COMPUTATIONAL FLUID DYNAMICS

Subject Code –BANES1-601 **L T P Cr** **Duration:45 Hours**
3 0 0 3

COURSE OBJECTIVE

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

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

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

DETAILED CONTENTS

UNIT –I (10Hrs.)

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

UNIT –II (12 Hrs.)

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

UNIT –III (11 Hrs.)

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

UNIT –IV(12 Hrs.)

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

INSTRUCTIONAL STRATEGY

Session Plan / course-material uploading, Class-room teaching associatedwithassignments**,** presentations**,** quiz, viva-voce and evaluation.

RECOMMENDED BOOKS

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

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

HELICOPTER ENGINEERING

Subject Code –BANES1-602 **L T P Cr** **Duration:60 Hours**
3 1 0 4

COURSE OBJECTIVES

- The concepts related to Helicopter engineering and dynamics.
- Estimate the performance and stability aspects of helicopters.
- Analyze the vibrations of blade and helicopters under various dynamic conditions.

LEARNING OUTCOME

At the end of the course students will be able to:

- Explain various concepts and phenomena involved in helicopter engineering and dynamics.
- Estimate power requirement for various flight conditions such as hovering, climbing, forward flights etc.
- Estimate various other performance and stability parameters.
- Analyze vibration levels in blades and helicopters under various conditions.

DETAILED CONTENTS

UNIT – I (15hrs)

Helicopter history, basic control: Historical development of helicopter and overview, Classification based on main rotor configuration and tail rotor configuration. Comparative analysis, Major components of conventional helicopter, Composite structure.

Rigid, semi-rigid and articulated rotors, Feathering, flapping and lead-lag motion, Rigid, Semi-rigid and articulated helicopter control system, Collective and cyclic pitch control, Yaw control, Throttle control, Anti-torque control, Solidity, Tip-speed ratio, In-flow ratio, Figure of merit.

UNIT – II (15 hrs)

Aerodynamics of main rotor and helicopter vertical flight: Coning of rotor, Dissymmetry of lift, Precession, Coriolis effect, Compressibility effects, Retreating blade stall, Reverse flow region, Flapping, feathering and lead-lag motion, Autorotation, Schrenk's diagram, Various types of autorotative landings.

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

UNIT – III (15 hrs)

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

UNIT – IV (15hrs)

Helicopter vibration stability and control:

a) DYNAMIC STABILITY AND CONTROL

Longitudinal and lateral stability, Equations of motion, Stability characteristics, Auto stabilization, Control response.

b) HELICOPTER VIBRATIONS

Sources of vibration, Active and passive methods for vibration control, Fuselage response, Measurement of vibration in flight.

INSTRUCTIONAL STRATEGY

Teachers should invite experts to deliver lectures. Field visits may be arranged.

RECOMMENDED BOOKS

1. Helicopter Dynamics , ARS Braimwell, G. Done and D. Babuford, Butterworth Hermann publication
2. Helicopter Engineering, Jacob Shajuro, Hill Publication
3. Helicopter Engineering, Lalit Gupta, Himalaya Publication

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

AIRCRAFT STABILITY AND CONTROL

Subject Code –BANES1-603 | **L T P Cr** 3 1 0 4 | **Duration:60 Hours**

COURSE OBJECTIVE

- The course enables students to understand and apply various concepts related to aircraft stability and control.
- The course enables students to analyze and estimate various aspects related to longitudinal and lateral static and dynamic stability.

LEARNING OUTCOME

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

- Explain various concepts related to aircraft stability and control.
- Analyze and estimate static longitudinal stability (stick-fixed and stick-free).
- Analyze and estimate maneuvering longitudinal stability (stick-fixed and stick-free).
- Analyze and estimate static lateral and directional stability (stick-fixed and stick-free).
- Analyze and estimate dynamic longitudinal stability.
- Analyze and estimate dynamic lateral and directional stability.
- Analyze various longitudinal and lateral dynamic modes, coefficients and parameters.

UNIT –I(11 Hrs.)

Stick fixed static longitudinal stability: Introduction to stability, Criterion for static stability of an aircraft, Contribution of different parts to stick fixed static longitudinal stability of aircraft, Effect of power, Neutral point (stick fixed), Centre of gravity limits. Static margin, In flight measurement of stick fixed neutral point.

UNIT-II(16Hrs.)

Stick free static longitudinal stability: Contribution of different parts to stick free static longitudinal stability of aircraft, Control surface hinge moments, Floating and restoring tendencies, Different types of tabs used on airplanes, Effect of free elevator on airplane stability, Elevator control power, Stick force gradients, Neutral point (stick free), Controls free center of gravity limit. In flight measurement of stick free neutral point.

Maneuvering flight: Effect of acceleration on airplane stability, Elevator angle per g, Stick force per g, Maneuver points and in flight measurement of maneuver points (stick fixed and stick free), Maneuver margins.

UNIT-III(17Hrs.)

Directional stability and controls: Asymmetric flight, Weather cock stability, Contribution of different parts of Aircraft, Adverse yaw, Frise Aileron, Spoiler Controls. Rudder Fixed and Rudder free static directional stability, Rudder control power, Rudder lock.

Lateral stability and control: Dihedral Effect. Contribution of different parts of aircraft, Aileron control power, Cross coupling of lateral and directional effects.

UNIT- IV(16Hrs.)

Dynamic stability: Introduction to dynamics, Spring-mass system. Equations of motion, Stability and control derivatives, Longitudinal dynamic stability, Lateral and Directional dynamic stability, Analysis of different stability modes.

INSTRUCTIONAL STRATEGY

The course consists of conceptual and numerical contents for which a combination of LCD projector and black/white boards can be used as teaching aids.

RECOMMENDED BOOKS

1. Flight Stability and Automatic Control, R. C. Nelson, McGraw-Hill Book, 2007.
2. The Airplane Performance Stability and Control, C.D. Perkins and R.E. Hage, 1949.
3. Dynamics of Flight: Bernard Etkin, John Wiley and Sons, 1996.

AIRCRAFT MAINTENANCE

Subject Code –BANED1-611 **L T P Cr** **Duration:45 Hours**
3 0 0 3

COURSE OBJECTIVES

- To familiarize the students with maintenance and inspections required on aircraft.
- Use of Non Destructive Testing for finding flaws on the aircraft and components.
- To familiarize with Snag rectification and Emphasis should also be given on the Ground handling safety and support system.

LEARNING OUTCOME:-

At the end of the course students will gain knowledge of :

- Use of various types of tools, fits, clearances, and safety precautions used in aviation.
- Explain different types of non-destructive testing techniques.
- Analyze different types of Corrosion and maintenance procedures.
- Define transmission methods, pipes and union, flexible hoses used in aviation
- Explain various types of springs used on aircraft.

DETAILED CONTENTS

UNIT –I (08 Hrs.)

Safety precautions-aircraft and workshop: Aspects of safe working practices including precautions to take when working with electricity, gases especially oxygen, oils and chemicals; Instructions on the remedial action to be taken in the event of a fire or another accident with one or more of these hazards including knowledge on extinguishing agents.

Workshop Practices: Care of tools, control of tools, use of workshop materials; Dimensions, allowances and tolerances, standards of workmanship; Calibration of tools and equipment, calibration standards.

Tools: Common hand tool types; Common power tool types; Operation and use of precision measuring tools; Lubrication equipment and methods. Operation, function and use of electrical general test equipment.

Air Transport Association (ATA)Standards and Wiring Diagrams: Specification 100 of the Air Transport Association (ATA) of America; Aeronautical and other applicable standards including ISO, AN, MS, NAS and MIL; Wiring diagrams and schematic diagrams.

Fits and Clearances: Drill sizes for bolt holes, classes of fits; Common system of fits and clearances; Schedule of fits and clearances for aircraft and engines; Limits for bow, twist and wear; Standard methods for checking shafts, bearings and other parts.

UNIT-II (10 Hrs.)

Corrosion:
(a) Chemical fundamentals; Formation by, galvanic action process, microbiological, stress;
(b) Types of corrosion and their identification; Causes of corrosion; Material types, susceptibility to corrosion.
(c) Corrosion removal, assessment, re-protection and corrosion control programs.

Welding, Brazing, Soldering and Bonding :
(a) Soldering methods; inspection of soldered joints.
(b) Welding and brazing methods; Inspection of welded and brazed joints; Bonding methods and inspection of bonded joints.

Disassembly, Inspection, Repair and Assembly Techniques:
(a) Types of defects and visual inspection techniques.
(b) General repair methods, Structural Repair Manual; Ageing and fatigue.
(c) Non-destructive inspection techniques including, penetrant, radiographic, eddy current, ultrasonic and borescope methods.
(d) Disassembly and re-assembly techniques.
(e) Trouble shooting techniques

Maintenance Procedures: Maintenance planning; Modification procedures; Stores procedures; Certification/release procedures; Interface with aircraft operation; Maintenance Inspection/Quality Control/Quality Assurance; Additional maintenance procedures; Control of life limited components

UNIT-III (12 Hrs.)

Bearings: Introduction and function of bearings, loads, material, construction; Types of bearings and their application. Testing, cleaning and inspection of bearings; Lubrication requirements of bearings; Defects in bearings and their causes.

Transmissions: Gear types and their application; Gear ratios, reduction and multiplication gear systems, driven and driving gears, idler gears, mesh patterns; Belts and pulleys, chains and sprockets. Inspection of gears, backlash; Inspection of belts and pulleys, chains and sprockets; Inspection of screw jacks, lever devices, push-pull rod systems.

Control Cables : Types of cables; End fittings, turnbuckles and compensation devices; Pulleys and cable system components; Bowden cables; Aircraft flexible control systems.
Swaging of end fittings; Inspection and testing of control cables; Bowden cables; aircraft flexible control systems.

Pipes and Unions :
(a) Identification of, and types of rigid and flexible pipes and their connectors used in aircraft;
(b) Standard unions for aircraft hydraulic, fuel, oil, pneumatic and air system pipes.

Pipes and Hoses: Bending and belling/flaring aircraft pipes; Inspection and testing of aircraft pipes and hoses; Installation and clamping of pipes.

Springs: Types of springs, materials, characteristics and applications. Inspection and testing of springs.

UNIT-IV (15 Hrs)

General maintenance, ground handling safety and support system:

Part-I

Rigging of flight control surfaces and duplicate inspection; Rigging checks-Angular alignment checks and symmetry checks, Knowledge and use of Tensiometers, Protractors etc.

Part-II

Maintenance of hydraulic accumulators, reservoirs and filters, Maintenance of landing gear (L/G), Shock strut charging and bleeding,Maintenance of L/G brakes i.e., Dragging, Grabbing, Fading, Brakes and excessivebrake pedal travel. Maintenance on wheels, tyres and tubes i.e., dismantling, inspection, assembling, inflating, inspection and installation Storage of Rotables.

Part-III

General knowledge of ground handling of Aircraft, Aircraft Safety; Mooring, Jacking, Levelling, Hoisting of aircraft, Towing, Mooring of an a/c during adverse conditions. Aircraft cleaning and maintaining.
Ground signalling/marshalling of aircraft in day and night time.

Part-IV

Maintenance and handling of ground equipment's used in maintenance of aircraft. Compressors, Portable hydraulic test stands, Electrical power supply equipment, charging trolley. Air-conditioning and Heating unit, Ground support air start unit. Pressure oil unit, Fire extinguishers, jacks, Hoisting cranes/gantry, Ladders, Platforms, Trestles, and Chocks.

Part-V

Knowledge of safety and fire precautions to be observed during maintenance including refueling, defueling and engine start.

Part-VI

Brief knowledge of airport and its procedures. Control tower, Dispersal areas, Aprons, Tarmac, Taxy track, Runway and its ends. Approach and clear zone layout. Brief knowledge of the signals given by the control tower. Knowledge of Airfield lighting system, Aircraft Rescue and Fire Fighting.

INSTRUCTIONAL STRATEGY:

For better understanding of the subject, visit to CAR-M subpart F or CAR-145 approved maintenance organization is recommended. Students should be taken to Aircraft Maintenance workshops to demonstration various aircraft maintenance operation.

RECOMMENDED BOOKS

1. Airframe and Powerplant Mechanics (AC 65-15A)-Airframe Hand Book FAA.
2. Civil Aircraft Inspection Procedure (CAP 459) Part II Aircraft.
3. Aircraft Maintenance and Repair ByKroes, Watkin and Delph.
4. Acceptable Methods, Techniques and practices (FAA)-EA-AC 43.13-1 Aand2A.
5. FAA-H-8083-30 - Aircraft Maintenance Technician Handbook - General, US Department of Transportation, Federal Aviation Administration.

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

AUTOMATIC FLIGHT CONTROL

Subject Code –BANED1-612 **L T P Cr** **Duration:45 Hours**
3 0 0 3

COURSE OBJECTIVES

- To enable the student to understand fundamentals of control theory.
- The student shall be able to apply concept of control theory to design autopilot.
- The student shell be able to evaluate feedback control system

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Identify type of control system and develop Block Diagrams of Feedback control system
- Analyze Steady State response of Feedback Control System
- Conduct stability analysis of feedback control systems.
- Develop conceptual design of autopilot for aircraft

DETAILED CONTENTS

UNIT –I (8 Hrs.)

Introduction: Open Loop and Closed Loop (Feed Back) control systems. Types of Feedback Control Systems. Laplace's Transform. Application of open and closed loop control systems, digital, sophisticated and non-linear control system

UNIT –II (10 Hrs.)

Feed back control system: Transfer Function of Linear Systems. Impulse response of Linear Systems,

Block Diagrams of Feed Back Control Systems, Straight variables, Icon values, Multivariable Systems. Transformation of physical system to block diagram and its analysis, Block Diagram Algebra.

UNIT –III (13 Hrs.)

Analysis of feedback control systems: Typical Test Input Signals, Time Domain Performance Characteristics of Feedback Control Systems. Effects of Derivative and Integral Control. Steady State response of Feedback Control System-Steady State Error, Frequency Response.

System stability: Routh-Hurwitz Criterion, the Root Locus Method. Applications of this criterion to improve the system stability, sensitivity

UNIT –IV (14 Hrs.)

Auto-pilots: Longitudinal Auto Pilots: Brief description through Block Diagrams and Root Locus of Displacement Auto Pilot, Pitch Orientation Control System. Acceleration Control System.

Advance topics: Introduction to control tool box of MATLAB, Fly-By-Wire control system, Instrument Landing System

INSTRUCTIONAL STRATEGY

The teachers should invite experts to deliver lectures. Audio-video aid may be used. Field visits may be arranged.

RECOMMENDED BOOKS

1. "Modern Control Engineering" Katsuhiko Ogata, 5th Edition, 2009

2. "Flight Stability and Automatic Control" 2nd Edition, McGraw-Hill Education, 1997

3 "Dynamics of Flight: Stability and Control", Bernard Etkin, Wiley Publication. 1995

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

AERO ENGINE DESIGN

Subject Code –BANED1-613 **L T P Cr** **Duration:45 Hours**

3 0 0 3

COURSE OBJECTIVES

- To familiarize the students with aircraft engine design process.
- To educate component and subsystem design procedure.

LEARNING OUTCOME

At the end of the course students will gain knowledge of:

- Parametric analysis of aircraft engine.

- Design aircraft engine components and subsystems as per design constraints and requirements.

DETAILED CONTENTS

UNIT –I (6 Hrs.)

Introduction: Familiarizing with terminology, sample request for proposals,compressibleflow relationships

Constraint and mission analysis: Concept and Design tools: Constant speed climb, horizontal acceleration, climb and acceleration, takeoff acceleration, constant altitude cruise, constant altitude turn, subsonic loiter Calculations of take-off weight, Preliminary estimates of constraint analysis: Aerodynamics, Propulsion and weight fractions, Aircraft weight and fuel consumption

UNIT-II (12 Hrs.)

Parametric cycle analysis: Concept familiarizing, Design tools: Station numbering, gas model, mass flow rates, component efficiencies, engine performance analysis, Finding promising tools: parametric v/s performance behavior, Sample engine selection with parametric cycle analysis: suitable range of design parameters,

Performance cycle analysis: Concept familiarizing, Design tools: Mass flow parameters, performance of turbines, component performance analysis, iterative solutions, Component behavior: fan and compressor performance maps, combustor maps, turbine maps, component matching, Sample engine selection with parametric cycle analysis: the baseline engine

UNIT-III (12 Hrs.)

Installed performance: Concept familiarizing, Design tools: subsonic and supersonic inlet drag, exhaust nozzle drag, sizing the inlet area and exhaust nozzle, Software implementations on installation losses, Installed performance and final engine sizing

Engine system design and turbomachinery design: Concept and design tools, Engine system design: Engine static structure, shaft and bearing, lubricating system, fuel system, Engine component design for rotating turbomachinery: fan and compressor aerodynamics, turbine aerodynamics, Engine life

UNIT-IV (15 Hrs.)

Combustion system: Conceptual understanding, Design tools for main burner and afterburner: the combustion process, combustion stability and flame holding, Stirring and mixing, Total pressure losses, main burner components, Afterburner design parameters

Inlet and exhaust nozzles: Conceptual understanding, Design tools for inlet, Design tools for exhausts, nozzle types and functions

RECOMMENDED BOOKS

1. Jaw, Link C., and Jack D. Mattingly. "Aircraft engine controls." AIAA, Reston, VA (2009).
2. Oates, Gordon C., ed. Aircraft propulsion systems technology and design. American Institute of Aeronautics and Astronautics, 1989.
3. Oates, Gordon C., ed. Aerothermodynamics of aircraft engine components. American Institute of Aeronautics and Astronautics, 1985.

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, term project.

VIBRATION AND AERO ELASTICITY

Subject Code –BANED1-621	L	T	P	Cr	Duration:60 Hours
	4	0	0	4	

COURSE OBJECTIVES

- Explain fundamentals of vibration such as natural frequencies and modes, resonance, and effect of mass, stiffness and damping on vibration characteristics.
- Analyze dynamic aero elastic instability due to interactions among aerodynamics, structure and inertia effect such as flutter.
- Analyze and explain fundamentals of modeling and analysis techniques, including the energy approach.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Explain the concepts of vibration such as natural frequencies and modes, resonance and effect of mass, stiffness and damping on vibration characteristics.
- Analyze dynamic aero elastic instability due to interactions among aerodynamics, structure and inertia effect such as flutter.
- Apply the fundamental of vibration and aero elasticity on different engineering and airplane components.
- Analyze the effect of flutter and buffeting on airplane structure.
- Analyze effect of divergence on aircraft wing.

DETAILED CONTENTS

UNIT –I (11 Hrs.)

Undamped free and transient vibrations: Definitions and terminology, simple harmonic motion, combinations of two simple harmonic motions, solution of second order differential equations, complex numbers, classical solution, energy solution, summary of procedures for determining natural frequency, transient, response, equivalent systems.

UNIT-II (16 Hrs.)

Damped free and transient vibrations-single degree of freedom: Introduction, iscous damping, critical damping, over damping, under damping, equivalent dampers, Coulomb damping.

Steady state forced vibrations –single degree of freedom: Introduction, sources of excitation, impressed harmonic force, impressed force due to unbalance excitation, transverse critical speed of a single disk, motion excitation, transmissibility and isolation, summary of simple harmonic excitation, commercial isolator materials.

UNIT-III (17Hrs.)

Aero elasticity: Introduction, definition and historical background, static and dynamic aero elastic phenomenon, integration of aerodynamic, elastic and inertia forces, influence of aero elastic phenomenon on aircraft design, comparison of critical speeds.

Divergence of lifting surfaces: Phenomenon of divergence, divergence of 2-D wing section, divergence of an idealized cantilever wing, solution based on semi-rigid assumptions, solution to generalized coordinates method of successive approximation , use of numerical methods.

UNIT IV (16 Hrs.)

Steady state aero elastic problems: Loss and reversal of aileron control, 2-D and general case, lift distribution on a rigid and elastic wing, effect of reversal of aileron control on static longitudinal stability of airplane, flutter and buffeting.

INSTRUCTIONAL STRATEGY

This is a fundamental course in vibration and aero elasticity. The teachers are expected to lay stress on basics of damped and undamped vibrations. The teachers are expected to show the application of aero elasticity to the aircraft structural problems.

RECOMMENDED BOOKS

1 Mechanical vibrations: Austin H. Church, John Wiley and sons, 1963
2 Vibration problems in engineering: S. Timoshenko Van NostrandCo.,.John Wiley Publishers, 1974
3 Mechanical Vibrations: V.P. Singh, Dhanpat Rai and Co. Pvt. Ltd., Delhi., 2012
4 An introduction to the Theory of Aeroelasticity: Y.C.Fung, Dover Publications., 1969
5 Aeroelasticity: R.L. Bisplinghoff Holt Ashley R.L. Halfman, Addison Wesley Publishing Co. Reading, Mass., 1965,

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, model/prototype making.

OPTIMIZATION TECHNIQUES

Subject Code –BANED1-622 **L T P Cr** **Duration:60 Hours**
4 0 0 4

COURSE OBJECTIVES

The course aims at building capabilities in the students for analysing different situations in the industrial/ business scenario involving limited resources and finding the optimal solution within constraints.

LEARNING OUTCOMES

After undergoing the subject, student will be able to:

- Formulate and solve linear programming problems.
- Solve the problems on networks models such as Transportation, Assignment, Shortest path, minimal spanning tree, and Maximal flow.

- Solve the problems of Project Management using CPM and PERT
- Solve Non-linear Programming problems of some kinds.
- Implement the Linear programming techniques using C or any other optimization software.

DETAILED CONTENTS

Unit I(15 Hrs)

Scope of Operations Research: Introduction to linear and non-linear programming formulation of different models.

Linear Programming:Geometryof linear programming, Graphical method, Linear programming (LP)in standard form, Solutionof LPby simplexand revised simplex methods, Exceptional casesin LP, Duality theory, Dual Simple method, Sensitivity analysis.

Unit II(15 Hrs)

Network Analysis: Transportation problem (with trans shipment), Assignment problem, Traveling-salesman problem, shortest route problem, Minimal spanning tree, Maximum flow problem.

Integer Programming: Branchand bound algorithm, Travelling salesman problem.

Dynamic programming:Forward recursions, General problem, Reliability problem, Capital budgeting problem, Cargo-loading problem.

Unit III (15 Hrs)

CPM and PERT: Drawing of networks, Removal of redundancy, Network computations, Free slack, Total slack, Crashing, Resource allocation.

Unit IV(15 Hrs)

Non-Linear Programming: Characteristics, Concepts of convexity, maxima and minima of functionsof n-variables using Lagrange multipliers and Kuhn-Tuker conditions, One dimensional search methods, Fibonacci, golden section methodand gradient methodsfor unconstrained problems.

Software:Introductionto softwarefor optimization techniques (TORA).

RECOMMENDED BOOKS

1. Wagner, H. M. - 'Principles of Operations Research - Prentice Hall, New Delhi – 1998
2. J. K. Sharma. - 'Operations Research Theory and Applications' - Macmillan India Ltd, New Delhi - 2013 - 5th Edition
3. Taha H. A. - 'Operations Research: An Introduction' - Prentice Hall, New Delhi - 2010 - 9th Edition
4. Ravindra A., Phillips, D. J. and Solberg, J. J. - 'Operations Research - Principles and Practice' - John Wiley & Sons – 2005
5. Hadley G. - 'Linear Programming' - Narosa Book Distributors Private Ltd. – 2006
6. Gupta P K, & Hira D.S., "Operations Research", Third Edition, S Chand & Company Ltd., New Delhi, 2005.

MEANS OF ASSESSMENT

Assignments and quiz/class tests, mid-term and end-term written tests, term project.

COMPTATIONAL FLUID DYNAMICA LAB

Subject Code –BANES1-604 | **L T P Cr** 0 0 2 1 | **Duration:30 Hours**

COURSE OBJECTIVES

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

DETAILED CONTENTS

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

MEANS OF ASSESSMENT

Actual laboratory and practical work, model/prototype making, assembly and disassembly exercises and viva-voce.