CURRICULUM AND SYLLABUS (R2015)

CHOICE BASED CREDIT SYSTEM

(Applicable to the batches admitted from July 2016)

B.Tech - AEROSPACE ENGINEERING

FULL TIME

III – VIII SEMESTERS

SEMESTER III								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								
1	BMA302	BS	Mathematics – III	4	3	2	0	4
2	BAN301	PC	Fundamentals of Aeronautics and Astronautics	3	3	0	0	3
3	BAN302	PC	Fundamentals of Fluid Mechanics	4	4	0	0	4
4	BAN303	PC	Fundamentals of Aero – Thermodynamics	4	4	0	0	4
5	BAN304	PC	Fundamentals of Structural Mechanics	4	4	0	0	4
6	BAN305	PC	Mechanics and Machines	3	3	0	0	3
PRACTICAL								
7	BCE3L4	PC	Strength of Materials Laboratory	3	0	0	3	2
8	BCE3L3	PC	Fluid Mechanics and Machinery Laboratory	3	0	0	3	2
9	BME3L1	PC	Machine Drawing Laboratory	3	0	0	3	2
TOTAL				**32**	**21**	**02**	**09**	**28**

SEMESTER IV								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								

1	BMA401	BS	Numerical Methods	3	3	2	0	4
2	BAN401	PC	Aircraft Structures – I	4	4	0	0	4
3	BAN402	PC	Aerodynamics – I	4	4	0	0	4
4	BAN403	PC	Aircraft Propulsion	4	4	0	0	4
5	BAN404	PC	Aircraft Systems and Instrumentation	3	3	0	0	3
6	BCE407	BS	Environmental Studies	3	3	0	0	3
PRACTICAL								
7	BAN4L1	PC	Aircraft Structures Laboratory	3	0	0	3	2
8	BAN4L2	PC	Manufacturing Engineering Laboratory	2	0	0	2	1
9	BAN4L3	PR	Computer Aided Design and Drafting Laboratory	2	0	0	2	1
TOTAL				**30**	**21**	**02**	**07**	**26**

SEMESTER V								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								
1	BAN501	PC	Aircraft Structures – II	4	4	0	0	4
2	BAN502	PC	Aerodynamics – II	4	4	0	0	4
3	BAS501	PC	Rocket Propulsion	4	4	0	0	4
4	BAN504	PC	Flight Mechanics	4	4	0	0	4
5	BAN505	PC	Manufacturing Engineering	3	3	0	0	3
6	-	PE	Core Elective – I	3	3	0	0	3
PRACTICAL								
7	BAN5L1	PC	Aerodynamics Laboratory	3	0	0	3	2

8	BAN5L2	PC	Aero Design and Modeling Laboratory	2	0	0	2	1
9	BAN5L3	PR	Computer Aided Analysis Laboratory	2	0	0	2	1
10	BAN5C1	PR	Comprehension – I	0	0	0	0	1
TOTAL				**29**	**22**	**0**	**07**	**27**

SEMESTER VI								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								
1	BSS601	HS	Value Education and professional Ethics	3	3	0	0	3
2	BAN601	PC	Aerospace Structural Materials and Composites	3	3	0	0	3
3	BAN602	PC	Finite Element Methods	4	4	0	0	4
4	BAN603	PC	Control Engineering	3	3	0	0	3
5	-	CE	Core Elective – II	3	3	0	0	3
6	-	NE	Non – Major Elective – I	3	3	0	0	3
PRACTICAL								
7	BAN6V1	PR	Value Added Program	2	0	0	2	1
8	BAN6L1	PC	Aircraft Systems Laboratory	3	0	0	3	2
9	BAN6L2	PC	Propulsion Laboratory	3	0	0	3	2
10	BAN6L3	PC	Aircraft Design Project – I	4	0	0	4	2
TOTAL				**31**	**19**	**0**	**12**	**26**

SEMESTER VII								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								
1	BAN701	PC	Computational Fluid Dynamics	3	3	0	0	3
2	BAS701	PC	Satellite Technology	3	3	0	0	3
3	BAN703	PC	Heat Transfer	3	3	0	0	3
4	-	CE	Core Elective – III	3	3	0	0	3
5	-	NE	Non – Major Elective – II	3	3	0	0	3
6	-	OE	Open Elective – I	3	3	0	0	3
PRACTICAL								
7	BAN7L1	PC	Airframe and Aero Engine Repair Laboratory	2	0	0	2	1
8	BAN7L2	PC	Satellite Design Laboratory	2	0	0	2	1
9	BAN7L3	PC	Aircraft Design Project – II	4	0	0	4	2
10	BAN7P1	PR	Term Paper	4	0	0	4	2
TOTAL				**30**	**18**	**0**	**12**	**24**

SEMESTER VIII								
Sl. No.	**Code No.**	**Category**	**Course Title**	**Contact Periods**	**L**	**T**	**P**	**C**
THEORY								
1	-	NE	Non – Major Elective – III	3	3	0	0	3
2	-	OE	Open Elective – II	3	3	0	0	3
PRACTICAL								
3	BAN8P1	PR	Project Work	18	0	0	18	9

4	BAN8C2	PR	Comprehension – II	0	0	0	0	1
TOTAL				**24**	**06**	**0**	**18**	**16**

Total No. of Contact Hours : 248 Hours

Total No. of Credits :198

SUMMARY OF CURRICULUM STRUCTURE AND CREDIT & CONTACT HOUR DISTRIBUTION

Sl. No.	Category of Courses	Semester wise Credits								No. of Credits	% of Credits
		I	II	III	IV	V	VI	VII	VIII		
1	**Humanities and Social Sciences (HS)**	**6**	**7**	**-**	**3**	**-**	**3**	**-**	**-**	**16**	**8.08**
2	**Basic Sciences (BS)**	**11**	**10**	**4**	**7**	**-**	**-**	**-**	**-**	**32**	**16.16**
3	**Engineering Sciences (ES)**	**10**	**7**	**-**	**-**	**3**	**-**	**-**	**-**	**20**	**10.10**
4	**Professional Core (PC)**	**-**	**-**	**24**	**18**	**19**	**16**	**13**	**-**	**90**	**45.45**
5	**Core Electives (CE)**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**-**	**9**	**4.55**
6	**Non Major Elective (NE)**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**3**	**9**	**4.55**
7	**Open Electives (OE)**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**6**	**3.03**
8	**Project Work, Technical Seminar, Internship, Term Paper etc. (PR),**	**-**	**-**	**-**	**1**	**2**	**1**	**2**	**10**	**16**	**8.08**
Total Credit		**27**	**24**	**28**	**26**	**27**	**26**	**24**	**16**	**198**	
Total Contact Hours		**37**	**35**	**32**	**30**	**29**	**31**	**30**	**24**	**248 Hours**	

LIST OF ELECTIVES

List of Core Elective (CE) I:

Code No.	Course Title	L	T	P	C
BASE01	Theory of Elasticity	3	0	0	3
BANE02	Rockets and Missiles	3	0	0	3
BASE02	Electric Propulsion	3	0	0	3
BASE03	Launch Vehicle Aerodynamics	3	0	0	3

List of Core Elective (CE) II:

Code No.	Course Title	L	T	P	C
BASE04	Space Mechanics	3	0	0	3
BASE05	Guidance and Control	3	0	0	3
BANE07	Theory of Vibrations	3	0	0	3
BASE06	Space Vehicle Design	3	0	0	3

List of Core Elective (CE) III:

Code No.	Course Title	L	T	P	C
BASE07	Spacecraft Attitude Dynamics and Control	3	0	0	3
BANE10	Cryogenic Rocket Propulsion	3	0	0	3
BASE08	Space Mission Design and Analysis	3	0	0	3
BANE12	Hypersonic Aerodynamics	3	0	0	3

List of Non Major Elective (NE) I:

Code No.	Course Title	L	T	P	C
BANE13	An Introduction to Combustion	3	0	0	3
BASE09	Solar Thermal Energy	3	0	0	3

BANE15	Nano Science and Technology	3	0	0	3
BANE16	Unmanned Aerial Vehicle	3	0	0	3

List of Non Major Elective (NE) II:

Code No.	Course Title	L	T	P	C
BANE17	Boundary Layer Theory	3	0	0	3
BANE18	Fatigue and Fracture Mechanics	3	0	0	3
BANE19	High Temperature Materials	3	0	0	3

List of Non Major Elective (NE) III:

Code No.	Course Title	L	T	P	C
BASE10	High Temperature Gas Dynamics	3	0	0	3
BASE11	Spacecraft Power Systems	3	0	0	3
BANE14	Principles of Turbomachinery in Airbreathing Engines	3	0	0	3

List of Open Elective (OE) I:

Code No.	Course Title	L	T	P	C
BASE12	Systems Engineering	3	0	0	3
BANE24	Aerospace Bio – Medical and Life Support Engineering	3	0	0	3
BBA001	Principles of Management and Organizational Behaviour	3	0	0	3
BBA009	Intellectual Property Rights	3	0	0	3
BSS001	NSS Paper I	2	0	2	3

List of Open Elective (OE) II:

Code No.	Course Title	L	T	P	C
BANE25	Industrial Aerodynamics	3	0	0	3

BANE26	Mechanics of Heterogeneous Materials	3	0	0	3
BBA007	Engineering Economics and Cost Analysis	3	0	0	3
BBA008	Total Quality Management	3	0	0	3
BSS002	NSS Paper II	2	0	2	3
BMO001	Massive Open Online Course	3	0	0	3

BHARATH INSTITUTE OF HIGHER EDUCATION AND RESEARCH

DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER III

BMA302	**MATHEMATICS - III**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**1**	**0**	**4**
	Prerequisite – Mathematics I & II				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce Fourier series analysis that is important to many applications in engineering apart from its use in solving boundary value problems.
2. To acquaint the student with Fourier transform techniques used in wide variety of situations.
3. To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes
4. To develop Z transform techniques for discrete time systems.
5. To develop the Fourier transform techniques and convolution theorem.

COURSE CONTENT

UNIT I	**PARTIAL DIFFERENTIAL EQUATIONS**	**12**

Formation of PDE by eliminating arbitrary constants, functions – Solutions of first order PDE – Standard types-homogeneous linear PDE of second order with constant coefficients - Lagrange's Linear PDE – Method of grouping, multiplier methods.

UNIT II	**FOURIER SERIES**	**12**

Dirichlet's conditions – General Fourier series – Half-range Sine and Cosine series – Parseval's identity – Harmonic Analysis.

UNIT III	**BOUNDARY VALUE PROBLEMS**	**12**

Classifications of second order linear partial differential equation – Solutions of one dimensional wave equation and one-dimensional heat equation.

UNIT IV	**LAPLACE TRANSFORMS**	**12**

Laplace transform of simple functions – Transform of elementary functions – Basic properties – initial and final value theorem – Transform of derivatives and integrals – transform of periodic functions – inverse Laplace transforms –Convolution theorem (excluding proof) – Solution of linear ODE of second order with constant coefficients and solutions of simultaneous first order differential equations with constant coefficients using Laplace transformation techniques.

UNIT V	**FOURIER TRANSFORMS**	**12**

Fourier integral theorem – Fourier transform pair-Sine and Cosine transforms – Properties – Transform of simple function – Convolution theorem – Parseval's identity.

Text Books:

1. Grewal, B.S., Higher Engineering Mathematics, Khanna Publications, 2007.

References:

1. Glyn James, Advance Modern Engineering Mathematics, Pearson Education, 2007.
2. Kreyszig. E, Advanced Engineering Mathematics, (8th edition), John Wiley & Sons, Singapore, 2000.

3. Kandasamy P et al, Engineering Mathematics, Vol. II & III (4th revised edition), S. Chand & Co., New Delhi, 2000.
4. Narayanan S., Manicavachagom Pillay T. K., Ramanaiah G., Advanced Mathematics for Engineering Students, Volume II & III (2nd edition), S. Viswanathan Printers and Publishers, 1992.
5. Venkataraman M. K., Engineering Mathematics – Vol. III – A & B (13th edition), National Publishing Co., Chennai, 1998.
6. Julius S. Bendat and Allan G. Piersol., Random Data: Analysis and Measurement Procedures (4th edition), Wiley Series in Probability and Statistics, 2010.
7. *https://www.wolfram.com/**mathematica**/*

BAN301	**FUNDAMENTALS OF AERONAUTICS AND ASTRONAUTICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To equip the student with the knowledge about the development of aircrafts and spacecrafts through historical reviews and about their basic configurations.
2. To accustom the student to the various basic aerodynamic terms and about the generation of aerodynamic forces.
3. To introduce to the student about the basic types of aircraft constructions and materials and the various loads acting on it.
4. To familiarize the student on the different kinds of propulsion for aircrafts and materials for gas turbine engines
5. To acquaint the student about space vehicles, re- entry, heat transfer and basics of satellite technology

COURSE CONTENT

UNIT I	**EVOLUTION OF FLIGHT**	**8**

Brief history of Aviation-Hot air balloon and heavier than air flying machines-early airplane configurations-Modern Airplanes-Components of airplane and their functions-Rotary wing aircrafts-Space vehicles.

UNIT II	**FUNDAMENTALS OF AERODYNAMICS**	**11**

International Standard Atmosphere-Pressure, Temperature and Density altitude, Bernoulli's equation-Mach number-subsonic, transonic, sonic and supersonic flow regimes, Measurement of pressure and airspeed- IAS,EAS and TAS. Airfoil geometry and nomenclature - airfoil characteristics - lift, drag and moment coefficients-angle of attack-aspect ratio- induced drag and parasite drag.

UNIT III	**AIRCRAFT STRUCTURES AND MATERIALS**	**8**

Structural components of an airplane- monocoque and semi monocoque structure –materials for structural components – composite materials and their significance in Aviation Technology.

UNIT IV	**AIRCRAFT PROPULSION**	**10**

Propeller Engine – Gas Turbine Engine – Turbo prop, Turbo jet, Turbo fan Engines -variation of thrust, powerand specific fuel consumption with speed and altitude – materials for engine components.

UNIT V	**SPACE VEHICLES AND ASTRONAUTICS**	**8**

Basics of Rocket Technology – escape velocity – re-entry vehicles – Satellite technology– Hypersonic vehicles, Elements of Astronautics.

TEXTBOOKS:

1. Anderson, J. D., Introduction to Flight, Tata-McGraw-Hill Higher Education, 6thedition 2010.

REFERENCES:

1. Kermode, A. C, Barnard, R. H and Philpott, D. R, Mechanics of Flight, Pearson education, 2012.
2. Shevell, R. C., Fundamentals of Flight., Prentice hall (2nd edition), 1989.
3. Steven, A. Brandt, Randall J. Stiles, John J. Bertin and Ray Whitford, Introduction to Aeronautics: A Design Perspective, AIAA Education series (2nd edition),2004.
4. Torenbeek, E and Wittenberg, H, Flight Physics:Essentials of Aeronautical Disciplines and Technology, with Historical Notes, Springer, 2009.

BAN302	**FUNDAMENTALS OF FLUID MECHANICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To learn concepts of fluid, properties of fluid and its classification.
2. To understand fluid statics and dynamics.
3. Significance of similarity and model studies
4. To know about boundary layer concepts and its applications to pipe design.
5. To learn about pumps and turbine design.

COURSE CONTENT

UNIT I INTRODUCTION 10

Fluid –definition-Fluid properties-Newton’s law of viscosity-Classification of fluids-fluid statics-Hydrostatic forces on submerged surfaces- basics of Stability of floating bodies

UNIT II FLUID FLOW ANALYSIS AND FLOW MEASUREMENT 12

Ideal and real flow-Concept of continuum-Eulerian and Lagrangian approaches-Velocity field-Pathline, Streakline, Streamline- Stream tube- Fluid acceleration-Continuity, momentum differential equations-Navier Stokes equation-Bernoulli’s equation and its applications-Venturimeter-Orifice meter, Coefficient of Discharge, Flow Rate and Velocity Measurement.

UNIT III DIMENSIONAL ANALYSIS 12

Dimensional Homogeneity, Buckingham’s Pi Theorem-Non dimensional numbers and their significance-Flow similarity, similitude, incomplete similarity and model studies – distorted models

UNIT IV FLOW THROUGH PIPES 14

Laminar and turbulent flow- Boundary layer flow – Boundary layer thickness - Reynolds number and its significance-Laminar fully developed pipe flow-Hagen-Poiseuille flow-Coefficient of friction-Head loss – Darcy-Weisbach equation-Hydraulic gradient- Total energy lines-Moody’s diagram

UNIT V FLUID MACHINERY 12

Classification of fluid machines-Reciprocating and centrifugal pumps-impulse and reaction turbines and velocity triangles-Working principle of Pelton, Francis and Kaplan turbines

TEXTBOOKS:

1. Rathakrishnan. E, Fundamentals of Fluid Mechanics, Prentice-Hall (3rd edition), 2012.

REFERENCES:

1. Bansal. R. K., “A textbook of Fluid Mechanics”, Laxmi Publications, 2008
2. Frank M White, Fluid Mechanics, The McGraw Hill companies. (7th edition), 2011.
3. Yunus A Cengel and John M Cimbala, Fluid mechanics: Fundamentals and Applications, Tata McGraw Hill (2nd edition), 2010.

4. Irving H Shames, Mechanics of Fluids, The McGraw Hill companies (4th edition), 2003.
5. Yuan, S.W, Foundations of Fluid Mechanics, Prentice-Hall, 1967.
6. reu.eng.ua.edu › Programs
7. www.fluidmechanics.co.uk/.

BAN303	**FUNDAMENTALS OF AERO – THERMODYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**0**	**0**	**3**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce the concept of thermodynamic analysis using first law that is central to many applications in engineering.
2. To acquaint the student with the basics of second law and entropy
3. To introduce a basic idea about gas power cycles.
4. To develop the basic understanding of vapour power cycles.
5. To develop the basic understanding of refrigeration and air-conditioning system.

COURSE CONTENT

(Use of Steam Tables is Permitted)

UNIT I	**BASIC CONCEPTS AND FIRST LAW**	**14**

Continuum, microscopic and macroscopic approach, thermodynamic system and surrounding, state, path, process, heat and work, zeroth law, concept of ideal and real gases, internal energy, specific heat capacities, enthalpy, first law of thermodynamics – PMM-1 – applications of first law to open and closed systems, steady flow energy equation

UNIT II	**SECOND LAW AND ENTROPY**	**12**

Second law of thermodynamics, Kelvin – Planck’s and Clausius Statements, PMM-2, reversibility and irreversibility, Carnot theorem, concept of entropy, Clausius inequality, principal of increase in entropy, absolute entropy, entropy change in non-flow processes, availability, exergy

UNIT III	**AIR POWER CYCLES**	**12**

Carnot, Otto, Diesel, Dual, Stirling and Ericsson cycle - Air standard efficiency – Mean effective pressure

UNIT IV	**VAPOUR POWER CYCLES, REFRIGERATION AND AIR CONDITIONING**	**11**

Formation of Steam – Ideal Rankine cycle – Steam tables and Mollier diagram – Principles of refrigeration and Psychrometry, Joule cycle - Properties of refrigerants - Vapour compression - Co-efficient of performance – Working principle and types of Air conditioning.

UNIT V	**BRAYTON CYCLE**	**11**

Introduction to aircraft propulsion – gas turbine engine cycles – open and closed Brayton cycle – Brayton cycle with reheat, regeneration and intercooling.

TEXTBOOKS:

1. Rathakrishnan E., Fundamentals of Engineering Thermodynamics, Prentice-Hall India, 2012.

REFERENCES:

1. Nag.P.K.,Engineering Thermodynamics, Tata McGraw-Hill, New Delhi, 2007.
2. Yunus A Cengel and Michael A Boles., Thermodynamics- an Engineering approach, McGraw Hill Education

(7th edition), 2012.
3. Holman.J.P.,Thermodynamics, McGraw-Hill (3rd edition), 2007.
4. Merle C Potter and Craig W Somerton., Thermodynamics for Engineers, Schaum’s Outline Series, Tata McGraw-Hill (2nd edition), 2009.
5. www.thermocalc.com/
6. www.grc.nasa.gov/WWW/cdtb/software/t-mats.html

BAN304	**FUNDAMENTALS OF STRUCTURAL MECHANICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1. To provide the students, an understanding about the basics of strength of materials
2. To acquaint the student with the procedures for estimating the stresses acting in beams
3. To impart knowledge on estimation of deflections of various types of beams under different loading conditions
4. To develop the basic understanding of torsion of structural members
5. To develop the basic understanding about the bi-axial state of stress and basics of elasticity

COURSE CONTENT

UNIT I **INTRODUCTION TO STRENGTH OF MATERIALS** **16**

Introduction to mechanics of deformable bodies - Material selection criteria – stress – strain – Stress and strain diagram - Hook’s law - Elastic constants – definition of engineering constants: elastic moduli – Young’s modulus, Bulk Modulus& Volumetric Strain, Poisson’s ratio, Shear Modulus, relation between three elastic moduli and Poison’s ratio, Statically determinate and indeterminate problems in tension and compression – Thermal stress – Impact loading – Composite bars

UNIT II **STRESSES IN BEAMS** **10**

Shear force and bending moment diagrams for simply supported, cantilever beams and overhanging beams– bending stress variation in beams of symmetric sections, neutral axis

UNIT III **DEFLECTION OF BEAMS** **10**

Double integration, Macaulay’s method, moment area method, conjugate beam method, method of superposition, Maxwell’s reciprocal theorem.

UNIT IV **TORSION** **10**

Torsion of solid and hollow circular shafts – Power transmission in shafts – Open and closed-coiled helical springs – Stresses in helical springs.

UNIT V **BI – AXIAL STRESSES AND ELEMENTS OF ELASTICITY** **14**

Stresses in thin cylindrical and spherical shell under internal pressure and volumetric strain– Principle stresses and maximum shear stresses– Combined loading – Mohr’s circle and its construction – concept of theory of elasticity, basic assumptions, coordinate transformation, plane stress and plane strain conditions, stress tensor

TEXTBOOKS:
1. Gere & Timoshenko, Mechanics of Materials, McGraw Hill, 1993

REFERENCES:
1. F. P. Beer, E.R. Johnston, and J.T. Dewolf, Mechanics of Materials, McGraw-Hill (4th edition), 2006
2.Dym,C.L., and Shames,I.H., Solid Mechanics, McGraw Hill, Kogakusha, 1973.
3. Stephen Timoshenko, Strength of Materials, Vol I & II, CBS Publishers and Distributors, Third Edition.
4. R.K. Rajput, Strength of Materials, S. Chand and Co., 1999.

5. William Nash, Strength of Materials, Tata McGraw Hill, 2004
6. Timoshenko,S. and Young,D.H., Elements of Strength of Materials, T.VanNostrand Co. Inc., Princeton, N.J., 1977.
7. www.mdsolids.com/
8. https://www.actuspotentia.com/MechMat.shtml

BAN305	**MECHANICS OF MACHINES**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	3	0	0	3
	Prerequisite – Engineering Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1. To impart students with the knowledge about motion, masses and forces in machines.
2. To enable students to apply fundamental of mechanics to machines which include engines, linkages etc.,
3. To impart students with the knowledge about various power transmitting devices such as gears, belts etc.
4. To facilitate students to understand the concept of balancing of rotating and reciprocating masses
5. To give awareness to students on the phenomenon of vibration and its effects

UNIT I	**MECHANISMS**	**12**

Machine Structure – Kinematic link, pair and chain – Grueblers criteria – Constrained motion – Degrees of freedom –Kutzbach criterion - Slider crank and crank rocker mechanisms – Inversions – Applications – Kinematic analysis of simple mechanisms – Determination of velocity and acceleration.

UNIT II	**FRICTION**	**12**

Friction in screw and nut – Pivot and collar – Thrust bearing – Plate and disc clutches – Belt (Flat and Vee) and rope drives. Ratio of tensions – Effect of centrifugal and initial tension – Condition for maximum power transmission – Open and crossed belt drive.

UNIT III	**GEARING AND CAMS**	**9**

Gear profile and geometry – Nomenclature of spur and helical gears – Gear trains: Simple, Compound gear trains and epicylic gear trains - Determination of speed and torque - Cams – Types of cams and followers.

UNIT IV	**FORCE ANALYSIS AND BALANCING**	**15**

Introduction to force analysis - Static and dynamic – Inertia force and inertia torque – D'Alembert's principle - Static and dynamic balancing – Single and several masses in different planes –Balancing of reciprocating masses- primary balancing and concepts of secondary balancing – Single and multicylinder engines (Inline) – Balancing of radial V engine – direct and reverse crank method.

UNIT V	**VIBRATION**	**12**

Free, forced and damped vibrations of single degree of freedom systems – Force transmitted to supports – Vibration isolation – Vibration absorption – Torsional vibration of shaft – Single and multi rotor systems – Geared shafts – Critical speed of shaft.

Text Books:
1. Rattan.S.S., Theory of Machines, Tata McGraw–Hill Publishing Co, New Delhi, 2004.
2. Balaguru. S., Dynamics of Machinery, SciTech publication (2nd edition), 2009.

Reference Books:

1. Rao, J.S and Dukkipati, R.V, “Mechanism and Machine Theory”, Second Edition, Wiley Eastern Ltd., 1992.
2. Malhotra, D.R and Gupta, H.C., “The Theory of Machines”, SatyaPrakasam, Tech. India Publications, 1989.
3. Gosh, A. and Mallick, A.K., “Theory of Machines and Mechanisms”, Affiliated East West Press,1989.
4. Shigley, J.E. and Uicker, J.J., “Theory of Machines and Mechanisms”, McGraw-Hill, 1980.
5. Burton Paul, “Kinematics and Dynamic of Planer Machinery”, Prentice Hall, 1979.
6. *ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5593596*
7. *www.simple**machines**.org/*

BCE3L4	**STRENGTH OF MATERIALS LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**3**	**2**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1. To enable the student to understand about the tensile test and stress – strain curves and also about the compression tests
2. To accustom the student about shear test, torsion test and hardness tests.
3. To introduce to the student about the impact test.
4. To acquaint the student about the open and closed coil spring tests.
5. To introduce to the student about fatigue test.

LIST OF EXPERIMENTS

1	Tension test of a mild steel and aluminium rod.
2	Shear test on mild steel and aluminium rod.
3	Torsion test on mild steel rod.
4	Hardness test (a) Brinell& (b) Rockwell.
5	Impact tests (a) Izod& (b) Charpy.
6	Estimation of Stiffness of a Helical Spring (a) Open Coil & (b) Closed Coil
7	Fatigue test: Rotating beam.
8	Block compression test.
9	Flexural test by 3 point bending method

REFERENCES:

1. Strength of Materials Lab Manual, Department of Aeronautical Engineering, 2017

BCE3L3	FLUID MECHANICS AND MACHINERIES LABORATORY	L	T	P	C

	Total Contact Hours – 45	**0**	**0**	**3**	**2**
	Prerequisite – Nil				
	Course Designed by – Department of Civil Engineering				

OBJECTIVES

1. To help the student to understand about pipe flow losses and flow through notches and weirs.
2. To accustom the student about buoyancy test and Bernoulli's principle
3. To introduce to the student about the various flow meters
4. To acquaint the student about the performance characteristics of various pumps
5. To introduce to the student about the performance characteristics of various turbines

LIST OF EXPERIMENTS

1	Determination of pipe flow losses.
2	Calibration of orifice meter and venture meter.
3	Flow through notches and weir.
4	Flow through open orifice
5	Buoyancy experiment – Metacentric Height.
6	Verification of Bernoulli's Equation.
7	Performance characteristics of centrifugal pump.
8	Performance characteristics of submergible pump.
9	Performance characteristics of jet pump.
10	Performance characteristics of oil gear pump.
11	Characteristics of impulse turbine – Pelton wheel turbine.
12	Characteristics of reaction turbine – Francis turbine

REFERENCES:

1. Fluid Mechanics and Machineries Lab Manual, Department of Civil Engineering, 2017

	MACHINE DRAWING LABORATORY	**L**	**T**	**P**	**C**
BME3L1	Total Contact Hours – 45	0	0	3	2
	Prerequisite – Engineering Graphics				
	Course Designed by – Department of Mechanical Engineering				

OBJECTIVES

1. To give the students an idea of fundamental issues common to almost all areas of machine drawing.
2. To train the student to draw an assembled diagram of a machine part based on the details of individual parts.
3. To help the student to understand the machine drawing, nomenclature and various notations.
4. To train the students to prepare a working drawing of machines.
5. To enable the student to communicate his ideas through drawings.

Indian standard code (BIS) of practice for engineering drawing – general principle of presentation, conventional representation of threaded parts, springs, Gears and common features, Abbreviations and symbols used in technical drawings.

Tolerance – Types – Symbols used and representation on the drawing – fit types, selection for different application – Allowance, Interchangeability. Surface finish Relation to the manufacturing processes – Types of representation on the drawing welding symbols.

Preparation of working drawing for given machine components: Bolts, Screws, Studs, Nuts, Keys and Key-ways.

Preparation of simple assembly drawings: Different types of cotter and knuckle joints.

Preparation of simple assembly drawing for following machine with part drawings given: Screw jack, Plummer block, connecting rod, machine vice, tail stock of lath, fuel injection pump for single cylinder engine, stop valve.

Text Books:

1. Narayanan. K. L. Machine Drawing, New age publisher, 2006.

References:

1. Bhatt, N. D.., Machine Drawing, Charotar publishing house, 2000.
2. Gopala Krishnan, Machine Drawing, Subash publishers, 2001.
3. *https://www.smartdraw.com/software/mechanical-drawing-software.htm*
4. *https://www.**machine**designonline.com/*

BHARATH INSTITUTE OF HIGHER EDUCATION AND RESEARCH

DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER IV

BMA402	**NUMERICAL METHODS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	3	2	0	4
	Prerequisite – Mathematics III, Engineering Physics, Engineering Mechanics				
	Course Designed by – Department of Mathematics				

OBJECTIVES

1. To introduce the solution of equations and Eigen value problems.
2. To acquaint the student with interpolation techniques used in wide variety of situations.
3. To introduce the effective mathematical tools for the solutions of numerical differentiation and integration.
4. To develop the initial value problems for ordinary differential equations.
5. To develop the boundary value problems for ODE and PDE.

UNIT I	**INTERPOLATION (FINITE DIFFERENCES)**	**12**

Iterative method, Newtown-Raphson method for single variable-solutions of linear system by Gaussian, Gauss-Jordan, Jacobian and Gauss-Siedel methods, Inverse of matrix by Gauss-Jordan method , Eigen value of a matrix power and Jacobian methods.

UNIT II	**INTERPOLATION (FINITE DIFFERENCES)**	**12**

Newton’s Divided difference formula, Lagrange’s interpolation-forward and backward difference formula-Stirling’s and Bessel’s central difference formula.

UNIT III	**NUMERICAL DIFFERENTIATION AND INTEGRATION**	**12**

Numerical differentiation with interpolation polynomials, Numerical integration by Trapezoidal Simpson’s 1/3” and 3/8” rule, Double integrals using Trapezoidal and Simpson’s rule.

UNIT IV	**INITIAL VALUE PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS**	**12**

Single step methods, Taylor series, Euler and modified Euler, Runge kutta method of first and second order differential equations, multiple step methods, Milne and Adam’s – Bash forth predictor and corrector method.

UNIT V	**BOUNDARY VALUE PROBLEMS FOR ODE AND PDE**	**12**

Finite difference for the second order ordinary differential equations, finite difference solutions for one dimensional heat equations (both implicit and explicit), one dimensional wave equation, Two dimensional, Laplace and Poisson equation.

Text Books:

1. Jain. M. K. Iyengar, S. R. K. And Jain, R K., Numerical Methods for Scientific and Engineering Computation, 3rd edition, New age international publication, company, 1993
2. Grewal, B.S., Higher Engineering Mathematics, Khanna Publications, 2007.

References:

1. M. K. Venkatraman., Numerical Methods, NPC, Chennai.
2. Richard W. Hamming., Numerical Methods for Scientists and Engineers, Dover Publications (2nd edition), 1987.
3. *https://www.wolfram.com/**mathematica**/*

BAN401	**AIRCRAFT STRUCTURES – I**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint students with the fundamentals of aircraft structures.
2. To acquaint students with statically determinate and indeterminate structures.
3. To introduce students to energy methods applied to simple aerospace structural elements.
4. To introduce various structural analysis of various column type aerospace structural elements.
5. To introduce various failure theory of structural analysis.

COURSE CONTENT

UNIT I **TRUSSES AND FRAMES** **12**

Statically determinate frames - Analysis of plane Truss - Method of joints - 3 D Truss-Plane frames - Composite beam.

UNIT II **STATICALLY INDETERMINATE BEAMS** **12**

Propped Cantilever - Fixed-Fixed beams - Clapeyron's Three Moment Equation – moment distribution method.

UNIT III **ENERGY METHODS** **14**

Strain energy evaluation in structural members – Castigliano’s Theorem – dummy load & unit load methods – Maxwell’s reciprocal theorem – energy methods applied to statically determinate and indeterminate beams, frames, rings & trusses

UNIT IV **COLUMNS** **12**

Euler’s column curve – inelastic buckling – effect of initial curvature – the Southwell plot – columns with eccentricity – use of energy methods – theory of beam columns – beam columns with different end conditions – stresses in beam columns.

UNIT V **FAILURE THEORY** **10**

Fail safe and safe life structures, factor of safety, Brief introduction of yield material, brittle vs. ductile behavior, Creep and creep rupture, viscoelastic materials - environmental stress, stress potentials, effect of time and temperature - Fatigue and Fracture - Maximum Stress theory – Maximum Strain Theory – Maximum Shear Stress Theory – Distortion Theory – Maximum Strain energy theory – Application to aircraft Structural problems.

TEXTBOOKS:

1.“Rajput, R. K.”, “A Textbook of Strength of Materials”, S Chand Publications, 2018 Edition

REFERENCES:

1. Timoshenko, S., Strength of Materials, Vol. I and II, Princeton D. Von NostrandCo, 1990.
2. Peery, D. J., and Azar J. J., Aircraft Structures, McGraw – Hill (2nd edition), 1999.
3.Bruhn.E.F., Analysis and design of flight vehicle structures,Tri set of offset company, 1973.
4. Michael C.Y.Niu,Airframe structural design (ISBN No.962-7128-04-X), 1998
5. Rivello,Theory and Analysis of Flight Structures, McGraw-Hill, 1969.

BAN402	**AERODYNAMICS – I**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Fundamentals of Fluid Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce student about basic concepts of mathematical formulation of air flow.
2. To impart theoretical knowledge about the elementary flow and their combination to analysis flow over real object.
3. To Study the distribution of pressure around airfoil for incompressible inviscid flow. To study transformation of flow over circle cylinder into flow over the airfoil
4. To study flow around wing and measure lift generated.
5. To introduce the students about viscous flow theory for flow over flat and solution for incompressible

COURSE CONTENT

UNIT I	**BASIC AERODYNAMIC PRINCIPLES**	**12**

Models of fluid - System and Control volume approach, substantial, local and convective derivative, Continuity, momentum and energy equations, Inviscid flow, Euler equation, incompressible Bernoulli's Equation. Circulation and Vorticity

UNIT II	**FUNDAMENTALS OF INVISCID FLOWS**	**12**

Elementary Flows and their combinations – Ideal Flow over a circular cylinder, D'Alembert's Paradox, Magnus effect, KuttaJoukowski Theorem, Starting Vortex, Kutta condition, Real flow over smooth and rough cylinder

UNIT III	**AIRFOIL THEORY**	**12**

Complex Potential, Methodology of Conformal Transformation, Kutta-Joukowski transformation and its applications, Karman Trefftz Profiles, Thin Airfoil theory and its applications.

UNIT IV	**FINITE WING THEORY**	**12**

Vortex Filament, Biot and Savart Law, Bound Vortex and trailing Vortex, Horse Shoe Vortex, Lifting Line Theory and its limitations, induced drag coefficient, elliptic and general lift distribution, Oswald's wing efficiency factor, effect of plan form and aspect ratio

UNIT V	**VISCOUS FLOW THEORY**	**12**

Laminar Boundary layer and its thickness, displacement thickness, momentum thickness, Energy thickness, Shape parameter, Boundary layer equations for a steady two dimensional incompressible flow, Boundary Layer growth over a Flat plate, Critical Reynolds Number, Blasius solution, Basics of Turbulent flow

TEXTBOOKS:

1. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill Book Co., 2006, Sixth Edition

REFERENCES:

1. Rathakrishnan,E., Theoretical Aerodynamics, John Wiley & Sons, Inc., 2013
2. Milne Thomson, L.H., Theoretical Aerodynamics, Macmillan, 1985
3. John J Bertin., Aerodynamics for Engineers, Pearson Education Inc, 5th Edition.
4. Clancy L J., Aerodynamics, John Wiley & sons, 1991.

BAN403	**AIRCRAFT PROPULSION**	**L**	**T**	**P**	**C**

	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Fundamentals of Aero – Thermodynamics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To provide students with an overview of various aerospace propulsion systems.
2. To provide students with a sound foundation in the fundamentals of thermodynamics of aircraft engines
3. To teach students the elementary principles of inlets and nozzle
4. To teach students basic principles of compressors and turbines used in aircraft propulsion
5. To teach students about the various type of combustion chamber and combustion process

COURSE CONTENT

UNIT I	**FUNDAMENTALS OF ENGINES**	**10**

Gas turbine engine cycle - Engine performance parameters – Efficiencies, Methods of thrust augmentation – Characteristics of propeller, turboprop, turbofan and turbojet engines.

UNIT II	**INLETS AND NOZZLES**	**14**

Subsonic inlets– External and internal flow pattern – inlet performance criterion –Boundary layer separation – Supersonic inlets – the starting problem – external deceleration– Exhaust nozzles –Theory of flow in isentropic nozzles – Losses in nozzles –Nozzle efficiency—nozzle choking –Over expanded and under expanded nozzles – Ejector and variable area nozzles

UNIT III	**COMPRESSORS**	**12**

Principle of operation of centrifugal compressor – Work done and pressure rise – Velocity diagrams – Concept of pre whirl – Rotation stall – Operating Principle of axial flow compressor – Velocity triangles – degree of reaction – Centrifugal and Axial compressor performance characteristics.

UNIT IV	**COMBUSTION CHAMBERS**	**12**

Classification of combustion chambers - Combustion process – Stoichiometric Ratio – Equivalence Ratio – Important factors affecting combustion chamber design — Combustion chamber performance – Effect of operating variables on performance – Flame tube cooling – Flame stabilization – flame holders.

UNIT V	**TURBINES**	**12**

Operating Principle of axial flow turbine – Stator and rotor blades – losses in the blade – choice of blade profile, chord and pitch – stage and overall performance – blade cooling – radial flow turbine.

TEXTBOOKS:

1. Ganesan, V., Gas Turbines, Tata McGraw Hill Publications, Third Edition (Units 1, 3, 4 & 5)
2. Hill, P.G. & Peterson, C.R, Mechanics & Thermodynamics of Propulsion, Addison – Wesley Longman INC, 1999. (Unit 2)

REFERENCES:

1. Cohen, H. Rogers, G.F.C. and SaravanaMuttoo, H.I.H., Gas Turbine Theory, Longman, 1989.
2. Ahmed F. El-Sayed, Aircraft Propulsion and Gas turbine engines, CRS Press, 2008
3. Saeed Farokhi, Aircraft Propulsion, John Wiley & Sons, Inc ., 2009
4. Rolls Royce Jet Engine – 5thEdition – 1996.
5. Oates, G.C., Aero thermodynamics of Aircraft Engine Components, AIAA Education Series.

BAN404	**AIRCRAFT SYSTEMS AND INSTRUMENTATION**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Aeronautics and Astronautics				

	Course Designed by – Department of Aeronautical Engineering

OBJECTIVES

1. To acquaint the student with the various aircraft systems
2. To introduce to the student about the different control systems in aircrafts
3. To familiarize the student to the different systems associated with aircraft engines
4. To acquaint the student to the several auxiliary systems in aircrafts
5. To enable the student to understand about the working of basic aircraft instruments

COURSE CONTENT

UNIT I	**AIRCRAFT SYSTEMS**	**12**

Hydraulic systems - Study of typical workable system - components –Hydraulic systems controllers – Pneumatic systems - Advantages - Working principles - Typical Air pressure system – Brake system- Typical Pneumatic power system - Components, Landing Gear systems – Classification.

UNIT II	**AIRPLANE CONTROL SYSTEMS**	**10**

Conventional Systems - fully powered flight controls - Power actuated systems – Modern control systems - Digital fly by wire systems - Auto pilot system active control Technology.

UNIT III	**ENGINE SYSTEMS**	**8**

Fuel systems for Piston and jet engines, - Components of multi engines. Lubricating systems for piston and jet engines - Starting and Ignition systems - Typical examples for piston and jet engines.

UNIT IV	**AUXILIARY SYSTEMS**	**8**

Basic Air cycle systems - Vapour Cycle systems, Evaporative vapour cycle systems - Oxygen systems - Fire protection systems, Deicing and anti-icing systems.

UNIT V	**AIRCRAFT INSTRUMENTS**	**7**

Flight Instruments and Navigation Instruments – Gyroscope - Accelerometers, Air speed Indicators - Mach Meters - Altimeters - Principles and operation – Operation and Working Principle of various types of engine instruments – Tachometers, Temperature gauges, Pressure Gauges.

TEXTBOOKS:

1.General Hand Books of Airframe and Powerplant Mechanics, U.S. Dept. ofTransportation, Federal Aviation Administration, The English Book Store, NewDelhi1995.

REFERENCES:

1. Mekinley, J.L. and Bent, R.D., Aircraft Power Plants, McGraw-Hill, 1993.
2. Pallet, E.H.J., Aircraft Instruments & Principles, Pitman & Co., 1993.
3. Treager, S., Gas Turbine Technology, McGraw-Hill, 1997.

BCE407	**ENVIRONMENTAL STUDIES**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Engineering Chemistry, Biology for Engineers				
	Course Designed by – Department of Humanities and Sciences				

OBJECTIVES

1. To acquaint the student about the various natural resources and their associated problems
2. To accustom the student about ecosystem and the different types of ecosystems and their importance
3. To introduce to the student about the values of bio diversity and the importance of its conservation and also on environmental pollution
4. To familiarize the student on the social issues that have a direct effect on the environment
5. To help the student understand about the effects of human population on the environment and remedial measures

<table>
<tr><td>UNIT I</td><td>NATURAL RESOURCES AND ASSOCIATED PROBLEMS</td><td>6</td></tr>
<tr><td colspan="3">The multidisciplinary nature of environmental studies definition , scope and importance – need for public awareness – Natural Resources – Forest Resources – Water Resources - Mineral Resources –Energy resources – Land Resources – Role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles.</td></tr>
<tr><td>UNIT II</td><td>ECOSYSTEMS</td><td>9</td></tr>
<tr><td colspan="3">Concept of an ecosystem structure and function of an ecosystem, produces consumers and decomposes, energy flow in the ecosystem, Ecological succession food chains, food webs and ecological pyramids, introduction, types, characteristics features, structure and function of different ecosystem</td></tr>
<tr><td>UNIT III</td><td>BIODIVERSITY AND ENVIRONMENTAL POLLUTION</td><td>12</td></tr>
<tr><td colspan="3">BIODIVERSITY
Introduction – definition ;.genetic, species and ecosystem diversity, biogeographically classification of India, value of biodiversity; consumptive use productive use social, ethical aesthetic and option values, biodiversity at global, national and local levels India as a mega-diversity nation, hot spots of biodiversity, threats to biodiversity habitual loss poaching of wild life man, wildlife conflicts, endangered and endemic species of India, conservation of biodiversity in-situ and ex-situ conservation of biodiversity.
ENVIRONMENTAL POLLUTION
Definition,causes, effects and control measure of air pollution, water pollution, soil pollution, marine pollution , noise pollution, thermal pollution, nuclear hazards, solid waste management – causes, effects and its control measure – role of an individual in presentation of pollution and case studies.</td></tr>
<tr><td>UNIT IV</td><td>SOCIAL ISSUES AND THE ENVIRONMENT</td><td>9</td></tr>
<tr><td colspan="3">From unsustainable to sustainable development, urban problems related to energy, water conservation, rain water harvesting, watershed management, resettlement and rehabilitation of people its problems and concerns , case studies environmental ethics, issues and possible solution climate change global warming add rain, ozone layer depletion nuclear accident and holocaust case studies waste land reclamation, various environment protection act , issues involved enforcement of environmental legislation public awareness.</td></tr>
<tr><td>UNIT V</td><td>HUMAN POPULATION AND THE ENVIRONMENT</td><td>9</td></tr>
<tr><td colspan="3">Population growth variation among nations, population explosion family welfare program environment and human health, human right, value education, HIV/AIDS, women and child welfare role of information technology in environment and human health case studies.</td></tr>
<tr><td colspan="3">FIELDWORK
Visit to a local area to document assets river forest/ grass land/ hill mountain, visit to local polluted site rural/industrial / agricultural, study of common plants, insects, birds, study of simple ecosystems = ponds, river hill slopes etc(field work equal to 5 lecture hours)</td></tr>
<tr><td colspan="3">Text Books:
1. Sharma.B.K. andKaur, Environmental Chemistry, Goel Publishing House, Meerut, 1994.
2. De.A.K., Environmental Chemistry, New Age International (p) lt., New Delhi, 1996.
3. Kurian Joseph and Nagendran.R, Essential of Environmental Studies, Pearson Education, 2004.</td></tr>
<tr><td colspan="3">References:
1. Dara S.S., A Text Book of Environmental Chemistry and Pollution Control, S.Chand and company Ltd., New Delhi, 2004.
2. Jeyalakshmi.R, Principles of Environmental Science, First Edition, Devi Publications, Chennai, 2006.
3. Kamaraj.P and Arthanareeswari.M, Environmental Science - Challenges and Changes, first Edition, Sudhandhir Publications, 2007.</td></tr>
</table>

<table>
<tr><td rowspan="4">BAN4L1</td><td>AIRCRAFT STRUCTURES LABORATORY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>0</td><td>0</td><td>3</td><td>2</td></tr>
<tr><td colspan="5">Prerequisite – Fundamentals of Structural Mechanics</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
</table>

OBJECTIVES

1. To acquaint the student to the various experimental processes to carry out structural analysis.
2. To familiarize to the student about the analysis of beams.
3. To enable the student to understand about the analysis of columns.
4. To help the student to understand about the effect of complex loading on aircraft structures.
5. To introduce to the student about the shear flow estimation in aircraft structures.

LIST OF EXPERIMENTS

1	Determination of Young's modulus of aluminum using electrical extensometers.
2	Deflection of beams with various end conditions.
3	Verification of Maxwell's theorem and principle of superposition.
4	Column – Testing.
5	Testing of riveted joints.
6	Unsymmetrical Bending of a Beam
7	Determination of Shear Centre in open Section
8	Determination of Shear Centre in closed Section
9	Combined bending and Torsion of a Hollow Circular Tube
10	Constant Strength Beams
11	Wagner beam – Tension field beam
12	Material properties test of composite laminate

REFERENCES:

1. Aircraft Structures Lab Manual, Department of Aeronautical Engineering, 2017

<table>
<tr><td rowspan="4">BAN4L2</td><td>MANUFACTURING ENGINEERINGLABORATORY</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>0</td><td>0</td><td>2</td><td>1</td></tr>
<tr><td colspan="5">Prerequisite – Nil</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
</table>

OBJECTIVES

1. To introduce student to various machine cutting operation
2. To train the student for using the lathe
3. To train the student for performing various operation using lathe

4. To train the student for performing drilling operations and boring operation
5. To train the student for using the surface grinding machine and milling machine

LIST OF EXPERIMENTS

1	Study of centre, capstan and automatic lathes and their accessories.
2	Exercise on setting the work piece and the tool in the lathe.
3	Plane turning and step turning.
4	Taper turning and knurling.
5	Eccentric Turning.
6	Thread cutting and grooving.
7	Drilling and reaming.
8	Drilling and boring.
9	Surface grinding
10	Study of shaper and planer machines.
11	Study of milling and grinding machines.

REFERENCES:

1. Machine Shop Lab Manual, Department of Mechanical Engineering, 2017

BAN4L3	COMPUTER AIDED DESIGNING AND DRAFTING LABORATORY	L	T	P	C
	Total Contact Hours – 45	0	0	2	1
	Prerequisite – Engineering Graphics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student with various computer software for engineering design
2. To familiarize the student with to the various options and types of designs that can be carried out using commercial designing software
3. To train the student on the designing of basic mechanical parts
4. To train the student on the assembly of different mechanical parts
5. To train the student on the drafting of the part / model / assembly designed.

LIST OF EXPERIMENTS

1	Study of various software for engineering design and drafting
2	Study of commercial software packages and their tools
3	Exercise on 2D drawing
4	Exercise on pad and groove
5	Exercise on shaft, mirror and array

6	Exercise on threading, bores and tappings
7	Exercise on part assembly
8	Exercise on drafting
9	Exercise on surface modeling
10	Exercise on kinematics
REFERENCES: 1. CADD Lab Manual, Department of Aeronautical Engineering, 2017	

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DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER V

<table>
<tr><td rowspan="4">BAN501</td><td>AIRCRAFT STRUCTURES – II</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 60</td><td>4</td><td>0</td><td>0</td><td>4</td></tr>
<tr><td colspan="5">Prerequisite – Aircraft Structures – I</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
</table>

OBJECTIVES

1. To understand the basic concepts of Aircraft structural Mechanics in Aeronautical engineering and society. Understand the basics of unsymmetrical bending loadings and the parameters and know how to use them in real problems.
2. Understand the basic concept of shear flow in open sections and know how to use it to solve engineering problems and understand shear flow in closed sections and know how to use them to solve engineering problems.
3. Understand the buckling of plates and using the concepts to solve the sheet panel problems.
4. Understand the basics of stress analysis in wing and fuselage and to develop the skill to solve fundamental engineering problem.
5. Overall improvement in subject knowledge in Aircraft Structures.

COURSE CONTENT

UNIT I	**UNSYMMETRICAL BENDING**	**12**

Bending of symmetric beams subject to skew loads - bending stresses in beams of unsymmetrical sections – generalized ‘k’ method, neutral axis method, principal axis method- advantages and disadvantages.

UNIT II	**SHEAR FLOW IN OPEN SECTIONS**	**12**

Thin walled beams – concept of shear flow – the shear centre and its determination – shear flow distribution in symmetrical and unsymmetrical thin-walled sections – structural idealization – shear flow variation in idealized sections.

UNIT III	**SHEAR FLOW IN CLOSED SECTIONS**	**12**

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

UNIT IV	**BUCKLING OF PLATES**	**12**

Bending of thin plates – rectangular sheets under compression - local buckling stress of thin walled sections – crippling strength by Needham’s and Gerard’s methods – thin-walled column strength – load carrying capacity of sheet stiffener panels – effective width – inter-rivet and sheet wrinkling failures - short panel failing strength.

UNIT V	**STRESS ANALYSIS OF WING AND FUSELAGE**	**12**

Wing structural arrangements – factors influencing - wing stress analysis methods – determination of shear force and bending moment distribution over fuselage – Numerical problems – Tension field beam – general Wagner equation - Semi-tension field beams.

TEXTBOOKS:

1. Megson T M G, ‘Aircraft Structures for Engineering Students’, Fifth Edition, Elsevier Aerospace Engineering Series,2007. (Units 1, 2, 3 & 5)
2. Peery, D.J., and Azar, J.J., Aircraft Structures, 2nd edition, McGraw – Hill, N.Y., 1999 (Unit 4)

REFERENCES:

1. Rivello, R.M., Theory and Analysis of Flight Structures, McGraw Hill, 1993.
2. Howard D Curtis, ‘Fundamentals of Aircraft Structural Analysis’, WCB-McGraw Hill, 1997
3. Bruhn. E.H., ‘Analysis and Design of Flight Vehicles Structures’, Tri-state off-set company, USA, 1985

BAN502	**AERODYNAMICS – II**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Aerodynamics – I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To make the student understand concepts and 1-d equations used for compressible flows.
2. To acquaint the student with the estimation of flow properties across normal shock, oblique shock and expansion waves.
3. To familiarize the student to the governing equations in compressible flows.
4. To educate the student on problems faced by high speed flow airfoils, wings and airplane configuration and to understand design modifications required to overcome problems.
5. To create awareness among the students about various experimental methods and measurement techniques.

COURSE CONTENT

(Use of Gas Tables is permitted)

UNIT I	**FUNDAMENTAL ASPECTS OF COMPRESSIBLE FLOW**	**12**

Compressibility, Continuity, Momentum and Energy equation for steady one dimensional flow, Compressible Bernoulli’s equation, Area – Mach number – Velocity relation, Mach cone, Mach angle, One dimensional Isentropic flow through variable area duct, Isentropic relations - Critical conditions, Characteristic Mach number, Maximum discharge velocity.

UNIT II	**SHOCKS AND EXPANSION WAVES**	**14**

Normal shock relations, Prandtl’s relation, Hugonoit equation, Rayleigh Supersonic Pitot tube equation, Oblique shocks, θβM relation, Shock Polar, Reflection of oblique shocks, Left running and Right running waves, Interaction of oblique shock waves, slip line, Rayleigh flow, Fanno flow, Expansion waves, Prandtl-Meyer expansion, Maximum turning angle, Simple and non-simple regions, Operating characteristics of convergent and convergent-divergent nozzles.

UNIT III	**TWO DIMENSIONAL COMPRESSIBLE FLOW**	**14**

Potential equation for 2-dimensional compressible flow, Linearization of potential equation,Small perturbation theory, Linearized Pressure Coefficient, Linearized subsonic flow, Prandtl-Glauert rule, Linearized supersonic flow, Method of characteristics, Wave drag coefficient.

UNIT IV	**HIGH SPEED FLOW OVER AIRFOILS, WINGS AND AIRPLANE CONFIGURATION**	**10**

Critical Mach number, Drag divergence Mach number, Shock Stall, Shock- Boundary layer interaction, Supercritical Airfoil Sections, Transonic area rule, Swept wing, Airfoils for supersonic flows, Lift, drag, Pitching moment and Centre of pressure for supersonic profiles, Shock-expansion theory, wave drag, supersonic wings.

UNIT V	**EXPERIMENTAL METHODS**	**10**

Wind tunnels for Subsonic, transonic, Supersonic and hypersonic flows, Various Measurement techniques – velocity, pressure, Flow visualization techniques in high speed flows, Shock tube, Gun tunnels

TEXTBOOKS:

1. Rathakrishnan.. E, Gas Dynamics, Prentice Hall of India, Sixth Edition, 2017.

REFERENCES:

1. Anderson, J. D, Modern Compressible Flow, Third Edition, Tata McGraw-Hill & Co., 2012.
2. Shapiro, A. H., Dynamics and Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.
3. Zucrow, M. J. and Anderson, J. D., Elements of Gas Dynamics, McGraw- Hill & Co., 1989.
4. Oosthuizen,P.H., &Carscallen,W.E., Compressible Fluid Flow, McGraw- Hill & Co., 19976.
5. Yahya S.M., Fundamentals of Compressible Flows, Third Edition, New Age International Publishers, 2003.

BAS501	**ROCKET PROPULSION**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**0**	**0**	**3**
	Prerequisite – Aircraft Propulsion				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student about the basic theory of rocket propulsion.
2. To introduce to the student about the significance and applications of solid propellant rockets.
3. To introduce to the student about the significance and applications of liquid propellant rockets.
4. To help the student understand about the modern propulsion techniques.
5. To help the student understand about the types and performance of rocket nozzle.

COURSE CONTENT

UNIT I	**THEORY OF ROCKET PROPULSION**	**10**

Brief History – Classification – Rocket Principle and Rocket Equation – Mass Ratio – Specific Impulse – Desirable Parameters of Rockets – Propulsive Efficiency – Performance Parameters – Staging and Clustering of Rockets – Statics Testing of Rockets

UNIT II	**SOLID PROPELLANT ROCKETS**	**12**

Operating principle – Specific impulse of a rocket – Igniters – Internal ballistics – Selection criteria of solid propellants – propellant grain design considerations – Progressive, Regressive and neutral burning in solid rockets.

UNIT III	**LIQUID PROPELLANT ROCKETS**	**14**

Liquid propellant rockets – selection of liquid propellants – performance and choice of various feed systems for liquid propellant rockets – hydrazine monopropellant rockets–basics of cryogenic techniques – Cooling in liquid rockets and the associated heat transfer problems – advantages of liquid rockets over solid rockets –draining of propellant tanks under microgravity conditions

UNIT IV	**MODERN PROPULSION TECHNIQUES**	**12**

Hybrid Rockets, Burning Mechanism, Advantages of Hybrid Rockets over Solid and Liquid Propellant Rockets – Nuclear Rockets – Pulse Detonation Rockets – Beamed Rockets and Sail Propulsion – Basics of Electrothermal, Electrostatic and Electromagnetic Thrusters

UNIT V	**ROCKET NOZZLE AND PERFORMANCE**	**12**

Nozzle types – Effect of Shape and Area Ratio – Performance Losses, Flow Separation in Nozzles – Mass Flow Rate and Characteristic Velocity – Thrust Coefficient – Bell Nozzle – Unconventional Nozzles, SERN nozzle – Aerospike nozzle, annular nozzles.

TEXTBOOKS:

1. Ramamurthi, K., “Rocket Propulsion”, Trinity Press, First Edition, 2010

REFERENCES:

1. 2. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 8th Edition, 2010.
2. J D Mattingly, “Elements of Propulsion - Gas Turbines and Rockets “, AIAA Education Series, 2006.
3. Thomas A Ward, “Aerospace Propulsion Systems”, John Wiley & Sons Inc., New York,2010.

4. DanM.Goebel, Ira Katz, ‘Fundamentals of Electric Propulsion’, John Wiley & Sons Inc, New York, 2003.

BAN504	FLIGHT MECHANICS	L	T	P	C
	Total Contact Hours – 60	4	0	0	4
	Prerequisite – Fundamentals of Aeronautics and Astronautics, Aerodynamics I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To understand aircraft performance relating to steady level
2. To understand aircraft performance relating to Range, Endurance, climb & Glide
3. To acquire knowledge about Take off, Landing and Turning performance
4. To understand the principles of stability and control relating to longitudinal stability
5. To understand the principles of stability and control relating to directional and lateral stability

UNIT I	STEADY LEVEL FLIGHT	12
International Standard Atmosphere, TAS, IAS and EAS, Streamlined and Bluff body – Skin friction Drag, Pressure Drag and Induced Drag – Drag Polar – Various drags of an airplane – Methods of Drag Reduction - Effect on Drag Polar. Steady level flight, Thrust required and Power required, Thrust available and Power available for propeller driven and jet powered aircraft, Effect of altitude, conditions for minimum drag and minimum power required		
UNIT II	**RANGE, ENDURANCE, CLIMB AND GLIDE PERFORMANCE**	**12**
Range and Endurance of Propeller and Jet aircrafts, Shallow and steep angles of climb, Rate of climb, Climb hodograph, Maximum Climb angle and Maximum Rate of climb- Effect of design parameters for propeller and jet aircrafts, Absolute and service ceiling, Cruise climb, Gliding flight, Glide hodograph		
UNIT III	**TAKE OFF, LANDING AND TURNING PERFORMANCE**	**10**
Take-off and landing performance, Turning performance, bank angle and load factor, Constraints on load factor, Pull up and pull down maneuvers, maximum turn rate, V-n diagram.		
UNIT IV	**LONGITUDINAL STABILITY**	**14**
General concepts, Static and dynamic stability, Stability and Controllability, Requirements of control surfaces, criteria for longitudinal static stability, contribution to stability by wing, tail, fuselage, wing fuselage combination, Total longitudinal stability, Neutral point-Stick fixed and Stick free aspects, Free elevator factor, static margin, Hinge moment, Power effects on stability-propeller and jet aircrafts, longitudinal control, Movement of centre of gravity, elevator control power, elevator angle to trim, elevator angle per g, maneuver point, Stick force gradient and stick force per g, Aerodynamic balancing Aircraft Equations of motion, small disturbance theory, Estimation of longitudinal stability derivatives Routh’s discriminant, solving the stability quartic, Phugoid motion, Factors affecting the period and damping.		
UNIT V	**LATERAL AND DIRECTIONAL STABILITY**	**12**
Directional stability-yaw and sideslip, contribution to static directional stability by wing, fuselage, vertical tail, Power effects on directional stability-propeller and jet aircrafts, Rudder lock and Dorsal fin, Directional control, rudder control power, rudder requirements, adverse yaw, asymmetric power condition, spin recovery, Lateral stability-Dihedral effect, contribution of various components, lateral control, aileron control power,		

strip theory, roll control by spoilers, aileron reversal, aileron reversal speed

Text Books:

1. Anderson, Jr., J.D. Aircraft Performance and Design, McGraw-Hill International Edition, 2012. (Units 1, 2 & 3)
2. Nelson, R.C." Flight Stability & Automatic Control", McGraw Hill, 2005. (Units 4 & 5)

References:

1. Houghton,E.L. and Carruthers, N.B. Aerodynamics for engineering students, Edward Amold Publishers, 2000
2.Pamadi, B.N. Performance, Stability, Dynamics, and Control of Airplanes, AIAA Education Series, 2004
3. McCormick, B.W. "Aerodynamics, Aeronautics & Flight Mechanics", John Wiley, 1995.
4. Babister, A.W. "Aircraft Stability and response", Pergamon Press, 1996.
5. Etkin, B., "Dynamics of Flight Stability and Control", John Wiley, New York, 1982.
6. Perkins C.D. &Hage R.E. "Airplane performance, stability and control", John Wiley & Sons 1976.

<table>
<tr><td rowspan="4">BAN505</td><td>MANUFACTURING ENGINEERING</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Nil</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To introduce the student about various metal working process
2. To impart theoretical knowledge about the metal cutting and machining process.
3. Introduce students about various special purpose machine and milling machine.
4. Introducing students about various drilling, boring and surface finish operations.
5. Introduce to students about various non-conventional processes.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">METAL WORKING PROCESS</td><td>8</td></tr>
<tr><td colspan="6">Mechanical working of metals –hot and cold working –rolling, extrusion, spinning, wire-drawing, press working. Welding – different types of gas and arc welding process, soldering and brazing. Casting –different types, furnaces</td></tr>
<tr><td>UNIT II</td><td colspan="4">MACHINING PROCESSES</td><td>10</td></tr>
<tr><td colspan="6">Lathe – introduction, types, construction, mechanisms and attachments for various operations, nomenclature of single point cutting tool. Capstan and turret lathes various mechanisms, tool and loading arrangement. Automatic lathes - single spindle and multi spindle mechanisms, Introduction to CNC machining</td></tr>
<tr><td>UNIT III</td><td colspan="4">SHAPER, PLANER AND MILLING PROCESSES</td><td>10</td></tr>
<tr><td colspan="6">Shaper, planer and slotter: types, specifications, mechanisms, holding devices, difference between shaper and planer. Milling machine – types and specification, mechanisms, holding devices, milling operations.</td></tr>
<tr><td>UNIT IV</td><td colspan="4">DRILLING, BORING, BROACHING, SURFACE FINISHING PROCESSES</td><td>9</td></tr>
<tr><td colspan="6">Drilling, Boring- Specification, Nomenclature of drilling and reaming tool and its specification. Broaching: Specification, types, mechanisms, nomenclature of broaching tool. Grinding process, Types of grinding machines, Grinding Wheels, Honing, Super finishing, Polishing, Metal spraying, Galvanizing, Electroplating.</td></tr>
<tr><td>UNIT V</td><td colspan="4">NON – TRADITIONAL MACHINING PROCESSES</td><td>8</td></tr>
<tr><td colspan="6">Non-traditional machining techniques, classification, Abrasive jet machining, Electrical Discharge Machining, E. D wire cutting, Electro chemical machining, Electron Beam Machining, Laser Beam Machining, Ultrasonic</td></tr>
</table>

Machining – Introduction to 3D Printing

TEXTBOOKS:

1.HajraChowdary S.K, The fundamentals of work shop technology Vol. I & II, Media publishers, 1997.

REFERENCES:

1. W.A.J. Chapman., Workshop Technology. Vol I, II& III, 1975, ELBS.
2. Roy A Lindberg, Process and Material Manufacture, PHI, 1995.
3. Kalpakjan, Manufacturing Engineering and Technology, Addison Wesley, 2005.
4. P.C. Sharma., A text book of Production Technology, S.Chand& Company ltd, 2007.
5. P.N.Rao. Manufacturing Technology-Foundry Forging and Welding, TMH publishing co, 2009.

BAN5L1	**AERODYNAMICS LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**3**	**2**
	Prerequisite – Aerodynamics – I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student to the various experimental processes to carry out flow analysis
2. To introduce to the student about different types of wind tunnels, measurements and calibration processes
3. To acquaint the student about the estimation of aerodynamic forces through pressure distribution
4. To enable the student to understand about the different flow visualization techniques

LIST OF EXPERIMENTS

1	Calibration of subsonic wind tunnel.
2	Pressure distribution over smooth cylinder
3	Pressure distribution over rough cylinder.
4	Pressure distribution over symmetric airfoil.
5	Pressure distribution over cambered airfoil.
6	Pressure distribution over a wing
7	Pressure distribution over a building model.
8	Determination of base drag of a missile model.
9	Study of flow field over a backward facing step.
10	Power estimation of Wind Turbine
11	Aerodynamic studies of automotive models.
12	Flow visualization at subsonic velocity (a) Using Tuft (b) Oil flow visualization.

REFERENCES:

1. Aerodynamics Lab Manual, Department of Aeronautical Engineering, 2017

BAN5L2	**AERO DESIGN AND MODELING LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 30	**0**	**0**	**2**	**1**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To design and fabricate gliders, catapult and power gliders.
2. To design and fabricate single, double and pivoted double crank flapping wing mechanism.
3. To design and fabricate wing, vertical and horizontal stabilizer using light weight materials.
4. To design and fabricate fuselage and control surfaces using light weight materials.
5. To estimate discharge rate of Li-Po battery, propeller thrust and assembling Remote Control Aircraft

LIST OF EXPERIMENTS

1	Design and fabrication of gliders using light weight materials.
2	Design and fabrication of catapult.
3	Design and fabrication of power gliders.
4	Design and fabrication of single and double crank flapping wing mechanism.
5	Design and fabrication of pivoted double crank flapping wing mechanism.
6	Design and fabrication of wing using light weight materials.
7	Design and fabrication of horizontal and vertical stabilizer using light weight materials.
8	Design and fabrication of fuselage using light weight materials
9	Design and fabrication of control surfaces using glass fibers composite.
10	Estimation the discharge rate of Li-Po battery for different thrust setting.
11	Estimating the propeller thrust for different voltage setting.
12	Assembling of Remote Control Aircraft.

REFERENCES:

1. Aero Design and Modeling Lab Manual, Department of Aeronautical Engineering, 2017

BAN5L3	**COMPUTER AIDED ANALYSIS LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 30	**0**	**0**	**2**	**1**
	Prerequisite – Aerodynamics I, Aircraft Structures I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student with various computer software for engineering analysis
2. To familiarize the student with to the various options and types of analysis that can be carried out using commercial software
3. To train the student on basic structural analysis
4. To train the student on basic thermal analysis

5. To train the student on basic fluid flow analysis	
LIST OF EXPERIMENTS	
1	Study of commercial software packages and their tools
2	Stress analysis of beams with different loading conditions
3	Stress analysis of a plate with circular hole
4	Stress analysis of an axisymmetric component
5	Vibration analysis of cantilever beam
6	Simple conduction example
7	Thermal mixed boundary example
8	Flow field analysis of jets
9	Flow field simulation over an airfoil
10	Fluid – Structure interaction
REFERENCES: 1. CAA Lab Manual, Department of Mechanical Engineering, 2017	

OPTIONS FOR CORE ELECTIVE I (CE I)

BASE01	**THEORY OF ELASTICITY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES To make the student understand theoretical concepts of material behaviour with particular emphasis on their elastic property.					
COURSE CONTENT					
UNIT I	**BASIC EQUATIONS OF ELASTICITY**				**9**
Stress – Strain – Stress Strain relationships - Equations of Equilibrium, Compatibility equations and strains, Boundary Conditions, Saint Venant’s principle - Principal Stresses Stress Ellipsoid - Stress invariants.					
UNIT II	**TWO DIMENSIONAL FORMULATION**				**9**
Plane Strain – Plane Stress – Generalized Plane Stress- Anti-planeStrain – Airy Stress Function – Polar Co-Ordinate Formulation – Cartesian Co-Ordinate Solution Using Polynomials and Fourier Methods- General Solutions in Polar Co- Ordinates.					
UNIT III	**TORSION**				**9**
Navier’s theory, St. Venant’s theory, Prandtl’s theory on torsion, semi- inverse method and applications to shafts of circular, elliptical, equilateral triangular and rectangular sections.					
UNIT IV	**ANISOTROPIC ELASTICITY**				**9**

Neumann Principle – Material Symmetry – Restrictions on Elastic Moduli – Torsion of a Solid Possessing a Plane of Material Symmetry – Plane Deformation Problems – Applications To Fracture Mechanics

UNIT V	**THEORY OF PLATES**	**9**

Classical plate theory – Assumptions – Governing equations – Boundary conditions – Navier’s method of solution for simply supported rectangular plates – Levy’s method of solution for rectangular plates under different boundary conditions.

TEXTBOOKS:

1.Timoshenko, S., and Goodier, T.N., Theory of Elasticity, McGraw – Hill Ltd., Tokyo, 1990.
2.MartinH.Sadd, Elasticity Theory, Applications and Numeric, Elsevier, 2005.

REFERENCES:

1.Wang, C.T., Applied Elasticity, McGraw – Hill Co., New York, 1993.
2.Sokolnikoff, I.S., Mathematical Theory of Elasticity, McGraw – Hill New York, 1978.
3. Enrico Volterra& J.H. Caines, Advanced Strength of Materials, Prentice Hall New Jersey, 1991
4.Ansel C Ugural and Saul K Fenster, ‘Advanced Strength and Applied Elasticity’, 4th Edition, Prentice Hall, New Jersey, 2003.

BANE02	**ROCKETS AND MISSILES**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Aerodynamics – I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

To learn about the aerodynamics and stability of Rockets and Missiles.

COURSE CONTENT

UNIT I	**AERODYNAMICS OF ROCKETS AND MISSILES**	**9**

Airframe components of rockets and missiles – forces acting on a missile while passing through atmosphere – classification of missiles – slender body aerodynamics – method of describing forces and moments – lift force and lateral moment –lateral aerodynamic damping moment – longitudinal moment – drag estimation – body upwash and body downwash in missiles – rocket dispersion.

UNIT II	**ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD**	**9**

One dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields – description of vertical, inclined and gravity turn trajectories – determination of range and altitude – simple approximations to burn out velocity and altitude – estimation of culmination time and altitude.

UNIT III	**ROCKET SYSTEMS**	**9**

Ignition system in rockets – types of igniters and igniter design considerations – injection system of liquid rockets and their design considerations – design considerations of liquid rocket thrust chambers – cryo fuel systems – combustionmechanisms of liquid and solid propellants.

UNIT IV	**STAGING AND CONTROL OF ROCKETS AND MISSILES**	**9**

Design philosophy behind multistaging of launch vehicles and ballistic missiles – multistage vehicle optimization – stage separation techniques in atmosphere and in space – stage separation dynamics and lateral separation characteristics – various types of thrust vector control methods including secondary injection thrust vector control – numerical problems on stage separation and multistaging.

UNIT V	**MATERIALS FOR ROCKETS AND MISSILES**	**9**

Selection criteria of materials for rockets and missiles – materials for various airframe components and engine parts

– materials for thrust control devices – various adverse conditions faced by aerospace vehicles and the requirement of materials to perform under these conditions.

TEXTBOOKS:

1. Ramamurthy K, “Rocket Propulsion”, Trinity Publications, 2017. (Units 2, 3 & 5)
2.Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 9th Edition (Units 1 & 4)

REFERENCES:

1. J.D.Mattingly, Elements of Propulsion - Gas Turbines and Rockets, AIAA Education series,2006,.
2. Mathur, M.L., and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”,Standard Publishers and Distributors, Delhi, 1988.
3. Martin J L Turner, Rocket and Spacecraft Propulsion, Springer-Praxis Publishing, 2001
4. www.propulsion-analysis.com/
5. www.rocket.com/design-and-analysis

<table>
<tr><td rowspan="4">BASE02</td><td>ELECTRIC PROPULSION</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Aircraft Propulsion</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To introduce basic physics of electric propulsion systems.
2.To know about physics of Ionized gases
3.To get knowledge about electro thermal propulsion
4.To know about various electromagnetic propulsion and its systems
5. To introduce to the concepts of electrostatic propulsion.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">INTRODUCTION TO THE BASIC PHYSICS OF ELECTRIC PROPULSION SYSTEMS</td><td>8</td></tr>
<tr><td colspan="6">Historical outline - Definition of Electric Propulsion - High impulse Space Missions - Exhaust velocity and specific impulse - Power supply penalty – Electric charges and Electrostatic fields - Currents and Magnetic interactions - Time dependent fields and Electromagnetic wave propagation - Application to ionized gas flows</td></tr>
<tr><td>UNIT II</td><td colspan="4">PHYSICS OF IONIZED GASES</td><td>12</td></tr>
<tr><td colspan="6">Atomic structure of gases - Ionization processes - Particle collisions in an ionized gas - Electrical conductivity of an ionized gas - Kinetic Theory</td></tr>
<tr><td>UNIT III</td><td colspan="4">ELECTRO-THERMAL PROPULSION</td><td>9</td></tr>
<tr><td colspan="6">One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency - Resistojets - Electrical discharges - Arcjets - Operation and Analysis - Materials - Advantages and Disadvantages</td></tr>
<tr><td>UNIT IV</td><td colspan="4">ELECTROMAGNETIC PROPULSION</td><td>9</td></tr>
<tr><td colspan="6">The Lorentz force - Magnetogasdynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self induced fields - Sources of the conducting gas - The magnetoplasmadynamic arc - Magneto- plasmadynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Traveling wave acceleration</td></tr>
<tr><td>UNIT V</td><td colspan="4">ELECTROSTATIC PROPULSION</td><td>7</td></tr>
<tr><td colspan="6">One dimensional space-charge flows - Basic relationships - The acceleration- deceleration concept - Ion engines - Design and Performance - Hall effect – Hall thrusters - Field emission electric propulsion (FEEP) - Colloid thrusters</td></tr>
</table>

TEXTBOOKS:

1. Robert G. Jahn, “Physics of Electric Propulsion”, McGraw-Hill Series, New York, 1968.

REFERENCES:

1. George W. Sutton, “Engineering Magnetohydrodynamics”, Dover Publications Inc., New York, 2005 2. George P. Sutton & Oscar Biblarz, “Rocket Propulsion Elements, John Wiley & Sons Inc., New York, 8th Edition, 2010.

BASE03	**LAUNCH VEHICLE AERODYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Applied Dynamics and Vibrations, Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the students with the basics of high speed aerodynamics.
2. To acquaint the students familiarize with boundary layer theory.
3. To make the students familiarize with launch vehicle configurations and drag estimation.
4. To acquaint the students with the concepts of Aerodynamics of slender and blunt bodies.
5. To familiarize the students with Aerodynamic aspects of launching phase.

COURSE CONTENT

UNIT I	**BASICS OF HIGH SPEED AERODYNAMICS**	**9**

Compressible flows-Isentropic relations-mathematical relations of flow properties across shock and expansion waves-fundamentals of Hypersonic Aerodynamics

UNIT II	**BOUNDARY LAYER THEORY**	**9**

Basics of boundary layer theory-compressible boundary layer-shock shear layer interaction -Aerodynamic heating-heat transfer effects

UNIT III	**LAUNCH VEHICLE CONFIGURATIONS AND DRAG ESTIMATION**	**9**

Types of Rockets and missiles-various configurations-components-forces on the vehicle during atmospheric flight-nosecone design and drag estimation.

UNIT IV	**AERODYNAMICS OF SLENDER AND BLUNTBODIES**	**9**

Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles-determination of aero elastic effects.

UNIT V	**AERODYNAMIC ASPECTS OF LAUNCHING PHASE**	**9**

Booster separation-crosswind effects-specific consideration sin missile launching-missile integration and separation-methods of evaluation and determination-Stability and Control Characteristics of Launch Vehicle Configuration-Wind tunnel tests –Comparison with CFD Analysis.

TEXTBOOKS:

1. Anderson, J.D., “Fundamentals of Aerodynamics”, McGraw-Hill BookCo. NewYork, 2010. (Units 1 & 2)
2. Chin SS, Missile Configuration Design, McGrawHill, New York, 1961. (Unit 3)
3. Anderson, J.D., “Hypersonic and High Temperature Gas Dynamics”, AIAA Education Series.(Units 4 & 5)

REFERENCES:

1. Nielson, Jack N, Stever, Gutford, “Missile Aerodynamics”, McGraw Hill, New York, 1960.
2. Anderson Jr.,D.,–“Modern compressible flows”, McGraw-Hill BookCo.,NewYork1999.
3. Charles D.Brown, “Spacecraft Mission Design”, AIAA Education Series, Published by AIAA, 1998
4. Elements of Space Technology for Aerospace Engineers”, Meyer Rudolph X, Academic Press,1999

BHARATH INSTITUTE OF HIGHER EDUCATION AND RESEARCH

DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER VI

<table>
<tr><td rowspan="4">BSS601</td><td>VALUE EDUCATION AND PROFESSIONAL ETHICS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Nil</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To teach the philosophy of Life, personal value, social value, mind cultural value and personal health
2. To teach professional ethical values, codes of ethics, responsibilities, safety, rights and related global issues.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">PHILOSOPHY OF LIFE AND INDIVIDUAL QUALITIES</td><td>9</td></tr>
<tr><td colspan="6">Human Life on Earth - Purpose of Life, Meaning and Philosophy of Life. The Law of Nature – Protecting Nature /Universe. Basic Culture - Thought Analysis - Regulating desire - Guarding against anger - To get rid of Anxiety – The Rewards of Blessing - Benevolence of Friendship - Love and Charity - Self – tranquility/Peace</td></tr>
<tr><td>UNIT II</td><td colspan="4">SOCIAL VALUES (INDIVIDUAL AND SOCIAL WELFARE)</td><td>9</td></tr>
<tr><td colspan="6">Family - Peace in Family, Society, The Law of Life Brotherhood - The Pride of Womanhood – Five responsibilities/duties of Man : - a) to himself, b) to his family, c) to his environment, d) to his society, e) to the Universe in his lives, Thriftness (Thrift)/Economics. Health - Education - Governance - People’s Responsibility / duties of the community, World peace.</td></tr>
<tr><td>UNIT III</td><td colspan="4">MIND CULTURE & TENDING PERSONAL HEALTH</td><td>9</td></tr>
<tr><td colspan="6">Mind Culture - Life and Mind - Bio - magnetism, Universal Magnetism (God –Realization and Self Realization) - Genetic Centre – Thought Action – Short term Memory – Expansiveness – Thought – Waves, Channelising the Mind, Stages - Meditation, Spiritual Value. Structure of the body - the three forces of the body- life body relation, natural causes and unnatural causes for diseases, Methods in Curing diseases</td></tr>
<tr><td>UNIT IV</td><td colspan="4">ENGINEERING AS SOCIAL EXPERIMENTATION AND ENGINEERS’S RESPONSIBILITIES FOR SAFETY</td><td>9</td></tr>
<tr><td colspan="6">Engineering as Experimentation – Engineer as Responsible Experimenters – Codes of Ethics – The Challenger, case study. Assessment of Safety and Risk – Risk Benefit Analysis and Reducing Risk – The Three Mile Island and Chernobyl case studies.</td></tr>
<tr><td>UNIT V</td><td colspan="4">ENGINEER’S RESPONSIBILITIES FOR RIGHTS AND GLOBAL ISSUES</td><td>9</td></tr>
<tr><td colspan="6">Collegiality and Loyalty – Respect for Authority – Collective Bargaining – Confidentiality – Conflicts of Interest – Occupational Crime – Whistle Blowing – Professional Rights – Employee Rights – Intellectual Property Rights (IPR) – Discrimination.
Multinational Corporations – Environmental Ethics – Computer Ethics – Weapons Development –Engineers as Managers – Consulting Engineers – Engineers as Expert Eye Witnesses and Advisors – Moral Leadership</td></tr>
<tr><td colspan="6">TEXTBOOKS:
1. Value Education for Health, Happiness and Harmony, The World Community Service, Centre Vethathiri Publications (Unit I – III).
2. Mike W Martin and Roland Schinzinger, Ethics In Engineering, Tata Mcgraw Hill, Newyork 2005 (Units IV & V)</td></tr>
</table>

REFERENCES:
1. Philosophy of Universal Magnetism (Bio - magnetism, Universal Magnetism) The World Community Service Centre Vethathiri Publications (for Unit III)
2. Thirukkural with English Translation of Rev. Dr. G.U. Pope, Uma Publication, 156, Serfoji Nagar, Medical College Road,Thanjavur 613 004 (for Units I - III)
3. R S Nagaarazan, Textbook On Professional Ethics And Human Values, New Age International Publishers, 2006 (for Units IV-V)
4. Charles D Fledderman, Engineering Ethics, Prentice Hall, New Mexico, 2004(for Units IV-V)

<table>
<tr><td rowspan="4">BAN601</td><td>AEROSPACE STRUCTURAL MATERIALS AND COMPOSITES</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours –45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Aircraft Structures – I</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To acquaint the student with various types of aerospace composite materials.
2. To develop the understanding of composite mechanics.
3. To learn different theory of laminate design.
4. To learn different theory of failure analysis.
5. To have a clear understanding of composite fabrication process.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">INTRODUCTION TO AEROSPACE MATERIALS</td><td>9</td></tr>
<tr><td colspan="6">Introduction – Monocoque and semi monocoque structure – Wrought Aluminum Alloys – Cast Aluminum Alloy – Plastics and Rubber – Introduction to FRP, Glass and Carbon Composites– Fibers and Resins –Thermoplastics and Thermoset– Super Alloys. Emerging Trends in Aerospace Materials.</td></tr>
<tr><td>UNIT II</td><td colspan="4">MICRO MECHANICS</td><td>9</td></tr>
<tr><td colspan="6">Micro mechanics – Mechanics of materials approach, elasticity approach to determine material properties – Fiber Volume ratio – Mass fraction – Density of composites-Generalized Hooke’s Law - Elastic constants for anisotropic, orthotropic and isotropic materials. Numerical problems.</td></tr>
<tr><td>UNIT III</td><td colspan="4">MACRO MECHANICS</td><td>9</td></tr>
<tr><td colspan="6">Macro Mechanics – Stress-strain relations with respect to natural axis, arbitrary axis – Determination of material properties - Experimental characterization of lamina. Numerical problems.</td></tr>
<tr><td>UNIT IV</td><td colspan="4">LAMINATION THEORY AND FAILURE ANALYSIS</td><td>9</td></tr>
<tr><td colspan="6">Governing differential equation for a unidirectional lamina and general laminate, angle ply and cross ply laminate, Failure criteria for composites-Failure modes of sandwich panels – Numerical problems.</td></tr>
<tr><td>UNIT V</td><td colspan="4">FABRICATION METHODS</td><td>9</td></tr>
<tr><td colspan="6">Various open and closed mould processes, Manufacture of fibers, Types of resins, properties and applications, Netting analysis-Basic design concepts of sandwich construction - Materials used for sandwich construction.</td></tr>
<tr><td colspan="6">TEXTBOOKS:
1. Autar K Kaw, ‘Mechanics of Composite Materials’, CRC Press, 2005.</td></tr>
<tr><td colspan="6">REFERENCES:
1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites," John Wiley and sons. Inc., New York, 1995.
2. Lubin, G., "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989.
3. Calcote, L R. “The Analysis of laminated Composite Structures”, Von – Nostrand Reinhold Company, New</td></tr>
</table>

York 1998.
4. MadhujiMukhapadhyay, Mechanics of Composite Materials and Structures, University Press, 2004
5. Allen Baker, "Composite Materials for Aircraft Structures", AIAA Series, II Edition, 1999.

BAN602	**FINITE ELEMENT METHODS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**4**	**0**	**0**	**4**
	Prerequisite – Aircraft Structures – I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1. To acquaint the student with basic numerical methods for analyzing structural components.
2. To develop the understanding of finite element modeling and analysis of bars.
3. To develop the understanding of finite element modeling and analysis of beams, trusses and plates.
4. To develop the understanding of finite element modeling and analysis of three dimensional systems and axisymmetric bodies.
5. To acquaint with the application of finite element method to aerospace structures.

COURSE CONTENT

UNIT I INTRODUCTION 12

Introduction to FEA - historical background - Review of various approximate methods – Rayleigh Ritz method, Weighted residual methods - Convergence criteria - Fundamentals of Finite Element Modeling – Element Division - Numbering Scheme - Examples of Finite Element Modeling

UNIT II ONE DIMENSIONAL SYSTEMS 12

Direct stiffness method – spring element- Derivation of the stiffness matrix- Example of a springassemblage- Assembly of global stiffness matrix-Types of boundary conditions- The Potential energy approach –Examples- bar element – Coordinate systems and Shape Functions- The Potential Energy Approach- Assembly of Global Stiffness Matrix and Load Vector - Boundary Conditions- Temperature Effects – Heat transfer problems in 1D bar and wall

UNIT III TWO DIMENSIONAL SYSTEMS 12

Beam element – element stiffness – load vector – global stiffness matrix – boundary conditions – solution, Plane truss structure - Coordinate Transformation – Local & Global Coordinate- The Element Stiffness Matrix- Stress Calculations- Temperature Effects –Examples.Plane stress & strain – Constant Strain Triangle (CST)- Potential Energy Approach - Element Stiffness; Force Terms, Stress Calculations- Temperature Effects- Examples

UNIT IV THREE DIMENSIONAL SYSTEMS 12

Axisymmetric formulation – Element stiffness matrix and force vector – Body forces and temperature effects – Stress calculations – Boundary conditions and Nodal Solution; Mapping and Numerical Integration—Applications to cylinders under internal or external pressures – Rotating discs - Isoparametric Representation- Four nodedquadrilateral for axisymmetric problems

UNIT V APPLICATIONS OF FEM TO AEROSPACE STRUCTURES 12

Linear static analysis-non linear static analysis –dynamic analysis-simple harmonic motion-damping consideration-forced vibration -Case studies and problems using software packages and programming.

TEXTBOOKS:
1. Tirupathi.R. Chandrapatha and Ashok D. Belegundu", Introduction to Finite Elements in Engineering", Prentice Hall India, Fourth Edition, 2011.

REFERENCES:
1. Reddy J.N.,"An Introduction to Finite Element Method ",McGraw Hill , 3rd edition, 2005.
2. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2nd 2001.

3. Bathe, K.J. and Wilson, E.L., “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India, 1985.
4. Rao. S.S., “Finite Element Methods in Engineering”, Butterworth and Heinemann, Fourth Edition, 2005.
5. Daryl L. Logan, “A First Course in the Finite Element Method”, 5th Edition, PWS Publishing Company, Boston, 2010.

BAN603	**CONTROL ENGINEERING**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Basic Electrical and Electronics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To provide students an understanding on various physical systems, development of flight control system and their important. Also Introduce students the concept of electrical analogies to mechanical system
2. Introduce students the concept of feedback control system, Block diagram reduction technique and signal flow graph
3. To impart knowledge on various signals, system response on respective signals and time response of first order and second order system. Also to provide knowledge on steady state errors
4. To provide knowledge on concept of stability, Routh Hurwitz criteria for stability. Make student to develop Stability analysis using Bode plot, Root locus technique
5. To provide students brief knowledge on digital control system, Digital controllers.

COURSE CONTENT

UNIT I	**SYSTEM AND REPRESENTATION**	**9**

Basic elements in control systems – Open and closed loop systems – Electrical analogy of mechanical systems – Transfer function – Block diagram reduction techniques

UNIT II	**TIME RESPONSE**	**9**

Time response – Time domain specifications – Types of test input- I and II order system response – Error coefficients – Generalised error series – Steady state error- P, PI, PID modes of feedback control – Time response analysis.

UNIT III	**FREQUENCY RESPONSE**	**9**

Frequency response – Bode plot- polar plot – Determination of closed loop response from open loop response – Correlation between frequency domain and time domain specifications.

UNIT IV	**CONCEPT OF STABILITY**	**9**

Characteristics equation – Root Locus construction - Routh Hurwitz stability criterion

UNIT V	**SAMPLED DATA SYSTEMS**	**9**

Sampled data control systems- functional elements – sampling process- z-transforms-properties inverse z transforms – ZOH and First Order Hold process- pulse transfer functions – step response – Introduction to digital control system, Digital Controllers and Digital PID controller

TEXTBOOKS:

1. Nagarath.I.J. and Gopal M, “ Control System Engineering’, New Age International Publishers, New Delhi, 2015. (Units 1 to 4)
2. Houpis, C.H. and Lamont, G.B. Digital control Systems, McGraw Hill Book co., New York, U.S.A. 1995 (Unit 5)

REFERENCES:

1. OGATO, Modern Control Engineering, Fifth Edition, Prentice-Hall of India Pvt.Ltd., New Delhi, 2010.
2. Kuo, B.C. Automatic Control Systems, Prentice-Hall of India Pvt.Ltd., New Delhi, 2009.

3. Azzo, J.J.D. and C.H. Houpis, Feedback Control System Analysis And Synthesis, McGraw-Hill International 3rd Edition, 1998.
4. Naresh K Sinha, Control Systems, New Age International Publishers, New Delhi, 1998.

BAN6V1	**VALUE ADDED PROGRAM**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	0	0	2	1
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To boost up the technical writing skills of the student
2. To enhance the presentation skills of the student
3. To familiarize the student on attractive resume writing
4. To familiarize the student on Interviews and Group Discussions
5. To advance the problem solving ability of the student

COURSE CONTENT

1	A business letter to a company asking for Quotation.
2	A cover letter for applying a Job.
3	A sample Email communication for the given situation.
4	A model Technical report writing.
5	An activity to analysis the audience.
6	An activity to practice the body language.
7	An activity to practice the voice modulation.
8	An activity to present a self introduction.
9	An activity to present a technical seminar.
10	An activity to write a proper resume.
11	A mock interview and group discussion.
12	Problems on critical reasoning and sentence correction.
13	Problems on number, Simple interest and compound interest.
14	Problems on Analytical and Logical Reasoning.
15	Problems on probability, permutation and combination.

References:

1. Value Added Program Preparatory Material, Department of Aeronautical Engineering, 2017

BAN6L1	AIRCRAFT SYSTEM LABORATORY	L	T	P	C
	Total Contact Hours – 45	0	0	3	2
	Prerequisite – Aircraft Systems and Instrumentation				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. Appreciate the need of various aircraft systems, components, accessories and its functions.
2. Understand the importance of aircraft system maintenance and checks.
3. Understand the jacking procedure, levelling and symmetric checks done in the aircraft.
4. Understand the rigging procedure of the aircraft, Understand the operation of Brake torque load test and fuel clogging test
5. Develop the skills of trouble shooting and rectification of snags.

1	Aircraft systems observations during Ground run.
2	Aircraft “Mooring” procedure.
3	Aircraft “Levelling” procedure
4	Control System “Rigging check” procedure
5	Aircraft “Symmetry Check” procedure
6	Procedure to find the centre of gravity of Aircraft
7	“Flow test” to assess of filter element clogging
8	“Pressure Test” To assess hydraulic External/Internal Leakage
9	“Functional Test” to adjust operating pressure
10	“Pressure Test” procedure on aircraft fuel system components
11	“Brake Torque Load Test” on wheel brake units
12	Maintenance and rectification of snags in hydraulic systems.
13	Rectification of snags in aircraft fuel systems.
14	Tyre pressure checking and Oleo leg pressure procedure.
15	Landing gear strut wheel dismantling and assembly procedure.

References:

1. Aircraft Systems Lab Manual, Department of Aeronautical Engineering, 2017

BAN6L2	**PROPULSION LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**3**	**2**
	Prerequisite –Aircraft Propulsion				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. Understand the need of various incompressible circular and non-circular jets.
2. Understand the importance of velocity in supersonic circular and noncircular jets.
3. Understand the determination of wall jet velocity profile in the aircraft.
4. Understand the need of operation of a ramjet engine.
5. Develop the studies of liquid fuel atomizer and pre-mixed flame.

LIST OF EXPERIMENTS

1	Estimation of spread rate in incompressible circular jets.
2	Estimation of spread rate in incompressible non- circular jets.
3	Estimation of centre line velocity decay in supersonic circular jets.
4	Estimation of centre line velocity decay in supersonic non-circular jets.
5	Determination of Wall jet velocity profile.
6	Study of free convective heat transfer over a flat plate.
7	Study of forced convective heat transfer over a flat plate.
8	Study of conduction heat transfer in a flat plate.
9	Operation of a subsonic Ramjet engine.
10	Velocity and pressure measurements of Co-axial jets.
11	Effect of swirl on diffusion flame.
12	Studies on liquid fuel atomizers and premixed flame

REFERENCES:

1. PropulsionLab Manual, Department of Mechanical Engineering, 2017

BAN6L3	**AIRCRAFT DESIGN PROJECT I**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**4**	**2**
	Prerequisite – Flight Mechanics, Engineering Graphics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To familiarize the student to the different configurations of airplanes and on the comparison of the parameters of different airplanes to arrive at a proper selection of main parameters to design a new aircraft
2. To enable the student to be able to estimate the weight of the aircraft according to the main parameters selected
3. To enable the student to select an appropriate powerplant and estimate the wing geometry according to the results of weight estimation

4. To enable the student to calculate tail dimensions and to estimate the total drag of the airplane and also to perform a stability analysis of the airplane
5. To make the student able to draft a three view diagram of the designed airplane.

LIST OF EXPERIMENTS	
1	Comparative configuration study of different types of airplanes
2	Comparative study on specification and performance details of aircraft
3	Preparation of comparative data sheets
4	Work sheet layout procedures
5	Comparative graphs preparation.
6	Selection of main parameters
7	Preliminary weight estimations.
8	Power plant selection.
9	Aerofoil selection
10	Wing and stabilizers selection.
11	Control surfaces designing.
12	Drag estimation
13	Detailed performance calculations
14	Stability Estimates
15	Preparation of layouts of balance diagram and three view drawings

REFERENCES:

1. Aircraft Design Project Reference Guide, “E. Tulapurkara”, NPTEL, 2017
2. Aircraft Performance and Design, “John D Anderson”, Tata McGraw Hill Publications
3. Nelson, R.C.” Flight Stability & Automatic Control”, McGraw Hill, 1998.

OPTIONS FOR CORE ELECTIVE II (CE II)

BASE04	**SPACE MECHANICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**0**	**0**	**3**
	Prerequisite – Introduction to Aerospace Engineering				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about the basic concepts in space mechanics and about the laws that govern motion in space
2. To enable the student to decide on the locations for satellite injections in to the orbit and the various perturbations on satellites in space
3. To acquaint the student about the interplanetary trajectories and to select/design appropriate trajectory according to mission requirements

4. To introduce to the student about the trajectories for ballistic missiles
5. To familiarize the student about the different types of materials used in spacecrafts

COURSE CONTENT

UNIT I	**BASIC CONCEPTS AND THE GENERAL N- BODY PROBLEM**	**12**
The solar system – reference frames and coordinate systems – terminology related to the celestial sphere and its associated concepts – Kepler's laws of planetary motion and proof of the laws – Newton's universal law of gravitation - the many body problem- Lagrange-Jacobi identity – the circular restricted three body problem – libration points – the general N-body problem two body problems – relations between position and time.		
UNIT II	**SATELLITE INJECTION AND SATELLITE PERTURBATIONS**	**12**
General aspects of satellite injection – satellite orbit transfer – various cases – orbit deviations due to injection errors – special and general perturbations – Cowell's method and Encke's method – method of variations of orbital elements – general perturbations approach.		
UNIT III	**INTERPLANETARY TRAJECTORIES**	**10**
Two-dimensional interplanetary trajectories – fast interplanetary trajectories – three dimensional interplanetary trajectories – launch of interplanetary spacecraft – trajectory estimation about the target planet – concept of sphere of influence – Lambert's theorem		
UNIT IV	**BALLISTIC MISSILE TRAJECTORIES**	**14**
Introduction to ballistic missile trajectories – boost phase – the ballistic phase – trajectory geometry – optimal flights – time of flight – re-entry phase – the position of impact point – influence coefficients.		
UNIT V	**MATERIALS FOR SPACECRAFT**	**12**
Space environment – peculiarities of space environment – effect of space environment on materials of spacecraft structure – materials required for the construction of space craft – TPS for re-entry space vehicles.		

TEXTBOOKS:
1.Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman &Co., Ltd, London, 1982

REFERENCES:
1. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 7th Edition, 2001.
2. Parker, E.R., "Materials for Missiles and Spacecraft", McGraw Hill Book Co. Inc., 1982.

BASE05	**GUIDANCE AND CONTROL**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Basic Electricals and Electronics, Flight Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1.To make the students learn about the operating principle of guidance law
2.To make the students study about the augmentation systems
3.To acquaint the students study longitudinal stability and to design the longitudinal autopilot
4.To make the students understand lateral stability and to design the lateral autopilot
5.To acquaint the students understand the missile and launch vehicle guidance

COURSE CONTENT

UNIT I	**INTRODUCTION**	**4**
Introduction to Guidance and control - Definition, Historical background.		

<table>
<tr><td>UNIT II</td><td>AUGMENTATION SYSTEMS</td><td>7</td></tr>
<tr><td colspan="3">Need for automatic flight control systems, Stability augmentation systems, control augmentation systems, Gain scheduling concepts.</td></tr>
<tr><td>UNIT III</td><td>LONGITUDINAL AUTOPILOT</td><td>12</td></tr>
<tr><td colspan="3">Displacement Autopilot-Pitch Orientation Control system, Acceleration Control System, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control law design using back stepping algorithm.</td></tr>
<tr><td>UNIT IV</td><td>LATERAL AUTOPILOT</td><td>10</td></tr>
<tr><td colspan="3">Damping of the Dutch Roll, Methods of Obtaining Coordination, Yaw Orientation Control system, turn compensation, Automatic lateral Beam Guidance. Introduction to Fly-by-wire flight control systems, Lateral control law design using back stepping algorithm.</td></tr>
<tr><td>UNIT V</td><td>MISSILE AND LAUNCH VEHICLE GUIDANCE</td><td>12</td></tr>
<tr><td colspan="3">Operating principles and design of guidance laws, homing guidance laws- short range, Medium range and BVR missiles, Launch Vehicle- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance schemes.</td></tr>
<tr><td colspan="3">TEXTBOOKS:
1. Blake Lock, J.H “Automatic control of Aircraft and missiles” John Wiley Sons, New York, 1990.</td></tr>
<tr><td colspan="3">REFERENCES:
1. Stevens B.L & Lewis F.L, “Aircraft control & simulation”‘, John Wiley Sons, New York, 1992.
2.Collinson R.P.G, “Introduction to Avionics”, Chapman and Hall, India, 1996.
3. Garnel.P. &East.D.J, “Guided Weapon control systems”, Pergamon Press, Oxford, 1977.
4. Nelson R.C “Flight stability & Automatic Control”, McGraw Hill, 1989.
5. BernadEtikin, ”Dynamic of flight stability and control”, John Wiley, 1972.
6. Jan Roskam, “Airplane Performance, Stability and Control”, DAR Corporation, 1997.</td></tr>
</table>

<table>
<tr><td rowspan="4">BANE07</td><td>THEORY OF VIBRATIONS</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Aircraft Structures – I</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To know about the role of Vibrations, vibration analysis and ideas about Aero elasticity in engineering and industry.
2. To make thorough understanding of single degree of freedom, Two degrees of freedom and multi degrees of freedom systems and deriving equations to solve for natural frequency.
3. To understand the Newton second Law, Energy method and know how to use it to solve single degree of freedom systems.
4. To understand the approximate methods to solve vibration engineering problems in Two degree and multi degree of freedom systems.
5. To understand the collars triangle and various aero elastic phenomena in the aircraft structural components.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">SINGLE DEGREE OF FREEDOM SYSTEMS</td><td>10</td></tr>
<tr><td colspan="6">Vibration Terminologies, Simple harmonic motion, Newton’s law, D’ Alembert’s principle, Energy methods, Free vibrations, Damped vibrations, Forced Vibrations with and without damping, Support excitation,Transmissibility, Vibration measuring instruments.</td></tr>
</table>

UNIT II	**MULTI DEGREE OF FREEDOM SYSTEMS**	**10**

Two degrees of freedom systems, static and dynamic couplings, Vibration absorbers, Principal co-ordinates, principal modes and orthogonal condition, Eigen value problems, Lagrangean equations and applications.

UNIT III	**CONTINUOUS SYSTEMS**	**8**

Vibration of elastic bodies, vibration of strings, Longitudinal –lateral and Torsional vibrations.

UNIT IV	**APPROXIMATE METHODS**	**9**

Approximate methods-Rayleigh’s method, Dunkerleys method, Holzer method, Matrix iteration method

UNIT V	**ELEMENTS OF AEROELASCTICITY**	**8**

Vibrations due to coupling of bending and torsion, collars triangle, aero elastic instabilities and their prevention, Wing divergence,reversal of aileron control, Flutter and its prevention.

TEXTBOOKS:

1. V. P. Singh, “Mechanics of Vibration”, (Units 1 to 4)
2. Y.C. Fung, “An Introduction to the Theory of Aeroelasticity”, John Wiley & Sons Inc., New York, 2008. (Unit 5)

REFERENCES:

1. Leonard Meirovitch, “Fundamentals of Vibrations”, McGraw Hill International Series, 2001
2. Bisplinghoff R.L., Ashely H and Hogman R.L., Aeroelasticity – Addison Wesley Publication, New York, 1983.
3. R.H. Scanlan and R.Rosenbaum, “Introduction to the study of Aircraft Vibration and Flutter”, Macmillan Co., New York, 1981.
4. R.D.Blevins, “Flow Induced Vibrations”, Krieger Pub Co., 2001
5. Thomson W T, ‘Theory of Vibration with Application’ - CBS Publishers, 1990.
6. Timoshenko S., Vibration Problems in Engineering – John Wiley and Sons, New York, 1993.

BASE06	**SPACE VEHICLE DESIGN**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**0**	**0**	**3**
	Prerequisite – Aircraft Structures – I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

To introduce to the student about the design of a space vehicle

COURSE CONTENT

UNIT I	**FUNDAMENTAL ASPECTS OF SPACE SYSTEMS ENGINEERING**	**12**

Space Systems Engineering – Definition, Requirements of Systems Engineering, Design Team, Tradeoffs, Top level requirements, Functional requirements, Functional Block diagram, Tradeoff analysis, Communication Systems and Power systems, Technology Tradeoffs

UNIT II	**SPACE MISSIONS**	**12**

Space Missions - Low Earth Orbit, Flight Tests, Earth Observation, Space observation, Medium Altitude Earth Orbit, Geosynchronous Earth Orbit, Communications Satellites, Weather satellites, Lunar and Deep space missions – Inner and outer planetary missions, Observation of small bodies – comets and asteroids, Orbit Design Considerations, Advanced Mission concepts-Large Space structures, Space stations, space colonies, Use of lunar and asteroid materials, Nuclear waste disposal

UNIT III	**ENVIRONMENTAL CONSTRAINTS**	**12**

Natural and Manmade environments, Earth environment – corrosion due to humidity, Clean room, problems in transporting, Launch environment, Shuttle Vibration, Atmospheric environment – wind shear constraint, density shear, Effect of Polar mesospheric clouds during re – entry, Space and Upper Atmosphere environment – Effect of vacuum on materials, Space plasma and spacecraft charging, Magnetic field, Weightlessness and microgravity, Radiation – Van Allen Radiation belt, Micrometeoroids, Orbital debris, Thermal environment		
UNIT IV	**LAUNCH VEHICLE SELECTION AND ATMOSPHERIC ENTRY**	**12**
Solid vs Liquid propellant, Hybrid propulsion, Space shuttle payload accommodations, expendable launch vehicles, Atmospheric entry – Requirements, fundamentals of entry flight mechanics, ballistic entry, gliding entry, skip entry, Cross-Range entry, Entry heating, free molecular heating, Thermal protection, Entry vehicle design		
UNIT V	**STRUCTURAL DESIGN CONSIDERATIONS**	**12**
Vehicle center of mass, Vehicle moment of inertia, structural loads, load alleviation, modal analysis, fracture mechanics, stress levels and safety factors, large structures, structural materials, films and fabrics		
TEXTBOOKS: 1.Michael D.Griffin and James R. French, “ Space Vehicle design” AIAA Education Series, Second Edition, 2004		
REFERENCES: 1. NickolayZosimovych, “ Commercial Launch Vehicle Design” , LAP LAMBERT Academic Publishing , 2016		

OPTIONS FOR NON – MAJOR ELECTIVE I (NE)

BANE13	**INTRODUCTION TO COMBUSTION**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Aero – Thermodynamics				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES 1. To acquaint with the basics of combustion. 2. To understand the combustion process in aircraft piston engines. 3. To understand the combustion process in gas turbine engines. 4. To understand the combustion process in scramjet engines. 5. To understand the combustion process in rocket engines.					
COURSE CONTENT					
UNIT I	**INTRODUCTION TO COMBUSTION**				**9**
Thermochemical equations – heat of reaction- first, second and third order reactions – premixed flames – diffusion flames – Stoichiometric ratio, equivalence ratio – measurement of burning velocity – various methods – effect of various parameters on burning velocity – flame stability – deflagration – detonation – Rankine-Hugoniot curves – radiation by flames					
UNIT II	**COMBUSTION IN AIRCRAFT PISTON ENGINES**				**9**
Introduction to combustion in aircraft piston engines – various factors affecting the combustion efficiency - fuels used for combustion in aircraft piston engines and their selection – detonation in piston engine combustion and the methods to prevent the detonation					
UNIT III	**COMBUSTION IN GAS TURBINE ENGINES**				**9**
Combustion in gas turbine combustion chambers - recirculation – combustion efficiency, factors affecting combustion efficiency, fuels used for gas turbine combustion chambers – combustion stability – ramjet combustion – differences between the design of ramjet combustion chambers and gas turbine combustion chambers- flame holders types – numerical problems.					

UNIT IV	**COMBUSTION IN SCRAMJET ENGINES**	**9**
Introduction to supersonic combustion – need for supersonic combustion for hypersonic air-breathing propulsion- supersonic combustion controlled by diffusion, mixing and heat convection – analysis of reactions and mixing processes - supersonic burning with detonation shocks - various types of supersonic combustors.		
UNIT V	**COMBUSTION IN ROCKET ENGINES**	**9**
Solid propellant combustion - double and composite propellant combustion – various combustion models – combustion in liquid rocket engines – single fuel droplet combustion model – combustion hybrid rockets		

TEXTBOOKS:

1.Stephen R turns, "An Introduction to Combustion", Tata Mc. Graw Hill Publishing Co., Ltd., New Delhi, Reprint 2013. (Units 1 & 2)
2. Lefebvre AG and Dilip R ballal, "Gas Turbine Combustion", CRC press, Third Edition, 2010. (Unit 3)
3. Corin Segal, "The Scramjet engine", Cambridge University Press, 2009 (Unit 4)
4. Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 7th Edition, 2001 (Unit 5)

REFERENCES:

1. Warnatz J, Maas U and Dibble RW,"Combustion",Springer, Fourth Edition,2006.
2. Beer, J.M., and Chiger, N.A. "Combustion Aerodynamics", Applied Science Publishers Ltd., London, 1981.
3. Sharma, S.P., and Chandra Mohan, "Fuels and Combustion", Tata Mc. Graw Hill Publishing Co., Ltd., New Delhi, 1987

BASE09	**SOLAR THERMAL ENERGY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To make the students learn basics of renewable and non-renewable energy sources
2. To acquaint the students with solar collection theory and technologies
3. To make the students familiarize with the concepts of Solar concentration systems & Technologies
4. To acquaint the students with the concepts of Solar Power generation systems
5. To familiarize the students with thermal storage and solar cooling methods and technologies

COURSE CONTENT

UNIT I	**INTRODUCTION**	**9**
Introductory aspects of non-renewable and renewable energy sources – fundamentals of thermal radiation – resource assessment – solar radiation concepts – solar-earth geometry – models to predict global and daily and hourly irradiation.		
UNIT II	**SOLAR COLLECTION THEORY AND TECHNOLOGIES**	**8**
Heat transfer in solar collectors – basic modeling aspects – steady and dynamic analysis – performance parameters.		
UNIT III	**SOLAR CONCENTRATION SYSTEMS AND RECEIVERS**	**10**
Overview and introduction to concentration optics – concentration ratio and thermodynamic maximum – linear concentration: trough and linear Fresnel – point concentration: dish and tower (central receiver system).		
UNIT IV	**SOLAR POWER GENERATION SYSTEMS**	**9**
Overview and types of systems – components and sub systems – aspects of design and performance prediction.		

<table>
<tr><td>**UNIT V**</td><td>**THERMAL STORAGE AND SOLAR COOLING**</td><td>**9**</td></tr>
<tr><td colspan="3">Need for thermal storage – methods – simple models for thermal storage - solar liquid absorption and solar solid sorption technologies</td></tr>
<tr><td colspan="3">**TEXTBOOKS:**
1. Boyle, G., Renewable Energy: Power for a Sustainable Future, 3rd ed., Oxford Univ. Press (2012).</td></tr>
<tr><td colspan="3">**REFERENCES:**
1. Duffie, J. A. and Beckman, W. A., Solar Engineering of Thermal Processes, John Wiley (1991).
2. Sukhatme, S. P. and Nayak, J. K., Solar Energy: Principles of Thermal Collection and Storage, 3rd ed., McGraw-Hill (2009).</td></tr>
</table>

<table>
<tr><td rowspan="4">**BANE15**</td><td>**NANO SCIENCE AND TECHNOLOGY**</td><td>**L**</td><td>**T**</td><td>**P**</td><td>**C**</td></tr>
<tr><td>Total Contact Hours – 45</td><td>**3**</td><td>**0**</td><td>**0**</td><td>**3**</td></tr>
<tr><td colspan="5">Prerequisite – Fundamentals of Structural Mechanics</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">**OBJECTIVES**
To acquaint about the applications and significance of nanomaterials in aerospace engineering.</td></tr>
<tr><td colspan="6">**COURSE CONTENT**</td></tr>
<tr><td>**UNIT I**</td><td colspan="4">**INTRODUCTION**</td><td>**9**</td></tr>
<tr><td colspan="6">Introduction to nanoscale materials - atomic & molecular size. Scientific revolutions-nanotechnology applicationarea. Scope of nanoscience and technology</td></tr>
<tr><td>**UNIT II**</td><td colspan="4">**NANOSTRUCTURES AND DIMENSIONS**</td><td>**9**</td></tr>
<tr><td colspan="6">Classification of nanostructures-zero, one, two and three dimensional nanostructures. Size Dependency inNanostructures-quantum size effects in nanostructures.</td></tr>
<tr><td>**UNIT III**</td><td colspan="4">**NANOMATERIAL SYNTHESIS**</td><td>**9**</td></tr>
<tr><td colspan="6">Synthesis of nanomaterials-top down and bottom up approach. Method of nanomaterials preparation – wet chemical synthesis-mechanical grinding-gas phase synthesis.</td></tr>
<tr><td>**UNIT IV**</td><td colspan="4">**NANOMATERIAL PROPERTIES**</td><td>**9**</td></tr>
<tr><td colspan="6">Surface to volume ratio. Surface properties of nanoparticles. Mechanical, optical, electronic, magnetic, thermaland chemical properties of nanomaterials. Size dependent properties-size dependent absorption spectra.Shape impact.</td></tr>
<tr><td>**UNIT V**</td><td colspan="4">**PHYSICAL PROPERTIES OF NANOSTRUCTURED MATERIALS**</td><td>**9**</td></tr>
<tr><td colspan="6">Quantum dots-optical properties and applications. Carbon nanotubes-physical properties and applications.Magnetic behavior of nanomaterials. Electronic transport in quantum wires.</td></tr>
<tr><td colspan="6">**TEXTBOOKS:**
1. T. Pradeep, “Nano the Essential Nanoscience and Nanotechnology”, Tata McGraw hill, 2007.</td></tr>
<tr><td colspan="6">**REFERENCES:**
1. Charles P. Poole, Frank J. Owens, “Introduction to Nanotechnology”, Wiley Interscience, 2003.
2. Mark A. Ratner, Daniel Ratner, “Nanotechnology: A gentle introduction to the next Big Idea”, Prentice Hall P7R:1st Edition, 2002.
3. J. Dutta, H. Hoffmann, “Nanomaterials”, Topnano-21, 2003.
4. Mick Wilson, KamaliKannargare., Geoff Smith, “Nano technology: Basic Science and Emergingtechnologies”, Overseas Press, 2005.</td></tr>
</table>

BANE16	UNMANNED AERIAL VEHICLE	L	T	P	C
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Fundamentals of Aeronautics and Astronautics, Flight Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about the basic ideas of Unmanned Aerial Vehicles
2. To familiarize the students about the aerodynamics and airframe configurations
3. To accustom the student to the wide variety of unmanned aerial vehicles
4. To acquaint the student about the various communication and navigation systems of unmanned aerial vehicles
5. To enable the student to understand about the control and stability of UAV’s

COURSE CONTENT

UNIT I	INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS	9

The Systemic Basis of UAS-System Composition- Conceptual Phase-Preliminary Design-Selection of the System- Some Applications of UAS

UNIT II	AERODYNAMICS AND AIRFRAME CONFIGURATIONS	9

Lift-induced Drag - Parasitic Drag - Rotary-wing Aerodynamics - Response to Air Turbulence - Airframe Configurations Scale Effects - Packaging Density – Aerodynamics - Structures and Mechanisms - Selection of power-plants - Modular Construction - Ancillary Equipment

UNIT III	CHARACTERISTICS OF AIRCRAFT TYPES	9

Long-endurance, Long-range Role Aircraft – Medium-range, Tactical Aircraft - Close-range/Battlefield Aircraft - MUAV Types - MAV and NAV Types - UCAV - Novel Hybrid Aircraft Configurations - Research UAV

UNIT IV	COMMUNICATIONS NAVIGATION	9

Communication Media - Radio Communication - Mid-air Collision (MAC) Avoidance - Communications Data Rate and Bandwidth Usage - Antenna Types NAVSTAR Global Positioning System (GPS) - TACAN - LORAN C - Inertial Navigation - Radio Tracking - Way-point Navigation

UNIT V	CONTROL AND STABILITY	9

HTOL Aircraft - Helicopters - OTE/OTE/SPH - Convertible Rotor Aircraft - Payload Control - Sensors – culmon filter- Autonomy

Text Books:

1. Reg Austin., Unmanned Aircraft Systems, John Wiley and Sons., 2010

References:

1. Milman&Halkias, “Integrated Electronics”, McGraw Hill, 1999.
2. Malvino& Leach, “Digital Principles & Applications”, McGraw Hill, 1986
3. Collinson R.P.G, “Introduction to Avionics”, Chapman and Hall, India, 1996
4. BernadEtikin,‟Dynamic of flight stability and control‟, John Wiley, 1972

BHARATH INSTITUTE OF HIGHER EDUCATION AND RESEARCH

DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER VII

BAN701	**COMPUTATIONAL FLUID DYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite –Aerodynamics - I, Numerical Methods				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To make the student be familiar with the various fluid flow analysis technique.
2. To give insight of various computational technique for fluid flow analysis.
3. To acquaint the student with various challenges involved in computational techniques.
4. To get exposure regarding its applications and recent developments.
5. To learn advanced computing techniques like parallel computing, vector computing etc.

COURSE CONTENT

UNIT I	**FUNDAMENTAL CONCEPTS**	**10**

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Substantial Derivative-Non conservative and conservative form of Continuity, Momentum and Energy equations-Well posed and ill posed problems.

UNIT II	**INTRODUCTION TO FINITE DIFFERENCE METHOD**	**9**

Classification of PDEs-Reduction of system of second order PDEs-Boundary conditions-Mathematical behavior of PDEs on CFD-Elliptic, Parabolic, Hyperbolic Equations. Derivation of Finite Difference Equations- Use of Finite Difference method.

UNIT III	**FINITE DIFFERENCE METHOD FOR DIFFUSION**	**10**

Explicit Methods-The FTCS method, Richardson method, DuFort& Frankel method-Implicit methods-Laasonen method, Crank Nicolson method, Beta formulation. Terminologies in Finite difference equations-Types of error-Error analysis-Consistency analysis-Von-Neuman stability analysis.

UNIT IV	**FINITE VOLUME METHOD FOR DIFFUSION AND CONVECTION**	**9**

Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems -Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Finite volume formulation for steady state One, Two and Three -dimensional diffusion problems.

UNIT V	**TURBULENCE MODELLING**	**7**

Turbulence models, mixing length model, Two equation (k-€) models – High and low Reynolds number models. Large eddy simulation- Direct numerical simulation.

TEXTBOOKS:

1. JiyuanTu, Guan,HengYeoh, Chaoqun Liu, “Computational Fluid Dynamics A Practical Approach” Springer Verlag,2012.
2. J. D.Anderson, “Computational Fluid Dynamics”, McGraw Hill International, 2012.

REFERENCES:

1. H.K. Versteeg and W. Malalsekera “An Introduction to Computational Fluid Dynamics, The Finite Volume Method”, Longman Scientific & Technical, 2007.
2. T. J. Chung, “Computational Fluid Dynamics”, Cambridge University Press, 2002.

3. C. Hirch, “Numerical Computation of Internal and External Flows” Volume-2, John Wiley and Sons, 1994.
4.http://www.cfdonline.com

BAS701	**SATELLITE TECHNOLOGY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Basic Electricals and Electronics, Mechanics of Machines				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about different types of satellites and their functions
2. To accustom the student to the governing equations of motion and orbital mechanics
3. To acquaint the student to the structure of the satellites and the components used and their thermal protection
4. To familiarize the student about the control system for spacecraft
5. To enable the student to understand about the power system in a satellite and the various bus electronics used

COURSE CONTENT

UNIT I	**INTRODUCTION TO SATELLITE SYSTEMS**	**9**

Common satellite applications and missions – Typical spacecraft orbits – Definitions of spin the three axis stabilization-Space environment – Launch vehicles – Satellite system and their functions (structure, thermal, mechanisms, power, propulsion, guidance and control, bus electronics).

UNIT II	**SATELLITE DYNAMICS**	**9**

Fundamental of satellite dynamics – Time and coordinate systems – Orbit determination and prediction – Orbital maneuvers – GPS systems and application for satellite/orbit determination – Ground station network requirements.

UNIT III	**SATELLITE STRUCTURES & THERMAL CONTROL**	**9**

Satellite mechanical and structural configuration: Satellite configuration choices, launch loads, separation induced loads, deployment requirements – Design and analysis of satellite structures – Structural materials and fabrication – The need of thermal control: externally induced thermal environment – Internally induced thermal environment - Heat transfer mechanism: internal to the spacecraft and external heat load variations – Thermal control systems: active and passive methods.

UNIT IV	**SPACECRAFT CONTROL**	**9**

Control requirements: attitude control and station keeping functions, type of control maneuvers – Stabilization schemes: spin stabilization, gravity gradient methods, 3 axis stabilization – Commonly used control systems: mass expulsion systems, momentum exchange systems, gyro and magnetic torque - Sensors star and sun sensors, earth sensor, magnetometers and inertial sensors

UNIT V	**POWER SYSTEM AND BUS ELECTRONICS**	**9**

Solar panels: Silicon and Ga-As cells, power generation capacity, efficiency – Space battery systems – battery types, characteristics and efficiency parameters – Power electronics. Telemetry and telecommand systems: Tm & TC functions, generally employed communication bands (UHF/VHF, S, L, Ku, Kaetc), their characteristics and applications- Coding Systems – Onboard computer- Ground checkout Systems.

TEXTBOOKS:

1. Spacecraft Thermal Control, Hand Book, Aerospace Press, 2002.
2. Introduction Space Flight, Francis J. Hale Prentice Hall, 1994.

REFERENCES:

1. Analysis and Design of Flight Vehicle Structures, Tri-State off set company, USA, 1980.
2. Space Systems Engineering Rilay, FF, McGraw Hill, 1982.
3. Principles of Astronautics Vertregt. M., Elsevier Publishing Company, 1985

4 .Space Communications Systems, Richard.F, FilipowskyEugen I Muehllorf Prentice Hall, 1995
5. Space Vehicle Design, Michael D. Griffin and James R. French, AIAAEducation Series, 1991.

BAN703	**HEAT TRANSFER**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Aero – Thermodynamics, Fluid Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student about the fundamentals of heat transfer.
2. To introduce to the student about the heat transfer analysis of conduction problems.
3. To introduce to the student about the heat transfer analysis of convection problems.
4. To introduce to the student about the heat transfer analysis of radiation problems.
5. To help the student understand about the various heat transfer problems in the aerospace applications.

COURSE CONTENT

(Use of Heat and Mass Transfer Data Book is permitted)

UNIT I	**CONDUCTION HEAT TRANSFER – STEADY STATE**	**10**

Modes of heat transfer: One dimensional steady state heat conduction: Composite Medium – Critical thickness – Effect of variation of thermal Conductivity – Extended Surfaces.

UNIT II	**CONDUCTION HEAT TRANSFER – TRANSIENT**	**12**

Heat Conduction: Lumped System Analysis – Heat Transfer in Semi-infinite and infinite solids – Transient Heat Transfer – Temperature charts

UNIT III	**CONVECTIVE HEAT TRANSFER**	**14**

Introduction – Free convection in atmosphere - free convection on a vertical flat plate – Empirical relation in free convection – Forced convection – Laminar and turbulent - convective heat transfer analysis in flows between parallel plates, over a flat plate and in a circular pipe. Empirical relations.

UNIT IV	**RADIATIVE HEAT TRANSFER AND HEAT EXCHANGERS**	**12**

Concept of black body-Intensity of radiation-Laws of Black body Radiation-Radiation from non-black surfaces-real surfaces – Radiation between surfaces-Radiation shape factors-Radiation shields.

Types of heat exchangers -overall heat transfer coefficient- LMTD- NTU method of heat exchanger Analysis.

UNIT V	**HEAT TRANSFER PROBLEMS IN AEROSPACE ENGINEERING**	**12**

Heat transfer problems in gas turbine engines, rocket nozzles and re-entry vehicles – Numericaltechniques to solve heat transfer problems in aerospace engineering –numerical problems using software and programming.

TEXTBOOKS:

1. Sachdeva, S.C. “Fundamentals of Engineering, Heat and Mass Transfer, Wiley Eastern Ltd. Fourth Edition, New Delhi, 2012. (Units 1 to 4)
2. Sunden B, Juan Fu, “Heat Transfer in Aerospace Applications”, Academic Press, First Edition, 2016 (Unit 5)

REFERENCES:

1. Sutton, G.P., "Rocket Propulsion Elements ", John Wiley and Sons, 8th Edition.2010.
2. Lienhard J. H., “A Heat Transfer Text Book”, Phlogiston Press, U.S.A., 2008.
3. Ozisik M.N., “Heat Transfer A Basic Approach”, The McGraw-Hill Company, reprint 1995.
4. Holman, J.P., "Heat Transfer ", McGraw Hill Book Co., Inc., New York, TenthEdition.,2009.

BAN7L1	AIRFRAME AND AERO ENGINE REPAIR LAB	L	T	P	C
	Total Contact Hours – 45	0	0	2	1
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To know the basic concepts of the maintenance and repair of both piston and jet aero engines and the procedures followed for overhaul of aero engines.
2. To practice the procedures of dismantling of piston engine and jet engine, study of components, accessories of both engines and handling safety precautions.
3.To demonstrate the various inspection methods such as visual inspection dimensional checks and testing methods especially NDT have studied clearly and
4. Ability to inspect surface defects, internal defects, by using dye penetrant method and identification of defects on jet engine components.
5. To know about the reassembly procedure of piston engines, jet engines and starting procedure of piston engines.

COURSE CONTENT

1	Dismantling and reassembling a piston engine
2	Piston Engine - cleaning, visual inspection, NDT checks.
3	Piston Engine Components - dimensional checks.
4	Study of carburetor, fuel pump, spark plug and ignition system.
5	Dismantling and reassembling a jet engine
6	Jet Engine – identification of components & defects.
7	Jet Engine – NDT checks and dimensional checks
8	Engine starting procedures.
9	Aircraft wood gluing by single scarf and double scarf joint point.
10	Welded single & double V-joints using MIG, TIG & PLASMA welding.
11	Fabric and Riveted patch repairs.
12	Tube bending and flaring
13	Sheet metal forming.
14	Repairing of Acrylic sheets.
15	Repairing the composite panels.

References:

1. Airframe and Aero Engine Repair Lab Manual, Department of Aeronautical Engineering, 2015

BAS7L1	**SATELLITE DESIGN LABORATORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 30	**0**	**0**	**2**	**1**
	Prerequisite – Basic Electricals and Electronics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
To help the student to understand the process of satellite design.

LIST OF EXPERIMENTS

1	Introduction – Payload Specifications and Requirements
2	Study of Various Types of Sensors and Accessories in Nano Satellites
3	Cost Estimation and Feasibility Studies
4	Design and Fabrication of a Structural Framework for a Nano Satellites
5	Demonstration of Onboard GPS for recovery
6	Design of Communication System for Data Transfer
7	Design of Thermal Protection System
8	Design of Electro Magnetic Shield
9	Exercise on Selection of Appropriate Power Source and Distribution System
10	Assembling and Packing of Nano Satellite

REFERENCES:
1. Analysis and Design of Flight Vehicle Structures, Tri-State off set company, USA, 1980.
2. Space Systems Engineering Rilay, FF, McGraw Hill, 1982.

BAN7L3	**AIRCRAFT DESIGN PROJECT II**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**4**	**2**
	Prerequisite – Aircraft Structures – II				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES
1. To introduce to the student about the various kinds of loads acting on an airplane and about the detailed structural design of an aircraft
2. To enable the student to be able to estimate the loads on aircraft’s wing and fuselage
3. To enable the student to able to perform a detailed design of the aircraft’s wing and fuselage components
4. To enable the student to make a detailed design report and a layout of aircraft drawings
5. To enable the student to model the designed aircraft and perform a flow analysis and structural analysis

LIST OF EXPERIMENTS

1	V-n diagram for the design study
2	Gust and maneuverability envelopes
3	Critical loading performance and final V-n graph calculation
4	Structural design study – Theory approach

5	Load estimation of wings
6	Load estimation of fuselage.
7	Balancing and Maneuvering loads on tail plane, Aileron and Rudder loads.
8	Detailed structural layouts.
9	Design of some components of wings, fuselage
10	Preparation of a detailed design report with drawings.
11	Preparation of model using computer aided design packages.
12	Preparation of structural analysis report for wing.
13	Preparation of structural analysis report for Fuselage.
14	Preparation of flow analysis report for wing.
15	Preparation of flow analysis report for fuselage.

REFERENCES:

1. Aircraft Performance and Design, “John D Anderson”, Tata McGraw Hill Publications
2. Analysis and Design of Flight Vehicle Structures, E F Bruhn
3. CADD and CAA Lab Manuals, Department of Aeronautical Engineering, 2015

BAN7P1	**TERM PAPER**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**0**	**0**	**4**	**2**
	Prerequisite – Aerodynamics II, Aircraft Structures II, Advanced Aerospace Propulsion				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To acquaint the student with theoretical and experimental studies related to aeronautical science.
2. To enable the student to get involved in key area of research in the branch of study.
3. To perform the literature studies and survey that will help in formulating the problem statement.
4. To enable the student to understand the concept of the acquired statement to get the idea about the work.
5. To work according to the acquired idea and to develop report in the form as specified in the guidelines

DESCRIPTION

The objective of term paperis to enable the students in convenient groups of not more than 4 members on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Each student shall finally produce a comprehensive report covering background information, literature survey and problem statement. This final report shall be in typewritten form as specified in the guidelines.

OPTIONS FOR CORE ELECTIVE (CE) III

BASE07	**SPACECRAFT ATTITUDE DYNAMICS AND CONTROL**	**L**	**T**	**P**	**C**

<table>
<tr><td rowspan="3"></td><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Space Mechanics</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">OBJECTIVES
1. To acquaint the students with the knowledge of attitude sensors
2. To acquaint the students familiarize with control actuators
3. To make the students familiarize with attitude dynamics, attitude and orbital disturbances
4. To acquaint the students with the concepts of attitude stabilization schemes and orbit maneuvers.
5. To familiarize the students with missiles and launch vehicle guidance.</td></tr>
<tr><td colspan="6">COURSE CONTENT</td></tr>
<tr><td>UNIT I</td><td colspan="4">ATTITUDE SENSORS</td><td>8</td></tr>
<tr><td colspan="6">Relative Attitude sensors – Gyroscopes, Motion reference Units, Absolute Attitude sensors – Horizon sensor, Orbital Gyrocompass, Earth sensors, sun sensors (Digital and analog), star sensor- Magnetometer</td></tr>
<tr><td>UNIT II</td><td colspan="4">CONTROL ACTUATORS</td><td>9</td></tr>
<tr><td colspan="6">Fundamental principles of operation of Thrusters- Momentum Wheel-Control Moment Gyros Reaction wheel-Magnetic Torques- Reaction Jets- Ion Propulsion- Electric propulsion- solar sails</td></tr>
<tr><td>UNIT III</td><td colspan="4">ATTITUDE DYNAMICS, ATTITUDE AND ORBITAL DISTURBANCES</td><td>9</td></tr>
<tr><td colspan="6">Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics- disturbing forces due to Drag, Solar radiation Pressure and forces - Disturbances due to Celestial bodies</td></tr>
<tr><td>UNIT IV</td><td colspan="4">ATTITUDE STABILIZATION SCHEMES & ORBIT MANEUVERS</td><td>10</td></tr>
<tr><td colspan="6">Spin, Dual spin - Gravity gradient - Zero momentum system - Momentum Biased system - Reaction control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer Station Keeping and fuel Budgeting</td></tr>
<tr><td>UNIT V</td><td colspan="4">MISSILE AND LAUNCH VEHICLE GUIDANCE</td><td>9</td></tr>
<tr><td colspan="6">Operating principles and design of guidance laws - homing guidance laws- short range - Medium range and BVR missiles - Launch Vehicle- Introduction - Mission requirements- Implicit guidance schemes - Explicit guidance - Q guidance schemes</td></tr>
<tr><td colspan="6">TEXTBOOKS:
1. Marcel J. Sidi, “Spacecraft Dynamics and control, A Practical Engineering Approach”, Cambridge University Press.2000</td></tr>
<tr><td colspan="6">REFERENCES:
1. James R Wertz, Spacecraft Attitude Determination and control, Reidel Publications.2001.
2. Vladimir A Chobotov,”Spacecraft Attitude Dynamics and Control (Orbit)”, Krieger Publishing Company Publishers, 1991.
3. Blake Lock, J.H ‘Automatic control of Aircraft and missiles ‘, John Wiley Sons, New York, 1990.
4. Meyer Rudolph X, Elements of Space Technology for Aerospace Engineers”, Academic Press, 1999
5. Kaplan M, “Modern Spacecraft Dynamics and control”, Wiley Press, 1979.</td></tr>
</table>

<table>
<tr><td rowspan="4">BANE10</td><td>CRYOGENIC ROCKET PROPULSION</td><td>L</td><td>T</td><td>P</td><td>C</td></tr>
<tr><td>Total Contact Hours – 45</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td colspan="5">Prerequisite – Advanced Aerospace Propulsion</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
</table>

OBJECTIVES

1. To introduce to the student the basics of cryogenic systems and associated processes.
2. To acquaint the student with the propellants used in cryogenic technology.
3. To introduce the various equipment and accessories used in cryogenic rocket propulsion.
4. To familiarize the student to the different flow circuits and parts in a cryogenic engine.
5. To enable the student to understand about various challenges in implementing cryogenic rocket technology.

COURSE CONTENT

UNIT I	INTRODUCTION TO CRYOGENIC SYSTEMS	9

Cryogenic systems and basic components, Properties of Cryogenic fluids,Liquefaction systems, ideal, Cascade, LindeHampson and Claude cycles and their derivatives; Refrigerators:Stirling, Gifford-McMahon cycles and their derivatives. Cryogenic Insulations: Foam, Fibre, powder and Multilayer.

UNIT II	CRYO FUEL SYSTEMS	9

Cryogenic and semi – cryogenic propellants - Hydrogen - properties, and pretreatment - Liquefaction of hydrogen - Linde, Claudeand helium - hydrogen condensing cycles, Ortho-para conversion. Storage and handling of liquefied hydrogen

UNIT III	CRYO EQUIPMENT AND ACCESSORIES	9

Mechanical and Thermal Properties of engineering materials at low temperatures; Compressors: types, construction and characteristics; Expansion machines:characteristics of reciprocating and turbine expanders, design of J-T expander; Heat exchangers: types, design approaches and selection criteria, Design ofcryogenic storage vessels, transfer devices, insulation system, valves; Characteristics of cryogenic pumps,Instrumentation in cryogenic systems

UNIT IV	CRYOGENIC ENGINES	9

Fluid circuits of various cryogenic engines andsemi-cryogenic engines; Design of regeneratively cooled combustion chamber, film cooling, dump cooling,transpiration cooling and radiation cooling. Design of expansion nozzle- characteristics, Design of injector–hydraulic characteristics; Engine thrust and mixture ratio control, Igniters, Propellant tanks.

UNIT V	CHALLENGES IN CRYOGENIC ROCKET TECHNOLOGY	9

Problems in storage and handling of cryogenic propellants: safety aspects, Thermal protectionsystems for stage tanks, Thermal stratification- destratification, Geysering effect – geyseringelemination, Zero“g” problems – restart mechanism.

TEXTBOOKS:

1.“A text book of Cryogenics”, “Valery V. Kostionk”, Discovery Publishing House, 2010. (Units 1 to 3)

2. “Operation of a Cryogenic Rocket Engine”, “Kitsche, Wolfgang”, Springer Publications, 2011. (Units 4 & 5)

REFERENCES:

1. “Rocket Propulsion Elements”, “Sutton G. P., Bibliarz”

BASE08	**SPACE MISSION DESIGN AND ANALYSIS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Aeronautics and Astronautics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To make the students learn basics of Space Mission design process
2. To acquaint the students with Spacecraft system Engineering
3. To make the students familiarize with the concepts of general N – body diagram

4. To acquaint the students with the concepts of Satellite injection and reentry flight dynamics 5. To familiarize the students with interplanetary trajectories		
COURSE CONTENT		
UNIT I	**SPACE MISSION DESIGN PROCESS**	**9**
Classification of space missions – Low earth, Medium altitude, Geo-stationary, deep space, space mission life cycle, Mission objectives, identification of mission needs, requirements and constraints, mission characterization, mission evaluation, orbit and constellation design - Space Environment – peculiarities, survivability, selection of spacecraft material - Selection of launch system		
UNIT II	**SPACECRAFT SYSTEM ENGINEERING**	**9**
Spacecraft design and sizing, spacecraft payload design, spacecraft subsystems, functional requirement - Propulsion, attitude determination and control, power systems, thermal control, navigation and guidance, telemetry, tracking and command systems, ground system design		
UNIT III	**GENERAL N-BODY PROBLEM**	**9**
Relative Motion in the N-body Problem, Two body problem, orbit determination techniques, Kepler’s equation, Lamberts problem - Restricted Three Body Problem – Lagrange points - Jacobi Integral, orbital perturbation		
UNIT IV	**SATELLITE INJECTION AND REENTRY FLIGHT DYNAMICS**	**9**
Launching of a satellite - General aspects of satellite Injections, launch vehicle ascent trajectories, injection parameters and orbital elements, launch vehicle performance, orbit deviations due to injection errors - Reentry flight dynamics – fundamentals of entry flight mechanics, fundamentals of entry heating, entry vehicle design, landing and recovery techniques		
UNIT V	**INTERPLANETARY TRAJECTORIES**	**9**
Patched Conic Approximation - Patched Conic Procedure - Sphere of Influence - Locating the Planets - Design of the Transfer Ellipse - Design of the Departure Trajectory - Design of the Arrival Trajectory - Gravity-Assist maneuver - Establishing Planetary Orbit – Motion of the Earth-Moon System - Time of Flight and Injection Velocity - Lunar Patched Conic		
TEXTBOOKS: 1.Cornelisse, J.W, Schoyer H F R, and Wakker K F, "Rocket Propulsion and Space Dynamic", Pitman Publishing Co., 1979		
REFERENCES: 1. Peter Fortescue, John Stark, Graham Swinerd, “Spacecraft systems engineering” Wiley 2004 2. Vincent N Pisacane, “Fundamentals of space system design” Oxford University Press, 2005 3. W J Larson and J R Wertz, “Space Mission Analysis and Design”, Kluwer Academic Publishers, 1999. 4. Michael Griffin, “Space Vehicle Design”, AIAA education series, 2004 5. Ashish Tewari, “Atmospheric and Space Flight Dynamics”, Birkhauser, Boston, 2007		

BANE12	**HYPERSONIC AERODYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Aerodynamics – I				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES 1. To study the environment around hypersonic vehicles created by strong shock waves. 2. To introduce students to real gas effects caused by high temperature conditions. 3. To study pressure and heat transfer phenomena at the stagnation point of a hypersonic vehicle. 4. To study the distribution of pressure around a general vehicle shape.					

5. To study the distribution of heat transfer and skin friction around a general vehicle shape.		
COURSE CONTENT		
UNIT I	**FUNDAMENTALS OF HYPERSONIC AERODYNAMICS**	**9**
Introduction to hypersonic aerodynamics-differences between hypersonic aerodynamics and supersonic aerodynamics-concept of thin shock layers-hypersonic flight paths – hypersonic similarity parameters-shock wave and expansion wave relations of inviscid hypersonic flows.		
UNIT II	**SIMPLE SOLUTION METHODS FOR HYPERSONIC IN VISCID FLOWS**	**9**
Local surface inclination methods-Newtonian theory-modified Newtonian law-tangent wedge and tangent cone and shock expansion methods-approximate theory-thin shock layer theory.		
UNIT III	**VISCOUS HYPERSONIC FLOW THEORY**	**9**
Boundary layer equation for hypersonic flow-hypersonic boundary layers-self similar and non self similar boundary layers-solution methods for non self similar boundary layers aerodynamic heating.		
UNIT IV	**VISCOUS INTERACTIONS IN HYPERSONIC FLOWS**	**9**
Introduction to the concept of viscous interaction in hypersonic flows-strong and weak viscous interactions-hypersonic viscous interaction similarity parameter-introduction to shock wave boundary layer interactions.		
UNIT V	**INTRODUCTION TO HIGH TEMPERATURE EFFECTS**	**9**
Nature of high temperature flows-chemical effects in air-real and perfect gases-Gibb's free energy and entropy-chemically reacting mixtures-recombination and dissociation.		
TEXTBOOKS: 1. EthirajanRathakrishnan., "High Enthalpy Gas Dynamics", John Wiley and Sons, 2015		
REFERENCES: 1.John. D. Anderson. Jr., "Hypersonic and High Temperature Gas Dynamics", AIAA Series, New York, 2006. 2. John. D. Anderson. Jr., "Modern compressible flow with historical perspective", McGraw Hill Publishing Company, New York, 1996. 3. John. T Bertin, "Hypersonic Aerothermodynamics", published by AIAA Inc.,Washington. D.C., 1994.		

OPTIONS FOR NON MAJOR ELECTIVE (NE) II

BANE17	**BOUNDARY LAYER THEORY**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Fluid Mechanics				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES 1. To acquaint with the fundamentals of viscous flow. 2. To learn the different regime of viscous flow and its solution. 3. To understand the concept of laminar boundary layer. 4. To understand the concept of turbulent boundary layer. 5. To acquaint the concept of compressible boundary layer.					
COURSE CONTENT					
UNIT I	**FUNDAMENTAL EQUATIONS OF VISCOUS FLOW**				**9**
Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum-Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow,					

Non dimensionalising the basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow		
UNIT II	**SOLUTIONS OF VISCOUS FLOW EQUATIONS**	**9**
Solutions of viscous flow equations, Couette flows, Hagen-Poisuelle flow, Flow between rotating concentric cylinders, Combined Couette-Poiseuille Flow between parallel plates, Creeping motion, Stokes solution for an immersed sphere, Development of boundary layer, Displacement thickness, momentum and energy thickness.		
UNIT III	**LAMINAR BOUNDARY LAYER EQUATIONS**	**9**
Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body-Flow separation- similarity solutions, Blasius solution for flat-plate flow, Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature –Reynold's analogy, Integral equation of Boundary layer – Pohlhausen method – Thermal boundary layer calculations		
UNIT IV	**TURBULENT BOUNDARY LAYEREQUATIONS**	**9**
Turbulence-physical and mathematical description, Two-dimensional turbulent boundary layer equations — Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient, Eddy Viscosity, mixing length , Turbulence modeling		
UNIT V	**COMPRESSIBLE BOUNDARY LAYERSEQUATIONS**	**9**
Compressible boundary layer equations, Recovery factor, similarity solutions, laminar supersonic Cone rule, shock-boundary layer interaction		
TEXTBOOKS: 1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York, 2005.		
REFERENCES: 1. Schlichting, H., Boundary Layer Theory, McGraw-Hill, New York, 2000. 2. Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.		

BANE18	**FATIGUE AND FRACTURE MECHANICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES 1. To familiarize the student about the basic terminologies of fatigue and fracture mechanics 2. To enable the student to grasp the various statistical tools used in fatigue analysis 3. To acquaint the student about the physical processes taking place during fatigue 4. To introduce to the student about the mechanism taking place during fracture 5. To make the student realize about the importance of fatigue and fracture mechanics in aerospace industry					
COURSE CONTENT					
UNIT I	**FATIGUE OF STRUCTURES**				**9**
S.N. curves - Endurance limits - Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams - Notches and stress concentrations - Neuber's stress concentration factors - Plastic stress concentration factors - Notched S.N. curves.					
UNIT II	**STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR**				**9**
Low cycle and high cycle fatigue - Coffin - Manson's relation - Transition life - cyclic strain hardening and					

softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner’s theory - Other theories.		
UNIT III	**PHYSICAL ASPECTS OF FATIGUE**	**9**
Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.		
UNIT IV	**FRACTURE MECHANICS**	**9**
Strength of cracked bodies - Potential energy and surface energy - Griffith’s theory - Irwin - Irwin extension of Griffith’s theory to ductile materials - stress analysis of “cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.		
UNIT V	**FATIGUE DESIGN AND TESTINIG**	**9**
Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.		
TEXTBOOKS: 1. Matej Billy, “Cyclic Deformation and Fatigue of Metals”, Elsevier Science Ltd., 1993. (Units 1 to 3) 2. Prashant Kumar, Elements of Fracture Mechanics, Tata McGraw Hill, New Delhi, India, 2009. (Unit 4) 3. Barrois W, Ripely, E.L., “Fatigue of aircraft structure”, Pergamon press. Oxford, 1983 (Unit 5)		
REFERENCES: 1. K. R.Y. Simha, Fracture Mechanics for Modern Engineering Design, Universities Press (India) Limited, 2001 2. D. Broek, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Dordrecht, 1986. 3. T.L. Anderson, Fracture Mechanics - Fundamentals and Applications, 3rd Edition, Taylor and Francis Group, 2005		

BANE19	**HIGH TEMPERATURE MATERIALS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				
OBJECTIVES 1. To acquaint the student with the fundamentals of creep. 2. To make the student understand about design with creep resistance. 3. To familiarize the student about fracture, cracks and their mechanics. 4. To introduce to the student about oxidation and corrosion in hot environments. 5. To acquaint the student with various super alloys and other materials.					
COURSE CONTENT					
UNIT I	**INTRODUCTION TO HIGH TEMPERATURE MATERIALS**				**6**
Components exposed to high temperatures, significance of high temperature materials, recent trends in high temperature material research					
UNIT II	**CREEP AND DESIGN FOR CREEP RESISTANCE**				**12**
Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate.Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep, ductile and brittle materials, Monkman-Grant relationship.					
UNIT III	**FRACTURE**				**9**
Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, and ductile fracture due to micro void coalescence-diffusion controlled void growth; fracture maps for different alloys and					

oxides.		
UNIT IV	**OXIDATION AND HOT CORROSION**	**9**
Oxidation, Pilling, Bedworth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, methods of combat hot corrosion.		
UNIT V	**SUPER ALLOYS AND OTHER MATERIALS**	**9**
Iron base, Nickel base and Cobalt base super alloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase, embrittlement, solidification of single crystals, Intermetallics, high temperature ceramics.		
TEXTBOOKS: 1. Raj. R., "Flow and Fracture at Elevated Temperatures", American Society for Metals,USA, 1985. (Units 1, 2, 3 & 5) 2. David J. Young, "High Temperature Oxidation and Corrosion of Metals", Second Edition, Elsevier Science Ltd., 2016 (Unit 4)		
REFERENCES: 1. Boyle J.T, Spencer J, "Stress Analysis for Creep", Butterworths, UK, 1983. 2. Bressers. J., "Creep and Fatigue in High Temperature Alloys", Applied Science, 1981. 3. McLean D., "Directionally Solidified Materials for High Temperature Service", TheMetals Society, USA, 1985. 4. Hertzberg R. W., "Deformation and Fracture Mechanics of Engineering materials", 4thEdition, John Wiley, USA, 1996. 5. Courtney T.H, "Mechanical Behavior of Materials", McGraw-Hill, USA, 1990.		

OPTIONS FOR OPEN ELECTIVE (OE) I

BASE12	**SYSTEMS ENGINEERING**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Nil				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES To introduce the concepts related to system engineering and its significance with respect to aerospace systems.		
COURSE CONTENT		
UNIT I	**INTRODUCTION**	**9**
Overview, Systems definition and concepts, Conceptual system design, Systems thinking and Systems Engineering.		
UNIT II	**DESIGN AND DEVELOPMENT**	**9**
Detail Design Requirements, The Evolution of Detail Design, Design Data, Information, and Integration, Various phases in product life cycle, Systems verification & Integration		
UNIT III	**DESIGN FOR OPERATIONAL FEASIBILITY**	**9**
Design for Reliability, Maintainability, Usability, Sustainability and Affordability - Definition and Explanation, Measures, System Life Cycle cost, Analysis Methods, Practical considerations.		
UNIT IV	**SYSTEMS ENGINEERING MANAGEMENT**	**9**
Systems Engineering Planning and Organization, Systems Engineering Management Plan (SEMP), Program Leadership and Direction, Risk Management, Evaluation and Feedback.		

UNIT V	CASE STUDIES	9
Systems Integration -Aircraft Systems, Missile Systems, Satellite Systems-Launch Vehicle Systems and Radar, Design Drivers in the Project, Product, Operating Environment-Interfaces with the Subsystems		
TEXTBOOKS: 1. Systems Engineering and Analysis by Benjamin S. Blanchard / WolterJ.Fabrycky, Prentice Hall, International Version 2010		
REFERENCES: 1. Alexander Kossiakoff, William N. Sweet, Systems Engineering : Theory & Practice, John Wiley &Sons, 2002 2. James N. Martin, Systems Engineering Guidebook: A Process for Developing Systems and Products, CRC Press, 1997 3. Gandoff, M.,(1990). Systems Analysis and Design 4. Andrew P Sage and James E Armstrong, Systems Engineering, Wiley Inter science publications, (2004)		

BANE24	**AEROSPACE BIO – MEDICAL AND LIFE SUPPORT ENGINEERING**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Basic Electrical and Electronics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To apply engineering methods to the study of astronaut adaptation to reduced gravity environments.
2. To use analytical techniques, such as structural idealizations, control theory, electrical circuit, and mechanical system analogs to model astronaut performance.
3. To enable quantitative assessment of the effectiveness of countermeasures.
4. To consider the socio-political implications for advanced technological R&D (e.g., space policy, health policy, international collaboration).
5. To teach, perform outreach, and demonstrate mastery of a chosen engineering concept.

COURSE CONTENT

UNIT I	INTRODUCTION	9
Physiological problems associated with human space flight – review of terminologies		
UNIT II	**BIO – MECHANICS IN SPACE FLIGHT**	**9**
Bone Mechanics, Muscle Mechanics, Musculoskeletal Dynamics, and the Cardiovascular System during space flight – their equations of motion		
UNIT III	**BIO – MECHANICAL MODELING**	**9**
Structural idealizations – mechanical and electrical modeling of muscle groups – musculoskeletal groups – joints, electrical analogies to model astronaut performance		
UNIT IV	**LIFE SUPPORT SYSTEMS**	**9**

Onboard environment control systems – waste product management and recycling system – bio – monitoring and control		
UNIT V	**EXTRA – VEHICULAR ACTIVITY**	**9**
Extra Vehicular activity – challenges – specialties of space suits – life support system for EVA		

Text Books:

1. “Space Physiology”, Beckers, Frank, Bart Verheyden, Andre E Aubert, Wiley Encylopaedia of Bio – medical engineering, John Wiley and Sons, Inc., 2006
2. “Fundamentals of Space Life Sciences”, Diamandis, Peter H. Edited by Susanne Churchill. Malabar, FL: Krieger Publishing Co., 1997.

References:

1. “Human Anatomy Manual: The Skeleton”, Gatesville, TX, Medical Plastics Laboratory, Inc., 1997
2. Gomi, Hiroaki, and MitsuoKawato. "Equilibrium-Point Control Hypothesis Examined by Measured Arm Stiffness during Multijoint Movement." Science 272, no. 5258 (1996): 117-120.
3. Aubert, A.E., F. Beckers, and B. Verheyden. "Cardiovascular Function and Basics of Physiology in Microgravity." Acta Cardiol 60, no. 2 (2005): 129-151.
4. Flash, T. "The Control of Hand Equilibrium Trajectories in Multi-joint Arm Movements." Biological Cybernetics 57 (1987): 257-274.
5. Bizzi, E., W. Chapple, and N. Hogan. "Mechanical Properties of Muscles: Implications for Motor Control." Trends in Neurosciences 5, no. 11 (1982): 395-398.
6. Shenkman, Boris S., and Inessa B. Kozlovskaya. "Results of Studies of the Effects of Space Flight Factors of Human Physiological Systems and Psychological Status, and Suggestions of Future Collaborative Activities between the NSBRI and the IBMP." Section 3: Muscles. State Research Center of Russian Federation Institute for Biomedical Problems Report, Moscow, 2000.
7. Stuster, J., C. Bachelard, and P. Suedfeld. "The Relative Importance of Behavioral Issues during Long-duration ICE Missions." Aviat. Space Env. Med. (September 2000): A17-A25.
8. Brubakk, A. "Man in Extreme Environments." Aviat. Space Env. Med. (September 2000): A126-A130.

BBA001	**PRINCIPALS OF MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Nil				
	Course Designed by – Department of Management Studies				

OBJECTIVES

1. To acquaint the student about the management, various types of management function and structure.
2. To give insight of various methods of management of organization and managerial aspects.
3. To acquaint the student with various functions of organizational behavior.
4. To get exposure regarding its applications and recent developments of group dynamics and trade union
5. To help the student understand about the professional ethics and social responsibilities.

COURSE CONTENT

<table>
<tr><td>UNIT I</td><td>MANAGEMENT FUNCTIONS & STRUCTURE</td><td>9</td></tr>
<tr><td colspan="3">Management – Definition – Basic Function – Contribution of Taylor &Fayol. Types of structure – Line, staff, Functional, Committee, and Project & Matrix – Structures. Departmentalization – Centralization – Decentralization – span of control. Management By Objectives –Management By Exception.</td></tr>
<tr><td>UNIT II</td><td>MANAGEMENT OF ORGINASATION</td><td>9</td></tr>
<tr><td colspan="3">Forms of Business / Industrial Ownership – Sole Trader, Partnership, Company, Performance Appraisal – Basic Principles – Pitfalls – Methods to Overcome. Industrial Safety – Causes of Accidents – Cost of Accident – How to minimize Accidents. Plant Layout & Maintenance – Need, Types & Managerial Aspects.</td></tr>
<tr><td>UNIT III</td><td>ORGANISATIONAL BEHAVIOUR</td><td>9</td></tr>
<tr><td colspan="3">OB – Definition – Nature & Scope – Contributing Disciplines – Importance of OB to Managers. Personality – Definition – Theories – Factors Influencing Personality. Motivation – Definition – Theories. Theory X & Y – Transactional Analysis. Morale & Job Satisfaction – Factors Influencing Job Satisfaction.</td></tr>
<tr><td>UNIT IV</td><td>GROUP DYNAMICS</td><td>9</td></tr>
<tr><td colspan="3">Group – Definition – Types – Determinants of Group Cohesiveness – Communication – Process – Barriers – Effective Communication. Leadership Theories – Factors Contributing to Effective Leadership – Role of Trade Union in Organizations – Functions of Trade Union – Why Trade Union is required? – Types of Trade Union.</td></tr>
<tr><td>UNIT V</td><td>PROFESSIONAL ETHICS</td><td>9</td></tr>
<tr><td colspan="3">Ethics in Workplace – Formulation of Ethics – Managerial Ethics – Managing Ethical Behaviour – Codes of Ethics – Encouraging Ethical Behaviour – Social Responsibility – Spirituality.</td></tr>
<tr><td colspan="3">Text Books:
1. Gupta C.B., Management Theory and Practice, 14th Edition, Sultan Chand & Sons, 2009.
2. Dr. Prasad L.M., Principle & Practice of Management, 7th Edition, Sultan Chand & Sons, 2008.</td></tr>
<tr><td colspan="3">References:
1. Aswathappa, Organizational Behaviour, 8th Edition, Himalaya Publishing House, 2010.
2. Dr. Prasad L.M., Organizational Behaviour, 4th Edition, Sultan Chand & Sons, 2008.
3. Harold Koontz, Principles of Management, 1st Edition, Tata McGraw Hill, 2004.</td></tr>
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BHARATH INSTITUTE OF HIGHER EDUCATION AND RESEARCH

DEPARTMENT OF AERONAUTICAL ENGINEERING

B. TECH AEROSPACE ENGINEERING – REGULATIONS 2015 (CBCS)

SEMESTER VIII

BAN8P1	**PROJECT WORK**	**L**	**T**	**P**	**C**
	Total Contact Hours – 60	**0**	**0**	**18**	**9**
	Prerequisite – Aerodynamics II, Aircraft Structures II, Advanced Aerospace Propulsion				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about the scientific method of research
2. To accustom the student to the processes involved during a project work
3. To enable the student to understand the concepts of scrutiny to get the idea about the work that takes place during a project
4. To familiarize the student on the preparation of technical reports/paper of his/her project work
5. To enable the student to be able to make a proper presentation of his/her assigned work/project

DESCRIPTION

The objective of the project work is to enable the students in convenient groups of not more than 4 members on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Eighteen periods per week shall be allotted in the time table and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project. Each student shall finally produce a comprehensive report covering background information, literature survey, problem statement, project work details and conclusion. This final report shall be in typewritten form as specified in the guidelines.

OPTIONS FOR NON – MAJOR ELECTIVE (NE) III

BASE10	**HIGH TEMPERATURE GAS DYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Aerodynamics II				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce the students the basics of High Temperature Gas.
2. To acquaint the students with fundamentals of Statistical Thermodynamics.
3. To make the students understand the kinetic theory and basics of hypersonic flows.
4. To make the students understand the basics of inviscid high temperature flows.
5. To acquaint the students with the basic knowledge transport properties in high temperature gas.

COURSE CONTENT

UNIT I	**INTRODUCTION**	**8**

<table>
<tr><td colspan="3">Nature of high temperature flows – Chemical effects in air – Real perfect gases – Gibb’s free energy and entropy by chemical and non-equilibrium – Chemically reacting mixtures and boundary layers.</td></tr>
<tr><td>**UNIT II**</td><td>**STATISTICAL THERMODYNAMICS**</td><td>**8**</td></tr>
<tr><td colspan="3">Introduction to statistical thermodynamics – Relevance to hypersonic flow - Microscopic description of gases – Boltzmann distribution – Cartesian function</td></tr>
<tr><td>**UNIT III**</td><td>**KINETIC THEORY AND HYPERSONIC FLOWS**</td><td>**9**</td></tr>
<tr><td colspan="3">Chemical equilibrium calculation of equilibrium composition of high temperature air – equilibrium properties of high temperature air – collision frequency and mean free path – velocity and speed distribution functions.</td></tr>
<tr><td>**UNIT IV**</td><td>**INVISCID HIGH TEMPERATURE FLOWS**</td><td>**10**</td></tr>
<tr><td colspan="3">Equilibrium and non – equilibrium flows – governing equations for inviscid high temperature equilibrium flows – equilibrium normal and oblique shock wave flows – frozen and equilibrium flows – equilibrium conical and blunt body flows – governing equations for non-equilibrium inviscid flows.</td></tr>
<tr><td>**UNIT V**</td><td>**TRANSPORT PROPERTIES IN HIGH TEMPERATURE GAS**</td><td>**10**</td></tr>
<tr><td colspan="3">Transport coefficients – mechanisms of diffusion – total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting and absorbing gases</td></tr>
<tr><td colspan="3">**TEXTBOOKS:**
1. “Ethirajan Rathakrishnan”, “High Enthalpy Gas Dynamics”, John Wiley and Sons, 2017</td></tr>
<tr><td colspan="3">**REFERENCES:**
1. John D. Anderson, Jr., Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2. John D. Anderson, Jr., Modern Compressible Flow with Historical perspective McGraw Hill Series, New York, 1996.
3. William H. Heiser and David T. Pratt, Hypersonic Air breathing propulsion, AIAA Education Series.
4. John T. Bertin, Hypersonic Aerothermodynamics publishers - AIAA Inc., Washington, D.C., 1994.
5. T.K.Bose, High Temperature Gas Dynamics</td></tr>
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<table>
<tr><td rowspan="4">**BASE11**</td><td>**SPACECRAFT POWER SYSTEMS**</td><td>**L**</td><td>**T**</td><td>**P**</td><td>**C**</td></tr>
<tr><td>Total Contact Hours – 45</td><td>**3**</td><td>**0**</td><td>**0**</td><td>**3**</td></tr>
<tr><td colspan="5">Prerequisite – Basic Electricals and Electronics</td></tr>
<tr><td colspan="5">Course Designed by – Department of Aeronautical Engineering</td></tr>
<tr><td colspan="6">**OBJECTIVES**
The students will understand the advanced concepts of Spacecraft power systems, its elements, energy storage technology, power convertors and power distribution.</td></tr>
<tr><td colspan="6">**COURSE CONTENT**</td></tr>
<tr><td>**UNIT I**</td><td colspan="4">**SPACECRAFT ENVIRONMENT & DESIGN CONSIDERATION**</td><td>**9**</td></tr>
<tr><td colspan="6">Orbit definition /Mission Requirements of LEO, GEO, GTO & HEO, Lunar orbits, IPO with respect to Power Generation – Power System Elements - Solar aspect angle Variations</td></tr>
<tr><td>**UNIT II**</td><td colspan="4">**POWER GENERATION**</td><td>**9**</td></tr>
<tr><td colspan="6">Study of Solar spectrum - Solar cells - Solar Panel design - Solar Panel Realization – Solar Panel testing - Effects of Solar cells and panels (IR, UV, Particles)</td></tr>
<tr><td>**UNIT III**</td><td colspan="4">**ENERGY STORAGE TECHNOLOGY**</td><td>**9**</td></tr>
<tr><td colspan="6">Types of batteries – Primary & Secondary batteries - Nickel Cadmium - Nickel-Hydrogen – Nickel metal hydride - Lithium-ion –Lithium Polymer - Silver Zinc– Electrical circuit model – Performance characteristics of batteries -</td></tr>
</table>

Application of batteries in launch vehicles and satellites – Fuel Cell – Polymer Electrolyte membrane Fuel Cell – Regenerative Fuel Cell		
UNIT IV	**POWER CONVERTERS**	**9**
DC – DC converters – Basic Convertors - Buck, Boost, Buck- boost converter –Derived converters: Fly back converter – Transformer coupled forward converter – Push-Pull converter - CUKs convertor– Resonant converter – Voltage and current regulators		
UNIT V	**POWER CONTROL, CONDITIONING AND DISTRIBUTION**	**9**
Solar Array Regulators – Battery changing schemes – Protection Schemes - Distribution – Harness - Thermal Design - EMI/EMC/ESD/Grounding schemes for various types of circuits and systems		
TEXTBOOKS: 1. Patel, Mukund R, 'Spacecraft Power Systems' CRC Press Boca Raton, 2005		
REFERENCES: 1. Hyder, A k et.al, 'Space Power Technologies' Imperial College Press London,2000 2. Fortescue, Peter et.al, 'Spacecraft Systems Engineering' John Wiley England,2003. 3. P R K Chetty, 'Spacecraft Power Systems', 1978.		

BANE14	**PRINCIPLES OF TURBOMACHINERY IN AIRBREATHING ENGINES**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	**3**	**0**	**0**	**3**
	Prerequisite – Aircraft Propulsion				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES 1. To familiarize the student on the working principle of air breathing engines 2. To enable the student to be able to design axial flow compressors and fans based on the operating requirements 3. To student should be able to design axial flow turbines based on the operating requirements 4. To acquaint the student about the designing procedure for centrifugal compressors 5. To enable the student to design radial flow turbines based on operating conditions		
COURSE CONTENT		
UNIT I	**INTRODUCTION TO TURBOMACHINERY**	**9**
Turbomachinery- definition, Classification of Turbomachines, Power absorbing and power producing turbomachines, Centrifugal compressor-components, Axial compressor-components, Single stage and multi stage, subsonic and transonic axial compressors, Radial turbine-components, Axial turbine-single and multistage, Review of basic laws-conservation of mass, momentum and energy, Euler's turbo machine equation, simple gas turbine cycle, Variation of thrust and SFC with Mach number and altitude for typical turbojet engine		
UNIT II	**CENTRIFUGAL COMPRESSORS**	**9**
Work done and pressure rise, impeller, velocity triangle, slip factor, power input factor, Coriolis acceleration, diffuser, compressibility effects, inlet Mach number for impeller and diffuser, prewhirl, Compressor characteristics, non-dimensional quantities, stage pressure ratio, Instability-surge, rotating stall, choking		
UNIT III	**AXIAL FLOW COMPRESSORS**	**9**
Basic operation, stator, rotor, velocity triangle, factors affecting stage pressure ratio, de Haller number, diffusion factor, degree of reaction, radial equilibrium of fluid element, basic design process, estimation of number of stages, considerations in blade design, blade cascade, compressibility effects, axial compressor characteristics		
UNIT IV	**AXIAL AND RADIAL TURBINES**	**11**

Elementary theory of axial flow turbines, blade loading coefficient, flow coefficient, degree of reaction, rotor blade loss, Vortex theory-Free vortex design, constant nozzle angle design, choice of blade profile, pitch and chord, rotor blade stresses, Firtree root, limiting factors in turbine design, Radial flow turbine		
UNIT V	**MATCHING OF COMPONENTS AND BLADE COOLING**	**7**
Component characteristics-compressor, turbine, off-design operation, load characteristics, equilibrium running, matching of two turbines in series, turbine blade cooling		

TEXTBOOKS:

1. Ganesan. V, “Gas Turbines”, Tata McGraw Hill Education, 3rd Edition, 2010 (Units 1 to 4)
2. Cohen H, Rogers GFC, and Saravanamuttoo HIH, “Gas Turbine Theory” Addison Wesley Longman Limited, 1998 (Unit 5)

REFERENCES:

1. El-Wakil, M M; Powerplant Technology, 1984, McGraw-Hill Pub.
2. NASA-SP-290, Axial Flow turbines, 2002 (re-release), NTIS, USA.
3. J H Horlock, Axial flow compressors, Butterworths, 1958, UK.
4. J H Horlock, Axial Flow Turbines, Butterworths, 1965, UK.
5. B Lakshminarayana; Fluid Mechanics and Heat Transfer in turbomachineries,1995, USA.
6. Nicholas Cumpsty, Compressor Aerodynamics, 2004, Kreiger Publications, USA.
7. Johnson I.A., Bullock R.O. NASA-SP-36, Axial Flow Compressors, 2002 (re-release), NTIS.
8. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press, 2008

OPTIONS FOR OPEN ELECTIVE (OE) II

BBA008	**TOTAL QUALITY MANAGEMENT**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Nil				
	Course Designed by – Department of Management Studies				

OBJECTIVES

1. To introduce to the student about the basic terms related to quality and concepts of quality management
2. To familiarize the student about the basic principles of total quality management
3. To acquaint the student with the basic statistical tools used in process control
4. To introduce to the student about the various tools used in implementing and checking total quality management
5. To familiarize the student about the different quality systems used in auditing the quality of a company/industry/organization

COURSE CONTENT

UNIT I	**INTRODUCTION**	**9**
Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs – Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review, Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council, Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.		
UNIT II	**TQM PRINCIPLES**	**9**

Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality, Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy, PDSA Cycle, 5S, Kaizen, Supplier Partnership –Partnering, sourcing, Supplier Selection, Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy, Performance Measure.

UNIT III	**STATISTICAL PROCESS CONTROL (SPC)**	**9**

The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes, Process capability, Concept of six sigma, New seven Management tools.

UNIT IV	**TQM TOOLS**	**9**

Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment (QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA –Stages of FMEA.

UNIT V	**QUALITY SYSTEMS**	**9**

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System –Elements, Implementation of Quality System, Documentation, Quality Auditing, TS16949, ISO 14000 – Concept, Requirements and Benefits.

Text Books:

1. Dale H. Besterfiled, et al., "Total Quality Management", Pearson Education, Inc.2003. (Indian reprint 2004). ISBN 81-297-0260-6.

References:

1. Evans. J. R. & Lindsay. W,M "The Management and Control of Quality", (5th Edition),South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).
2. Feigenbaum.A.V. "Total Quality Management", McGraw-Hill, 1991.
3. Oakland.J.S. "Total Quality Management", Butterworth Hcinemann Ltd., Oxford,1989.
4. Narayana V. and Sreenivasan, N.S. "Quality Management – Concepts and Tasks",New Age International 1996.
5. Zeiri. "Total Quality Management for Engineers", Wood Head Publishers, 1991.

BANE25	**INDUSTRIAL AERODYNAMICS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Aerodynamics I				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about the aerodynamics taking place in the atmosphere
2. To familiarize the student about the aerodynamics of flow over bluff bodies and its effect on those bodies
3. To acquaint the student about the various mechanisms and procedures by which energy can be extracted from the wind
4. To accustom the student about the aerodynamics of flow around buildings, towers and bridges and also about ventilation and architectural aerodynamics
5. To familiarize the student about the loads on a structure due to wind and the resulting vibrations and their calculations

COURSE CONTENT		
UNIT I	**ATMOSPHERIC BOUNDARY LAYER**	**9**
Atmospheric circulation-Local winds-Terrain types-Mean velocity profiles-Power law and logarithm law-wind speeds-Turbulence profiles-Roughness parameters-simulation techniques in wind tunnels		
UNIT II	**BLUFF BODY AERODYNAMICS**	**9**
Boundary layers and separation-Two dimensional wake and vortex formation-Strouhal and Reynolds numbers-Separation and reattachments-Power requirements and drag coefficients of automobiles-Effects of cut back angle-aerodynamics of trains.		
UNIT III	**WIND ENERGY COLLECTORS**	**9**
Horizontal and vertical axis machines-energy density of different rotors-Power coefficient-Betz coefficient by momentum theory.		
UNIT IV	**BUILDING AERODYNAMICS**	**9**
Pressure distribution on low rise buildings-wind forces on buildings-Environmental winds in city blocks-special problems of tall buildings-building codes-ventilation and architectural aerodynamics		
UNIT V	**FLOW INDUCED VIBRATIONS**	**9**
Vortex shedding, lock & effects of Reynolds number on wake formation in turbulent flows- across wind galloping-wake galloping-along wind galloping of circular cables-oscillation of tall structures and launch vehicles under wind loads-stall flutter.		

Text Books:

1. Blevins R.D “Flow Induced Vibrations”, Van Nostrand, 1990
2. Sovran, M(ed) “Aerodynamic drag mechanism of bluff bodies and road vehicles”,Plenum Press, N.Y, 1990

References:

1. Sachs P “Wind Forces in Engineering”, Pergamon Press, 1988
2. Scorer R.S “Environmental Aerodynamics”, Ellis Harwood Ltd, England, 1978
3. Calvert N.G “Wind Power Principles”, Charles Griffin & Co London, 1979.

BANE26	**MECHANICS OF HETEROGENEOUS MATERIALS**	**L**	**T**	**P**	**C**
	Total Contact Hours – 45	3	0	0	3
	Prerequisite – Engineering Physics I, Fundamentals of Structural Mechanics				
	Course Designed by – Department of Aeronautical Engineering				

OBJECTIVES

1. To introduce to the student about the various heterogeneous materials.
2. To accustom the student to the mechanics of heterogeneous materials.
3. To acquaint the student to the structure of particulate, fibrous and cellular solids and their properties.
4. To familiarize the student about the hierarchical structure in heterogeneous materials.
5. To enable the student to understand various design considerations in application of heterogeneous materials.

COURSE CONTENT

<table>
<tr><td>UNIT I</td><td>INTRODUCTION</td><td>9</td></tr>
<tr><td colspan="3">Material heterogeneity. Survey of laminated, fibrous, particulate, cellular and porous, platelet structures. Single crystal properties and polycrystal properties. Heterogeneity of biological materials and designed heterogeneity. Strength of fibers. Constituent materials. Griffith's experiments, stress concentrations. Concept of equivalent homogeneity. Micro and nanotructures.</td></tr>
<tr><td>UNIT II</td><td>STRUCTURE OF HETEROGENEOUS MATERIALS</td><td>9</td></tr>
<tr><td colspan="3">Unidirectional fibrous media. Bounds on physical properties: Voigt and Reuss bounds; Hashin-Shtrikman. Prediction of stiffness and strength for different directions. Symmetry and physical properties. Crystal symmetry classes. Generalized Hooke's law of elasticity. Modulus and compliance matrices. Anisotropy and dielectric and piezoelectric properties. Thermal expansion. Experimental methods.</td></tr>
<tr><td>UNIT III</td><td>PARTICULATE, FIBROUS AND CELLULAR SOLIDS</td><td>12</td></tr>
<tr><td colspan="3">Structure. Particulate materials. Dental composites, metal matrix composites, asphalt. Toughened polymers via compliant inclusions. Stiffness vs. volume fraction. Self healing polymers. Attainment of the Hashin-Shtrikman bounds. Unidirectional fibrous materials; stiffness, strength, thermal expansion. Fibrous solids with short-fibers. Nano-tubes as fibers. Platelet reinforcement. Shear lag model. Laminates. Polycrystalline aggregates. Piezoelectric composites. Metal matrix composites. Structure property relations of cellular solids. Lightweight cellular solids. Foams, structural honeycombs, sandwich structures. Polymer lattice structures. Syntactic foams. Poisson's ratio of composites and foams. Applications.</td></tr>
<tr><td>UNIT IV</td><td>HIERARCHICAL STRUCTURE</td><td>6</td></tr>
<tr><td colspan="3">Structure within structure. Bone, wood, tendon and other materials of biological origin. Fibrous aspects of bone structure. Tendon and ligament as fibrous biological materials. Biological cellular solids. Cellular architecture of bone, wood, bamboo.</td></tr>
<tr><td>UNIT V</td><td>DESIGN CONSIDERATIONS</td><td>9</td></tr>
<tr><td colspan="3">Fracture mechanics, stress concentrations, free-edge effects. In situ composites; eutectic structure. Gradient effects. Role of microstructure size. Generalized continuum models; Cosserat elasticity. Toughness: empirical criteria; causal mechanisms. Spongy impact absorber, bone cement.</td></tr>
<tr><td colspan="3">Text Books:
1. L. J. Gibson, and M. F. Ashby, Cellular Solids, Cambridge, (1999).
2. M. F. Ashby and D. R. H. Jones, Engineering Materials, 2nd ed. Butterworth, (1998).</td></tr>
<tr><td colspan="3">References:
1. J. F. Nye, Physical Properties of Crystals, Oxford, (1976).
2. B. D. Agarwal and L. J. Broutman, Analysis and Performance of Fiber Composites, J. Wiley, 2nd ed. (1990).</td></tr>
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