail.

LEARNING OUTCOMES

- After undergoing the subject, student will be able to: Comprehend and explain the functioning of various avionic systems and sub systems.
- Understand and describe the functioning of various air data sensors employed in an aircraft and comprehend their limitations for civil and military aircraft.
- Explain working of various display systems and their functioning so as to visualize the required data during the operation of various avionics systems.

- Describe working of various communication systems and their functioning so as to facilitate the communication between the pilot and ATC.
- Explain working of various navigation systems and their functioning so as to facilitate the navigation between the pilot, aircraft and ATC.
- Explain working of various autopilot systems and their functioning so as to facilitate comfortable and hands-off flight.

UNIT-I (10 Hrs)

Avionics Technology: Processors, Memory Devices, Digital Data Buses –MIL-STD-1553B, ARINC 429, ARINC 629, Fiber Optic Buses, LRU architecture for avionics packaging, software, environmental effects, difference in avionics architecture of commercial and military aircraft.

UNIT-I (12 Hrs)

Sensors: Air Data Sensing – Use of pitot static probe, static probe to derive air data indications; Role of Air Data Computer (ADC), Magnetic Sensing – Magnetic Heading Reference System (MHRS),

Inertial Sensing – Position Gyros, Rate Gyros, Accelerometers

Radar Sensing - Radar Altimeter (RADALT), Doppler Radar, Weather Radar.

UNIT-III (13Hrs)

Display: Comparison of earlier flight deck (Electromechanical type instruments) to modern flight deck (glass fight deck), Cathode Ray Tube (CRT), Active Matrix Liquid Crystal Display (AMLCD), Head Down Display (HDD), Head Up Display (HUD),Helmet Mounted Display (HMD), Integrated Standby Instrument System (ISIS)

Communication: HF, U/VHF, Satellite Communication, Air Traffic Control (ATC) Transponder, Traffic Collision & Avoidance System (TCAS), Identification of Friend & Foe (IFF)

UNIT-IV(10 Hrs)

Navigation: Automatic Direction Finding, Very High Frequency Omni-Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation (TACAN), VORTAC (VOR+TACAN), Satellite Navigation System-Global Positioning System (GPS), Differential GPS, Instrument Landing System (ILS), Transponder Landing System (TLS), Microwave Landing System (MLS), Astronavigation.

Automatic Flight Control System: Longitudinal, Lateral & Direction Autopilot

RECOMMENDED BOOKS

1. Ian Moir, Allan Seabridge and Malcom Jukes, “Civil Avionics Systems”, Wiley
2. Thomas Eismin, “Aircraft Electricity and Electronics”, McGraw Hill, 6the edition
3. R. P. G. Collison., “Introduction to Avionics Systems”, Springer Netherlands.
4. E.H.J. Pallett, “Aircraft Instruments and Integrated Systems”, Longman

HELICOPTER DYNAMICS

Subject Code –BASED1-613	L T P Cr 3 0 0 3	Duration:45 Hours

COURSE OBJECTIVE

To help the students understand the concepts and estimate the performance and stability aspects of helicopters, analyze the vibrations of blade and helicopters under various dynamic conditions

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Understand the basic concepts and phenomena involved in helicopter engineering and dynamics.
- Estimate the power requirement for various flight conditions such as hovering, climbing, forward flights etc. and understand the aerodynamics of the main rotor.
- Estimate various performance parameters during hovering and vertical flight.
- Estimate different performance parameters during forward flight.
- Analyze stability and vibration levels in blades and helicopters under various conditions.

UNIT-I (10 Hrs)

Introduction and Basic Concepts: Historical development of helicopter and overview, Classification based on main rotor configuration and tail rotor configuration. Comparative analysis, Major components of conventional helicopter, Composite structure. Rigid, semi-rigid and articulated rotors, Feathering, flapping and lead-lag motion, Rigid, Semi-rigid and articulated helicopter control system, Collective and cyclic pitch control, Yaw control, Throttle control, Anti-torque control, Solidity, Tip-speed ratio, In-flow ratio, Figure of merit.

UNIT-II (12 Hrs)

Aerodynamics Of Main Rotor: Coning of rotor, Dissymmetry of lift, Precession, Coriolis effect, Compressibility effects, retreating blade stall, Reverse flow region, Flapping, feathering and lead-lag motion, Autorotation, Schrenk’s diagram, Various types of autorotative landings.

Performance During Hovering and Vertical: The actuator-disc theory, Working states of rotor, Optimum rotor, Efficiency of rotor, Ground effect on lifting rotor, The effect of finite number of blades, Induced velocity and induced power, Total power.

UNIT-III (13 Hrs)

Performance During Forward Flight: Blade forces and motion in forward flight, Force, torque and flapping coefficient, Induced velocity and induced power in forward flight – Mangler and Squire method, Flight and wind tunnel test, The vortex wake, Aerofoil characteristics in forward flight, Helicopter trim analysis, Performance in forward flight.

UNIT-IV (10 Hrs)

Dynamic Stability and Vibrations: Longitudinal and lateral stability, Equations of motion, Stability characteristics, Auto stabilization, Control response. Sources of vibration, Active and passive methods for vibration control, Fuselage response, Measurement of vibration in flight.

RECOMMENDED BOOKS

1. A.R.S. Bramwell, G. Done and D. Balmford, "Helicopter Dynamics", 2nd Ed., Butterworth Heinemann.
2. Jacob Shapiro, "Principles of Helicopter Engineering", 1st Ed., McGraw Hill.
3. C. Venkatesan, "Fundamentals of Helicopter Dynamics", 1st Ed., CRC Press.
4. E. Rathakrishnan, "Helicopter Aerodynamics", 1st Ed., PHI Learning

UNMANNED AERIAL VEHICLES

Subject Code –BASED1-621	L T P Cr	Duration:45 Hours
	3 0 0 3	

COURSE OBJECTIVE

- Comprehend the basic aviation history and UAV systems.
- Acquire the knowledge of basic aerodynamics, performance, stability and control.
- Understand the propulsion, loads and structures.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Apply the basic concepts of UAV systems.
- Explain the basic aerodynamics, performance, stability and control required for UAV.
- Select the propulsion system and materials for structures.

UNIT-I (10 Hrs)

Introduction: Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV

UNIT-II (12Hrs)

The Air Vehicle Basic Aerodynamics: Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag

Performance: Overview, climbing flight, Range and Endurance–for propeller-driven aircraft, range-ajet-driven aircraft, Guiding Flight

UNIT-III (13 Hrs)

Stability and Control: Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

Propulsion: Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power

UNIT-IV(10 Hrs)

Loads and Structures: Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques

Mission Planning and Control: Air Vehicle and Payload Control, Reconnaissance/ Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs

RECOMMENDED BOOKS

1. PaulGerinFahlstrom,ThomasJamesGleason,IntroductiontoUAVSystems,4thEdition, WileyPublication, 2012 John Wiley & Sons, Ltd
2. Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions.
3. UnmannedAerialVehicles:DOD'sAcquisitionEfforts,Publisher:AlphaEditions,.
4. Valavanis,KimonP.,UnmannedAerialVehicles,Springer,2011.
5. Valavanis,K.,Vachtsevanos,GeorgeJ.,HandbookofUnmannedAerialVehicles,Springer,2015.

MISSILE ENGINEERING

Subject Code –BASED1-622	L T P Cr	Duration:45 Hours
	3 0 0 3	

COURSE OBJECTIVE

The course will provide the fundamental aerodynamics of the missiles. It focuses on the different types of control systems employed and the stability analysis for various missiles. This course will also provide a basic understanding of missile navigation and control.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Understand the fundamental concepts of missile and distinguish the various types of missiles.
- Describe the forces and moments acting on an slender body vehicle.
- Analyze and describe the types of controls for various configurations.
- Evaluate the types of drag acting on a slender and non-slender missile nose.
- Analyze the static stability on an aerospace vehicle.
- Understand and describe the navigation and its stability aspects.

UNIT-I (10 Hrs)

Introduction: History of development of missiles, missiles versus airplanes aerodynamics, classification of missiles, axes, angle of bank, included angle, angle of attack and side slip, Indian missiles and their configurations and mission applications.

Slender Body Theory: Slender body at supersonic speeds, body of revolution at zero angle of attack, sources and doublets, slender body theory at angle of attack, slender body of general cross section at supersonic speeds, pressure coefficient, lift, side force, pitching moment and yawing moment, drag force, drag due to lift.

UNIT-II (12 Hrs)

Aerodynamic Controls: Types of controls, conventions, all moveable controls for planar configurations and cruciform configuration, coupling effects, trailing edge controls, non-linear effect in aerodynamic controls, estimation of hinge moments.

UNIT-III (13 Hrs)

Missile drag: Components of drag, pressure force drag of slender body of given shape, drag due to lift, pressure force drag of non-slender missile noses at zero angle of attack, shapes of bodies of revolution for least pressure force drag at zero angle of attack, pressure drag of wing alone, pressure force drag of wing-body combination at zero angle of attack, base drag, skin friction drag.

Stability Analysis: References axes, notation, general nature of aerodynamic forces, stability derivatives and its properties resulting from missile symmetries, Maple Synge analysis for cruciform, triform and other missiles. Bryson method, stability derivatives of slender flat triangular wing.

UNIT-IV(12 Hrs)

Missile Navigation and Control: Fully gimbaled gyroscope, rate gyroscope, integrating gyroscope, laser gyroscope, single axis stable platform, the stable platform, inertial navigation, stability of inertial navigation

RECOMMENDED BOOKS

1. Martin J.L. Turner., “Rocket and spacecraft propulsion”, Springer publishers.
2. William E. Wiesel., “Spaceflight Dynamics”, Mcgraw Hill.
3. J. N. Nielsen., “Missile Aerodynamics McGraw Hill publishers
4. Rama K. Yedavalli., “Flight Dynamics and Control of Aero and Space Vehicles”, John Wiley & Sons.