DR. A. P. J.ABDUL KALAM TECHNICAL UNIVERSITY

LUCKNOW, UTTAR PRADESH

STUDY &EVALUATION SCHEME WITH SYLLABUS

FOR

B. TECH. 3rd YEAR

AERONAUTICAL ENGINEERING

[Effective from Session: 2020-21]

Syllabus Content of B. Tech Aeronautical Engineering

B. Tech Aeronautical Engineering

Evaluation Scheme

SEMESTER- V													
Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KME 501	Heat and Mass Transfer	3	1	0	30	20	50		100		150	4
2	KAE 501	Design of Aircraft Elements	3	1	0	30	20	50		100		150	4
3	KAE 502	Aerodynamics-I	3	1	0	30	20	50		100		150	4
4	KAE 051-054	Department Elective-I	3	0	0	30	20	50		100		150	3
5	KAE 055-058	Department Elective-II	3	0	0	30	20	50		100		150	3
6	KME 551	Heat and Mass Transfer Lab	0	0	2				25		25	50	1
7	KAE 551	Design of Aircraft Elements and Simulation Lab	0	0	2				25		25	50	1
8	KAE 552	Aircraft Instrument Lab	0	0	2				25		25	50	1
9	KAE 553	Mini Project/ (Internship Assessment*)	0	0	2				50			50	1
10	NC+	Constitution of India / Essence of Indian Traditional Knowledge	2	0	0	15	10	25		50			
11	MOOCs (Essential for Hons. Degree)												
	Total		**17**	**3**	**6**							**950**	**22**

*****The Mini Project or internship (4 - 5 weeks) conducted during summer break after IV semester and will be assessed during V semester.

SEMESTER- VI													
Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	KAE 601	Aircraft Structure	3	1	0	30	20	50		100		150	4
2	KAE 602	Aerodynamics-II	3	1	0	30	20	50		100		150	4
3	KME 603	Theory of Machines	3	1	0	30	20	50		100		150	4
4	KAE 061-064	Department Elective-III	3	0	0	30	20	50		100		150	3
5		Open Elective-I	3	0	0	30	20	50		100		150	3
8	KAE 651	Aircraft Propulsion Lab	0	0	2				25		25	50	1
6	KAE 652	Aerodynamic Design & Testing Lab	0	0	2				25		25	50	1
7	KME 653	Theory of Machines Lab	0	0	2				25		25	50	1
9	NC +	Essence of Indian Traditional Knowledge/ Constitution of India	2	0	0	15	10	25		50			
10	MOOCs (Essential for Hons. Degree)												
		Total	**17**	**3**	**6**							**900**	**21**

AERONAUTICS ENGINEERING DEPARTMENTAL ELECTIVES

Student can choose any elective horizontally from the pool of electives

Sem V	**Code**	KAE 051	KAE 052	KAE 053	KAE 054
	Department Elective–I	Aircraft Propulsion–I	Space Flight Mechanics	Air Navigation	Aircraft Materials & NDT
Sem V	**Code**	KAE 055	KAE 056	KAE 057	KAE 058
	Department Elective–II	Aircraft Instruments	Mechanical Vibrations	Introduction to Aircraft Design	Aircraft Systems
Sem VI	**Code**	KAE 061	KAE 062	KAE 063	KAE 064
	Department Elective–III	Aircraft Propulsion–II	Introduction to UAV	Spacecraft Technology	Aircraft Evaluation
Sem VII	**Code**	KAE 071	KAE 072	KAE 073	KAE 074
	Department Elective–IV	Flight Mechanics	Aircraft Stability and Control	Helicopter Aerodynamics	Introduction to FEM
Sem VII	**Code**	KAE 075	KAE 076	KAE 077	KAE 078
	Department Elective–V	Aircraft Rules and Regulations	Aircraft Engine Maintenance	Introduction to CFD	Elements of Aeroelasticity

SEMESTER-V

Subject Code: KME 501	Heat and Mass Transfer	L T P : 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the fundamentals of heat and mass transfer.	K2
CO-2	Apply the concept of steady and transient heat conduction.	K3
CO-3	Apply the concept of thermal behavior of fins.	K3
CO-4	Apply the concept of forced and free convection.	K3
CO-5	Apply the concept of radiation for black and non-black bodies.	K3
CO-6	Conduct thermal analysis of heat exchangers.	K4

UNIT-1

Introduction to Heat Transfer (5Hours)

Introduction of thermodynamics and Heat Transfer, Modes of Heat Transfer: Conduction, convection and radiation, Effect of temperature on thermal conductivity of different types of materials, Introduction to combined heat transfer mechanism, General differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems, Initial and system boundary conditions.

Steady State one-dimensional Heat conduction (3 Hours)

Simple and Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation, Concept of thermal resistance, Analogy between heat and electricity flow, Thermal contact resistance and over-all heat transfer coefficient, Critical radius of insulation for cylindrical, and spherical bodies.

UNIT-2

Fins (3 Hours)

Heat transfer through extended surfaces and its classification, Fins of uniform cross-sectional area, Error in measurement of temperature of thermometer wells.

Transient Conduction (3 Hours)

Transient heat conduction, Lumped capacitance method, Time constant, Unsteady state heat conduction in one dimension only, Heisler charts and their applications.

UNIT-3

Forced Convection (5 Hours)

Basic concepts: Hydrodynamic boundary layer, Thermal boundary layer, Approximate integral boundary layer analysis, Analogy between momentum and heat transfer in turbulent flow over a flat surface, Mixed boundary layer, Flow over a flat plate, Flow across a single cylinder and a sphere, Flow inside ducts, Thermal entrance region, Empirical heat transfer relations, Relation between fluid friction and heat transfer, Liquid metal heat transfer.

Natural Convection (5 Hours)

Physical mechanism of natural convection, Buoyant force, Empirical heat transfer relations for

natural convection over vertical planes and cylinders, horizontal plates, cylinders and sphere, combined free and forced convection, Effect of turbulence.

UNIT-4

Thermal Radiation (8 Hours)

Basic concepts of radiation, Radiation properties of surfaces, Black body radiation Planck's law, Wein's displacement law, Stefan-Boltzmann law, Kirchhoff's law, Gray body, Shape factor, Black-body radiation, Radiation exchange between diffuse non-black bodies in an enclosure, Radiation shields, Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar radiation; Greenhouse effect, Radiation network analysis.

UNIT-5

Heat Exchanger (5 Hours)

Different types of heat exchangers, Fouling factors, Overall heat transfer coefficient, Logarithmic mean temperature difference (LMTD) method, Effectiveness-number of transfer unit (NTU) method and Compact Heat Exchangers.

Condensation and Boiling (3 Hours)

Introduction of condensation phenomena, Heat transfer relations for laminar film condensation on vertical surfaces and on outside& inside of a horizontal tube, Effect of non-condensable gases, Drop wise condensation, Heat pipes, Boiling modes, pool boiling, Hysteresis in boiling curve, Forced convection boiling.

Introduction to Mass Transfer (2 Hours)

Introduction of Fick's law of diffusion, Steady state equimolar counter diffusion, Steady state diffusion through a stagnant gas film, Heat and Mass Transfer Analogy -Convective Mass Transfer Correlations

Reference Books:-

1. Fundamentals of Heat and Mass Transfer, by Incroperra& DeWitt, John Wiley and Sons
2. Heat and Mass Transfer by Cengel, McGraw-Hill
3. Heat Transfer by J.P. Holman, McGraw-Hill
4. Heat and Mass Transfer by Rudramoorthy and Mayilsamy, Pearson Education
5. Heat Transfer by Ghoshdastidar, Oxford University Press
6. A text book on Heat Transfer, by Sukhatme, University Press.
7. Heat Transfer by Venkateshan, Ane Books Pvt Ltd
8. Schaum's outline of Heat Transfer by Pitts & Sisson McGraw-Hill
9. Heat and Mass Transfer by R Yadav, Central Publishing House

Subject Code: KAE-501	Design Of Aircraft Elements	L T P: 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the various structural components used in an aircraft and the loads they are subjected to.	K2
CO-2	Apply the basic concepts to design the aircraft structural components in order to meet desired needs within realistic constraints.	K3
CO-3	Understand the difference between various power transmission methods and their selection based on the requirements.	K2
CO-4	Identify the use and advantages-drawbacks of different types of rolling and sliding bearing.	K2
CO-5	Apply the basics concepts to design spur, helical and other gears.	K3
CO-6	Apply the basic concepts to design bearings for use in rotating components and make proper selection based on the requirements	K3

UNIT-1 **(9 Hours)**

Introduction

Design requirements foraircraft elements, Principles of aircraft design, Modes of failures and Factor of safety. Systematic design process, Use of standards in design, Manufacturing consideration in design, Selection of preferred sizes, Designation of carbon & alloy steels, Selection of materials for static and fatigue loads.

Design for Static and Fluctuating Loads

Principal Stresses, Stresses due to bending and torsion, Theories of failure, Cyclic stresses, Fatigue and endurance limit, Stress concentration factor, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria.

UNIT-2 **(9 Hours)**

Design of Riveted Joints

Comparison of different types of joints, Types of riveted joints, Failure and efficiency of riveted joints, Preliminary design of fuselage and wings, Eccentric loaded riveted joint.

Design of Shafts and Keys

Stresses in shafts, Materials for shaft, Design of shafts subjected to twisting, bending and combined twisting and bending, Shafts subjected to fatigue loads, Types of keys, their selection and strength.

UNIT-3 **(8 Hours)**

Rolling Contact Bearing

Types of ball bearings and roller bearings, Bearing life, Selection of rolling contact bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading.

Sliding Contact Bearing

Types and selection of sliding contact bearings, Lubricants and lubrication, Hydrostatic and

Hydrodynamic journal bearing, Heat generation, Thrust bearing: pivot and collar bearing.

UNIT-4 **(8 Hours)**

Design of Transmission Elements

Comparison of gear drive with belt drive and chain drive,Law of gearing, Types of gear tooth, Terminologies and standard proportions of gear systems, Force analysis, Beam strength and wear strength of gear tooth, Failure of gear tooth, Design of spur gears.

Helical Gears

Terminology and proportions for helical gears, Force components on gear, Virtual spur gear, Beam strength and wear strength of helical gears, Design of helical gears.

UNIT-5 **(8 Hours)**

Bevel and Worm gear

Terminologies, Types and Applications of bevel and worm gears, Force analysis for bevel and worm gears.

Design of Springs

Types of helical springs, Properties of spring materials, Stresses and deflection of helical springs of circular wire, Design of helical springs subjected to axial load and axial twist.

Note: Design data book is allowed in the examination.

Books and References:

1. V.B. Bhandari, Design of Machine Elements, Tata McGraw HillCo.
2. R.S. Khurmi and J.K. Gupta, A Textbook of Machine Design, S. Chand
3. Sadhu Singh, Machine Design,Khanna Book Publishing Co.

Subject Code: KAE-502	Aerodynamics-I	L T P: 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the applications in aerodynamic of basic and advance fluid mechanics.	K2
CO-2	Understand the basic equations of one dimensional compressible flow and incompressible flow and the application of continuity, momentum and energy equations.	K2
CO-3	Apply the concept of the stream function and potential function & there used to and application of potential complex for mathematics solution of flow over an arbitrary body.	K3
CO-4	Apply the concept of the real time viscous flows through channel and pipes and laminar and turbulent boundary layer flow. And their applications.	K3
CO-5	Apply the concept of the transformation of types of bodies into airfoil and changes flow properties due to transformation of body shape.	K3
CO-6	Apply the concept of the thin airfoil theory and wing theory and analysis of drag and lift forces on airfoil and wing according to these theories.	K3

UNIT-1 **(9 Hours)**

Two Dimensional Ideal Fluid Flow

Various types of fluid flow, Newton's law of viscosity, linear and angular deformations, path line, streamline equations, angular velocity, circulation, vorticity, vortex tube rotational &irrotational flow. Stream function and potential functions & relation between them, Kelvin'stheorem,Kutta-Joukowski theorem for lift, Aerodynamic forces on aircraft,Types ofaircraft wings,aspect ratio, aerodynamic center and center of pressure, Substantial derivative, continuity and momentum equations, impulse equations &resultant forces and direction.

UNIT-2 **(8 Hours)**

Viscous Flow Theory

Navier-Stoke's equations, Exact solutions of flow through channel (Couette flow) & flow through pipe (Poiseiulle flow), Velocities, stress and pressure distribution in these flows,Blasius solution of laminar flow, Boundary layer theory, Laminar and turbulent boundary layers, Boundary layer separation and its control. Suction, blowing of boundary layer, Boundary layer thickness and momentum thickness of laminar and turbulent, average skin friction coefficients and Drag force due to skin friction coefficients.

UNIT-3 **(9 Hours)**

Complex Potential

Its properties and applications to various flows such as uniform flow, source & sink flow, vortex flow, corner flow, source & sink doublet flow, vortex doublet flow, full and half body Rankine flow, stationery and rotating cylinder. Blasius Theorem, general expressions for lifts and drags on a body, According to Blasius Theorem. Types of Vortex, interaction and superimpose of vortices, Induced velocity due to vortices interaction, Nomenclature of airfoil & characteristics and types of airfoils.

UNIT-4 **(8 Hours)**

Thin Airfoil Theory (2-D Wing Theory)

Concept of circulation, generation of lift on thin airfoil,Vortex sheet, Kutta condition on thin airfoil, thin airfoil theory, Lift and pitching moment coefficient of flat plate (symmetric airfoil) and curved plates (cambered airfoils),Effect of flaps on aerodynamic coefficients. Mapping of flow fields, Joukowski transformation theorem, Joukowski transformation of circles into airfoil shapes, elliptical airfoil, Determination of pressure and velocity distributions on an airfoil.

UNIT-5 **(8 Hours)**

Lifting line theory (Finite Wing Theory)

Bound vortex and starting vortex, Vortex system of wing, horse-shoe vortex. Helmholtz's theorems,Biot-Savart's law, Induced velocity (downwash) of infinite, semi-infinite and finite filaments. Prandtl's classical lifting line theory, elliptic lift distribution, influence of aspect ratio on lift and drag, drag polar and lift correlation to aspect ratio. Calculation of lift and vortex induced drag, Panel methods: General description of the panel methods.

Books and References:

1. E.L. Houghton and A.E. Brock, Aerodynamics for EngineeringStudents.
2. W.F. Durand (Editore), Aerodynamics Theory, Vols. I to VI, Dover Publications, 1963.
3. A.H. Shapiro, Dynamics and Thermodynamics of Compressible Flow Volts.
4. John D. Anderson, Fundamentals ofAerodynamics.
5. A Ferri, Elements of Aerodynamics of Supersonic Flow, MacMillan,1949.
6. D.O. Dommasch, S.S. Sherby& T.F. Connolly, Airplane Aerodynamics

Subject Code: KME 551	Heat and Mass Transfer Lab	L T P : 0 0 2	Credits: 1

The students will be able to		Blooms Taxonomy
CO1	Apply the concept of conductive heat transfer.	K3
CO2	Apply empirical correlations for both forced and free convection to determine the value of convection heat transfer coefficient	K3
CO3	Apply the concept of radiation heat transfer for black and grey body.	K3
CO4	Analyze the thermal behaviour of parallel or counter flow heat exchangers	K4
CO5	Conduct thermal analysis of a heat pipe	K4

List of Experiments

Minimum eight experiment of the following

1. To determine thermal conductivity of conductive material(s).
2. To determine thermal conductivity of insulating material(s).
3. To determine heat conduction through lagged pipe.
4. To determine heat transfer through fin under natural convection.
5. To determine the heat transfer Rate and Temperature Distribution for a Pin Fin.
6. Determination of thermal conductivity of different types of fluids.
7. Experiment on Stefan's Law - determination of emissivity, etc.
8. Experiment on convective heat transfer through flat plate solar collector.
9. To compare LMTD and Effectiveness of Parallel and Counter Flow Heat Exchangers.
10. To find the heat transfer coefficient for Forced Convection in a tube.
11. To find the heat transfer coefficient for Free Convection in a tube.
12. To conduct experiments on heat pipe.
13. To study the rates of heat
14. transfer for different materials and geometries.
15. Visit to a Thermal Power Station for practical exposure.

Subject Code:KAE-551	Design Of Aircraft Elements And Simulation Lab	L T P: 0 0 2	Credits:1

The students will be able to		Blooms Taxonomy
CO-1	Understand the ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	K2
CO-2	Understand the general sequence of steps followed during the simulation of 2-D and 3-D objects subjected to various structural loadings.	K2
CO-3	Understand the different methods of meshing and its advantages and drawbacks	K2
CO-4	Apply the concept of geometry modeling and simulation to practical 2-D and 3-D objects subjected to general loadings.	K3
CO-5	Apply the basic concepts of FEM and also the error estimation and convergence while analyzing the validity of the simulations.	K3

The following list of practical has to be done on any structural simulation software

1. Introduction to geometry modeling and simulation software
2. CAD drawing of 2-D and 3-D geometric models.
3. Understand the general procedure followed to simulate any structural problem.
4. Understand the basics of domain discretization (meshing).
5. Understand how different loading conditions are applied to a CAD model.
6. Understand the simulation of 2-D symmetric and axisymmetric models.
7. Structural analysis of different configurations of fuselage and wings.
8. Structural analysis of aircraft landing gear.
9. Simulation of beams and shafts subjected to static and fatigue loads.
10. Post-processing and error analysis of computation results.

Subject Code:KAE-552	Aircraft Instruments Lab	L T P: 0 0 2	Credit-1

The students will be able to		Blooms Taxonomy
CO-1	Understand the concept of RF emission, microwave emission and electrostatic discharge.	K2
CO-2	Apply the concept to Measure the electrical quantities by application of measuring equipment.	K3
CO-3	Understand the different types of antenna used for communication and navigation equipment.	K2
CO-4	Apply minimizing interference in radio instrument by means of screening and shielding.	K3
CO-5	Apply the concept of Design electronic and digital circuits and combinational logic circuits.	K3

Minimum 10 out of following experiments (or such experiments):

1. Safety precaution associated with radio equipment hazards: high voltage, RF emission and microwave emissions, Electrostatic discharge, etc.
2. Wiring and cabling demonstration and practice in radio circuits.
3. AVO meter, Megger and bonding testers: demonstration and practice.
4. Soft and hard soldering practices.
5. Identification and inspection of antenna: external wire aerials, blade and rod aerials:
6. D/F loops and suppressed aerials viewing on A/C and inspection for physical condition. Aerial masts, static discharger's etc. inspection and servicing.
7. To demonstrate Modulation and demodulation.
8. To study of Interference (filtering and shielding) Troubleshooting Practices.
9. Familiarization with different types of transmission lines
10. Familiarization with logic gates function.
11. To study the function of encoder with logic gates.
12. To study the function of decoder with logic gates.
13. Familiarization with engine indicating and crew alerting system(EICAS) used in aircraft.
14. Familiarization with electronic flight instrument system used(EFIS) used in aircraft.

Subjective Code: KAE-051	Aircraft Propulsion-I	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the difference in working of CI and SI engines, their parts and advantages and disadvantages.	K2
CO-2	Apply the concept of the thermal power, efficiency and works of CI and SI engines and the various terms associated with IC engines like knocking, detonation, etc.	K3
CO-3	Apply the concept of the different cycles associated with IC engines like Otto cycle, Diesel cycle, Dual cycle and their application in aerospace propulsions.	K3
CO-4	Apply the concept of the types of carburetors & fuel injection systems, requirements of fuel injection & carburetors in engines.	K3
CO-5	Understand the working of non-air breathing engines, their classification and principles of operation.	K2
CO-6	Apply the concept of the different types of cooling systems, types of lubricants and Lubrication oils, Crank case ventilation, Supercharger & turbochargers and their applications.	K3

UNIT-1 **(8 Hours)**

Introduction to IC Engines

Classification and basic terminology and applications of IC engines.Air standard cycles: Otto cycle, Diesel cycle, Dual cycle, Sterling cycle, Ericsson cycles, Comparison of Otto, Diesel and Dual cycles, factors affecting the fuel air cycle, Actual cycle.

Fuels

Fuels for SI and CI engine , Important qualities of SI and CI engine fuels, Rating of SI engine and CI engine fuels, Dopes, Additives, Gaseous fuels, LPG, CNG, Biogas, Producer gas, Alternative fuels for IC engines. Fuels for Jet engine, important qualities of Jet engine Rating of Jet engine fuels.

UNIT-2 **(8 Hours)**

CI&SI Engines

Working of two stroke and four stroke CI &SI engines, Auto ignition of end charge, Flame speed of CI & SI Engines, Ignition delay, abnormal combustion and its control for CI & SI engines, Knock and detonation, Pre-ignition and post-ignition. Pressure versus specific volume (p-v) and pressure versus time diagrams for normal combustion, detonation in CI & SI Engines, Effect of engine operating variables on knock, knock rating of CI & SI engines, Valve timing diagram of CI & SI engines, Antiknock agents.

UNIT-3 **(9 Hours)**

Combustion chamber design

Combustion chamber requirements for SI and CI engines, types of carburetors &fuel injection systems, requirements of fuel injection & carburetors in engines, Injection timings & Fuel pumps, Ignition timing and spark plug in SI engine. Exhaust emissions from CI & SI engine and its control, scavenging in 2 stroke CI & SI engines.

Ignition System

Ignition timing and performance, Effect of ignition timing on output. Factors effecting spark advance, Ignition timing and cylinder temperature, Ignition process in CI engine, Location of spark plug in SI engine. Battery ignition system, Magneto ignition aircraft engine plugs. Altitude effects on ignition apparatus.

UNIT-4 **(9 Hours)**

Cooling and Lubrication Systems

Different types of cooling systems, Radiators and cooling fans, Engine friction. Various types of lubrication systems, Principles of Lubrication, Type of lubricants, Lubrication oils, Crankcase ventilation, Supercharger & turbochargers and their applications, advantages & disadvantages.

Propellers

Various types of propeller, parameters of propeller & application of propellers in SI engine, thrust & efficiency of propeller.

UNIT-5 **(9 Hours)**

Introduction to Rocket Propulsion

Classification of rockets motors, Principles of chemical, electrical and nuclear rockets, General characteristics of solid and liquid propellant rockets, Total impulse, specific impulse and impulse to weight ratio, Thrust and thrust coefficient, Exhaust velocity and propulsive efficiency of rocket motors. Mass ratio, combustion efficiency and internal efficiency, Different solid & liquid propellants, Propellants burning rate, Electro thermal, electro static and electromagnetic propulsion systems.

Books and References:

1. V. Ganesan, Internal Combustion Engines, Tata McGraw Hill.
2. Regowski, AR. Elements of Internal Combustion Eng.1953.
3. Lichty L.C., Internal Combustion Engines, McGraw Hill Book Co.

Subject Code: KAE-052	Space Flight Mechanics	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the Familiarize the basic concepts of orbital mechanics and its description– effect of space environment on materials of spacecraft structure.	K2
CO-2	Understand the different terminologies related to space flight. The Newton's universal law of gravitation - the many body problems.	K2
CO-3	Apply the concept of the different laws of planetary motion and the different types of satellites and missile systems.	K3
CO-4	Apply the concept of the different phases of satellite and missile launching and their trajectory and the various techniques of satellite injection and further maneuvering.	K3
CO-5	Apply the concept of the natural means to navigate accurately to the destination and analyze the chart reading and problem occurring on dead reckoning.	K3

UNIT-I **(8 Hours)**

Basic Concepts

Peculiarities of space environment and its description– effect of space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time. 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 proofs of the laws – Newton's universal law of gravitation - the many body problems, the celestial Sphere.

UNIT-II **(9 Hours)**

The General N-Body Problem

The Ecliptic Motion of Vernal Equinox – Sidereal Time – Solar Time -Standard Time – The Earth's Atmosphere. Study the basic concepts of orbital Mechanics with particular emphasis on interplanetary trajectories. The many body Problem – Lagrange, Jacobian identity The Circular Restricted Three Body Problem – Libration Points – Relative Motion in the N-body Problem – Two – Body Problem – Satellite Orbits – Relations Between Position and Time – Orbital Elements.

UNIT-III **(8 Hours)**

Satellite Injection And Satellite Orbit Perturbations

General Aspects of satellite Injections, Satellite Orbit Transfer, Various Cases – Orbit Deviations Due to Injection – Errors – Special and General Perturbations – Cowbell's Method- Neck's Method - Method of vibrations of Orbital Elements- General Perturbations Approach.

UNIT-IV **(8 Hours)**

Interplanetary Trajectories

Two Dimensional Interplanetary Trajectories – Fast Interplanetary Trajectories – Three Dimensional Interplanetary Trajectories – 3-Dimensional Interplanetary Trajectories – Launch if Interplanetary Spacecraft – Trajectory estimation about the Target Planet, Concept of the sphere of influence, Lambert's theorem.

UNIT-V **(8 Hours)**

Ballistic Missile Trajectories And Materials

The Boost Phase-The Ballistic Phase – Trajectory Geometry- Optimal Flights – Time of Flight – Re-entry Phase – The Position of the Impact Point – Influence Coefficients. Space Environment - Peculiarities - Effect of Space Environment, the Selection of Spacecraft Material.

Books and Reference:

1. Cornelisse, J.W. “Rocket Propulsion and Space Dynamic”, W.H. Freeman & Co., 1984.
2. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley, 1993.
3. Parker E.R., “Material for Missiles and Spacecraft”, McGraw – Hill Book Co.

Subject Code: KAE-053	Air Navigation	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the basic concept natural and radio equipment's assisted navigation system.	K2
CO-2	Understand the basic principle of operation of radio navigation system and Air Traffic Control Communication.	K2
CO-3	Formulate a comparative study system of different navigation system.	K4
CO-4	Apply the concept to Navigate correctly to the destination by application of both types of navigation system.	K3
CO-5	Analyze the chart reading and problem occurring on dead reckoning applying in natural means to navigate accurately to the destination	K4
CO-6	Apply the knowledge of celestial navigation system to fix the location of object.	K3

UNIT-I **(9 Hours)**

The Problems of Air Navigation

Aids of Navigation VOR, ADF, ILS, GCA, TACAN, Doppler and basics of inertial navigation: their limitations and uses, Weather, Air Traffic Control Communication.

Chart Projection for Air Navigation

The Round Earth on a Flat Chart, Properties obtainable in Projection, Distance on a Sphere, Direction on a Sphere, The Lambert Projection, The Mercator Projection, The Gnomonic Projection, Stereographic Projection, and Projections for Weather Charts.

UNIT-II **(9 Hours)**

Magnetism

Elementary laws of magnetism, Terrestrial magnetism, Horizontal and vertical components of earth's magnetic field and their variation with latitude Isogonics and agonic lines, Isoclinic lines. Aircraft Magnetism, Resolution into P.Q. and R components, compass course deviation.

Instruments

Units of measurement of distances and height, The function of navigational Instruments, Speed Indicator, Rate of Climb indicator, Altimeter, Magnetic Compass, Turn and Bank Indicator, The Directional Gyro, The Artificial Horizon, Radio, Radar Altimeter, Mach meter& Fluxgate Compass.

UNIT-III **(9 Hours)**

Chart Reading

Distinctive Properties of Charts, The importance of chart reading, Topographic Information Aeronautical Data, Legend and written Notes, The practice of Chart Reading.

Dead Reckoning

The place of Pilot age, Advantage of Dead Reckoning, Basic Problems in Dead Reckoning.

Special Problems & Dead Reckoning

Climb and Descent, off course corrections, Double Drift, Radius of Action, Cruise Control, Alternate Airport Problem, Interception, Tracking.

UNIT-IV **(8 Hours)**

Radio Navigation

Principles of radio transmission and reception, properties of electromagnetic waves, classification of frequency bands, elementary knowledge of Radar. Radio and radar aids and systems: Airborne D/F The manual loop and automatic radio compass including methods of calibration Ground D/F M.F., H.F. and V.H.F. Systems. Radio/Radar track guides approach and landing aids and systems including V.O.R., N.D.B. and I.L.S. Plotting Radio Bearings on Mercator Charts.

UNIT-V **(8 Hours)**

Celestial Navigation

Elements of Astronomy, the universe, Solar system, movements of earth, moon and planets, earth's orbit, Kepler's laws, declination, altitude, azimuth etc, Practical Value, Accuracy, Simplicity, Basic principles, The Line of position, Celestial Coordinates, Determining the Greenwich Hour Angle (GHA) Determining the Local Hour Angle (LHA), Radio Time Signals, Identification of Stars, Star Names, Brightness of Star, the planets, Motion of the Stars and Planets. The Practice of Celestial Navigation, Astro-Navigation instruments.

Books and References:

1. C.W. Martin, Air Navigation.
2. D.C.T. Benett, The Complete Air Navigation.
3. T.C. Lyon, Practical Air Navigation.
4. RAT Manual of Air Navigation, A.P. 1234Vols. A, B, D &E.

Subject Code: KAE-054	Aircraft Materials & Nondestructive Testing	L T P: 300	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the fabrication of aircraft parts of composites materials and should analyze sandwich , honeycomb and laminated plates	K2
CO-2	Understand the various maintenance practices in plastic and composite parts of aircraft and Should be aware of crack detection, inspection of parts.	K2
CO-3	Apply the concept of the hot oil and chalk, dye-penetrate, magnetic particles, X-ray, ultrasonic testing technique.	K3
CO-4	Understanding the working methodology, advantages and disadvantages of Nondestructive testing.	K2
CO-5	Apply the concept of the steps involved in the NDT process and the safe typractices in aircraft maintenance and NDT Process.	K3

UNIT-I **(8 Hours)**

Aircraft materials

Ferrous materials, nonferrous materials and alloys, ceramic materials and fiber reinforced composite materials, polymers, metal matrix particulate, Engineering Materials, Structural properties of materials, Atomic and lattice structure, bonding in Solids, Imperfections in crystals, Solid phase and phase diagrams ,Furnishing Materials: Plastic, wood, plywood, glue, dopes and rubber used in aircraft manufacture. Paints, surface finishes and materials.

UNIT-II **(9 Hours)**

Properties and testing

Isotropy, Orthotropic, True stress and strain, Strength and elasticity, Stiffness, Resistance, Plasticity, Ductility, Toughness and Hardness of materials, Concept of Fatigue and Creep, Mechanical Testing, Factors Affecting Strength, Deformation, Plasticity and Viscous elasticity, Fracture, Heat treatment, Chemical, thermal and technological Properties of testing and storage.

UNIT-III **(8 Hours)**

Specifications

Indian Standard, British, American, French, German, and International specifications, Corrosion of material, its detection and prevention. Protective finishes, Testing Destructive and non-destructive testing techniques. Crack detection, inspection of parts by hot oil and chalk, dye-penetrate, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods.

UNIT-IV **(9 Hours)**

Non-destructive testing

Importance of NDT in quality assurance. Different types of non-destructive techniques to obtain information regarding size, location and orientation of damage or cracks. Visual inspection techniques coin tapping technique for composite structures and adhesive bonds. Ultrasonic testing: Pulse echo technique, pitch-catch technique, through transmission technique, A-scan B-Scan the methods of NDT and highlight its role in quality assurance. The emphasis should also be on its application during the process of design, manufacturing and maintenance.

UNIT-V **(8 Hours)**

X-ray radiography

Absorption spectra, short wave length, X-ray for detection of voids. Die penetration technique, Magnetic particle testing.

In each of the above techniques

a) Theory and basic principles,
b) advantages/disadvantages,
c) material of parts that can be inspected,
d) Physical size and shape limitation,
e) economics of process,
f) types of defects that can be detected,
g) environment limitation are to be discussed along with equipment used for each of the techniques.

Books and References:

1. K Hajra Chowdhary S, Materials, Science and Engineering Processes, Media Promoters
2. George E. F. Titterton, Aircraft Materials, English Book Stores, Delhi
3. M L Begman, Manufacturing Processes, Asia Publishing House, Bombay.
4. Nondestructive Testing, Edword Arnold, U.K

Subject Code: KAE-055	Aircraft Instruments	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand layout of instruments in cockpit, convert numbers from one to other system and logic gates.	K2
CO-2	Understand operation of data conversion, transportation of data and bus architecture used in aircraft.	K2
CO-3	Apply the concept of microprocessor architecture, operation and its elements function in aircraft digital system.	K3
CO-4	Apply the knowledge of shielding, screening, earthing and static charge to reduce the interference in the electronics instruments.	K3
CO-5	Apply the concept of Design of basic display system used in aircraft instruments and operation of avionic system used in aircraft.	K3

UNIT-I **(8 Hours)**

Electronic Instrument System and logic gates

Typical system arrangement and cockpit layout of Electronics instrument systems. Numbering System: binary, octal and hexadecimal: Demonstration of conversion between the decimal And binary, octal and hexadecimal systems and vice versa. Logic Circuits: Identification of common logic gate symbols and equivalent circuits. Application used for aircraft systems.

UNIT-II **(8 Hours)**

Data Conversion and data buses

Analogue Data, Digital Data: Operation and application of analogue to digital, and digital to analogue converters, inputs and outputs, limitations of various types Data Buses: Operation of data buses in aircraft systems, including knowledge of ARINC and other specifications. schematic diagrams. Interpretation of logic diagrams.

UNIT-III **(9 Hours)**

Microprocessors

Functions performed and overall operation of a microprocessor. Basic operation of each of the following microprocessor elements: control and processing unit, clock, register, arithmetic logic unit.

Integrated Circuits

Operation and use of encoders and decoders; Function of encoder types; Uses of medium, large and very large scale integration. Multiplexing. Operation, application and identification in logic diagrams of multiplexers and de-multiplexers.

UNIT-IV **(9 Hours)**

Fiber Optics

Advantages and disadvantages of fiber optic data transmission over electrical wire propagation: Fiber optic data bus, Fiber optic related terms, Termination, Couplers, control terminals, remote terminals. Application of fiber optics in aircraft systems.

Electronic Displays

Principles of operation of common types of displays used in modern aircraft, including Cathode Ray Tubes, Light Emitting Diodes and Liquid Crystal Display. Electrostatic Sensitive Devices. Special

handling of components sensitive to electrostatic discharges. Awareness of risks and possible damage, component and personnel anti-state protection devices.

UNIT-V **(9 Hours)**

Electromagnetic Environment

Influence of the following phenomena on maintenance practices for electronic system: EMC-Electromagnetic Compatibility EMI Electromagnetic Interference HIRF-High Intensity, Radiated Field. Lightning, lightning protection.

Digital aircraft system and associated BTTE(Built in Test Equipment)

Such as: ACARS-ARINC Aircraft Communication & Addressing and Reporting System, ECAM-Electronics. Centralized Aircraft Monitoring. EFIS-Electronics Flight Instrument System, EICAS-Engine Indication & Crew Alerting System, FBW-Fly by Wire, FMS-Flight Management System, GPS-Global Positioning System & IRS-Inertial Reference System.

Books and References:

1. Aircraft instruments E H J Pallett, Pearson.
2. Aircraft digital electronic and computer system Mike Tooley, Elsevier.
3. Aircraft instruments and integrated system E H J Pallett, Pearson.
4. Aircraft instrumentation and system, S Nagabhushana and L. K. Sudha, I. K. International Pvt Ltd,
5. Aircraft instruments and avionics Max F. Henderson, Jeppesen

Subject code: KAE-056	Mechanical Vibrations	L T P:3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the different types of vibrations and its effect on the structural integrity.	K2
CO-2	Apply the concept the frequency and mode shapes corresponding to single and multi-degree of freedom systems.	K3
CO-3	Apply the concept of Single degree free and force vibration and the methods to minimize the effects of vibration.	K3
CO-4	Understand the continuous and discrete vibration systems and Analyze the problems related to continuous vibration of beams and shafts.	K2
CO-5	Apply the concept to design mechanical components with due consideration of the effect of vibration.	K3

UNIT-I **(8 Hours)**

Introduction

Classification of Vibration Systems, Harmonic motion, Vector representation of harmonic motion, Natural frequency & response, Effects of vibration, superposition of simple harmonic motions, beats, Fourier analysis-analytical and numerical methods, Single Degree Freedom System, Equation of motion, Newton's method, D' Alembert's principle, Energy method etc, Free vibration, Natural frequency, Equivalent systems, Displacement, Velocity and acceleration, Response to an initial disturbance.

UNIT-II **(8 Hours)**

Single Degree Freedom

Forced Vibration Forced vibration, Harmonic excitation with viscous damping, steady state vibrations, Forced vibrations with rotating and reciprocating unbalance, Support excitation, Vibration isolation, Transmissibility, Vibration measuring instruments, Displacement, velocity and acceleration measuring instruments.

UNIT-III **(8 Hours)**

Two Degree Freedom

Introduction, Principal modes, Double pendulum, Torsional system with damping, Coupled system, Principle of vibration absorber, Un-damped dynamic vibration absorbers, Torsional vibration absorber, Centrifugal pendulum absorbers, Vibration isolators and Dampers. Critical speed of shafts

UNIT-IV **(8 Hours)**

Longitudinal & Torsional vibrations, Damped vibrations, Vibrations of systems with viscous damping, Logarithmic decrement, Energy dissipation in viscous damping, Whirling of uniform shaft, Shaft with one disc with and without damping, Multi-disc shafts, Secondary critical speed.

UNIT-V **(9 Hours)**

Multi-degree Freedom system

Exact Analysis, Un-damped free and forced vibrations of multi-degree freedom systems, influence coefficients, Reciprocal theorem, Torsional vibration of multi-degree rotor system, Vibration of

gear system, Principal coordinates, Continuous systems- Longitudinal vibrations of bars, Torsional vibrations of circularshafts**.** Multi Degree Freedom system: Numerical Analysis by Rayleigh's method, Dunkerely's, Holzer's and Stodola methods, Rayleigh-Ritz method.

Books and References:

1. Mechanical Vibrations - G. K. Groover, Jain Brothers, Roorkee.
2. Mechanical Vibrations-Theory & Practice, S Bhave, Pearson Education.
3. Mechanical Vibrations-Theory & Applications, Singhal, Katson Books.

Subject Code: KAE-057	Introduction To Aircraft Design	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understandthebasicconfigurationsofaircraftlayoutsandbalancingloadseffectsonaircraft and Maneuvering loads on tail planes.	K2
CO-2	Understand the special designs and specifications of aircraft, structural design of fuselage, wing and other aircraft parts.	K2
CO-3	Apply the concept of the basic maneuvers such as gliding flight and calculations of take-off and landing.	K3
CO-4	Apply the concept of the design of new prototype of aircrafts and able to present new layout or plan	K3
CO-5	Apply the concept of the about component axis balance and internal balance are read and understood for the measurements in wind tunnel.	K3

UNIT-I **(8 Hours)**

Introduction

Wing Loading and Thrust Loading Basic Design - Lift and Drag**,** Range and Endurance**,** Mission Requirements. Range and Endurance: Propeller-driven Aircraft, Fuel Consumption: Cruise Flight, L/D for Maximum Range and Endurance, Range and endurance for Jet-driven Aircraft, Estimation of Fuel for a Mission. Design Considerations: Power Plant, Gross Weight. Design Considerations: Airfoil Selection.

UNIT-II **(9 Hours)**

Design Considerations

Wing. Wing Design: Air foil. Wing Design: t/c, Camber and Leading-Edge Radius.

Wing Design

Aspect Ratio. Wing Design: Sweep, Twist and Taper Ratio, Wing Arrangements, Tail Arrangements, Aircraft Structure, Wing Loading and Power Loading, Thrust Loading and Wing Loading. Thrust Loading, Wing Loading. Wing Loading: Maneuver, Climb and glide. Take-off: Wing Loading and Thrust Loading, Take-off and landing distance, Stall and High Life Devices.

UNIT-III **(8 Hours)**

Wing Loading

Take-off and Landing, Revision (Wing Loading and Thrust Loading).Wing Loading: Designers Approach. Wing Loading: Designers Approach, Stability Considerations, Static Stability Basics, Wing and tail contribution to Longitudinal Static Stability, Conceptual Design, and Conceptual design Elevator Effectiveness, Elevator Effectiveness, Pitching moment, Elevator Effectiveness, Aircraft Maintenance Guidelines, Inspection for Aircraft, Weight Fraction.

UNIT-IV **(8 Hours)**

Introduction to Wind Tunnel

Low speed wind tunnels, main features of supersonic, transonic and hypersonic tunnels, shock tunnels, closed and open circuit tunnels, Design of contraction and diffuser and other components of wind tunnel. Instrumentation and calibration of test section, blockage effects and boundary layer corrections, correction to lift drag, moment coefficient due to wind tunnel wall interference.

UNIT-V **(8 Hours)**

Measuring devices in Test Section

Pitot tube static tube, yaw probes, five-hole probe, hot wire anemometers. Flow visualization techniques oil flow and smock flow. Flow field pressure measurements, Schlieren, shadowgraph and interferometer technique, laser Doppler, hot wire PIV technique, Wind tunnel balances, mechanical and strain gauge balances and their design. Scale effects. Non - aeronautical use of wind tunnels.

Books and References:

1. Daniel P Raymer, Aircraft Design: A conceptual approach, AIAA Series,1992.
2. D Stanton, The Design of Airplane, GRANADA, UK, 1983.
3. John D Anderson (Jr.), Airplane Performance and Design, McGraw Hill1999.

Subject Code: KAE-058	Aircraft Systems	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the need of flight control systems and its various parts operation of flight control system.	K2
CO-2	Apply the concept the operation of fire protection system, operation of air-conditioning and cabin pressurization system.	K3
CO-3	Apply the concept of hydraulic and pneumatic systems and eliminate the problems of these systems	K3
CO-4	Understand de-icing system, its effects in flying and oxygen system layout and utility.	K2
CO-5	Apply knowledge of electrical system to operate electronic and other mechanical parts in the aircraft.	K3

UNIT-I **(8 Hours)**

Flight Control Systems

Principles of flight control, flight control surfaces, control surface actuation, flight control linkage systems, trim and feel. Power control, mechanical, direct drive, electromechanical, electro-hydrostatic actuation, and multiple redundancies, fly by wire system, Airbus and Boeing implementations, Inter-relationship of flight control, guidance and vehicle management systems.

Air conditioning and Cabin pressurization

Air Supply – Sources including engine bleed, APU and ground Cart - Air-conditioning System component layout, functioning of individual components & routine checks on the system - Distribution System - Flow temperature and humidity control.

UNIT-II **(8 Hours)**

Fire protection system

Fire and smoke detection and warning system, Fire Extinguishers system, Portable fire extinguisher type of Fire detectors, standard operating procedures for fire on ground. Fuel System: Characteristics of aircraft fuel systems, System layout, checks during routine servicing, and common problems in the system components, Fuel system components, fuel transfer pumps, fuel booster pumps, fuel transfer valves, non-return valves, Fuel quantity measurement systems, level sensors, fuel gauging probes, Fuel pressurization, engine feed, use of fuel as heat sink, external fuel tanks, fuel jettison, in-flight refueling.

UNIT-III **(8 Hours)**

Hydraulic and Pneumatic System

System layout, hydraulic reservoirs and accumulators, pressure Generation, pressure control, indication and warning system functioning of hydraulic pump, Checks on hydraulic oil, Pneumatic layout System. Pneumatic reservoirs and accumulators, pressure Generation, pressure control, indication and warning system functioning of Air Pump of Pneumatic Systems. Sources of pneumatic power, the engine bleed air, engine bleed air control, Uses of pneumatic power.

UNIT-IV(L- 8 Hours)

Ice protection system

Ice formation classification and detection, anti-icing system, de-icing system, and working of system in general, Effect of ice formation on functioning on various systems.

Oxygen system

System layout, supply regulation, sources, storage charging and distribution. Indications and warning Engine oxygen system, procedures for carrying out oxygen leak check, precaution while working on oxygen system.

UNIT-V(L- 8 Hours)

Electrical Systems

Aircraft electrical system characteristics, power (AC and DC) generation, Power generation control, voltage regulation, parallel operation, supervisory and protection functions. Modern electrical power generation types, constant frequency, variable frequency, variable speed constant frequency types, Primary power distribution, power conversion and energy storage. Secondary power distribution, power switching, load protection. Electrical loads, motors and actuators, lighting, heating, subsystem controllers, ground power, Emergency power generation, and Electrical load management system.

Books and References:

1. Air frame and Power plant mechanics –Airframe Handbook of Civil Air craft Injection Procedure.
2. J V Casamassa and RD Bent, Jet Aircraft Power Systems, McGraw Hill.
3. E H J Pallet, Automatic Flight Control, BSP ProfessionBooks.1993.
4. Civil Aircraft Inspection Procedures (CAP 459), Himalayan Books.

SEMESTER-VI

Subject Code: KAE-601	Aircraft Structure	L T P: 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the different components of aircraft structure and the loads acting on them.	K2
CO-2	Understand the common equations of solid mechanics using the theory of elasticity approach.	K2
CO-3	Apply the suitable theories of failure while designing the aircraft structural components.	K3
CO-4	Apply the basic concepts to design a new prototype of aircraft and able to present new layout or plan.	K3
CO-5	Develop the ability to analyze bending, torsion and buckling problems to a practical level and not just rely on the simple approximations.	K2
CO-6	Apply the vibration concepts to find out the mode shapes during vibration of muti-degree of freedom systems.	K3

UNIT-1 **(9 Hours)**

Introduction

Different structural components of aircraft and their configuration, Types of loads acting on aircraft structure, V-n diagram and Gust envelope, Properties and selection of aircraft materials, Honeycomb structures, Use of thin-walled cross-sections in aircraft structural components.

Composite Materials

Composition and Types of composite materials, Effective modulus of composite laminates, Applications of composites.

UNIT-2 **(8 Hours)**

Theory of Elasticity

Stresses on inclined plane subjected to tri-axial loading, 3-D principal stresses and strains, Stress-displacement relations, Strain compatibility, Equilibrium equations, Generalized Hooke's law, Types of materials based on elastic symmetry: anisotropic, orthotropic and isotropic materials. Plane stress and plane strain conditions, governing equations for plane elasticity, Compatibility relation in terms of stress components, Airy's stress function, Solution of plane elasticity problems using Airy's stress function.

UNIT-3 **(9 Hours)**

Torsion

St. Venant's torsion theory, Warping in shafts of circular and non-circular cross-sections, Difference between polar moment of inertia and torsional rigidity, Prandtl's stress function, Torsion of open and closed thin-walled sections, Torsion of multi-cell closed sections, Torsional shear flow.

Unsymmetrical Bending

Euler-Bernoulli beam equation for unidirectional and bidirectional bending, Timoshenko beam equation, Deflection of cantilever beam using Euler-Bernoulli and Timoshenko beam theory, Bending of unsymmetrical cross-sections, Structural idealization.

UNIT-4 **(8 Hours)**

Flexural Shear Stress

Transverse shear stress in solid cross-sections, Transverse shear stress and shear flow in general symmetric and unsymmetrical thin-walled sections, Location of shear center in open and closed cross-sections, Shear flow in multi-cell thin-walled sections, Combined torsional and flexural shear flow.

Buckling of Columns and Plates

Derivation of governing equation for column buckling, Euler's and Rankine's buckling load, Effect of end conditions on column buckling, buckling of thin plates.

UNIT-5 **(8 Hours)**

Vibration

Basic concepts of vibration, Types of vibration, General governing equation for vibration, Un-damped and Damped free vibration, Forced vibration, Logarithmic decrement, Torsional vibrations, Vibration of Two Degree of Freedom System, Coordinate coupling, Semi-definite systems

Vibration of Continuous Systems

Torsional vibration of shaft, longitudinal vibration of bars and lateral vibration of beams.

Books and References:

1. C. T. Sun, Mechanics of Aircraft Structures, John Wiley and Sons
2. T.H.G. Megson, Aircraft Structures for Engineering Students, Butterworth-Heinemann
3. S. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw Hill Education.
4. V. P. Singh, Mechanical Vibrations, Dhanpat Rai and Co.
5. Singiresu S. Rao, Mechanical Vibrations, Pearson Education

Subject Code: KAE-602	Aerodynamics-Ii	L T P: 3 1 0	Credits: 4

The students will be able to		Blooms Taxonomy
CO-1	Understand the basic equations of one dimensional compressible flow and the energy, momentum and continuity equations and its applications.	K2
CO-2	Understand the normal, oblique shock waves and expansion waves and Hodograph shock polar. Strong, weak and detached shocks	K2
CO-3	Apply the concept of blade propeller theory and understanding of elementary concept of helicopter hovering and climbing, helicopters Methods of control collective and cyclic pitch.	K3
CO-4	Apply the concept of linearized and exact 2-D supersonic flows theory and its application for calculation of lift and drag and pitching moment's centre of pressure.	K3
CO-5	Understand the calibration of a wind tunnel and differentiate the wind tunnels on the basis of circuit and the component axis balance and internal balances.	K2
CO-6	Apply the concept of and the measurements techniques in wind tunnel and the flow visualization techniques used in the wind tunnel testing.	K3

UNIT-I **(8 Hours)**

One dimensional compressible flow

1-DFlow equations, Velocity of sound, Isentropic subsonic and supersonic flows through converging and diverging passages, Supersonic flow through constant area ducts (Fanno flow), Rayleigh flow & flow through C-D nozzle. Area-velocity relations, Mach wave, Mach angle. Critical Mach number, critical pressure and & drag divergent, Area rule for design.

UNIT-II **(8 Hours)**

2-D supersonic flow

Two-dimensional flow equation, supersonic flow past wedges and concave corners, Normal shock & oblique shock waves, Normal shock relations & Oblique shock relations, Hodograph shock polar. Strong, weak and detached shocks, Prandtl-Meyer expansion flow past two dimensional concave corners, Expansion hodograph, Reflection of shocks and expansion waves Method of characteristics.

UNIT-III **(8 Hours)**

Differential Equation of motion

Steady compressible flows, Small perturbation potential equations, Solution for subsonic and supersonic flow, Prandtl-Glauert transformation relation for subsonic flows. Linearized and exact 2-D supersonic flows theory and its application for calculation of liftand drag and pitching moments centre of pressure, Method of characteristics, Prandtl-Glauert correction. Compressibility effects on aerodynamic coefficients.

UNIT-IV **(9 Hours)**

Aerodynamic Testing

Aerodynamic testing facilities for different speed regimes, low speed wind tunnels, closed and open circuit tunnels. Main features of Subsonic, supersonic and transonic tunnels, shock tunnels, Instrumentation and calibration of test section. Testing procedure, data reduction, blockage

effects and boundary layer corrections, correction to lift and drag,

Measuring devices in Test Section

Pitot static tube, yaw probes, five-hole probe, hot wire anemometers. Flow visualization techniques oil flow, tuft survey and smoke. Flow field pressure measurements, Schlieren, shadowgraph and interferometer technique, laser Doppler and PIV technique.

UNIT-V **(9 Hours)**

Propellers momentum and blade theories

Aerofoil characteristics in forward flight, use of propeller charts, Effect of solidity, profile drag, compressibility etc, Blade area required, number of Blades, Blade form. Selection and performance of fixed and variable pitch propellers, configurations based on torque reaction-Jet rotors and flapping and feathering, Rotor controls and various types of rotor, Blade loading, Power losses and Rotor efficiency.

Aerodynamics of Rotor Blade

Elementary concept of helicopter hovering and climbing, helicopters Methods of control collective and cyclic pitch changes - Lead - Lag and flapping hinges, Blade stall, maximum lift of the helicopter calculation of Induced Power, High speed limitations; parasite drag, power loading, ground effect.

Books and References:

1. John DAndersonJr., Fundamentals of Aerodynamics,2nd Ed.,McGrawHill.
2. JJ Bertinand, ML Smith, Aerodynamics for Engineers, 2nd Ed., PrenticeHall.
3. E. Rathakrishnan, Gas Dynamics, Prentice Hall of India.
4. John D Anderson Jr., Compressible flow, The basics with Applications, McGraw Hill.
5. E.L. Houghton and A, E, Brock, Aerodynamics for Engineering Students, Edward Arnold.

Subject Code: KME 603	Theory of Machines	L T P : 3 1 0	Credits: 4

Course Outcomes: The students will be able to		Blooms Taxonomy
CO1	Understand the principles of kinematics and dynamics of machines.	K2
CO2	Calculate the velocity and acceleration for 4-bar and slider crank mechanism	K3
CO3	Develop cam profile for followers executing various types of motions	K3
CO4	Apply the concept of gear, gear train and flywheel for power transmission	K3
CO5	Apply dynamic force analysis for slider crank mechanism and balance rotating & reciprocating masses in machines.	K3
CO6	Apply the concepts of gyroscope, governors in fluctuation of load and brake & dynamometer in power transmission	K3

Unit I **(09 Hours)**

Introduction, mechanisms and machines, kinematics and kinetics, types of links, kinematic pairs and their classification, types of constraint, degrees of freedom of planar mechanism, Grubler's equation, mechanisms, inversion of four bar chain, slider crank chain and double slider crank chain.

Velocity analysis

Introduction, velocity of point in mechanism, relative velocity method, velocities in four bar mechanism, instantaneous center.

Acceleration analysis

Introduction, acceleration of a point on a link, acceleration diagram, Corioli's component of acceleration, crank and slotted lever mechanism,.

Unit II **(10 Hours)**

Cams

Introduction, classification of cams and followers, cam profiles for knife edge, roller and flat faced followers for uniform velocity, uniform acceleration

Gears and gear trains

Introduction, classification of gears, law of gearing, tooth forms and their comparisons, systems of gear teeth, length of path of contact, contact ratio, minimum number of teeth on gear and pinion to avoid interference, simple, compound, reverted and planetary gear trains, sun and planet gear train.

Unit III **(08 Hours)**

Force analysis

Static force analysis of mechanisms, D'Alembert's Principle, dynamics of rigid link in plane motion, dynamic force analysis of planar mechanisms, piston force and crank effort. Turning moment on crankshaft due to force on piston, Turning moment diagrams for single cylinder double acting steam engine, four stroke IC engine and multi-cylinder engines, Fluctuation of speed, Flywheel.

Unit IV **(09 Hours)**

Balancing

Introduction, static balance, dynamic balance, balancing of rotating masses, two plane balancing,

graphical and analytical methods, balancing of reciprocating masses, balancing of single cylinder engine.

Governors

Introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, inertia governors. Effort and Power of governor.

Unit V **(09 Hours)**

Brakes and dynamometers

Introduction, Law of friction and types of lubrication, types of brakes, effect of braking on rear and front wheels of a four wheeler, dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer

Gyroscope

Space motion of rigid bodies, angular momentum, gyroscopic couples, gyroscopic stabilization, ship stabilization, stability of four wheel and two wheel vehicles moving on curved paths.

Text / Reference Books

1. Kinematics and dynamics of machinery: Wilson and Sadler, Third edition, Pearson.
2. Theory of Mechanisms and Machines: Amitabh Ghosh and Ashok Kumar Mallik, Third Edition Affiliated East-West Press.
3. Theory of Machines and Mechanisms: Joseph Edward Shigley and John Joseph Uicker, Jr. Oxford University Press
4. Kinematics and dynamics of machinery: R L Norton, McGraw Hill
5. Theory of Machines: S.S. Rattan, McGraw Hill
6. Theory of Machines: Thomas Bevan, CBS Publishers.

Suggested Software

MechAnalyzer

Subject Code: KAE-651	Aircraft Propulsion Lab	L T P: 0 0 2	Credit: 1

The students will be able to		Blooms Taxonomy
CO-1	Understand the difference in constructional arrangement of turbojet, turbofan, turboprop and turbo-shaft engines.	K2
CO-2	Understand the operation of different types of propellers and engine starting system and firing order of multi cylinder spark ignition.	K2
CO-3	Apply the concept of thrust, work done and efficiencies of turbojet, turbofan, turboprop and turbo-shaft engines.	K3
CO-4	Apply the concept of Analyze performance estimation of aircraft for the purpose of evaluation.	K3
CO-5	Understand the difference in operation and working process of two stroke and four stroke engines.	K2
CO-6	Apply the concept of Formulate a system for estimation of flight performance and stability with lift drag and thrust characteristics.	K3

Minimum 10 out of following such experiments (or such experiments)

1. To demonstrate the constructional arrangement and operation of turbojet and turbofan.
2. To demonstrate the constructional arrangement and operation of turboprop and turbo-shaft.
3. Recognition of visual defects of jet engines.
4. To demonstrate the operating principal 2-stroke and 4-strokeCIengines.
5. To demonstrate the operating principal 2-stroke and 4-strokeSIengines.
6. To demonstrate the operating principle of air cooled and water cooled piston engines.
7. To demonstrate the engine configuration and firing order.
8. To demonstrate the working of engine starting systems.
9. To demonstrate the installation and removal procedure of propellers.
10. To demonstrate operation of fixed and variable pitch propellers.
11. To demonstrate operation of turbine blades to turbine disc.
12. To demonstrate the working of exhaust gas temperature measurement system.
13. Calculate the cylinder area, sweep area and compression ratio for CI engine.
14. Test a piston engine and determine: Specific fuel consumption, Break horsepower, and Indicated horse power for four stroke petrol engines.
15. Test a piston engine and determine: Break thermal efficiency, Mechanical efficiency. Volumetric efficiency for four stroke petrol engine.
16. To determine velocity and pressure measurements in co-axial jets.

Subject Code: KAE-652	Aerodynamic Design And Testing Lab	L T P: 0 0 2	Credit: 1

The students will be able to		Blooms Taxonomy
CO-1	Understand the difference surface control arrangement of elevator, aileron, redder, flaps and spoiler.	K2
CO-2	Understand the Understand the operation of different types of wind tunnel and its calibration.	K2
CO-3	Apply the concept of flow visualization studies in low speed flow over airfoil with different angle of incidence.	K3
CO-4	Apply the concept of Pressure distribution of various airfoils can be identified and lift can be calculated.	K3
CO-5	Understand the force measurement using wind tunnel balance the velocity of the subsonic wind tunnel at various RPM.	K2
CO-6	Apply the concept of measurement technique of pressure, velocity, lift and drag forces in wind tunnel.	K3

Minimum 10 out of following such experiments (or such experiments)

1. To demonstrate the longitudinal, lateral and directional stability.
2. To demonstrate the effect of roll control: ailerons and spoilers &yaw control, rudder limiters.
3. To demonstrate the effect of pitch control pitch control: elevators and horizontal stabilators & variable stabilizers and canards.
4. To demonstrate the effect of high lift devices: slots, slats, flaps etc.
5. To demonstrate the effect of drag inducing devices: spoilers, lift dumpers, speed brakes:
6. Wind tunnel as a tool, their classification, uses and applications.
7. Flow visualization studies over airfoils /Cylinder in Smoke Tunnel.
8. Calibration of a subsonic Wind tunnel.
9. Measurement of pressure gradient along a wind tunnel.
10. Plot lift vs. angle of attack for the given airfoil at various speed.
11. Measurement of flow velocity in Wind tunnel by Hotwire Anemometer
12. Pressure distribution over a symmetric and cambered aerofoil.
13. Measurementofvelocityprofileinfavorableandadversepressuregradient.
14. Estimationofforcesanddragactingoverasymmetricalairfoilwithdifferentangleofattack.
15. Estimation of forces and drag acting over an unsymmetrical airfoil with different angle of attack.
16. Pressure distribution over an airfoil and to find lift and drag.
17. Pressure distribution over a 2D cylinder and to find lift and drag.

Subject Code: KME 653	Theory of Machines Lab	L T P : 0 0 2	Credits: 1

The students will be able to:		Blooms Taxonomy
CO1	Demonstrate various mechanisms, their inversions and brake and clutches in automobiles	K2
CO2	Apply cam-follower mechanism to get desired motion of follower.	K3
CO3	Apply the concepts of gears and gear train to get desired velocity ratio for power transmission.	K3
CO4	Apply the concept of governors to control the fuel supply in engine.	K3
CO5	Determine the balancing load in static and dynamic balancing problem	K3

List of Experiments

(Minimum eight experiments out of the following)

NOTE: Student has to write computer program in C / C++ / Python and to run to compute the output values for at least ONE experiments.

1. To study various types of kinematics links, pairs, chains & Mechanisms
2. To study Whitworth Quick Return Motion Mechanisms, Reciprocating Engine Mechanism, and Oscillating Engine Mechanism
3. To study of inversions of four bar linkage
4. To study of inversions of single/double slider crank mechanisms
5. To study various types of gear (Helical, cross helical, worm, bevel gear) and gear profile (involute and cycloidal) and condition for interference Helical, cross helical, worm, bevel gear
6. To compute the output velocity invarious gear trains
7. To study gyroscopic effects through models
8. To determine gyroscopic couple on Motorized Gyroscope
9. To perform experiment on dead weight type governor to prepare performance characteristic Curves, and to find stability & sensitivity
10. To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity
11. To determine whirling speed of shaft theoretically and experimentally
12. To perform the experiment for static / dynamic balancing
13. To perform experiment on brake
14. To perform experiment on clutch
15. To perform the experiment for static / dynamic balancing.
16. To perform experiment on longitudinal vibration
17. To perform experiment on transverse vibration

Subject Code: KAE-061	Aircraft Propulsion-Ii	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the working of turbojet, turboprop, turbofan and turbo-shaft engines and advantages and disadvantages, its applications.	K2
CO-2	Understand the jet propulsion is and how thrust is produced the working of turbofan, turbojet, turboprop and turbo-shaft engines.	K2
CO-3	Apply the concept of the energy transfer in turbo-machines and application of Euler momentum equation of.	K3
CO-4	Understand the characteristics and applications of different types of compressor and Principle of operations, design of radial blades, Analysis of work done and efficiencies.	K2
CO-5	Understand the process of combustion, types of combustors and related terminologies. Fuel injection atomization in simplex and duplex burners.	K2
CO-6	Apply the concept of the working of nozzles and inlets and their application in aircrafts & rockets.	K3

UNIT-I **(8 Hours)**

Introduction to Jet Engines

Development of Jet Aircraft Propulsion, Turbojet, Turbofan, Turbo-prop & Turbo shaft, various components & working of jet engines, Ramjet and Scramjet engine

Cycle Analysis

Brayton cycle, Ideal & real cycle analysis of turbojet & ramjet engine, Performance, Thrust equation.

UNIT-II **(9 Hours)**

Basics of Turbo machinery

Euler equation for turbo machinery and its significance, velocity triangles for a generalized turbo-machine, degree of reaction in turbo machines, free vortex and forced vortex.

Centrifugal compressor

Characteristics and applications, various parts and their working, Principle of operation, Analysis of work done and efficiencies, compressibility effects, Design of diffuser, Pressure losses, surging, chocking, and degree of reaction, Comparison between axial compressor & centrifugal compressor.

UNIT-III **(8 Hours)**

Axial Compressor

Characteristics and applications, parts of axial compressor. Principle of operation, two dimensional flow analyses, ideal and real work and efficiency of axial compressor, Analysis of Cascade effect & Losses, Factor effecting stage pressure, Blade design, stage performance estimation & off-design performance, compressibility effects, Degree of reaction, stalling, chocking & surging.

UNIT-IV **(8 Hours)**

Axial Turbine

Characteristics and applications, Blade (cascade) profile analysis. Analysis of multi-staging axial Turbine, estimation of stage performance, Work done, efficiency & degree of reaction, Turbine Cooling

Radial Turbine

Characteristics and applications, aerodynamics & thermodynamics, Principle of operations, design of radial blades, Analysis of work done and efficiencies, estimation of stage performance degree of reaction, Stalling& surging, Losses.

UNIT-V **(9 Hours)**

Combustion Chamber

Types of combustion systems, requirements, combustion process, mechanism & parameters, Combustion efficiency and intensity, losses, design of combustion chamber, combustion chamber performance, and Fuel injection atomization in simplex and duplex burners.

Nozzle

Nozzle configurations, under and over expanded nozzles, mass flow through a nozzle. Theory of isentropic C-D nozzles, Types of nozzles, their application in aircrafts & rockets.

Books and Reference -

1. Mechanics and Thermodynamics of Propulsion by Hill and Peterson.
2. V. Ganesan, Gas Turbines, McGraw Hill Education
3. H. Cohen and G.F.C Rogers, Saravanamutto, Gas Turbine Theory
4. J. Mattingly, Elements of Propulsion, Tata McGraw Hill

Subject Code: KAE-062	Introduction To UAV	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the basic types and configurations of aircraft layouts, composition and balancing loads effects on UAV.	K2
CO-2	Understand the different types of power plants, characteristics and the procedures for the propeller configuration in UAV.	K2
CO-3	Apply the concept of maneuvers such as gliding flight and calculations of CG of UAV and understanding the of aircraft design standards.	K3
CO-4	Understand with good knowledge about the navigation-ground control software system of UAV.	K2
CO-5	Apply the concept of design of new prototype of aircrafts and able to present new layout or plan special designs and specifications of UAV.	K3

UNIT-I **(8 Hours)**

Introduction to UAV

History of UAV –classification – Introduction to Unmanned Aircraft Systems models and prototypes System Composition-applications.

UNIT-II **(8 Hours)**

Design of UAV Systems

Introduction to Design and Selection of the System- Aerodynamics and Airframe Configurations Characteristics of Aircraft Types- Design Standards and Regulatory Aspects- UK,USA and Europe, Design for Stealth-control surfaces-specifications.

UNIT-III **(8 Hours)**

Avionics Hardware

Autopilot – AGL-pressure sensors-servos-accelerometer –gyros-actuators- power supply-processor, integration, installation, configuration, and testing.

UNIT-IV **(8 Hours)**

Communication Payloads and Controls

Payloads-Telemetry-tracking-Aerial photography-controls- PID feedback-radio control frequency range modems-memory system-simulation-ground test-analysis- trouble shooting.

UNIT-V **(8 Hours)**

Development of UAV Systems

Waypoints navigation-ground control software- System Ground Testing- System In-flight Testing Future Prospects and Challenges-Case Studies – Mini and Micro UAVs.

Books and References:

1. Reg. Austin “Unmanned Aircraft Systems UAV design, development”, Wiley, 2010.
2. Robert C. Nelson, Flight Stability and Automatic Control, McGraw-Hill, Inc, 1998.
3. Kimon P. Valavanis, “Advances in Unmanned Aerial Vehicles: to Autonomy”, Springer,2007.
4. Paul G Fahlstrom, Thomas J Gleason,“IntroductiontoUAVSystems”,UAVSystems,Inc,1998.

Subject Code: KAE-063	Spacecraft Technology	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand the basic types and configurations of aircraft layouts, the concepts involved in designing a spacecraft.	K2
CO-2	Understand the space environment and its effect on the spacecraft design and the various communication and power systems used in a spacecraft.	K2
CO-3	Apply the concept of types of electric thrusters, components and characteristics of an electric propulsion subsystem and advanced propulsion concepts.	K3
CO-4	Apply the concept of electrical power technology and control, power, structures, thermal, communications, and command and data handling.	K3
CO-5	Understand the basic spacecraft subsystems, including propulsion, attitude fundamentals of determination and control.	K2
CO-6	Apply the concept of standard practices followed for designing space systems.	K3

UNIT-I **(8 Hours)**

Introduction

Definition and terminologies related to spacecraft, introduction to different components and systems of a typical spacecraft. Study of some notable spacecrafts, Environment in the inner and outer space and how it affects the performance of spacecraft design, Basic considerations while designing a spacecraft.

UNIT-II **(8 Hours)**

Spacecraft Electronic Systems

Onboard Command and Data Handling including the specifications of microprocessors; commonly used data interfaces within spacecraft; the effects of radiation on processors and methods to deal with them; operational scheduling; failure detection, isolation and recovery), The basics of telecommunication and the main components of radios.

UNIT-III **(8 Hours)**

Spacecraft Structural Systems

Structures and deployable craft looking at structural concepts; structural materials; deployment mechanisms, etc, Thermal Control-both passive and active thermal control mechanisms and components, Methods of testing spacecraft components for structural strength and failure.

UNIT-IV **(8 Hours)**

Spacecraft Electrical Systems

Electrical Power Technology covering the selection and implementation of photovoltaic cells; different types of power conversion and distribution methods; battery technology; common failure modes and protection in terms of spacecraft applications.

UNIT-V **(8 Hours)**

Spacecraft Propulsion Systems

Applied Theory covering the fundamentals of rocket propulsion, main performance parameters of rockets and thrusters, ideal rocket theory basics and equations, Liquid Propellant Engines, Solid

Propellant Engines, hybrid rockets and pressure instabilities and real performance estimation.

Electric and Advanced Propulsion reviews the basics of electric propulsion theory, types of electric thrusters, components and characteristics of an electric propulsion subsystem and advanced propulsion concepts.

Books and References:

1. Cornelisse,J.W."RocketPropulsionandSpaceDynamic",W.H.Freeman&Co., 1984.
2. Sutton, G.P., "Rocket Propulsion Elements", John Wiley, 1993.
3. Van de Kamp, P., "Elements of Astro-mechanics", Pitman, 1979.
4. Parker E.R., "Material for Missiles and Spacecraft", McGraw – Hill Book Co., Inc., 1982.

Subject Code: KAE-064	Aircraft Evaluation	L T P: 3 0 0	Credits: 3

The students will be able to		Blooms Taxonomy
CO-1	Understand elements taken for consideration for the aircraft evaluation and various means to evaluate the performance of aircraft.	K2
CO-2	Understand the Evaluate by applying the aerodynamic characteristics and aircraft equipment performance during flying.	K2
CO-3	Apply the concept of aircraft aerodynamic properties and performance of aircraft instruments.	K3
CO-4	Apply the concept of Analyze performance estimation of aircraft for the purpose of evaluation.	K3
CO-5	Understand the design a data comparison system for performance characteristics of aircraft testing facility for aerodynamics characteristics.	K2
CO-6	Apply the concept of Formulate a system for estimation of flight performance and stability with lift drag and thrust characteristics.	K3

UNIT–I **(8 Hours)**

Basic Aerodynamics

International Standard Atmosphere and its significance pressure and density altitudes. Compressibility effect, Mach number and its variation with altitude and temperature Take-off and landing, single engine performance at altitude, climb and descent performance at altitude, Effect of horizontal speed during climb and decent on performance and economics , Cruise performance cruise at constant speed Constant altitude, constant angle of attack and their effect on block speed and economics

UNIT-II **(8 Hours)**

Aircraft Equipments

Cockpit layout and instrumentation, automatic landing system, Air Data Computer, ICAO Landing Categories, Communication and navigation equipment and their functions in general. Flight Recorder and Cockpit Voice Recorder and related regulatory requirements and there passenger amenities like passenger address system, crew intercom; music reproducer etc., Emergency facilities equipment and related regulation, Weather radar and its uses, Environmental control, air conditioning and pressurization their significance and necessity.

UNIT-III **(8 Hours)**

Aircraft Scheduling

Factor affecting airlines schedules, Commercial operation, Technical Metro logical, Airport Facilitation- runway Strength and related requirements, Load Classification. Criteria for runaway and aircraft, Air Traffic Control and other number and other ground Communication /navigation facilities-their relationship and effect on related aircraft equipment Airport emergency Facilities – Firefighting, First Aid etc. Total takeoff weight Balance diagram

UNIT-IV **(8 Hours)**

Performance Estimation

Power / Thrust availed and required Effect of altitude and forward speed on engine performance and power / thrust required, Level Flight performance, maximum minimum and optimum speeds, maximum range and endurance, Maximum rate of climb and its variation with altitude, Absolute and service ceilings, takeoff and landing distances, Effect of ambient temperature and wind on

landing and takeoff distances, One engine take off for multi-engine civil airplanes.

Longitudinal Stability

Preliminary calculations of horizontal tail setting, Static stability and static margin, V-N Diagram: Gust and maneuverability envelope.

UNIT-V **(8 Hours)**

Principles of Aerodynamic Testing

Brief history of the development of different types of Aerodynamic testing facilities, Drop tests, Rotating f tests. Low speeds high sub- sonic speed transonic supersonic and hyper – sonic wind tunnels. Wind tunnel types according to fabrications. Description and principle of operation, types of mode tests possible areas of application and limitations of each of the facilities, Basic principles of flight testing and performance reduction.

Books and Reference:

1. G. Corning , Supersonic and Subsonic Airplane Design
2. K.D Wood Aerospace Vehicle Design, Volume-I Aircraft design, Johnson Publishing Co.
3. F.K. Teichman, Air plane Design Manual , Sir Issac Pitman &Sons Ltd,1950
4. C.D. Perkins and R.E. Hage, Airplane Performance Stability and Control, John

B. Tech Aeronautical Engineering
Evaluation Scheme
Effective in Session 2021-22 (Yet to finalized)

MESTER- VII

Sl. No.	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-1/HSMC-2	3	0	0	30	20	50		100		150	3
2		Departmental Elective-IV	3	0	0	30	20	50		100		150	3
3		Departmental Elective-V	3	0	0	30	20	50		100		150	3
4		Open Elective-II	3	0	0	30	20	50		100		150	3
5		Lab-1	0	0	2				25		25	50	1
6		Mini Project or Internship Assessment*	0	0	2				50			50	1
7		Project	0	0	8				150			150	4
8		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**12**	**21**						**850**	**18**

*The Mini Project or internship (5 - 6 weeks) conducted during summer break after VI semester and will be assessed during VII semester.

SEMESTER- VIII

Sl. No	Code	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1		HSMC-2/HSMC-1	3	0	0	30	20	50		100		150	3
2		Open Elective-III	3	0	0	30	20	50		100		150	3
3		Open Elective-IV	3	0	0	30	20	50		100		150	3
4		Project	0	0	18				100		300	400	9
5		MOOCs (Essential for Hons. Degree)											
		Total	**9**	**0**	**18**	**27**						**850**	**18**

Subject Code: KAE-071	Flight Mechanics	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the standard atmosphere and its significance.	K2
CO-2	Understand the performance of an aircraft during different cruising and maneuvering regimes of flight.	K2
CO-3	Understand the conditions corresponding to static and dynamic stability of an aircraft.	K2
CO-4	Apply the principles of dynamic stability to prevent an aircraft from different divergent and oscillatory modes.	K3
CO-5	Apply the knowledge of structural, propulsion and aerodynamic considerations to predict the safe operating velocity for an aircraft.	K3

UNIT-1 **(8 hours)**

Introduction

Standard Atmosphere, variation of pressure and density with altitude, geo-potential and geometric altitude, pressure, temperature and density altitude. Forces and moments acting on a flight vehicle - Equation of motion of a rigid flight vehicle, Different types of drag, Drag polar, Types of airspeeds, airspeed indicator, altimeter, rate of climb indicator, mach meter, Variation of thrust and power with velocity and altitude for air breathing engines.

UNIT-2 **(8 hours)**

Cruising and Maneuvering Flight Performance

Performance of airplane in level flight, power available and power required curves. Maximum speed in level flight, Conditions for minimum drag and power required, Range and endurance of aircraft, Climbing and gliding flight (Maximum rate of climb and steepest angle of climb, minimum rate of sink and shallowest angle of glide), Turning rate and turn radius, Bank rate and bank angle, load factor, limitations on turn, V-n diagram, load factor and Gust envelope, take-off and landing performance.

UNIT-3 **(8 hours)**

Static Longitudinal Stability

Static and dynamic stability - Purpose of controls in airplanes –Static, Longitudinal stability-Stick fixed stability, Basicequilibriumequation-Stabilitycriterion-Effectsoffuselageand tail; Influence of CG location- Power effects - Stick fixed neutral point and static margin- Stick free stability-Hinge moment coefficient -Stick free neutral points- Stick force gradients

UNIT-4 **(8 hours)**

Static Lateral and Directional Stability

Dihedral effect - Lateral control - Coupling between rolling and yawing moments – Roll stability and control, Adverse yaw effects- Aileron reversal - Static directional stability and control, Weathercock effect - Rudder requirements, Rudder lock. Aerodynamic balancing, peddle fixed and peddle stability, roll control reversal.

UNIT-5 **(8 hours)**

Dynamic Stability

Degree of freedom of rigid bodies in space, Introduction to dynamic longitudinal stability: - Euler angles, velocities in 3- direction, Decoupling of longitudinal and lateral-directional dynamics; Modes of stability- longitudinal modes; lateral-directional modes, effect of freeing the stick- Brief description of lateral and directional Dynamic stability: Phugoid motion, short period motion, Spiral, divergence, Dutch roll, auto rotation and spin, approximation of longitudinal and lateral modes, Factors affecting time period and damping.

Book and References:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley
2. Nelson,R.C."FlightStabilityandAutomaticControl",McGraw-HillBookCo
3. Mc Cornick W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley
4. Babister, A.W., "Aircraft Dynamic Stability and Response", Pergamon Press, Oxford
5. J.D, Anderson, "Introduction to Flight", Tata McGraw Hill

Subject Code: KAE-072	Aircraft Stability and Control	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the basics of control theory and its application in aircraft control systems.	K2
CO-2	Understand the PI, PD and PID controller design and its implementation in avionics components.	K2
CO-3	Understand the functioning of auto-pilot system in an aircraft.	K2
CO-4	Apply the concept of aircraft control for obstacle clearance and motion planning	K3
CO-5	Apply the stability criteria to determine the stability level for different configurations of aircraft.	K3

UNIT-1 **(8 hours)**

Introduction to Modern Control Theory, Introduction to state-space versus transform methods in linear systems, internal versus input/output formulation, discrete-time and continuous- time systems, Fundamental concepts of linearity, causality, time-invariance, Solution to LTI and LTV systems, Solutions to homogeneous and non homogeneous cases. Computation of matrix exponentials using Laplace transforms and Jordan Normal form, positive definite matrices, quadratic forms.

UNIT-2 **(8 hours)**

Coordinate systems, Attitude dynamics and control, Rotational kinematics, Direction cosine matrix, Euler angles, Euler's Eigen axis rotation, Quaternion, Rigid body dynamics of launch vehicle, Angular momentum, Inertia matrix, Principal axes, Effect of aerodynamics, Generalized equations of motion, derivation of dynamic equations, structural dynamics and flexibility, actuator dynamics, gimbaled engine dynamics, External forces and moments, Linear model for Aero-structure-control-slosh interaction studies.

UNIT-3 **(8 hours)**

Classical linear time invariant control systems, Transfer function representations; stability; time domain characteristics, proportional–integral–derivative (PID) controller design for aerospace systems, Proportional term, Steady-state error, Integral term, Derivative term, Transient Response via Gain Adjustment, Lag Compensation, Lead Compensation, Lag-Lead Compensation.

UNIT-4 **(8 hours)**

Equations of motion, Stability derivatives, Routh's discriminant, solving the stability quartic, Stability definitions, characteristic equation, location of roots in the s-plane for stability, Routh-Hurwitz criteria of stability, Root locus and Bode techniques and its application to controller design for aerospace systems., concept and construction, frequency response. Gain Margin and Phase Margin via the Nyquist Diagram, Stability, Gain Margin, and Phase Margin via Bode Plots, Relation Between Closed-Loop Transient and Closed-Loop Frequency Responses.

UNIT-5 **(8 hours)**

Basics of feedback control: History and motivation for feedback; terminologies, Frequency response, Stability concepts, Bandwidth, Transient response, Closed loop design specifications, tracking and disturbance rejection, Sensitivity to parameter variations. Obstacle avoidance and Motion planning, the canonical problem, Configuration space, Different types of obstacles, Planning via retraction, Planning via cell decomposition, Probabilistic planning, Planning via artificial potentials, Motion planning for manipulators.

Books and References:

1. Perkins C.D, & Hage, R.E."Airplane Performance, Stability and Control", Wiley Toppan
2. Babister, A.W. "Aircraft stability and response ", Pergamum Press
3. Nelson, R.C. "Flight Stability & Automatic Control ", McGraw Hill

Subject Code: KAE-073	Helicopter Aerodynamics	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the functioning of a typical helicopter including the working of its flight control systems.	K2
CO-2	Understand the differences between the aerodynamics of an aircraft and a helicopter.	K2
CO-3	Understand the structural considerations of a helicopter including the study of failure modes.	K2
CO-4	Understand the flight performance of a helicopter during both hovering and forward flight.	K2
CO-5	Apply the above concepts to do preliminary design of a helicopter system.	K3

UNIT-1 **(8 hours)**

Types of helicopter, mechanism, characteristics, working of helicopter, Theory of Flight—Rotary Wing Aerodynamics: Terminology; Effects of gyroscopic precession; Torque reaction and directional control, Dissymmetry of lift, Blade tip stall; Translating tendency and its correction; Coriolis Effect and compensation; Vortex ring state, power settling.

UNIT-2 **(8 hours)**

Flight Control Systems: Cyclic control; Collective control; Swash plate; Yaw control: Anti-Torque Control, Tail rotor, bleed air; Main Rotor Head: Design and Operation features; Blade Dampers: Function and construction; Rotor Blades: Main and tail rotor blade construction and attachment; Trim control, fixed and adjustable stabilizers hovering performance.

UNIT-3 **(8 hours)**

Blade forces and motion in forward flight, Force, torque and flapping coefficient, Helicopter trim, Analysis, Performance in forward flight. Transmissions: Gear boxes, main and tail rotors; Clutches, free wheel units and rotor brake, Tail rotor drive shafts, flexible couplings, bearings, vibration dampers and bearing hangers.

UNIT-4 **(8 hours)**

Helicopter Structures: Airworthiness requirements for structural strength; Structural classification, primary, secondary and tertiary, fail safe, safe life, damage tolerance concepts; Zonal and station identification systems; Stress, strain, bending, compression, shear, torsion, tension, hoop stress, fatigue; Drain sand ventilation provisions.

UNIT-5 **(8 hours)**

Momentum and simple blade element theories, Blade advance ratio, Figure of merit-Profile and induced power estimation, Constant chord and ideal twist rotors, over pitching. Auto rotation and Ground effect, Rotor alignment; Main and tail rotor tracking; Static and dynamic balancing; Vibration types, vibration reduction methods; Ground resonance, helicopter spin and stall.

Books and Reference:

1. Automatic Flight Control – E.H.J. Pallet.
2. Aviation Maintenance Technician Handbook (General) 9A –FAA.

3. Helicopter Theory by Wayne Johnson.
4. Helicopter Calculation & Design Vol.I, II & III by A.V. Nekrasov, A.S. Braverman.

Subject Code: KAE-074	Introduction to Finite Element Methods	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the different governing equations of theory of elasticity to solve for deformation field in a component.	K2
CO-2	Understand the methods of numerical differentiation and make proper selection based on the problem.	K2
CO-3	Understand the different methods of meshing and their advantages and drawbacks.	K2
CO-4	Understand the generation of stiffness matrix for simple problems.	K2
CO-5	Apply the concepts of planar and axial symmetry while using the FEM methods.	K3

UNIT-1 **(8 hours)**

Introduction to Finite Element Method**,** Element Calculations**,** Global Assembly**,** Application of Boundary Conditions and Higher Order Approximation, Review of various approximate methods variational approach and weighted residual approach application to structural mechanics problems, finite difference methods, governing equation and convergence criteria of finite element method.

UNIT-2 **(8 hours)**

Finite Element Method for Higher Order Approximation**,** Natural Coordinate**,** Numerical Integration**,** Programming of Element Calculation1-D Finite Element Code**,** bar elements, uniform section, mechanical and thermal loading, varying section, 2D and 3D truss element. Beam element - problems for various loadings and boundary conditions.

UNIT-3 **(8 hours)**

Pre-Processor**,** Processor and Post-Processor**,** Testing of 1-D FE Code**,** Integral Formulations for Beam Problem**,** Finite Element Formulation for Beam Problem: Shape Functions**,** Evaluation of Element Quantities and Assembly Procedure, Plane stress, plane strain and axi-symmetric problems, Derivation of element matrices for constant and linear strain triangular elements and axi-symmetric element.

UNIT-4 **(8 hours)**

Integral Formulations of Two-Dimensional Problems**,** Finite Element Formulation of 2-D Problems: FE Equations**,** Evaluation of Element Quantities, Assembly and Application of Dirichlet Boundary condition**,** Evaluation of Element Right Side Vectors, Assembly and Application of Dirichlet Boundary condition, stiffness matrix and consistent load vector, evaluation of element matrices using numerical integration.

UNIT-5 **(8 hours)**

Lagrangian Triangular Elements**,** Simplest Rectangular Element**,** Axi-symmetric Problems, Heat transfer problems, steady state fin problems, derivation of element matrices for two dimensional problems, torsion problems. Method of factorization for solving simultaneous algebraic equations – Features of software packages, sources of error, 3D Frame elements - longitudinal and lateral vibration, Use of local and natural coordinates.

Books and Reference:

1. Tirupathi. R. Chandrapatha and Ashok D. Belegundu, "Introduction to Finite Elements in Engineering", Printice Hall India, Third Edition
2. Rao. S.S., "Finite Element Methods in Engineering," Butterworth and Heinemann
3. Reddy J.N., "An Introduction to Finite Element Method", McGraw Hill
4. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill
5. Bathe, K.J. and Wilson, E.L., "Numerical Methods in Finite Elements Analysis",
6. Larry J Segerlind, "Applied Finite Element Analysis", Second Edition, John Wiley and Sons.

Subject Code: KAE-075	Aircraft Rules and Regulations	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand to work on aircraft according to the various aircraft acts, rules and responsibility of operator/owner.	K2
CO-2	Understand procedure for defect recording, reporting and investigation during the servicing of aircraft in AMO.	K2
CO-3	Apply the knowledge of maintenance to keep all the certificate updated in time to keep the aircraft airworthy.	K3
CO-4	Apply the knowledge for ageing aircraft to be in continue airworthy condition.	K3
CO-5	Apply knowledge of fuelling, defueling and precautions to taken while working on aircraft.	K3
CO-6	Understand operation and installation procedure of radio equipment's.	K2

UNIT-1 **(8 Hours)**

Rules and Regulation of Aircrafts

Need for Rules and Regulations as they relate to registration of aircraft in India. Aircraft Manual, Aircraft Act 1934, Aircraft Rules 1937. Airworthiness Advisory Circulars issued by DGCA.

Procedure for issue of CAR and Responsibility of operator

Responsibility of operator/owners. Procedure for CAR issues.

Approval of cockpit check list, MEL & CDL

Minimum Equipment List Configuration Deviation List etc, Use of such documents. Preparation and use of cockpit and emergency check list.

UNIT-2 **(8 Hours)**

Defect Recording, Monitoring, Investigation and Reporting

Defect recording, reporting, investigation, rectification and analysis.

Approval of Organization

Requirements and procedure for issue/ extension in scope/renewal of organization in various categories: Layouts, Contents and requirements for quality control/ maintenance system/Quality Assurance/ Procedures Manuals.

UNIT-3 **(10 Hours)**

Airworthiness and Continued Airworthiness

General requirements for maintenance and certification of aircraft including gliders, micro-light aircraft, hot air balloons and Rebuilding of Aircraft. Documents associated with continued airworthiness of aircraft such as certificate of airworthiness, issue Revalidation and Suspension certificate of airworthiness, certificate of registration, Type certificate, certificate of maintenance, flight release, etc Procedures and requirements for issuance, renewal and restoration of validity of such documents, Conditions for suspension/cancellation of C of R, C of A, etc. Documents related with maintenance of aircraft and its components such as inspection schedules, special

inspection schedules, TBO/COSL, Maintenance Planning Documents, manufacturers Literatures, Procedures for preparation and approval of such documents.
Requirements for maintenance of aging aircraft, procedures and conditions for issuance of special flight permits.

UNIT-4 **(8 Hours)**

Requirement of Aircraft fuel, Refueling of Aircraft

Aircraft fuelling procedures. Unusable fuel supply-calibration of fuel quantity gauge of aircraft. Aviation fuel at airport Storage, Handling and quality controls.

Aircraft instrument, equipment and accessories

General requirement for installation and maintenance of various instruments and systems installed on aircraft. Minimum instrument required and additional equipment as per requirement. Requirements for installation and maintenance of various mandatory equipment's on aircraft such as CVR, DFDR, ACAS, GPWS/ EGPWS etc. Requirements for maintenance of test equipment's. Airworthiness procedure for cleaned room and environment for aircraft system/ accessories shop.

UNIT-5 **(10 Hours)**

Airborne communication, navigation & Radar Equipment

Installation of communication, Navigation and Radar equipment. Maintenance of Airborne Communication, Navigation and Radar Equipment. Installation of mode A', 'C' and mode S' transponders. Control of electromagnetic interference of aircraft.

Storage of Aircraft parts

Storage condition and storage/ service life of rubber part and aircraft components containing rubber parts. Fixation of Calendar period, for determining overhaul life of reciprocating engines.

Flight testing of aircraft

Flight Testing of aircraft for which a Certificate of Airworthiness has previously been issued.

Miscellaneous requirements

Weight and Balance Control of Aircraft. Provision of medical supplies in aircraft, Use of furniture material in aircraft, Aircraft Log Books. Documents to be carried on board by Indian Registered Aircraft. Procedure for issue of taxi permit.

Books and References:

1. Aircraft Act. 1934 & Aircraft rules 1937 by DGCA.
2. Civil Aviation Requirement Section-2 by DGCA.
3. Civil Aviation Requirement 21.
4. Civil Aviation Requirement 145
5. Civil Aviation Requirement M
6. www.dgca.nic.in

Subject Code: KAE-076	Aircraft Engine Maintenance	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the construction, installation and operation of piston and gas turbine engine.	K2
CO-2	Understand correct alignment of piston and turbine engine in aircraft.	K2
CO-3	Understand the various controls of piston engine and gas turbine engine and monitoring in related instrument.	K2
CO-4	Apply the concept of periodic servicing and rectification of defects.	K3
CO-5	Understand propeller and their mechanism with integration to piston and turbine engine.	K3

UNIT-1 **(8 Hours)**

Introduction

Types of piston and gas turbine engines and their relative merits and demerits, principle of operation of piston and gas turbine engines, general constructional details and functions of each part, Principles, arrangement, operation and inspection of complete fuel, lubrication, ignition and staring system as applicable to piston and gas turbine engines, Principles and operation of accessories such as fuel pump, oil pump, barometric pressure control and air fuel ratio control etc. As applicable to gas turbine and piston engines.

UNIT-2 **(8 Hours)**

Knowledge of material used in piston and gas turbine engines. Methods of checking of components prior to and during subassembly and subsequent assembly of the engine of both piston and gas turbine type for correct alignment, Weight and balance Knowledge of various gauges and precision instruments used. Inspection procedures for crack detection Such as die-penitent, magnetic particle Inspection, X- Ray, ultra-sonic and eddy Current.

UNIT-3 **(8 Hours)**

Engine controls and performance instruments, General principles of operation and methods of checking for correct functioning. Testing of piston and gas turbine engines, various test rigs/instruments and equipment used. Fault diagnosis and rectification during testing. Engine installation checks of aircraft engines, precautions and procedures prior to, during and after ground running checks with particular reference to operating limitation, priming bleeding, Trouble shooting and rectification.

UNIT-4 **(8 Hours)**

Procedure for short term and long-term storage of engines. Accessories priming and inhibition procedures. Periodical servicing, procedures, reporting and rectification of defects and inspection after shock landings. Maintenance of inspection records and clearance procedure for flights. Types of stores, maintenance of stores. Inspection of documents and procedures for storage of components.

UNIT-5 **(8 Hours)**

Types of propellers and their mechanisms, variable pitch, feathering propellers and associated control system components. Knowledge of lubricants, hydraulic fluids and fuels used in piston and

gas turbine engines. Maintenance objectives & legal requirements as related to power plants & systems. Accident reporting & investigation. Power augmentation devices, thrust reversers & auxiliary power unit.

Books and References:

1. Jet Engine Manual by E. Mangham and A Peace.
2. Fundamentals of Internal Combustion Engines by P.W. Gill, J.H. Smith & E.J. Ziurys.
3. Gas Turbine for Aircraft by A.W. Judge.
4. Gas Turbine Materials by G, Lueas and J.F. Pollock.

Subject Code: KAE-077	Introduction to CFD	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the governing equations of fluid flow in conservative and non-conservative forms.	K2
CO-2	Understand the methods of numerical differentiation.	K2
CO-3	Understand the different algorithms to capture shock in any flow field.	K2
CO-4	Apply the different methods of domain discretization to numerically solve any physical problem.	K3
CO-5	Apply boundary conditions corresponding to any CFD problem.	K3

UNIT-1 **(8 hours)**

Introduction to CFD

Principles of Conservation-Continuity Equation, Navier-Stokes Equation, Energy Equation and General Structure of Conservation Equations, Classification of Partial Differential Equations and Physical Behavior, Approximate Solutions of Differential Equations- Error Minimization Principles, Variation Principles and Weighted Residual Approach.

UNIT-2 **(8 hours)**

Finite Element Method, Finite Difference and Finite Volume Method, Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems, Boundary Condition Implementation and discretization of unsteady state Problems, Equations of fluid dynamics and their classification, Boundary conditions, Finite difference schemes- Projection and truncation error, Stability, consistency, accuracy and convergence of numerical schemes.

UNIT-3 **(8 hours)**

Basics of Finite Volume Method: Equations in integral form, numerical flux at cell faces, upwind methods, flux - vector splitting, flux- difference splitting, shock capturing methods, Introduction to CFD as a design tool; explicit and implicit methods; O.C.H types of grids. Important Consequences of discretization of time dependent diffusion type problems and stability analysis.

UNIT-4 **(8 hours)**

LAX Equivalence theorem, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): FTCS (Forward time central space) scheme, Stability analysis of parabolic equations (1-D unsteady state diffusion problems): CTCS scheme (Leap frog scheme), Dunford-Frankel scheme, Stability analysis of hyperbolic equations: FTCS, FTFS, FTBS and CTCS Schemes, Finite Volume Discretization of 2-D unsteady State Diffusion type Problems.

UNIT-5 **(8 hours)**

Solution of Systems of Linear Algebraic Equations: Elimination Methods, Iterative Methods, Gradient Search Methods, Discretization of Convection-Diffusion Equations: A Finite Volume Approach, Discretization of Naiver Stokes Equations- Stream Function Vorticity approach and Primitive variable approach, SIMPLE Algorithm, SIMPLER Algorithm, Unstructured Grid Formulation.

Books and References:

1. T.J.R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis.
2. O.C. Zicnkievicz and R.L. Taylor, The Finite Element Method, Vol I & II, McGrawHill
3. John. D. Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, McGraw Hill.
4. Charles Hirsch, Numerical Computation of Internal and External Flows, Wiley Series I.

Subject Code: KAE-078	Elements of Aeroelasticity	L T P: 3 0 0	Credits: 3

After completion of this course, the students will be able to		Blooms Taxonomy
CO-1	Understand the aerodynamic-structural interaction in an aircraft.	K2
CO-2	Understand the basics concepts of structural dynamics of a system of particles.	K2
CO-3	Understand the aero-elastic phenomenon like flutter and its affect on an aircraft.	K2
CO-4	Apply the concepts of vibrations and determine the modes and their frequencies for any system.	K3
CO-5	Analyze the structural strength of aircraft components with proper consideration of the effects of longitudinal and torsional vibrations.	K3

UNIT-1 **(8 hours)**

Rectilinear motion of a particle

Differential equation of motion in resisting medium, free vibrations with viscous damping, forced ration with harmonic disturbing force and general disturbing force, plane harmonic motion, Motion of a projectile with and without damp, motion of a particle subjected to a central force: planetary motion.

UNIT-2 **(8 hours)**

Dynamics of a System of Particles

Principle of Linear momentum and regular momentum, Rectilinear motion of a variable mass: Rockets, Kinetic energy and work, Law of conservation of energy. Equations of constraints, generalized coordinates, generalized forces, Equations of equilibrium, Generalized co-ordinates, Application of generalized coordinates in bending of beams, D' Alembert's principle, Lagrange's equation and applications, Hamilton's principle and application.

UNIT-3 **(8 hours)**

Small Oscillations of Conservative Systems

Free vibrations of derivative systems, Linear oscillations of two coupled masses, Free variation of system with two degrees of freedom and system with several degrees of freedom, Principal modes and their orthogonal property, Normal modes static coupling and dynamic coupling, Approximate methods of calculating principal frequencies.

UNIT-4 **(8 hours)**

Dynamics of Elastic Bodies

Vibration of a string under tension, Free vibration of beams with various end condition and the determination of the various modes of vibrations and their natural frequencies, variation of beams with concentrated masses, Critical speed of a rotating Forced vibration of beams, Tensional vibration of a shaft and –shaft combination, Approximate methods of calculating natural frequencies.

UNIT-5 **(8 hours)**

Nature of static aero elastic phenomenon , Wing diver, Gene and control system reversal for an idealized tow dimensional wing and approximate solution for a finite wing , Flutter phenomena and flutter analysis, Difference between flutter instability and resonance , Simplified expressions for aerodynamic forced and moments for an oscillating air foil, Determination of flutter speed and frequency for an idealized two dimensional wing as well as for a finite wing, Methods of flutter control and prevention, Elementary theory of buffeting.

Books and References:

1. W.T. Thomson, Vibration Theory and Application, Allen and Unwind
2. S. Timoshenko and D.H, Young, Advanced Dynamics , McGraw Hill
3. Y.C. Fung, Introduction to the Theory of Aero elasticity, Addison Wesley