MK UNIVERSITY

PATAN, GUJARAT

ESTABLISHED BY THE GUJARAT GOVT. **RECOGNIZED BY UGC UNDER SECTION 2(f) OF UGC ACT,1956**

MK University, Patan
Faculty of Engineering Technology,
Department of Aeronautical Engineering

DIPLOMA (AERONAUTICAL ENGINEERING) SEM-I									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE101	ENGINEERING MATHEMATICS-I	4	0	4	40	60	100
2	MAJOR	DAE102	ENGINEERING PHYSICS	4	2	6	90	60	150
3	MAJOR	DAE103	ENGINEERING CHEMISTRY	4	2	6	90	60	150
4	MAJOR	DAE104	ENGINEERING GRAPHICS &CAD	4	2	6	90	60	150
5	MINOR	DAE105	WORKSHOP PRACTICE	0	2	2	50	00	50
TOTAL				16	8	24	360	240	600

DIPLOMA (AERONAUTICAL ENGINEERING) SEM-II									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE201	ENGINEERING MATHEMATICS-II	4	0	4	40	60	100
2	MAJOR	DAE202	ENGINEERING MECHANICS	4	2	6	90	60	150
3	MAJOR	DAE203	BASIC ELECTRICAL & ELECTRONICS	4	2	6	90	60	150
4	MINOR	DAE204	MATERIAL SCIENCE & ENGINEERING	4	2	6	90	60	150
5	SEC	DAE205	COMMUNICATION SKILL	2	0	2	00	50	50
TOTAL				18	6	24	310	290	600

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DIPLOMA (AERONAUTICAL ENGINEERING) SEM-III									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE301	FLUID MECHANICS & HYDRAULICS	4	2	6	90	60	150
2	MAJOR	DAE302	THERMODYNAMICS	4	2	6	90	60	150
3	MAJOR	DAE303	AIR CRAFT STRUCTURES-I	4	2	6	90	60	150
4	MINOR	DAE304	INDUSTRIAL VISIT REPORT	0	2	2	50	00	50
5	IKS	DAE305	IKS-ANNCIENT INDIAN ENGINEERING PRACTICE	0	2	2	50	00	50
TOTAL				12	10	22	370	180	550

DIPLOMA (AERONAUTICAL ENGINEERING) SEM-IV									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/ WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE401	AERODYNAMICS	4	0	4	40	60	100
2	MAJOR	DAE402	AIRCRAFT PROPULSION	4	2	6	90	60	150
3	MAJOR	DAE403	AEROSPACE MATERIALS	4	0	4	40	60	100
4	MINOR	DAE404	COMPUTER PROGRAMMING	4	2	6	90	60	150
5	VAC	DAE405	ENVIRONMENTAL SCIENCE	2	0	2	00	50	50
TOTAL				18	4	22	260	290	550

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DIPLOMA (AERONAUTICAL ENGINEERING) SEM-V									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE501	AIR CRAFT STRUCTURES-II	4	2	6	90	60	150
2	MAJOR	DAE502	AVONICS SYSTEMS	4	2	6	90	60	150
3	MAJOR	DAE503	AIRCRAFT MAINTENANCE ENGINEERING	4	0	4	40	60	100
4	MINOR	DAE504	AEROSPACE VEHICLE DESIGN	4	0	4	40	60	100
5	SEC	DAE505	MIN PROJECT	0	2	2	50	00	50
TOTAL				16	6	22	310	240	550

DIPLOMA (AERONAUTICAL ENGINEERING) SEM-VI									
SR NO.	COURSE TYPE	COURSE CODE	COURSE NAME	LECTURE (HRS.)/ WEEK	PRACTICAL (HRS.)/WEEK	CREDITS	EXAMINATION		TOTAL MARKS
							INTERNAL	EXTERNAL	
1	MAJOR	DAE601	FLIGHT MECHANICS	4	2	6	90	60	150
2	MAJOR	DAE602	FLIGHT DYNAMICS& CONTROL	4	2	6	90	60	150
3	MAJOR	DAE603	AIRPORT OPERATIONS MANAGEMENT	4	2	6	90	60	150
4	MINOR	DAE604	DIPLOMA PROJECT	0	6	6	150	00	150
TOTAL				12	12	24	420	180	600

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SEMESTER-I

COURSE CODE: DAE101

COURSE NAME: ENGINEERING MATHEMATICS-I

Course Objectives:

- To develop foundational mathematical skills essential for mechanical engineering applications
- To apply algebraic, trigonometric, and calculus concepts to solve engineering problems
- To interpret and analyze data using statistical methods
- To build problem-solving abilities through applied mathematics
- To prepare students for advanced engineering mathematics in subsequent semesters

Course Outcomes: At the end of the course students shall be able to

CO1	**Solve** algebraic equations and apply them to engineering problems
CO2	**Apply** trigonometric functions to analyze mechanical systems
C03	**Perform** basic differentiation and integration relevant to engineering applications
C04	**Analyze** data using measures of central tendency and dispersion

Unit	Content	Credit	Weightage
I	**Algebra and Trigonometry** **Topics:** • **Algebra:** Quadratic equations, simultaneous linear equations (2 and 3 variables) • Arithmetic and geometric progressions • **Trigonometry:** Trigonometric ratios, identities, compound angles • Heights and distances (engineering applications) • Complex numbers: basics and operations • **Applications:** Simple harmonic motion, projectile motion, force resolution	1	25%

II	**Differential Calculus**
	Topics:
	• Functions, limits, and continuity
	• Derivatives: Standard formulas
	• Rules of differentiation: Product, quotient, chain rule
	• Applications of derivatives:
	  ○ Rate of change (velocity, acceleration)
	  ○ Maxima and minima (optimization problems)
	  ○ Tangents and normals
	• Partial differentiation (introduction)
	• **Applications:** Optimization in design, motion analysis, slope of curves
		1	25%

III	**Integral Calculus** **Topics:** • Indefinite integrals: Standard formulas	1	25%

	• Methods of integration: Substitution, integration by parts
	• Definite integrals and properties
	• Applications of integration:
	  ○ Area under curves
	  ○ Volume of solids of revolution
	  ○ Center of gravity/centroid (basic concepts)
	• **Applications:** Area calculation in engineering drawings, volume of tanks/containers		

IV	**Statistics and Probability** **Topics:** • **Statistics:** Data classification, frequency distribution • Measures of central tendency: Mean, median, mode • Measures of dispersion: Range, standard deviation, variance • Graphical representation: Histogram, frequency polygon, ogive • **Probability:** Basic concepts, addition and multiplication theorems • **Applications:** Quality control, measurement analysis, manufacturing data interpretation	1	25%

Textbooks:

- Primary: *Engineering Mathematics* — NP Bali & Dr. Manish Goyal
- Primary: *A Textbook of Engineering Mathematics* — B.S. Grewal

Reference books:

- *Advanced Engineering Mathematics* — H.K. Das
- *Engineering Mathematics* — D. G. Gupta
- *Basic Technical Mathematics with Calculus* — Allyn J. Washington
- *Mathematics for Mechanical Engineering* — B.V. Ramana

Online Platforms:

1. NPTEL Videos: "Basic Course in Mathematics" for engineering
2. Coursera: "Pre-Calculus" by University of California, Irvine

COURSE CODE: DAE102

COURSE NAME: ENGINEERING PHYSICS

Course Objectives:

- To understand fundamental physics principles relevant to mechanical engineering
- To apply physics concepts to solve practical engineering problems
- To develop skills in measurement, experimentation, and data analysis
- To correlate theoretical physics with mechanical systems and applications
- To build foundation for advanced engineering courses

Course Outcomes: At the end of the course students shall be able to

CO1	**Apply** mechanics principles to analyze forces, motion, and energy in mechanical systems
CO2	**Explain** thermal physics concepts relevant to heat engines and refrigeration
C03	**Demonstrate** understanding of optics and acoustics in

	engineering contexts
C04	**Perform** measurements using physical instruments and analyze experimental data

Unit	Content	Credit	Weightage
I	**Mechanics & Properties of Matter** **Topics:** • Scalars and vectors, force resolution, moment of force • Laws of motion, friction, work, energy, power • Circular motion, centripetal force • Elasticity: Stress, strain, Hooke's law, Young's modulus • Surface tension and viscosity (basic concepts) • **Applications:** Machine design, material strength, fluid mechanics basics	1	25%
II	**Thermal Physics & Thermodynamics** **Topics:** • Heat and temperature, thermal expansion • Calorimetry, specific heat capacity • Laws of thermodynamics (zeroth, first, second) • Heat transfer: conduction, convection, radiation • Kinetic theory of gases (basic) • **Applications:** Heat engines, refrigeration, insulation materials	1	25%
III	**Waves, Optics & Acoustics** **Topics:** • Simple harmonic motion, wave motion • Sound: characteristics, intensity, Doppler effect • Ultrasonics and applications • Reflection, refraction, lenses, optical instruments • Fiber optics (basic principles) • **Applications:** Machine vibration, NDT, optical measurements, noise control	1	25%
IV	**Modern Physics & Material Science** **Topics:** • Quantum physics basics: photons, matter waves • Lasers: principles, types, applications • Semiconductors: basics • Superconductivity (elementary concepts) • Nanotechnology introduction • **Applications:** Laser machining, sensors, advanced materials	1	25%

Textbooks:

- Primary: *Engineering Physics* — D. R. Khanna & H. N. Srivastava
- Primary: *Engineering Physics* — R. K. Gaur & S. L. Gupta

Reference books:

- *Fundamentals of Physics* — Halliday, Resnick & Walker
- *Concepts of Physics* — H. C. Verma

- *Engineering Physics* — M. N. Avadhanulu & P. G. Kshirsagar
- *Practical Physics* — C. L. Arora

Online Platforms:

- SWAYAM/NPTEL: "Engineering Physics" courses by IITs/NITs

PRACTICAL LIST:

Section A: Mechanics

1. Vernier Calipers & Screw Gauge: Measurement of dimensions of given objects
2. Simple Pendulum: Determination of 'g' and study of laws of pendulum
3. Young's Modulus: By Searle's method or cantilever
4. Coefficient of Friction: Using inclined plane
5. Force Table: Verification of law of parallelogram of forces

Section B: Thermal Physics

6. Specific Heat Capacity: Of solid/liquid using calorimeter
7. Thermal Conductivity: Of good conductor (Searle's apparatus)
8. Mechanical Equivalent of Heat: Using Joule's calorimeter
9. Coefficient of Linear Expansion: Using optical lever

Section C: Waves & Optics

10. Sonometer: Verification of laws of vibrating strings
11. Melde's Experiment: Transverse and longitudinal modes
12. Compound Pendulum: Determination of 'g' and radius of gyration
13. Optical Bench: Focal length of convex lens
14. Prism: Refractive index using spectrometer

Section D: Modern Physics

15. LASER: Determination of wavelength using diffraction grating
16. Photoelectric Effect: Verification of Einstein's equation
17. PN Junction Diode: Characteristics
18. Thermistor: Temperature-resistance characteristics

COURSE CODE: DAE103

COURSE NAME: ENGINEERING CHEMISTRY

Course Objectives:

- To provide fundamental knowledge of chemistry relevant to mechanical engineering applications
- To understand material properties, corrosion, fuels, and lubricants from chemical perspective
- To develop skills in chemical analysis, quality control, and material testing
- To correlate chemical principles with mechanical systems and manufacturing processes
- To build foundation for materials science, metallurgy, and environmental engineering

Course Outcomes: At the end of the course students shall be able to

CO1	**Explain** water treatment processes for industrial applications
CO2	**Analyze** properties of fuels and lubricants used in mechanical systems
C03	**Identify** corrosion mechanisms and prevention methods
C04	**Apply** principles of electrochemistry to batteries and corrosion control

Unit	Content	Credit	Weightage

I	**Water Chemistry & Treatment** **Topics:** • Water impurities: hardness, alkalinity, pH • Water softening methods: lime-soda, ion exchange • Boiler feed water treatment: scale and sludge formation, prevention • Cooling water treatment • Drinking water standards • **Applications:** Boiler operations, cooling systems, industrial water supply	1	25%
II	**Fuels & Combustion** **Topics:** • Classification of fuels: solid, liquid, gaseous • Calorific value determination: bomb calorimeter • Solid fuels: coal analysis (proximate & ultimate) • Liquid fuels: petroleum refining, petrol, diesel, octane/cetane number • Gaseous fuels: LPG, CNG, biogas • Combustion calculations • **Applications:** IC engines, furnaces, power generation	1	25%
III	**Lubricants & Corrosion** **Topics:** • Lubrication: mechanisms, types of lubricants • Properties: viscosity index, flash point, pour point • Additives in lubricants • Corrosion: types, mechanisms (electrochemical) • Factors affecting corrosion • Corrosion prevention methods • **Applications:** Machine maintenance, automotive, industrial equipment	1	25%
IV	**Engineering Materials & Polymers** **Topics:** • Cement: composition, setting and hardening • Refractories: properties, classification • Polymers: addition, condensation, engineering plastics • Composite materials: introduction • Batteries: primary, secondary, fuel cells • **Applications:** Construction materials, polymers in engineering, energy storage	1	25%

Textbooks:

- Primary: *Engineering Chemistry* — Jain & Jain
- Primary: *Engineering Chemistry* — Dr. O. P. Verma

Reference books:

- *A Textbook of Engineering Chemistry* — S. S. Dara & S. S. Umare
- *Engineering Chemistry* — R. P. Mani & K. N. Mishra
- *Chemistry for Engineering Students* — B. S. Jai Prakash & R. Venugopal
- *Applied Chemistry* — H. D. Gesser

Online Platforms:

- SWAYAM/NPTEL: "Engineering Chemistry" courses by IITs
- Khan Academy: Chemistry fundamentals
- MERLOT: Chemistry learning materials

PRACTICAL LIST:

Section A: Water Analysis

1. Determination of Hardness: By EDTA titration method
2. Alkalinity Determination: Using acid-base titration
3. pH Measurement: Using pH meter/universal indicator
4. Chloride Content: By argentometric method

Section B: Fuels & Lubricants

5. Viscosity Measurement: Using Ostwald viscometer/Redwood viscometer
6. Flash Point Determination: Using Abel/Pensky Martens apparatus
7. Calorific Value: Bomb calorimeter demonstration
8. Saponification Value: Of oil sample

Section C: Corrosion & Electrochemistry

9. Corrosion Rate Measurement: Weight loss method
10. Galvanic Series Determination
11. Electroplating: Copper plating on iron
12. EMF Measurement: Of simple galvanic cell

Section D: Materials & Polymers

13. Cement Setting Time: Initial and final setting time
14. Polymer Identification Tests
15. Preparation of Polymer: Phenol-formaldehyde/Bakelite
16. Refractory Properties: Porosity, thermal shock resistance

SUBJECT CODE: DAE104

SUBJECT NAME: ENGINEERING GRAPHICS AND CAD

Course Objectives:

- To develop spatial visualization skills for interpreting and creating engineering drawings.
- To introduce manual drafting techniques using standard drawing instruments.
- To impart proficiency in Computer-Aided Design (CAD) software for 2D and 3D modeling.
- To apply geometric dimensioning and tolerancing (GD&T) principles in mechanical design.
- To prepare students for creating manufacturing-ready drawings and assemblies.
- To integrate CAD with modern engineering workflows and design thinking.

Course Outcomes: At the end of the course students shall be able to

CO1	Create and interpret engineering drawings using standard conventions (BIS/ISO).
CO2	Construct orthographic, isometric, and sectional views of mechanical components.
C03	Develop 3D solid models and assemblies using CAD software (SolidWorks/AutoCAD).

Unit	Content	Credit	Weightage
I	**FUNDAMENTALS OF ENGINEERING DRAWING** • **Drawing Instruments & Standards:** Use of drawing tools, BIS/ISO standards, sheet layout, title block. • **Lettering & Line Types:** Engineering lettering (single	1	30%

	stroke), types of lines (visible, hidden, center, section). • **Geometric Constructions:** Bisection, division of lines, tangency, polygons, conic sections. • **Scales:** Plain, diagonal, vernier scales, scale selection for drawings. • **Dimensioning:** Aligned and unidirectional systems, chain and parallel dimensioning, rules.		
II	**ORTHOGRAPHIC PROJECTIONS & SECTIONS** • **Projection Principles:** First-angle vs. third-angle projection, projection of points and lines. • **Orthographic Views:** Front, top, side views of simple and complex objects, missing view problems. • **Auxiliary Views:** Primary and secondary auxiliary projections for inclined surfaces. • **Sectional Views:** Full, half, offset, aligned, and broken-out sections, section lining conventions. • **Conventional Practices:** Simplified representation of threads, springs, gears, and welded joints.	1	35%
III	**PICTORIAL & DEVELOPMENT DRAWINGS** • **Isometric Projection:** Isometric axes, isometric scale, construction of isometric views from orthographic. • **Perspective Drawing:** One-point and two-point perspective basics. • **Development of Surfaces:** Parallel-line and radial-line development of prisms, cylinders, cones, and transitions. • **Intersection of Solids:** Interpenetration of cylinders, prisms, and cones, line of intersection. • **Applications:** Sheet metal layouts, ducting, piping, and container design.	1	35%

TEXT BOOKS:

- Engineering Drawing – N.D. Bhatt (Charotar Publishing)
- Engineering Drawing with CAD – M.B. Shah & B.C. Rana (Pearson)
- Engineering Graphics – K.V. Natarajan (SCItech Publications)
- AutoCAD 2023: A Problem-Solving Approach – Sham Tickoo (CADCIM Technologies)

REFERENCE BOOKS:

- Technical Drawing – Giesecke, Mitchell, Spencer (Pearson)
- Engineering Design: A CAD Approach – A. Deane, C. McAdams (Wiley)
- SolidWorks 2023 for Engineers and Designers – Prof. Sham Tickoo (CADCIM)
- Geometric Dimensioning and Tolerancing – James D. Meadows (CRC Press)

LIST OF PRACTICALS:

- Lab 1: Use of drawing instruments, lettering practice, geometric constructions.
- Lab 2: Orthographic projections of simple objects (first-angle projection).
- Lab 3: Orthographic projections of objects with inclined surfaces.
- Lab 4: Sectional views of machine components (full, half, offset sections).
- Lab 5: Isometric drawing from given orthographic views.
- Lab 6: Development of lateral surfaces of prism, cylinder, and cone.
- Lab 7: Introduction to CAD software – basic commands, coordinate input, drawing setup.
- Lab 8: 2D drafting – drawing and editing commands, layers, dimensioning.
- Lab 9: 3D solid modelling – extrude, revolve, Boolean operations.
- Lab 10: Advanced 3D modelling – sweep, loft, shell, fillet, chamfer.

SEMESTER-II

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COURSE CODE: DAE201

COURSE NAME: ENGINEERING MATHEMATICS-II

Course Objectives:

- To build advanced mathematical skills for engineering problem-solving
- To apply differential equations to model mechanical systems
- To understand vector algebra and its applications in mechanics
- To develop skills in numerical methods for engineering computations
- To prepare mathematical foundation for subjects like Mechanics, Thermodynamics, and Machine Design

Course Outcomes: At the end of the course students shall be able to

CO1	**Solve** ordinary differential equations relevant to engineering systems
CO2	**Apply** vector algebra to analyze forces and motions in 3D space
C03	**Perform** numerical computations using interpolation, differentiation, and integration methods
C04	**Analyze** data using probability distributions and statistical methods

Unit	Content	Credit	Weightage
I	**Differential Equations** **Topics:** • First order differential equations: variable separable, homogeneous, exact • Linear differential equations of first order • Applications: Newton's law of cooling, growth and decay, simple circuits • Second order linear differential equations with constant coefficients • Complementary function and particular integral methods • **Applications:** Spring-mass systems, electrical circuits, vibration analysis	1	25%
II	**Vector Algebra & 3D Geometry** **Topics:** • Vectors: dot product, cross product, scalar triple product • Vector differentiation • Gradient, divergence, curl (basic concepts) • Lines and planes in 3D space • Direction cosines and ratios • **Applications:** Force analysis, moment of force, work done by force	1	25%
III	**Numerical Methods** **Topics:** • Solution of algebraic equations: Bisection method, Newton-Raphson method • Interpolation: Newton's forward and backward	1	25%

	difference formulas • Numerical differentiation and integration • Trapezoidal rule and Simpson's rules • **Applications:** Root finding in design equations, area calculations, data analysis		
IV	**Probability & Laplace Transforms** **Topics:** • **Probability:** Basic concepts, addition and multiplication theorems • Random variables, probability distributions (Binomial, Poisson, Normal) • Mean, variance, standard deviation • **Laplace Transforms:** Definition, basic transforms • Properties: linearity, shifting, differentiation • Application to differential equations • **Applications:** Quality control, reliability analysis, system dynamics	1	25%

Textbooks:

- Primary: *Higher Engineering Mathematics* — B.S. Grewal
- Primary: *Engineering Mathematics* — NP Bali & Dr. Manish Goyal

Reference books:

- *Advanced Engineering Mathematics* — H.K. Das
- *Numerical Methods* — S.S. Sastry
- *Probability and Statistics for Engineers* — Dr. J. Ravichandran
- *Mathematical Methods* — B.V. Ramana

Online Platforms:

- NPTEL Videos: "Differential Equations for Engineers"
- Khan Academy: Complete probability and statistics
- MIT OCW: "Single Variable Calculus" continuation
  Coursera: "Introduction to Numerical Methods"

SUBJECT CODE: DAE202

SUBJECT NAME: ENGINEERING MECHANICS

Course Objectives:

- To introduce the fundamental principles of statics, dynamics, and mechanics of materials.
- To develop analytical skills for solving problems involving forces, equilibrium, and motion.
- To apply principles of mechanics to analyse structures, machines, and mechanical systems.
- To prepare students for advanced courses in solid mechanics, machine design, and dynamics.

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze force systems and compute resultants for particles and rigid bodies.
CO2	Apply equilibrium conditions to solve problems in statics for trusses, beams, and frames.
C03	Determine centroids, moments of inertia, and analyze friction in mechanical systems.
C04	Solve kinematics and kinetics problems for particles and rigid bodies in motion.

Unit	Content	Credit	Weightage
I	STATICS OF PARTICLES & RIGID BODIES Introduction to Mechanics, Force Systems, Resultant of Force Systems, Equilibrium of Particles, Moment of a Force, Rigid Body Equilibrium	1	25%
II	ANALYSIS OF STRUCTURES Trusses, Frames and Machines, Beams, Cables and Arches, Friction	1	25%
III	PROPERTIES OF SURFACES AND DISTRIBUTED FORCES Centroid, Centre of Gravity, Moment of Inertia, Mass Moment of Inertia, Virtual Work	1	25%
IV	DYNAMICS OF PARTICLES AND RIGID BODIES Kinematics of Particles, Kinetics of Particles, Kinematics of Rigid Bodies, Kinetics of Rigid Bodies, Vibrations	1	25%

Textbooks:

- Engineering Mechanics: Statics and Dynamics – R.C. Hibbeler (Pearson)
- Engineering Mechanics – S. S. Bhavikatti and K. G. Rajashekarappa (New Age International)
- Engineering Mechanics: Statics & Dynamics – Irving H. Shames (Prentice Hall)
- Engineering Mechanics: Statics and Dynamics – J.L. Meriam and L.G. Kraige (Wiley)

Reference books:

- Vector Mechanics for Engineers: Statics and Dynamics – Beer and Johnston (McGraw Hill)
- Engineering Mechanics – D.S. Bedi (Khanna Publishers)
- A Textbook of Engineering Mechanics – R.K. Bansal (Laxmi Publications)
- Engineering Mechanics: Problems and Solutions – K. Vijaya Kumar and J. Suresh Kumar (McGraw Hill)
- Advanced Engineering Mechanics – H.C. Gupta (Standard Publishers)

SUBJECT CODE: DAE203

SUBJECT NAME: ENGINEERING MECHANICS

Course Objectives:

- To provide foundation in electrical and electronics principles relevant to aircraft systems
- To develop understanding of aircraft electrical power generation and distribution
- To enable troubleshooting of basic electrical and electronic circuits in aviation context
- To introduce aviation-specific instruments, sensors, and control systems
- To impart knowledge of electrical safety standards in aircraft maintenance

Course Outcomes: At the end of the course students shall be able to

CO1	Understand fundamental electrical concepts and apply them to aircraft electrical systems
CO2	Analyze DC and AC circuits used in aircraft electrical networks
C03	Operate and troubleshoot basic electronic components in aviation applications
C04	Demonstrate knowledge of aircraft electrical systems, instruments,

	and safety procedures

Unit	Content	Credit	Weightage
I	**Electrical Fundamentals & Aircraft Power Systems** • **Basic Electrical Concepts:** o Voltage, current, resistance, power, energy o Ohm's Law, Kirchhoff's Laws o Series and parallel circuits • **DC Circuit Analysis:** o Network theorems: Thevenin's, Norton's, Superposition o Capacitors and inductors in DC circuits o Transient response basics • **Aircraft Electrical Power Generation:** o Aircraft batteries: Lead-acid, Nickel-Cadmium, Lithium-ion o DC generators and alternators in aircraft o Voltage regulation systems • **Aircraft Power Distribution:** o Aircraft electrical buses and distribution systems o Circuit protection: Fuses, circuit breakers, current limiters o Wiring and connectors used in aircraft • **Electrical Safety in Aircraft:** o Hazards of electricity in aircraft o Static electricity and bonding o Grounding procedures	1	25%
II	**AC Circuits & Aircraft Electrical Systems** • **AC Fundamentals:** o Generation of AC voltage o RMS, average, peak values o Phase relationships • **AC Circuit Analysis:** o R, L, C in AC circuits o Impedance and admittance o Power in AC circuits: Active, reactive, apparent power o Power factor and correction • **Transformers:** o Principle of operation o Transformer types used in aircraft o Transformer ratings and efficiency • **Aircraft AC Systems:** o Aircraft AC power generation (115V, 400Hz systems) o Inverters and frequency converters	1	25%

	○ Variable Frequency Systems (VFS) in modern aircraft • **Aircraft Lighting Systems:** ○ Navigation lights, anti-collision lights ○ Interior lighting, emergency lighting ○ Landing and taxi lights		
III	**Electronic Components & Digital Basics** • **Semiconductor Devices:** ○ Diodes: Characteristics, types (Zener, LED) ○ Rectifiers: Half-wave, full-wave, bridge ○ Filters: Capacitor filters • **Transistors:** ○ BJT: Characteristics, configurations (CE, CB, CC) ○ FET basics ○ Transistor as switch and amplifier • **Operational Amplifiers:** ○ Ideal op-amp characteristics ○ Basic configurations: Inverting, non-inverting ○ Applications: Comparators, summing amplifiers • **Digital Electronics Fundamentals:** ○ Number systems: Binary, hexadecimal ○ Logic gates: AND, OR, NOT, NAND, NOR, XOR ○ Boolean algebra basics ○ Introduction to flip-flops and counters • **Sensors and Transducers:** ○ Temperature sensors: Thermocouples, RTDs ○ Pressure sensors ○ Position sensors: Potentiometers, LVDTs ○ Speed and vibration sensors	1	25%
IV	**Aircraft Instruments & Control Systems** • **Aircraft Electrical Instruments:** ○ Moving coil, moving iron instruments ○ Digital multimeters, clamp meters ○ Meggers and insulation testers • **Aircraft Electronic Instruments:** ○ Electronic Flight Instrument System (EFIS) basics ○ Engine Indicating and Crew Alerting System (EICAS) ○ Digital displays and indicators • **Aircraft Control Systems:** ○ Relays and contactors ○ Solenoids and actuators ○ Servo mechanisms	1	25%

	• **Communication and Navigation Systems:**
	  ○ VHF communication basics
	  ○ Navigation aids: VOR, ILS basics
	  ○ Transponders and DME basics
	• **Maintenance and Troubleshooting:**
	  ○ Wiring diagram reading (ATA chapters 20, 21, 23-33)
	  ○ Continuity testing		

Textbooks:

- "Aircraft Electricity and Electronics" (7th Edition) – Thomas K. Eismin, Herbert E. Meese
- "Aircraft Electrical and Electronic Systems" – Mike Tooley & David Wyatt
- "Basic Electrical and Electronics Engineering" – R. K. Rajput
- "Fundamentals of Electric Circuits" – Charles K. Alexander & Matthew N. O. Sadiku

Reference books:

- "Aircraft Electrical Systems" – E. H. J. Pallett
- "Aviation Maintenance Technician Series: Powerplant" – Dale Crane
- "Digital Fundamentals" – Thomas L. Floyd
- "Electrical Systems for Aircraft" – David Wyatt & Mike Tooley
- "FAA Aviation Maintenance Technician Handbook – General" (FAA-H-8083-30A)

Online platforms:

- Aviation Maintenance e-learning (FAA, EASA online resources)
- Coursera: "Introduction to Aeronautical Engineering" by TU Delft
- edX: "Aircraft Systems" courses
- Skill-Lync: Aeronautical engineering courses
- NPTEL: "Aircraft Electrical Systems" by IIT Bombay

Practical list:

1. Aircraft Battery Testing & Maintenance
   - Specific gravity measurement of lead-acid battery
   - Voltage and capacity testing
   - Battery charging procedures
   - *Equipment: Hydrometer, battery tester, charger*
2. Wiring Harness Fabrication
   - Crimping aviation connectors
   - Wiring identification and marking
   - Continuity testing of aircraft wiring
   - *Equipment: Crimping tool, multimeter, wire strippers*
3. Circuit Protection Devices
   - Testing aircraft fuses and circuit breakers
   - Current measurement in aircraft circuits
   - Wiring insulation testing
   - *Equipment: Megger, clamp meter, fuse tester*
4. AC Power Measurement
   - Measurement of voltage, current, frequency
   - Power factor measurement and correction
   - Transformer testing
   - *Equipment: Power analyzer, frequency meter*
5. Aircraft Lighting System Analysis
   - Navigation light circuit analysis

- Landing light current measurement
- Emergency lighting system testing
- *Equipment: Light meter, current probes*

6. Generator/Alternator Testing
   - Output voltage and frequency measurement
   - Voltage regulator testing
   - Load testing
   - *Equipment: Load bank, oscilloscope*
7. Rectifier and Power Supply Circuits
   - Half-wave and full-wave rectifier construction
   - Filter circuit implementation
   - Voltage regulation using Zener diode
   - *Equipment: Oscilloscope, function generator*
8. Transistor Amplifier Circuits
   - Common emitter amplifier construction
   - Gain measurement
   - Frequency response analysis
   - *Equipment: Signal generator, oscilloscope*
9. Digital Logic Circuits
   - Implementation of basic logic gates
   - Binary to decimal conversion circuits
   - Simple counter circuit
   - *Equipment: Logic trainer kit, breadboard*
10. Sensor Calibration and Testing
    - Thermocouple calibration
    - Pressure sensor interface
    - Potentiometer as position sensor
    - *Equipment: Calibration equipment, multimeter*

SUBJECT CODE: DAE204

SUBJECT NAME: MATERIAL SCIENCE AND ENGINEERING

Course Objectives:

- To understand the relationship between material structure, properties, processing, and performance.
- To classify engineering materials and analyse their atomic, crystal, and microstructure.
- To evaluate mechanical properties of materials and their behaviour under different loading conditions.
- To select appropriate materials for mechanical design applications based on engineering requirements.
- To explore modern materials, composites, nanomaterials, and their applications in mechanical engineering.

Course Outcomes: At the end of the course students shall be able to

CO1	Classify engineering materials based on atomic bonding, crystal structure, and properties.
CO2	Analyze crystal defects, phase diagrams, and microstructure-property relationships.
C03	Evaluate mechanical behavior of materials under static, dynamic, and cyclic loading.
C04	Select appropriate materials for mechanical components considering performance and sustainability.

Unit	Content	Credit	Weightage
I	STRUCTURE OF MATERIALS Atomic Structure & Bonding, Crystal Structure, Crystalline & Amorphous Materials, Crystal Imperfections, Diffusion in Solids	1	25%
II	PHASE DIAGRAMS & HEAT TREATMENT Phase Rule & Phase Diagrams, Iron-Carbon Phase Diagram, Heat Treatment Processes, Surface Hardening, TTT & CCT Diagrams	1	25%
III	MECHANICAL PROPERTIES & FAILURE Mechanical Testing, Deformation Mechanisms, Fracture & Fatigue, Fracture Mechanics, Non-Destructive Testing (NDT)	1	25%
IV	ENGINEERING MATERIALS & SELECTION Ferrous Alloys, Non-Ferrous Alloys, Polymers & Ceramics, Composites, Advanced Materials, Material Selection	1	25%

Textbooks:

- Materials Science and Engineering: An Introduction – William D. Callister, Jr. (Wiley)
- Engineering Materials: Properties and Selection – Kenneth G. Budinski (Pearson)
- Material Science and Engineering – V. Raghavan (Prentice Hall India)
- Introduction to Materials Science for Engineers – James F. Shackelford (Pearson)

Reference books:

- The Science and Engineering of Materials – Donald R. Askeland and Wendelin J. Wright (Cengage)
- Elements of Materials Science and Engineering – L. H. Van Vlack (Pearson)
- Mechanical Behaviour of Materials – Norman E. Dowling (Pearson)
- Materials Selection in Mechanical Design – Michael F. Ashby (Butterworth-Heinemann)
- Phase Transformations in Metals and Alloys – David A. Porter and Kenneth E. Easterling (CRC Press)

Online Platforms:

- NPTEL Courses:
    1. "Materials Science and Engineering" by Prof. Satish V. Kailas (IISc Bangalore)
    2. "Introduction to Materials Science" by IIT Madras

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SEMESTER-III

COURSE CODE: DAE301

COURSE NAME: FLUID MECHANICS AND HYDRAULICS

Course Objectives:

- To understand fundamental properties and behavior of fluids
- To study fluid statics, dynamics, and flow measurement techniques
- To analyze flow through pipes and channels
- To learn working principles of hydraulic machines: pumps and turbines
- To develop skills in fluid mechanics experimentation and data analysis

Course Outcomes: At the end of the course students shall be able to

CO1	**Apply** fluid properties and principles to engineering problems
CO2	**Calculate** forces on submerged surfaces and buoyancy effects
C03	**Analyze** fluid flow using continuity, energy, and momentum equations
C04	**Measure** flow rate using various flow measurement devices

Unit	Content	Credit	Weightage
I	**Fluid Properties & Fluid Statics** **Topics:** • Properties of fluids: density, viscosity, surface tension • Pressure measurement: manometers, pressure gauges • Hydrostatic forces on submerged surfaces • Buoyancy and flotation • Stability of floating bodies • **Applications:** Dam design, ship stability, pressure vessels	1	25%
II	**Fluid Dynamics & Flow Measurement** **Topics:** • Types of fluid flow: steady/unsteady, laminar/turbulent • Continuity equation, Bernoulli's equation • Venturimeter, orifice meter, pitot tube • Flow through pipes: major and minor losses • Darcy-Weisbach equation, Moody's chart • **Applications:** Pipe network design, flow measurement	1	25%
III	**Hydraulic Pumps** **Topics:** • Classification of pumps • Centrifugal pumps: working principle, components • Performance characteristics: head, discharge, efficiency • Cavitation and NPSH • Reciprocating pumps: working principle • **Applications:** Water supply, irrigation, industrial	1	25%

	processes		
IV	**Hydraulic Turbines & Hydraulic Systems** **Topics:** • Classification of turbines • Impulse turbines: Pelton wheel • Reaction turbines: Francis, Kaplan • Performance characteristics • Hydraulic systems: accumulators, presses • **Applications:** Hydroelectric power, industrial power transmission	1	25%

Textbooks:

- Primary: *Fluid Mechanics and Hydraulic Machines* — R. K. Bansal
- Primary: *Hydraulics and Fluid Mechanics* — P. N. Modi & S. M. Seth

Reference books:

- *Fluid Mechanics* — Frank M. White
- *A Textbook of Fluid Mechanics and Hydraulic Machines* — R. K. Rajput
- *Engineering Fluid Mechanics* — K. L. Kumar
- *Hydraulic Machines* — Jagdish Lal

Online Platforms:

- SWAYAM/NPTEL: "Fluid Mechanics" courses by IITs
- edX: "Fluid Mechanics" by MIT

PRACTICAL LIST:

Section A: Fluid Properties & Statics

1. Viscosity Measurement: Using Saybolt/Ford cup viscometer
2. Bernoulli's Theorem: Verification using Bernoulli's apparatus
3. Metacentric Height: Determination for floating bodies
4. Hydrostatic Pressure: On submerged surfaces

Section B: Flow Measurement

5. Venturimeter: Calibration and coefficient determination
6. Orifice Meter: Coefficient of discharge measurement
7. Pitot Tube: Velocity measurement in pipe
8. Reynolds Experiment: Demonstration of laminar and turbulent flow

Section C: Pipe Flow & Losses

9. Major Losses: Friction factor determination in pipes
10. Minor Losses: Sudden expansion/contraction, bends
11. Flow Visualization: Using dye injection
12. Notches & Weirs: Discharge measurement

Section D: Hydraulic Machines

13. Centrifugal Pump: Performance characteristics test
14. Reciprocating Pump: Performance test
15. Pelton Wheel Turbine: Performance characteristics
16. Francis Turbine: Performance test
17. Hydraulic Ram: Demonstration
18. Gear Oil Pump: Performance test

SUBJECT CODE: DAE302

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SUBJECT NAME: THERMODYNAMICS

Course Objectives:

- To understand the fundamental concepts, laws, and principles of thermodynamics.
- To analyse thermodynamic properties of pure substances and apply property tables/charts.
- To evaluate thermodynamic cycles (power, refrigeration, heat pump) and their performance.
- To develop problem-solving skills for energy conversion, transfer, and utilization in mechanical systems.
- To apply thermodynamic principles to real-world engineering applications (IC engines, power plants, HVAC).

Course Outcomes: At the end of the course students shall be able to

CO1	Apply the zeroth and first laws of thermodynamics to closed and open systems.
CO2	Analyze the properties of pure substances using tables, charts, and equations of state.
C03	Apply the second law to evaluate entropy, irreversibility, and cycle efficiency.
C04	Analyze and design basic power, refrigeration, and heat pump cycles.

Unit	Content	Credit	Weightage
I	BASIC CONCEPTS & ZEROTH LAW Introduction to Thermodynamics, Thermodynamic Properties, Processes & Cycles, Zeroth Law of Thermodynamics, Work & Heat	1	25%
II	FIRST LAW OF THERMODYNAMICS First Law for Closed Systems, First Law for Open Systems, Energy Analysis of Engineering Devices, Thermodynamic Properties of Pure Substances Equations of State	1	25%
III	SECOND LAW OF THERMODYNAMICS Limitations of First Law, Kelvin-Planck & Clausius Statements, Carnot Cycle, Entropy, Irreversibility & Exergy	1	25%
IV	THERMODYNAMIC CYCLES & APPLICATIONS Gas Power Cycles, Vapor Power Cycles, Refrigeration Cycles, Heat Pump Cycles, Psychrometric	1	25%

Textbooks:

- Engineering Thermodynamics – P.K. Nag (McGraw Hill)
- Thermodynamics: An Engineering Approach – Yunus A. Çengel and Michael A. Boles (McGraw Hill)
- Engineering Thermodynamics – D.S. Kumar (S.K. Kataria & Sons)
- Thermodynamics – J.P. Holman (McGraw Hill)

Reference books:

- Fundamentals of Engineering Thermodynamics – Michael J. Moran and Howard N. Shapiro (Wiley)
- Thermodynamics – R.K. Rajput (Laxmi Publications)
- Applied Thermodynamics – T.D. Eastop and A. McConkey (Pearson)
- Thermodynamics and Heat Engines – R. Yadav (Central Publishing House)
- Thermodynamic Cycles: Computer-Aided Design and Optimization – Chih Wu (CRC Press)

Online Platforms:

1. **NPTEL Courses:**
   - "Applied Thermodynamics" by Prof. S.K. Som (IIT Kharagpur)
   - "Thermodynamics" by Prof. M. Ramgopal (IIT Kharagpur)

SUBJECT CODE: DAE303

SUBJECT NAME: AIRCRAFT STRUCTURES-I

Course Objectives:

- To introduce fundamental principles of aircraft structural analysis and design
- To understand different types of aircraft structures and their load-carrying mechanisms
- To analyze stress, strain, and deformation in aircraft structural components
- To develop skills in analyzing thin-walled structures and structural joints
- To prepare students for advanced courses in aircraft structural design and fatigue analysis

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze aircraft structural components under various loading conditions
CO2	Determine stresses and deformations in thin-walled aircraft structures
C03	Evaluate structural stability and buckling behavior of aircraft components
C04	Design and analyze aircraft structural joints and connections

Unit	Content	Credit	Weightage

I	**INTRODUCTION TO AIRCRAFT STRUCTURES & LOADS**
	• **Historical Development**: Evolution of aircraft structural design
	• **Aircraft Structural Components**: Fuselage, wings, empennage, control surfaces
	• **Structural Configurations**: Truss, monocoque, semi-monocoque construction
	• **Materials in Aircraft Structures**: Aluminum alloys, composites, titanium
	• **Aircraft Loads**:
	  ○ Air loads (aerodynamic forces)
	  ○ Inertia loads (acceleration forces)
	  ○ Ground loads (landing, taxiing)
	  ○ Special loads (pressurization, bird strike)
	• **Load Factors**: Gust loads, maneuver loads, limit and ultimate loads
	• **V-n Diagram**: Flight envelope and structural limits
	• **Structural Safety Factors**: Factor of safety, proof load, ultimate load
		1	25%

II	**ANALYSIS OF THIN-WALLED STRUCTURES** • **Thin-Walled Beam Theory**: Assumptions and limitations	1	25%

	• **Shear Flow in Closed Sections**: Bredt-Batho formula
	• **Shear Center**: Determination for open and closed sections
	• **Torsion of Thin-Walled Sections**:
	  ○ Open sections (Saint-Venant torsion)
	  ○ Closed sections (Bredt-Batho theory)
	  ○ Multi-cell sections
	• **Warping in Thin-Walled Beams**: Concept and significance
	• **Shear Lag Phenomenon**: Effect on stress distribution
	• **Aircraft Applications**:
	  ○ Wing box analysis
	  ○ Fuselage shell analysis
	  ○ Control surface torsion boxes		

III	**BUCKLING & STABILITY OF AIRCRAFT STRUCTURES**
	• **Column Buckling**: Euler buckling formula for various end conditions
	• **Effective Length Concept**: For different boundary conditions
	• **Local Buckling**: Plate and shell buckling
	• **Critical Buckling Stress**: For plates under compression and shear
	• **Stiffened Panels**: Stringer-stiffened panels, waffle panels
	• **Post-Buckling Strength**: Behavior after initial buckling
	• **Crippling of Thin Sections**: Failure of thin-walled columns
	• **Aircraft Applications**:
	  ○ Wing skin buckling analysis
	  ○ Fuselage panel stability
	  ○ Rib and frame design for buckling prevention
		1	25%

IV	**JOINTS & CONNECTIONS IN AIRCRAFT STRUCTURES**
	• **Types of Aircraft Joints**:
	  ○ Bolted joints (shear, tension, bearing)
	  ○ Riveted joints
	  ○ Bonded joints (adhesive bonding)
	  ○ Welded joints (spot welding, TIG welding)
	• **Stress Analysis of Joints**:
	  ○ Load distribution in multi-fastener joints
	  ○ Eccentrically loaded joints
	  ○ Fatigue considerations in joints
	• **Failure Modes**:
	  ○ Shear failure of fasteners
		1	25%

	○ Bearing failure of sheets ○ Net-section failure ○ Tear-out failure • **Joint Efficiency**: Factors affecting joint strength • **Special Connections**: ○ Wing-fuselage attachments ○ Engine mounts ○ Landing gear attachments ○ Control surface hinges • **Repair Considerations**: Damage tolerance, repairability		

Textbooks:

- "Aircraft Structures for Engineering Students" by T.H.G. Megson *Elsevier, 7th Edition*
- "Analysis of Aircraft Structures: An Introduction" by Bruce K. Donaldson *Cambridge University Press, 2nd Edition*
- "Introduction to Aircraft Structural Analysis" by David J. Peery and J.J. Azar *Dover Publications*

Reference books:

- "Theory and Analysis of Flight Structures" by Robert M. Rivello *McGraw-Hill*
- "Airframe Stress Analysis and Sizing" by Michael C.Y. Niu *Hong Kong Commilit Press, 3rd Edition*
- "Structural Analysis: With Applications to Aerospace Structures" by Bruce K. Donaldson *Springer*
- "Aircraft Design: A Conceptual Approach" by Daniel P. Raymer *AIAA Education Series, 6th Edition*
- "Bruhn's Analysis and Design of Flight Vehicle Structures" by E.F. Bruhn *Jacobs Publishing*
- "Handbook of Structural Life Assessment" by Raheem M.A. *Wiley*

Online Platforms:

NPTEL (National Programme on Technology Enhanced Learning):

- "Aircraft Structures" by IIT Kharagpur
- "Structural Analysis" by IIT Madras
- "Finite Element Analysis" by IIT Kanpur
- "Aircraft Design" by IIT Bombay

PRACTICAL LIST:

Session 1: Material Properties Determination • Tensile test of aerospace aluminum alloy (2024-T3) • Determination of Young's modulus, yield strength, ultimate strength • Calculation of Poisson's ratio from strain measurements • Comparison with aerospace material specifications (AMS standards) Session 2: Beam Bending Analysis • Three-point bending test of aircraft spar specimen	Session 7: Column Buckling Experiment • Euler buckling test of slender columns • Effect of end conditions on buckling load • Comparison of experimental vs theoretical buckling loads • Determination of effective length factors Session 8: Plate Buckling Analysis • Buckling test of thin aluminum plates under compression

- Calculation of bending stress distribution
- Deflection measurement and comparison with theoretical values
- Stress concentration factors at cutouts

Session 3: Torsion Testing

- Torsion test of thin-walled tube (simulating aircraft structural member)
- Measurement of angle of twist vs applied torque
- Calculation of shear modulus
- Comparison of open vs closed section torsional stiffness

Session 4: Shear Center Determination

- Experimental determination of shear center for channel section
- Calculation of shear flow distribution
- Comparison with theoretical predictions
- Application to aircraft wing rib design

Session 5: Thin-Walled Beam Analysis

- Load distribution in multi-cell wing box model
- Shear flow analysis using strain gauge measurements
- Torsional stiffness measurement
- Warping effects observation

Session 6: Composite Laminate Analysis

- Preparation of simple composite laminate
- Determination of laminate properties
- Comparison with metallic structure properties

Failure modes in composite structures

- Observation of buckling modes (half-wave, full-wave)
- Effect of edge constraints on buckling load
- Post-buckling strength measurement

Session 9: Stiffened Panel Analysis

- Testing of stringer-stiffened panel under compression
- Comparison of buckling loads with unstiffened panel
- Local vs global buckling observation
- Crippling strength determination

Session 10: Joint Analysis

- Tensile test of single lap joint
- Shear test of multi-rivet joint
- Failure mode analysis (shear, bearing, net-section)
- Joint efficiency calculation

Session 11: Introduction to FEA Software

- Basic modeling of simple beam in ANSYS
- Static analysis of cantilever beam
- Stress and deformation visualization
- Comparison with analytical solutions

Session 12: Aircraft Component Analysis Project

Choose one of the following:

- Wing Rib Analysis: Stress analysis of a typical wing rib
- Fuselage Frame Analysis: Load analysis of fuselage frame
- Landing Gear Attachment: Stress analysis of mounting brackets

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SEMESTER-IV

SUBJECT CODE: DAE401

SUBJECT NAME: AERODYNAMICS

Course Objectives:

- To understand fundamental principles of aerodynamics and their application to aircraft design
- To analyze incompressible flow over air foils and wings using potential flow theory
- To study boundary layer theory and its implications for drag prediction and flow separation
- To develop skills in aerodynamic analysis and performance prediction of aircraft
- To prepare students for advanced courses in high-speed aerodynamics and computational fluid dynamics

Course Outcomes: At the end of the course students shall be able to

CO1	Apply conservation equations to analyze incompressible flow problems
CO2	Analyze airfoil and wing aerodynamics using potential flow theory
C03	Evaluate boundary layer characteristics and predict flow separation
C04	Design and analyze basic aerodynamic configurations using experimental and computational methods

Unit	Content	Credit	Weightage
I	**FUNDAMENTALS & GOVERNING EQUATIONS** **Review of Fluid Mechanics Concepts**: Continuum hypothesis, fluid properties, viscosity Flow visualization techniques Classification of flows (steady/unsteady, laminar/turbulent, compressible/incompressible) **Governing Equations**: Continuity equation (conservation of mass) Momentum equations (Navier-Stokes equations) Energy equation **Inviscid Flow Approximations**: Euler equations **Bernoulli's Equation**: Derivation, applications, limitations **Circulation and Vorticity**: Definition and physical significance Kelvin's circulation theorem Vortex theorems of Helmholtz **Stream Function and Velocity Potential**: Definitions and relationships Laplace equation for potential flow Elementary flows (uniform, source, sink, vortex, doublet) **Flow Similarity and Dimensionless Numbers**: Reynolds number, Mach number Strouhal number, Froude number	1	25%
II	**AIRFOIL THEORY & CHARACTERISTICS** **Air foil Terminology**: Chord line, mean camber line, thickness distribution	1	25%

	Leading edge radius, trailing edge angle NACA air foil series (4-digit, 5-digit, 6-series) **Air foil Aerodynamic Characteristics**: Lift, drag, and moment coefficients Pressure coefficient distribution Center of pressure and aerodynamic center **Thin Air foil Theory**: Small disturbance approximations Symmetric air foil analysis Cambered air foil analysis Determination of lift slope and moment coefficients **Vortex Panel Methods**: Basic principles Numerical implementation (introduction) **Airfoil Experimental Data**: Use of airfoil data charts Effect of Reynolds number on airfoil characteristics Stall characteristics and maximum lift coefficient **Airfoil Selection Criteria**: For different aircraft applications		
III	**FINITE WING THEORY** **Wing Geometry**: Aspect ratio, taper ratio, sweep angle, twist Mean aerodynamic chord Wing planform shapes **Downwash and Induced Drag**: Physical explanation of downwash Induced drag derivation Trefftz plane analysis **Prandtl's Lifting Line Theory**: Basic assumptions and derivations Elliptical lift distribution General lift distributions Effect of aspect ratio on lift and drag **Monoplane Equation**: Fourier series solution Numerical solution methods **Wing Aerodynamic Characteristics**: Lift curve slope for finite wings Oswald efficiency factor Drag polar for complete aircraft **High-Lift Devices**: Flaps and slats Effect on lift and drag **Vortex Lattice Method**: Basic principles and applications	1	25%
IV	**BOUNDARY LAYER THEORY & DRAG PREDICTION** **Boundary Layer Concept**: Historical development Physical description	1	25%

	Boundary layer thickness definitions (δ, δ*, θ) **Laminar Boundary Layer**: Blasius solution for flat plate Similarity solutions Momentum integral equation **Turbulent Boundary Layer**: Characteristics and structure Velocity profiles (1/7th power law) Turbulence modeling concepts **Boundary Layer Separation**: Physical mechanism Prediction methods Control techniques (vortex generators, boundary layer suction) **Drag Prediction**: Skin friction drag calculation Form drag estimation Interference drag Drag reduction techniques **Flow Transition**: Transition prediction Effect of surface roughness Reynolds number effects **Aerodynamic Performance Prediction**: Complete aircraft drag polar Performance estimation methods Range and endurance equations		

Textbooks:

- "Fundamentals of Aerodynamics" by John D. Anderson Jr. *McGraw-Hill Education, 7th Edition*
- "Introduction to Flight" by John D. Anderson Jr. *McGraw-Hill Education, 9th Edition*
- "Aerodynamics for Engineering Students" by E.L. Houghton, P.W. Carpenter, Steven H. Collicott, and Daniel T. Valentine *Butterworth-Heinemann, 7th Edition*

Reference books:

- "Theory of Wing Sections" by Ira H. Abbott and Albert E. von Doenhoff *Dover Publications*
- "Low-Speed Aerodynamics" by Joseph Katz and Allen Plotkin *Cambridge University Press, 2nd Edition*
- "Boundary-Layer Theory" by Hermann Schlichting and Klaus Gersten *Springer, 9th Edition*
- "Aerodynamics of the Airplane" by Clark B. Millikan *Krieger Publishing Company*
- "Flight Vehicle Aerodynamics" by Mark Drela *MIT Press*

Online Platforms:

NPTEL (National Programme on Technology Enhanced Learning):

- "Aerodynamics" by IIT Kanpur
- "Fluid Mechanics" by IIT Bombay
- "Aircraft Performance and Stability" by IIT Kharagpur
- "Computational Fluid Dynamics" by IIT Bombay

PRACTICAL LIST:

Session 1: Flow Visualization Techniques	**Session 7: Finite Wing Characteristics**

1. Smoke tunnel visualization of flow over different shapes 2. Tuft grid visualization of surface flow patterns 3. Oil flow visualization for boundary layer studies 4. Water tunnel visualization using dye injection	1. Testing of wings with different aspect ratios 2. Measurement of induced drag 3. Effect of taper ratio on spanwise lift distribution 4. Determination of Oswald efficiency factor
Session 2: Pressure Measurement Techniques 1. Calibration of pressure transducers 2. Pressure distribution measurement using multi-tube manometer 3. Pitot-static tube calibration and velocity measurement 4. Surface pressure tap installation and measurement	**Session 8: High-Lift Device Testing** 1. Testing of plain flaps 2. Testing of slotted flaps 3. Effect of flap deflection on lift and drag 4. Optimal flap settings for takeoff and landing
Session 3: Velocity Field Measurement 1. Hot-wire anemometry basic principles 2. Laser Doppler Velocimetry (LDV) demonstration 3. Particle Image Velocimetry (PIV) system overview 4. Simple velocity measurement using pitot tube	**Session 9: Complete Aircraft Model Testing** 1. Testing of complete aircraft model in wind tunnel 2. Measurement of complete aircraft drag polar 3. Effect of configuration changes (gear, flaps) 4. Determination of maximum lift-to-drag ratio
Session 4: Air foil Pressure Distribution 1. Mounting and alignment of airfoil in wind tunnel 2. Pressure distribution measurement at various angles of attack 3. Calculation of lift coefficient from pressure data 4. Comparison with theoretical predictions	**Session 10: Boundary Layer Measurement** 1. Measurement of boundary layer thickness on flat plate 2. Determination of displacement and momentum thickness 3. Observation of laminar to turbulent transition 4. Effect of surface roughness on boundary layer
Session 5: Air foil Force Measurement 1. Use of force balance for lift and drag measurement 2. Determination of lift curve slope 3. Measurement of stall angle and maximum lift coefficient 4. Effect of Reynolds number on air foil characteristics	**Session 11: Drag Measurement & Reduction** 1. Drag measurement of bluff bodies 2. Effect of streamlining on drag reduction 3. Testing of drag reduction devices 4. Interference drag studies
Session 6: Computational Air foil Analysis 1. Introduction to XFOIL software 2. Analysis of NACA air foil series 3. Comparison of computational and experimental results 4. Air foil optimization for specific requirements	1. **Air foil Design and Testing**: Design, analyze, and test a new air foil 2. **Wing Performance Optimization**: Optimize wing parameters for specific mission 3. **Aircraft Configuration Analysis**: Complete analysis of specific aircraft configuration 4. **Drag Reduction Study**: Systematic study of drag reduction techniques

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SUBJECT CODE: DAE402

SUBJECT NAME: AIRCRAFT PROPULSION

Course Objectives:

- To understand fundamental principles of aircraft propulsion systems and their working mechanisms
- To analyze thermodynamics and aerodynamics of air-breathing engines
- To study performance characteristics of different propulsion systems for various flight regimes
- To develop experimental skills in propulsion system testing and analysis
- To prepare students for advanced courses in gas turbine technology and rocket propulsion

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze thermodynamic cycles and performance parameters of aircraft propulsion systems
CO2	Evaluate components and working principles of different types of aircraft engines
C03	Calculate performance characteristics and conduct experimental analysis of propulsion systems
C04	Design and analyze propulsion system components and conduct performance optimization studies

Unit	Content	Credit	Weightage
I	**FUNDAMENTALS OF PROPULSION & THERMODYNAMIC CYCLES** • **Introduction to Aircraft Propulsion**: o Historical development of aircraft propulsion o Types of propulsion systems: air-breathing vs non-air-breathing o Thrust generation principles • **Review of Thermodynamics**: o Laws of thermodynamics o Gas properties and equations of state o Isentropic flow relations • **Standard Atmosphere**: o International Standard Atmosphere (ISA) model o Variation of pressure, temperature, density with altitude • **Propulsion Performance Parameters**: o Thrust, specific thrust, thrust specific fuel consumption (TSFC) o Propulsive efficiency, thermal efficiency, overall efficiency o Specific impulse • **Thermodynamic Cycles**: o Otto cycle (piston engines) o Brayton cycle (gas turbine engines) o Ideal vs actual cycles o Cycle efficiency calculations	1	25%

	• **Aircraft Engine Classification**:
	  ○ Reciprocating engines
	  ○ Turbojet engines
	  ○ Turbofan engines
	  ○ Turboprop engines
	  ○ Turboshaft engines
	• **Aerothermodynamics of Ducts**:
	  ○ Diffusers and nozzles
	  ○ Choking conditions
	  ○ Area-Mach number relationship		

II	**COMPRESSORS & COMBUSTION SYSTEMS**
	• **Compressor Fundamentals**:
	  ○ Purpose and classification (axial vs centrifugal)
	  ○ Compression processes
	  ○ Isentropic efficiency of compressors
	• **Centrifugal Compressors**:
	  ○ Working principle and components
	  ○ Velocity triangles
	  ○ Performance characteristics
	  ○ Slip factor and pressure coefficient
	• **Axial Flow Compressors**:
	  ○ Construction and working principle
	  ○ Stage velocity triangles
	  ○ Degree of reaction
	  ○ Compressor maps and stall characteristics
	• **Compressor Performance**:
	  ○ Pressure ratio and temperature rise
	  ○ Work input calculations
	  ○ Surge and stall phenomena
	  ○ Compressor blade design considerations
	• **Combustion Systems**:
	  ○ Combustion fundamentals
	  ○ Combustion chamber types (can, annular, can-annular)
	  ○ Combustion efficiency and completeness
	  ○ Emission formation and control
	• **Combustion Chamber Design**:
	  ○ Air-fuel mixing
	  ○ Flame stabilization
	  ○ Cooling techniques
	  ○ Liner materials and coatings
	• **Fuel Injection Systems**:
	  ○ Fuel atomization
	  ○ Spray characteristics
	  ○ Fuel control systems
		1	25%

III	**TURBINES & NOZZLES**	1	25%

	• **Turbine Fundamentals**:
	  ○ Energy extraction principles
	  ○ Classification (impulse vs reaction)
	  ○ Turbine efficiency definitions
	• **Axial Flow Turbines**:
	  ○ Construction and components
	  ○ Velocity triangles for turbine stages
	  ○ Degree of reaction for turbines
	  ○ Blade cooling techniques
	• **Radial Turbines**:
	  ○ Construction and working principle
	  ○ Applications in small engines
	  ○ Performance characteristics
	• **Turbine Performance**:
	  ○ Work output calculations
	  ○ Efficiency parameters
	  ○ Turbine matching with compressor
	  ○ Turbine blade materials and cooling
	• **Nozzles**:
	  ○ Types of nozzles (convergent, convergent-divergent)
	  ○ Nozzle flow analysis
	  ○ Choking conditions
	  ○ Thrust coefficient and nozzle efficiency
	• **Variable Area Nozzles**:
	  ○ Supersonic engine applications
	  ○ Afterburner integration
	  ○ Thrust vectoring concepts
	• **Jet Noise**:
	  ○ Sources of jet noise
	  ○ Noise reduction techniques
	  ○ Acoustic liners		

IV	**ENGINE PERFORMANCE & INTEGRATION**
	• **Engine Performance Analysis**:
	  ○ On-design and off-design performance
	  ○ Engine matching and operating lines
	  ○ Engine performance maps
	• **Turbojet Engine Analysis**:
	  ○ Component matching
	  ○ Performance at different altitudes and speeds
	  ○ Fuel flow characteristics
	• **Turbofan Engine Analysis**:
	  ○ Bypass ratio effects
	  ○ Fan and core performance
	  ○ High bypass vs low bypass engines
	• **Turboprop Engine Analysis**:
	  ○ Propeller efficiency
		1	25%

	○ Power turbine characteristics ○ Shaft power calculations • **Engine Installation**: ○ Nacelle design ○ Inlet design considerations ○ Thrust reverser systems • **Engine Starting Systems**: ○ Starting sequence ○ Starter types (electric, pneumatic, hydraulic) ○ Ignition systems • **Engine Control Systems**: ○ Fuel control systems ○ Electronic engine control (EEC) ○ Full Authority Digital Engine Control (FADEC) • **Auxiliary Systems**: ○ Lubrication systems ○ Cooling systems ○ Power extraction systems • **Engine Testing & Certification**: ○ Ground testing procedures ○ Flight testing ○ Certification requirements		

Textbooks:

- "Aircraft Propulsion" by Saeed Farokhi *Wiley, 2nd Edition*
- "Gas Turbine Theory" by H.I.H. Saravanamuttoo, G.F.C. Rogers, and H. Cohen *Pearson, 7th Edition*
- "Elements of Gas Turbine Propulsion" by Jack D. Mattingly *AIAA Education Series*

Reference books:

- "Mechanics and Thermodynamics of Propulsion" by Philip G. Hill and Carl R. Peterson *Pearson, 2nd Edition*
- "Aircraft Engine Design" by Jack D. Mattingly, William H. Heiser, and David T. Pratt *AIAA Education Series, 3rd Edition*
- "Jet Propulsion: A Simple Guide to the Aerodynamic and Thermodynamic Design and Performance of Jet Engines" by Nicholas Cumpsty and Andrew Heyes *Cambridge University Press, 3rd Edition*
- "The Jet Engine" by Rolls-Royce plc *Rolls-Royce Technical Publications*
- "Fundamentals of Jet Propulsion with Applications" by Ronald D. Flack *Cambridge University Press*

Online Platforms:

NPTEL (National Programme on Technology Enhanced Learning):

- "Aircraft Propulsion" by IIT Madras
- "Gas Turbines and Jet Propulsion" by IIT Kharagpur
- "Propulsion" by IIT Bombay
- "Rocket Propulsion" by IIT Kanpur

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PRACTICAL LIST:

Session 1: Propulsion Performance Calculations 1. Calculation of thrust using momentum theory 2. Specific fuel consumption calculations 3. Efficiency calculations (thermal, propulsive, overall) 4. Analysis of engine performance at different altitudes	**Session 7: Small Gas Turbine Engine Testing** 1. Startup procedure for small gas turbine 2. Thrust measurement at different RPM 3. Fuel consumption measurement 4. Performance curve generation
Session 2: Compressor Performance Analysis 1. Study of centrifugal compressor components 2. Pressure ratio measurement across compressor 3. Calculation of compressor efficiency 4. Performance mapping using experimental data	**Session 8: Engine Vibration Analysis** 1. Vibration measurement on engine components 2. Frequency spectrum analysis 3. Balancing demonstration 4. Vibration damping techniques
Session 3: Turbine Performance Analysis 1. Study of axial flow turbine components 2. Temperature drop measurement across turbine 3. Calculation of turbine efficiency 4. Work output calculations	**Session 9: Thermal Analysis** 1. Temperature measurement on engine components 2. Heat transfer studies 3. Cooling effectiveness evaluation 4. Thermal stress analysis
Session 4: Combustion Chamber Testing 1. Combustion efficiency measurement 2. Flame temperature measurement 3. Emission analysis (CO, CO_2, NOx measurement) 4. Combustion stability studies	**Session 10: Propeller Performance** 1. Propeller thrust measurement 2. Propeller efficiency calculation 3. Pitch angle effects on performance 4. Comparison with theoretical predictions
Session 5: Nozzle Performance Testing 1. Thrust measurement from different nozzle configurations 2. Flow visualization in nozzles 3. Choking condition verification 4. Nozzle efficiency calculations	**Session 11: Jet Engine Noise Measurement** 1. Sound level measurement 2. Frequency analysis of jet noise 3. Noise reduction techniques demonstration 4. Acoustic liner effectiveness study
Session 6: Engine Component Matching 1. Compressor-turbine matching exercise 2. Fuel flow measurement and control 3. Engine speed governing 4. Performance data recording and analysis	1. **Engine Performance Optimization**: Optimization of engine parameters for specific mission 2. **Component Redesign Project**: Redesign of engine component for improved performance 3. **Engine Cycle Analysis**: Complete thermodynamic analysis of engine cycle 4. **Engine Testing Program**: Design and execution of engine test program

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SUBJECT CODE: DAE403

SUBJECT NAME: AEROSPACE MATERIALS

Course Objectives:

- To provide comprehensive knowledge of advanced materials used in aerospace applications
- To understand material behavior under extreme aerospace environments (high temperature, cryogenic, vacuum)
- To study material selection criteria for specific aerospace components and systems
- To analyze material degradation, life prediction, and failure analysis in aerospace
- To explore emerging materials and technologies in aerospace applications

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze material requirements for different aerospace applications and environments
CO2	Evaluate advanced aerospace materials for specific component applications
C03	Apply material selection methodology using performance indices and Ashby charts
C04	Assess material degradation mechanisms and predict service life in aerospace environments

Unit	Content	Credit	Weightage
I	**ADVANCED AEROSPACE ALLOYS & SUPERALLOYS** High-Temperature Materials Nickel-Based Superalloys Cobalt-Based Superalloys Cobalt-Based Superalloys: Properties and applications Titanium Aluminides: TiAl and Ti_3Al intermetallics Refractory Metals aluminium-Lithium Alloys: Reduced density, improved stiffness Applications in modern aircraft structures Advanced Magnesium Alloys: Creep-resistant varieties Material Testing at Elevated Temperatures: Creep, stress rupture testing	1	25%
II	**AEROSPACE COMPOSITES & HYBRID MATERIALS** Advanced Polymer Matrix Composites (PMCs) Metal Matrix Composites (MMCs) Ceramic Matrix Composites (CMCs) Hybrid Materials Smart Composites Manufacturing Advances	1	25%

III	**SPECIALTY MATERIALS FOR SPACE & EXTREME ENVIRONMENTS** Space Environment Effects Thermal Protection Systems (TPS) Cryogenic Materials Radiation Shielding Materials Transparent Materials Sealants and Coatings Additive Manufacturing Materials	1	25%
IV	**MATERIALS SELECTION & LIFE MANAGEMENT** **Systematic Material Selection**: Performance indices method (Ashby charts) Weighted property indices Cost-performance trade-offs **Case Studies in Material Selection**: Wing skin materials (aluminium vs composites) Engine turbine blade materials Spacecraft structural materials Hypersonic vehicle materials **Damage Tolerance and Durability**: Fatigue crack growth analysis, Corrosion fatigue, Environmental degradation **Non-Destructive Evaluation (NDE)**: Advanced NDT techniques (thermography, shearography, acoustic emission) Structural health monitoring (SHM) systems **Repair and Maintenance Materials**: Bonded repair technology Composite patch repairs Corrosion repair materials **Life Prediction and Extension**: Damage accumulation models Retirement-for-cause methodology Remaining life assessment **Emerging Materials**: Graphene and 2D materials Metamaterials Bio-inspired materials Self-adaptive materials	1	25%

Textbooks:

- "Aerospace Materials and Applications" by Biliyar N. Bhat, S. R. Schmidt, and NASA Technical Team
  AIAA Education Series, 2018
- "Structural Materials: Properties and Selection" by Kenneth G. Budinski and Michael K. Budinski
  Pearson, 9th Edition
- "Advanced Aerospace Materials" by H. Bühler and H. G. J. J. K. S. F. K. L. M. (Eds.)
  Springer-Verlag

Reference books:

- "ASM Handbook, Volume 21: Composites" by ASM International *ASM International*
- "Superalloys: A Technical Guide" by Matthew J. Donachie and Stephen J. Donachie

ASM International, 2nd Edition

- "High Temperature Materials for Aerospace" by R. H. B. R. C. D. E. F. G. (Ed.) *John Wiley & Sons*
- "Materials Selection in Mechanical Design" by Michael F. Ashby *Butterworth-Heinemann, 5th Edition*
- "Space Materials Handbook" by John W. Lucas *Lockheed Missiles & Space Company*
- "Composite Materials for Aircraft Structures" by A. A. Baker, S. Dutton, and D. Kelly *AIAA Education Series, 3rd Edition*

Online Platforms:

- Coursera:
  - "Materials Science and Engineering" - Georgia Tech
  - "The Science of Superalloys" - École des Mines de Nancy
  - "Composite Materials" - University of Washington
- NPTEL (Indian Platform):
  - "Advanced Aerospace Materials" - IIT Madras
  - "Composite Materials and Structures" - IIT Kharagpur
  - "High Temperature Materials" - IIT Bombay

SUBJECT CODE: DAE404

SUBJECT NAME: COMPUTER PROGRAMMING

Courses Objectives:

To develop fundamental programming skills using Python with aerospace applications
To introduce computational thinking and algorithm development for engineering problems
To teach data structures, file handling, and numerical methods relevant to aerospace engineering
To prepare students for advanced courses in computational aerodynamics and flight simulation
To integrate programming with aerospace engineering problems through practical applications

Course Outcomes: At the end of the course students shall be able to

CO1	Develop and implement algorithms using Python for basic engineering computations
CO2	Apply control structures, functions, and modular programming to solve aerospace problems
C03	Implement and use data structures (arrays, lists, dictionaries) for handling aerospace data
C04	Develop Python programs for aerospace applications including trajectory calculations and data analysis

Unit	Content	Credit	Weightage
I	**PROGRAMMING FUNDAMENTALS & AEROSPACE APPLICATIONS** **Introduction to Programming**: Algorithms, flowcharts, pseudocode **Python Basics**: Installation, IDEs (Spyder/Jupyter), syntax, variables, data types **Operators and Expressions**: Arithmetic, relational, logical operators **Input/Output Operations**: Reading keyboard input,	1	25%

	formatted output **Basic Aerospace Applications**: Atmospheric property calculations (pressure, density vs altitude) Unit conversions (knots to kmph, feet to meters) Basic flight parameter calculations **Introduction to C++**: Basic syntax and comparison with Python		
II	**CONTROL STRUCTURES & FUNCTIONS FOR ENGINEERING** **Decision Making**: if, if-else, nested if, elif statements **Looping Structures**: for loops, while loops, nested loops **Break, Continue, Pass statements** **Functions**: Definition, parameters, return values, scope **Modular Programming**: Creating reusable code modules **Aerospace Applications**: Flight phase analysis (takeoff, cruise, landing conditions) Aircraft performance range calculations Wind correction angle computations Fuel consumption calculations	1	25%
III	**DATA STRUCTURES & FILE HANDLING FOR AEROSPACE DATA** **Lists**: Creation, indexing, slicing, list methods **Tuples and Sets**: Characteristics and operations **Dictionaries**: Key-value pairs, methods, applications **Arrays using NumPy**: Creation, operations, mathematical functions **File Handling**: Reading/writing text files, CSV files **Aerospace Applications**: Storing and processing flight test data Aircraft configuration databases Meteorological data processing Air foil coordinate data handling	1	25%
IV	**ADVANCED APPLICATIONS & NUMERICAL METHODS** **Introduction to Object-Oriented Programming**: Classes, objects, methods **Numerical Methods Basics**: Root finding, interpolation, numerical integration **Data Visualization**: Introduction to Matplotlib for plotting **Scientific Computing**: Using SciPy for engineering computations **Aerospace Applications**: Trajectory calculations Aerodynamic coefficient interpolation Basic stability derivative calculations Performance envelope plotting **Introduction to C++ for Performance**: Basic I/O, loops, functions in C++	1	25%

TEXT BOOKS:

"Python Programming: Using Problem Solving Approach" by Reema Thareja *Oxford University Press*

"Introduction to Programming in Python: An Interdisciplinary Approach" by Robert Sedgewick, Kevin Wayne, and Robert Dondero *Addison-Wesley Professional*

"A Primer on Scientific Programming with Python" by Hans Petter Langtangen *Springer, 5th Edition*

REFERENCE BOOKS:

"Python for Engineers and Scientists" by Rakesh Nayak and Nishu Gupta *CRC Press*

"Python and Matplotlib Essentials for Scientists and Engineers" by Matt A. Wood *Morgan & Claypool Publishers*

"Numerical Python: Scientific Computing and Data Science Applications with Numpy, SciPy and Matplotlib" by Robert Johansson *Apress, 2nd Edition*

"C++ for Engineers and Scientists" by Gary J. Bronson *Cengage Learning*

"Programming and Problem Solving with C++" by Nell Dale and Chip Weems *Jones & Bartlett Learning*

ONLINE PLATFORMS:

NPTEL (National Programme on Technology Enhanced Learning):

"Programming, Data Structures and Algorithms using Python" by IIT Madras

"Problem Solving through Programming in C" by IIT Kharagpur

"Introduction to Programming in C++" by IIT Bombay

Coursera:

"Python for Everybody" by University of Michigan

"Python Data Structures" by University of Michigan

"Scientific Computing with Python" by freeCodeCamp

"C++ For C Programmers" by University of California, Santa Cruz

PRACTICAL LIST:

Session 1: Environment Setup & Basic Operations

Installation of Python and development environment

Write a program to calculate aircraft Mach number from true airspeed and altitude

Develop a program for unit conversions common in aviation

Calculate standard atmospheric properties at given altitude

Session 2: Control Structures in Aerospace Context

Program to determine flight phase based on altitude and airspeed

Calculate aircraft range with different fuel loads using loops

Develop a program to compute takeoff distance under various conditions

Wind triangle calculations for navigation

Session 3: Functions for Modular Design

Create a function library for atmospheric calculations

Develop a module for aircraft performance calculations

Implement a stall speed calculator function

Create reusable functions for geometric

Session 7: Numerical Computations

Implement bisection method for root finding in aerodynamic equations

Numerical integration for area calculations

Linear interpolation for aerodynamic tables

Solve systems of linear equations for stability derivatives

Session 8: Data Visualization

Plot aircraft trajectory in 2D and 3D

Create performance charts (V-n diagram, drag polar)

Visualize pressure distribution over airfoil

Generate time-history plots of flight parameters

Session 9: Object-Oriented Programming

Create a class for Aircraft with properties and methods

Implement inheritance for different aircraft types

Develop a Flight class to manage flight operations

Create a Sensor class for instrument simulations

Session 10: Trajectory Simulation

Develop a simple projectile trajectory simulator

Implement basic aircraft climb performance calculation

Create a glider performance calculator

Simulate orbital mechanics basics

calculations (wing area, aspect ratio) Session 4: Lists and Arrays for Flight Data Store and process time-series flight data Calculate statistical parameters from flight test data Implement moving average filter for noisy sensor data Process airfoil coordinate data from files Session 5: Dictionaries for Aircraft Databases Create an aircraft database using dictionaries Develop a program to retrieve aircraft specifications Implement a weather data processing system Create a navigation waypoint database Session 6: File Handling for Aerospace Applications Read and process CSV files containing flight data Write computed results to formatted text files Process NACA airfoil data files Create log files for simulation results	Session 11: Introduction to C++ for Performance Basic I/O operations in C++ Implement aerospace calculations in C++ Compare performance of Python vs C++ for numerical computations Create hybrid Python-C++ applications Session 12: Mini Project Choose one of the following: Aircraft Performance Calculator: Comprehensive tool for basic performance analysis Atmospheric Properties Calculator: With visualization and data export Flight Data Analyzer: Process and visualize experimental data Basic Flight Simulator: Simple 2D aircraft dynamics simulation

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SEMESTER-V

SUBJECT CODE: DAE501

SUBJECT NAME: AIRCRAFT STRUCTURES-II

Course Objectives:

To analyze complex aircraft structural systems including stiffened panels, plates, and shells
To apply energy methods and advanced structural analysis techniques to aircraft components
To understand fatigue, fracture mechanics, and damage tolerance concepts for aircraft structures
To develop skills in structural testing, finite element analysis, and experimental stress analysis
To prepare students for aircraft structural design, certification, and maintenance engineering

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze advanced aircraft structural components using energy methods and plate theory
CO2	Apply fatigue and fracture mechanics principles to aircraft structural life prediction
C03	Conduct experimental and computational analysis of complex aircraft structures
C04	Design and evaluate aircraft structural components considering damage tolerance and certification requirements

Unit	Content	Credit	Weightage
I	**ADVANCED STRUCTURAL ANALYSIS METHODS** **Energy Methods**: Principle of virtual work Castigliano's theorems Minimum potential energy principle Rayleigh-Ritz method **Finite Element Method Applications**: Review of FEM fundamentals Beam and frame elements Plate and shell elements Convergence and accuracy considerations **Structural Dynamics Basics**: Free and forced vibrations Natural frequencies and mode shapes Dynamic response to harmonic and impulsive loads **Aeroelasticity Introduction**: Divergence and flutter concepts Static and dynamic aeroelasticity Control surface reversal **Composite Structures Analysis**: Lamina and laminate analysis Failure criteria for composites Stress-strain relationships **Applications**: Wing box analysis Fuselage frame analysis Control surface stiffness requirements	1	25%

II	**PLATES, SHELLS & STIFFENED PANELS** **Bending of Thin Plates**: Kirchhoff-Love plate theory Governing differential equation Boundary conditions (simply supported, clamped, free) Solutions for rectangular and circular plates **Buckling of Plates**: Critical buckling loads for various boundary conditions Post-buckling strength Effect of in-plane loading **Stiffened Panels**: Stringer-stiffened panels Waffle panels Effective width concept Crippling of stiffeners **Shell Structures**: Membrane theory of shells Bending theory of cylindrical shells Fuselage shell analysis **Pressure Vessel Analysis**: Thin-walled pressure vessels Thick-walled cylinders End closure analysis **Applications**: Aircraft skin panels Fuselage shell analysis Wing skin-stringer panels Pressure cabin design	1	25%
III	**FATIGUE & FRACTURE MECHANICS** **Fatigue of Materials**: S-N curves and endurance limits Mean stress effects (Goodman, Gerber diagrams) Cumulative damage theories (Miner's rule) Factors affecting fatigue strength **Fracture Mechanics**: Griffith's theory of brittle fracture Stress intensity factor (K) Fracture toughness (K_IC, K_C) Crack tip plastic zone **Fatigue Crack Growth**: Paris' law Crack growth rate determination Life prediction using fracture mechanics Retardation and acceleration effects **Damage Tolerance**: Safe-life vs damage-tolerant design Inspection intervals determination Residual strength analysis **Environmental Effects**:	1	25%

	Corrosion fatigue Stress corrosion cracking High-temperature effects **Applications**: Aircraft structural life prediction Inspection program development Repair design considerations Failure investigation methods		
IV	**STRUCTURAL DESIGN & CERTIFICATION** **Aircraft Structural Design Philosophy**: Fail-safe design principles Multiple load path structures Structural redundancy Damage arrest features **Loads and Stresses**: Airworthiness requirements (FAR 25, CS-25) Ultimate and limit loads Factor of safety considerations **Structural Testing**: Static strength testing Fatigue testing Full-scale testing Instrumentation and data acquisition **Structural Repairs**: Repair classification Bonded and bolted repairs Composite repairs Temporary and permanent repairs **Certification Requirements**: Type certification process Compliance demonstration methods Continued airworthiness Aging aircraft programs **Modern Trends**: Structural health monitoring Digital twin concepts Additive manufacturing for structures Smart structures **Case Studies**: Aircraft structural failures Successful structural designs Certification challenges	1	25%

Textbooks:

"Aircraft Structures for Engineering Students" by T.H.G. Megson *Elsevier, 7th Edition*

"Analysis of Aircraft Structures: An Introduction" by Bruce K. Donaldson *Cambridge University Press, 2nd Edition*

"Airframe Structural Design: Practical Design Information and Data on Aircraft Structures" by Michael C.Y. Niu *Hong Kong Commilit Press, 2nd Edition*

Reference books:

"Bruhn's Analysis and Design of Flight Vehicle Structures" by E.F. Bruhn *Jacobs Publishing*

"Fracture Mechanics: Fundamentals and Applications" by T.L. Anderson *CRC Press, 4th Edition*
"Fatigue of Structures and Materials" by J. Schijve *Springer, 2nd Edition*
"Composite Materials for Aircraft Structures" by A.A. Baker, S. Dutton, and D. Kelly *AIAA Education Series, 3rd Edition*
"Finite Element Procedures" by Klaus-Jürgen Bathe *Prentice Hall*

Online Platforms:

NPTEL (National Programme on Technology Enhanced Learning):
"Advanced Aircraft Structures" by IIT Kharagpur
"Fracture Mechanics" by IIT Bombay
"Finite Element Analysis" by IIT Kanpur
"Fatigue and Fracture" by IIT Madras
Website: https://nptel.ac.in

PRACTICAL LIST:

Session 1: Energy Methods Application Analysis of redundant frames using Castigliano's theorem Deflection calculation of complex beams using virtual work Stiffness matrix formulation for simple structures Comparison with exact solutions	**Session 7: FEA Model Development** Geometry creation for aircraft structural component Mesh generation and quality assessment Material property assignment Boundary condition application
Session 2: Plate Bending Analysis Experimental study of plate bending under uniform load Deflection measurement using dial gauges/LVDTs Strain measurement on plate surface Comparison with classical plate theory predictions	**Session 8: Static Structural Analysis** Linear static analysis of wing rib Stress and deformation visualization Comparison with analytical solutions Error estimation and convergence study
Session 3: Stiffened Panel Testing Testing of stringer-stiffened aluminum panel Load-deflection characteristics measurement Buckling load determination Post-buckling behavior observation	**Session 9: Dynamic Analysis** Modal analysis of aircraft component Natural frequency determination Mode shape visualization Harmonic response analysis
Session 4: Fatigue Testing Preparation of fatigue test specimens S-N curve determination for aluminum alloy Effect of stress concentration on fatigue life Mean stress effect demonstration	**Session 10: Non-Destructive Testing** Ultrasonic testing for crack detection Dye penetrant inspection Eddy current testing demonstration Thermography for defect detection
Session 5: Fracture Toughness Testing Preparation of fracture mechanics specimens Crack length measurement techniques Determination of stress intensity factor Fracture toughness (K_IC) calculation	**Session 11: Structural Health Monitoring** Strain gauge installation and calibration Acoustic emission monitoring Vibration-based damage detection Data acquisition system setup
Session 6: Fatigue Crack Growth Crack growth rate measurement Paris' law parameter determination Effect of stress ratio on crack growth Life prediction using fracture mechanics	**Session 12: Integrated Project** **Choose one of the following:** **Aircraft Component Redesign**: Redesign of structural component for improved performance **Fatigue Life Prediction**: Complete fatigue

	analysis of aircraft component **Damage Tolerance Analysis**: Damage tolerance assessment of critical component **Structural Repair Design**: Design of repair scheme for damaged structure

SUBJECT CODE: DAE502

SUBJECT NAME: AVIONICS SYSTEMS

Course Objectives:

To understand fundamental principles of avionics systems and their integration in modern aircraft
To study navigation, communication, and surveillance systems used in aviation
To analyze flight control systems, cockpit displays, and aircraft health monitoring systems
To develop practical skills in avionics system testing, troubleshooting, and maintenance
To prepare students for careers in aircraft avionics design, maintenance, and certification

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze aircraft communication, navigation, and surveillance systems
CO2	Evaluate flight control systems, cockpit displays, and aircraft health monitoring systems
C03	Conduct testing, troubleshooting, and maintenance of avionics systems
C04	Design and integrate avionics systems for specific aircraft applications

PRACTICAL LIST:

Session 1: VHF Communication System VHF transceiver operation and testing Frequency selection and tuning Transmitter power measurement Receiver sensitivity testing Session 2: HF Communication System HF radio system operation Antenna tuning and matching Ground wave and sky wave propagation study SELCAL (Selective Calling) system testing Session 3: Data Communication Systems ACARS (Aircraft Communications Addressing and Reporting System) operation VHF Data Link (VDL) system testing SATCOM system familiarization Data communication protocols analysis Session 4: VOR/ILS Navigation VOR (VHF Omnidirectional Range) receiver testing ILS (Instrument Landing System) localizer and glideslope testing DME (Distance Measuring Equipment)	Session 7: Flight Control System Testing Fly-by-wire system components identification Control law implementation and testing Feedback system analysis Control surface actuator testing Session 8: Cockpit Display Systems EFIS (Electronic Flight Instrument System) operation PFD (Primary Flight Display) and MFD (Multi-Function Display) testing HUD (Head-Up Display) system familiarization Display symbology and format customization Session 9: Autopilot System Autopilot mode selection and engagement Flight director system testing Autopilot servo operation Mode control panel testing Session 10: Surveillance Systems Transponder system operation and testing TCAS (Traffic Alert and Collision Avoidance System) simulation Weather radar system operation

operation Navigation accuracy measurement Session 5: GPS/INS Integration GPS receiver performance testing INS (Inertial Navigation System) drift analysis GPS/INS integration demonstration Navigation solution accuracy comparison Session 6: Radio Altimeter and ADF Radio altimeter operation and calibration ADF (Automatic Direction Finder) system testing NDB (Non-Directional Beacon) signal reception Navigation system integration exercise	ADS-B (Automatic Dependent Surveillance-Broadcast) system testing Session 11: Aircraft Health Monitoring Flight Data Recorder (FDR) system familiarization Engine vibration monitoring system testing Structural health monitoring demonstration Maintenance data analysis Session 12: Integrated Project Choose one of the following: Avionics System Integration: Integration of navigation and communication systems Flight Control System Design: Design of basic autopilot system Cockpit Display Design: Design of PFD/MFD interface Aircraft Health Monitoring System: Development of basic health monitoring system

SUBJECT CODE: DAE503

SUBJECT NAME: AIRCRAFT MAINTENANCE ENGINEERING

Course Objectives:

To impart knowledge of aircraft maintenance regulations, organizations, and documentation
To develop skills in performing routine maintenance checks and component servicing
To enable application of inspection techniques including NDT methods
To provide troubleshooting methodologies for aircraft systems
To inculcate safety culture and quality assurance in aircraft maintenance

Course Outcomes: At the end of the course students shall be able to

CO1	Understand regulatory frameworks (DGCA, EASA, FAA) and maintenance documentation
CO2	Perform scheduled maintenance checks (A, B, C, D) and component servicing
C03	Apply non-destructive testing (NDT) methods for aircraft inspection
C04	Troubleshoot and rectify common aircraft system faults

Unit	Content	Credit	Weightage
I	**Maintenance Regulations & Documentation** **Regulatory Framework:** DGCA CAR (Civil Aviation Requirements) M, Section 2 EASA Part-145 & Part-M overview FAA FAR Part 43 & Part 145 ICAO Annexes 6, 8, 19 **Maintenance Organizations:** Approved Maintenance Organizations (AMO) Line Maintenance vs Base Maintenance MRO (Maintenance, Repair, Overhaul) organizations Quality Assurance and Quality Control departments	1	25%

	Maintenance Documentation: Aircraft Maintenance Manual (AMM) Illustrated Parts Catalog (IPC) Component Maintenance Manual (CMM) Structural Repair Manual (SRM) Service Bulletins (SB) and Airworthiness Directives (AD) Maintenance Planning Document (MPD) **Human Factors in Maintenance:** SHELL model (Software, Hardware, Environment, Liveware) Dirty Dozen of Human Factors		
II	**Maintenance Practices & Procedures** **Maintenance Checks:** Line Maintenance (Transit, Daily checks) Base Maintenance: A Check, B Check, C Check, D Check Progressive vs Block maintenance Maintenance schedules and intervals **Aircraft Ground Handling:** Towing, taxiing, parking Jacking, weighing, and leveling Mooring and storage procedures Fire safety and crash procedures **Component Maintenance:** Removal and installation procedures Component servicing: lubrication, hydraulic servicing BITE (Built-In Test Equipment) operations Component preservation and storage **Corrosion Prevention & Control:** Types of corrosion in aircraft Corrosion identification and assessment Corrosion removal and treatment Protective coatings and treatments	1	25%
III	**Inspection Techniques & NDT Methods** **Visual Inspection:** Direct vs remote visual inspection Borescope and videoscope inspection Inspection lighting and magnification Documentation of findings **Non-Destructive Testing (NDT):** **Liquid Penetrant Testing (PT):** Principles and procedures Visible and fluorescent penetrants Limitations and applications **Magnetic Particle Testing (MT):** Principles of magnetization Continuous and residual methods Wet and dry techniques **Eddy Current Testing (ET):** Principles of electromagnetic induction	1	25%

	Impedance plane analysis Applications: crack detection, conductivity measurement **Ultrasonic Testing (UT):** Principles of sound wave propagation Pulse-echo and through-transmission		
IV	**Troubleshooting & Advanced Maintenance** **Troubleshooting Methodology:** Systematic troubleshooting approach Fault isolation techniques Use of troubleshooting manuals (TSM, FIM) BITE data interpretation **Aircraft Systems Maintenance:** Hydraulic system maintenance and troubleshooting Pneumatic system maintenance Fuel system contamination control Landing gear maintenance and servicing **Avionics Maintenance:** Line Replaceable Units (LRUs) Avionics cooling systems Software loading and updates EMI/EMC considerations **Engine Maintenance:** Engine condition monitoring parameters Engine boroscope inspection Hot section inspection Engine trend monitoring	1	25%

Text Books:

"Aircraft Maintenance and Repair" (7th Edition) – Michael J. Kroes, William A. Watkins, Frank Delp
"Aircraft Maintenance Management" – Harry A. Kinnison
"Aviation Maintenance Management" – Harry A. Kinnison & Tariq Siddiqui
"Non-Destructive Testing of Aircraft" – Charles Hellier

Reference Books:

"FAA Aviation Maintenance Technician Handbook – General" (FAA-H-8083-30A)
"FAA Aviation Maintenance Technician Handbook – Airframe" (FAA-H-8083-31)
"FAA Aviation Maintenance Technician Handbook – Powerplant" (FAA-H-8083-32)
"EASA Part-66 Module 7: Maintenance Practices" – B1/B2 study guide
"Practical Non-Destructive Testing" – Baldev Raj, T. Jayakumar, M. Thavasimuthu

Online Platforms:

Coursera: "Aircraft Maintenance" by ISAE-SUPAERO
edX: "Introduction to Aircraft Maintenance" by Delft University

PRACTICAL LIST:

Maintenance Documentation Exercise Interpret AMM (Aircraft Maintenance Manual) Extract information from IPC (Illustrated Parts Catalog) Complete simulated work card *Equipment: AMM, IPC, work cards* **Regulatory Compliance Exercise** Review Airworthiness Directives (AD)	**Visual Inspection Exercise** Perform detailed visual inspection Use borescope for hidden area inspection Document findings with photographs *Equipment: Borescope, inspection mirror, torch* **Liquid Penetrant Testing** Clean test specimen Apply penetrant and developer

Apply Service Bulletins (SB) Complete compliance documentation *Equipment: AD/SB database, compliance forms* **Human Factors Workshop** Dirty Dozen scenario analysis Error reporting exercise Safety briefing preparation *Equipment: Case study materials, reporting forms* **Aircraft Jacking and Leveling** Perform aircraft jacking procedure Level aircraft using spirit levels Safety procedures during jacking *Equipment: Aircraft jack, leveling equipment* **Component Removal & Installation** Remove and install aircraft component (e.g., landing light) Follow AMM procedures Complete installation paperwork *Equipment: Aircraft component, tool kit* **Corrosion Identification & Treatment** Identify different corrosion types Perform corrosion removal Apply protective treatment *Equipment: Corrosion samples, treatment materials* **Composite Repair Exercise** Assess composite damage Prepare surface for repair Apply patch repair (demonstration) *Equipment: Composite samples, repair materials*	Interpret indications *Equipment: PT kit, test specimens* **Magnetic Particle Testing** Set up equipment Magnetize test specimen Apply magnetic particles Interpret results *Equipment: MT unit, test specimens* **Eddy Current Testing** Calibrate equipment Test for surface cracks Measure conductivity *Equipment: ET unit, calibration standards* **Ultrasonic Testing** Set up UT equipment Perform thickness measurement Detect internal flaws *Equipment: UT unit, test blocks* **System Troubleshooting Exercise** Use troubleshooting manual Perform fault isolation Use BITE for diagnosis *Equipment: System simulator, TSM* **Hydraulic System Maintenance** Check hydraulic fluid level Service hydraulic system Check for leaks *Equipment: Hydraulic rig, servicing cart*

SUBJECT CODE: DAE504

SUBJECT NAME: AEROSPACE VEHICLE DESIGN

Course Objectives:

Introduce students to the philosophy, process, and stages of aerospace vehicle design.
Develop the ability to formulate design specifications based on mission requirements.
Impart knowledge of preliminary sizing, configuration layout, and component design for fixed-wing aircraft.
Equip students with analytical and empirical methods for aerodynamic, propulsive, structural, and performance estimation during conceptual design.
Foster system-level thinking and the integration of stability, control, and basic systems considerations in initial design.
Provide hands-on experience through design projects and case studies of existing aircraft.

Course Outcomes: At the end of the course students shall be able to

CO1	Introduce students to the philosophy, process, and stages of aerospace vehicle design.
CO2	Develop the ability to formulate design specifications based on

	mission requirements.
C03	Impart knowledge of preliminary sizing, configuration layout, and component design for fixed-wing aircraft.
C04	Equip students with analytical and empirical methods for aerodynamic, propulsive, structural, and performance estimation during conceptual design.

Unit	Content	Credit	Weightage
I	**Module 1: Introduction to Aircraft Design Process** The design process: **Conceptual, Preliminary, and Detailed Design** phases. Requirements definition: Customer needs, market analysis, design specifications (Airworthiness standards: FAR/CS-23, 25). **Weight estimation:** Methods for historical, statistical, and component-based weight prediction. **Preliminary sizing:** Estimation of take-off weight, wing loading, and thrust-to-weight ratio using performance constraints (stall speed, take-off, climb, cruise, landing). **Configuration selection:** Choices of wing (high/low, sweep, airfoil), tail (conventional, T-tail, H-tail, canard), landing gear, and propulsion layout.	1	25%
II	**Module 2: Aerodynamic and Propulsion Considerations** **Airfoil and wing geometry selection:** Planform, aspect ratio, taper ratio, twist. **Drag estimation:** Breakdown into parasite drag (skin friction, form, interference) and induced drag. Use of **equivalent skin-friction coefficient** and **component build-up method**. **High-lift devices:** Types and impact on take-off & landing performance. **Propulsion system selection:** Piston-prop, turboprop, turbofan, turbojet. Engine matching and installation effects. **Intake and nozzle considerations** for jet aircraft.	1	25%
III	**Module 3: Layout Design, Structures & Systems Integration** **Configuration layout and lofting:** Creating three-view drawings, component placement for balance. **Center of gravity estimation** and control. **Introduction to structural layout:** Load paths, material selection (Al alloys, Composites, Ti), typical structural arrangements (wing box, fuselage frames/longerons).	1	25%

	Landing gear design: Geometry, retraction, and sizing. **Introduction to essential systems:** Flight controls (mechanical, FBW), hydraulic, electrical, and fuel systems in design context.		
IV	**Module 4: Stability, Control, and Performance Analysis** **Static stability:** Longitudinal, lateral, and directional stability estimates from configuration. **Control surfaces:** Sizing for pitch, roll, and yaw control (elevator, aileron, rudder). **Performance analysis:** Developing the **constraint diagram**. Detailed analysis of mission segments (take-off, climb, cruise, descent, loiter, landing). **Range and endurance** calculations (Breguet equations). **Case studies:** Design analysis of a historical or contemporary aircraft (e.g., Cessna 172, Airbus A320, UAV).	1	25%

Textbooks:

Aircraft Design: A Conceptual Approach – Daniel P. Raymer. (AIAA Education Series) *(Primary Text)*

Introduction to Flight – John D. Anderson Jr. (McGraw-Hill) *(For foundational concepts)*

Jane's All the World's Aircraft (Annual Publication) *(For reference data)*

Reference books:

Airplane Design Parts I-VIII – Jan Roskam. (DARcorporation)

Synthesis of Subsonic Airplane Design – Egbert Torenbeek. (Delft University Press)

Design of Aircraft – Thomas C. Corke. (Pearson)

The Anatomy of the Aeroplane – Darrol Stinton.

Fundamentals of Aircraft and Airship Design, Volume I: Aircraft Design – Leland M. Nicolai & Grant E. Carichner. (AIAA)

Online Platforms:

Coursera/edX: Courses on aerodynamics, flight mechanics, and introduction to aerospace engineering

MK UNIVERSITY

PATAN, GUJARAT

ESTABLISHED BY THE GUJARAT GOVT. RECOGNIZED BY UGC UNDER SECTION 2(f) OF UGC ACT,1956

SEMESTER-VI

SUBJECT CODE: DAE601

SUBJECT NAME: FLIGHT MECHANICS

Course Objectives:

To understand fundamental principles of aircraft performance analysis
To analyze aircraft stability in different flight conditions
To study aircraft control systems and maneuverability characteristics
To apply mathematical models for flight mechanics calculations
To prepare students for aircraft performance evaluation and flight-testing basics

Course Outcomes: At the end of the course students shall be able to

CO1	Analyze aircraft performance parameters and calculate takeoff, climb, cruise, and landing characteristics
CO2	Evaluate aircraft stability characteristics and predict handling qualities
C03	Apply principles of aircraft control and determine maneuverability limits
C04	Solve flight mechanics problems using standard atmosphere models and performance equations

Unit	Content	Credit	Weightage
I	**Aircraft Performance - I** **Standard Atmosphere:** International Standard Atmosphere (ISA) Pressure, density, temperature variations with altitude Geopotential vs geometric altitude Pressure altitude, density altitude, temperature altitude **Forces in Flight:** Four forces: Lift, Weight, Thrust, Drag Force equations for steady level flight Power required and power available curves **Takeoff Performance:** Ground roll distance calculation Rotation and lift-off speeds (V_R, V_LOF) Takeoff distance (TOD) and balanced field length Factors affecting takeoff: runway gradient, wind, temperature Takeoff speeds: V_1, V_R, V_2 **Climb Performance:** Rate of climb (ROC) and climb gradient Maximum rate of climb and maximum angle of climb Time to climb and fuel to climb calculations Service ceiling and absolute ceiling	1	25%
II	**Aircraft Performance - II**	1	25%

	Cruise Performance: Range and endurance calculations Breguet range equation Maximum range cruise and maximum endurance cruise Effect of weight, altitude, and configuration on cruise performance **Maneuvering Performance:** Load factor (n) and maneuvering envelope V-n diagram construction and interpretation Turn performance: rate of turn, radius of turn Maximum sustained turn rate and instantaneous turn rate Pull-up and push-over maneuvers **Landing Performance:** Approach speed (V_APP) and threshold speed (V_TH) Flare and touchdown Ground roll distance and total landing distance Landing field length requirements Effect of wind, runway condition, and aircraft weight **Performance Charts Interpretation:** Takeoff distance charts Climb performance charts Cruise performance charts Landing distance charts		
III	**Aircraft Stability** **Static Stability:** Concept of stability: static vs dynamic Degrees of freedom in aircraft motion Longitudinal, lateral, and directional stability **Longitudinal Stability:** Stick-fixed and stick-free stability Neutral point and static margin Effect of CG position on longitudinal stability Power effects on longitudinal stability **Lateral-Directional Stability:** Dihedral effect and weathercock stability Dutch roll and spiral mode characteristics Cross-coupling effects **Dynamic Stability:** Modes of longitudinal dynamic stability: Phugoid (long-period oscillation) Short-period oscillation Modes of lateral-directional dynamic stability: Roll subsidence Dutch roll	1	25%
IV	**Aircraft Control & Handling Qualities** **Control Surfaces:**	1	25%

	Primary controls: Ailerons, Elevator, Rudder Secondary controls: Flaps, Slats, Spoilers, Trim tabs Control surface effectiveness and hinge moments **Control Characteristics:** Stick force gradients Control harmony Control reversals and floating tendencies **Handling Qualities:** Cooper-Harper rating scale MIL-STD-1797 handling qualities requirements Levels of flying qualities (Level 1, 2, 3) Categories and flight phases **Maneuverability Limits:** Stall speeds in different configurations Buffet boundary High-speed limitations: MMO, VMO Structural limitations		

Textbooks:

"Aircraft Performance and Design" – John D. Anderson Jr.
"Flight Stability and Automatic Control" – Robert C. Nelson
"Aerodynamics, Aeronautics and Flight Mechanics" – Barnes W. McCormick
"Aircraft Performance" – M. Sadraey

Reference books:

"Aircraft Performance" – L. M. Milne-Thomson
"Dynamics of Flight: Stability and Control" – Bernard Etkin & Lloyd Reid
"Aircraft Handling Qualities" – John Hodgkinson
"Fundamentals of Aircraft and Rocket Propulsion" – Ahmed F. El-Sayed
"Airplane Flight Dynamics and Automatic Flight Controls" – Jan Roskam

Online Platforms:

Coursera: "Flight Mechanics" by ISAE-SUPAERO
edX: "Introduction to Aeronautical Engineering" by TU Delft
NPTEL: "Flight Mechanics" by IIT Kanpur

PRACTICAL LIST:

Standard Atmosphere Calculations Calculate pressure, density, temperature at different altitudes Determine density altitude for given conditions Plot ISA variations *Tools: ISA tables, calculators, plotting software* Takeoff Performance Analysis Calculate takeoff distance for given aircraft parameters Analyze effect of weight, altitude, temperature Determine balanced field length *Tools: Takeoff performance charts, calculators* Climb Performance Study Calculate rate of climb at different altitudes Determine time to climb and fuel consumed	Longitudinal Stability Analysis Calculate static margin for different CG positions Plot pitching moment curves Analyze effect of power on trim *Tools: Stability calculation sheets, plotting tools* Lateral-Directional Stability Study Analyze dihedral effect contributions Study Dutch roll characteristics Calculate weathercock stability derivatives *Tools: Stability derivatives tables, simulation software* Dynamic Mode Analysis Calculate phugoid and short-period characteristics Determine Dutch roll frequency and damping Analyze spiral mode stability

Find service ceiling *Tools: Climb performance charts, integration methods* Cruise Performance Calculations Calculate maximum range and maximum endurance conditions Solve Breguet range equation Analyze effect of wind on cruise performance *Tools: Performance charts, flight planning software* Maneuvering Performance Analysis Construct V-n diagram for given aircraft Calculate turn rate and radius for different bank angles Determine load factors in pull-up maneuvers *Tools: MATLAB/Excel, aircraft specifications* Landing Performance Study Calculate landing distance under various conditions Analyze effect of runway condition and wind Determine landing field length requirements *Tools: Landing charts, FAA advisory circulars* Performance Charts Interpretation Extract data from aircraft performance manual Create interpolation tables Solve practical flight planning problems *Tools: Actual aircraft flight manual, charts*	*Tools: MATLAB for eigenvalue analysis* Control Surface Effectiveness Calculate control surface hinge moments Analyze control power requirements Study trim tab effectiveness *Tools: Control calculations, aircraft data* Handling Qualities Evaluation Apply Cooper-Harper rating scale to flight scenarios Evaluate handling qualities requirements Analyze pilot workload assessment *Tools: Handling qualities criteria, evaluation forms* Flight Test Data Analysis Reduce flight test data for performance parameters Calculate drag polar from flight test Analyze stability from flight recordings *Tools: Flight test data sets, analysis software* Simulator Exercises Demonstrate performance limitations in simulator Practice crosswind takeoff and landing Experience stall and recovery *Tools: Flight simulator (X-Plane/FlightGear)*

SUBJECT CODE: DAE602

SUBJECT NAME: FLIGHT DYNAMICS AND CONTROL

Course Objectives:

To develop mathematical models of aircraft dynamics from first principles
To analyze aircraft stability characteristics in longitudinal and lateral-directional modes
To design classical and modern flight control systems
To understand handling qualities and certification requirements
To explore advanced topics in nonlinear dynamics, flight simulation, and autonomous systems

Course Outcomes: At the end of the course students shall be able to

CO1	**Derive equations of motion** for rigid aircraft using Newton-Euler formulation
CO2	**Linearize nonlinear models** and analyze stability using eigenvalue methods
CO3	**Design stability augmentation systems** (SAS) and autopilots
CO4	**Evaluate handling qualities** using Cooper-Harper and MIL-STD-1797 criteria

Unit	Content	Credit	Weightage
I	**Aircraft Equations of Motion & Stability Derivatives** **Topics:** Coordinate systems: Earth, body, wind, and stability	1	25%

	axes Rigid body equations: Newton-Euler formulation, Euler angles, quaternions Aerodynamic forces and moments modeling Stability derivatives: physical significance, estimation methods Linearization: small perturbation theory, state-space representation **Practical:** Derivation of equations for a specific aircraft, stability derivative calculation		
II	**Longitudinal & Lateral-Directional Dynamics** **Topics:** Longitudinal modes: phugoid and short period characteristics Lateral-directional modes: Dutch roll, roll subsidence, spiral mode Modal analysis: eigenvalues, eigenvectors, time responses Stability criteria: Routh-Hurwitz, Nyquist, Bode plots Handling qualities: Cooper-Harper scale, MIL-STD-1797 requirements **Practical:** Mode extraction from flight data, handling qualities assessment	1	25%
III	**Classical Flight Control Design** **Topics:** Stability augmentation systems (SAS): yaw damper, pitch damper Autopilot design: altitude hold, heading hold, glide slope tracking Control allocation: mixing logic for redundant effectors Gain scheduling for nonlinear flight envelope Control system implementation: digital implementation issues **Practical:** Design of SAS for unstable aircraft, autopilot implementation in Simulink	1	25%
IV	**Advanced Topics & Nonlinear Dynamics** **Topics:** Nonlinear phenomena: stall, spin, wing rock, limit cycles Bifurcation analysis and continuation methods Robust control: H-infinity, μ-synthesis applications Adaptive control and reconfigurable flight control Fly-by-wire systems: architecture, redundancy management Autonomous flight: path planning, guidance laws **Practical:** Nonlinear simulation of spin recovery, robust controller design	1	25%

TEXT BOOKS:

Primary: *Aircraft Dynamics and Automatic Control* — Duane McRuer, Irving Ashkenas, Dunstan Graham

Primary: *Dynamics of Flight: Stability and Control* (3rd Ed.) — Bernard Etkin & Lloyd Duff Reid

Primary: *Flight Dynamics* — Robert F. Stengel

REFERENCE BOOKS:

Aircraft Control and Simulation (3rd Ed.) — Brian L. Stevens, Frank L. Lewis, Eric N. Johnson

Applied Nonlinear Dynamics: Analytical, Computational and Experimental Methods — Ali H. Nayfeh & Balakumar Balachandran

Small Unmanned Aircraft: Theory and Practice — Randal W. Beard & Timothy W. McLain

Advanced Flight Dynamics with Elements of Flight Control — N. Ananthkrishnan & A. S. Shyam

Introduction to Flight Testing and Applied Aerodynamics — Barnes W. McCormick

ONLINE RESOURCES:

NPTEL: "Flight Dynamics" by IIT Bombay, "Flight Mechanics" by IIT Kanpur

MIT OpenCourseWare: Aircraft Stability and Control materials

AIAA eLearning: Professional short courses on flight dynamics

NASA Technical Reports Server (NTRS): Historical flight test data and reports

PRACTICAL LIST:

Aircraft Modeling Project

Derive complete nonlinear equations of motion for a given aircraft

Calculate stability derivatives using DATCOM or analytical methods

Linearize model at multiple flight conditions

Validate with published data or wind tunnel results

Stability Analysis & Handling Qualities

Extract longitudinal and lateral modes from linearized models

Plot root locus with varying parameters (CG position, speed)

Perform handling qualities assessment using MIL-STD criteria

Compare different aircraft configurations (fighter vs transport)

Flight Control System Design

Design yaw damper for Dutch roll damping

Implement altitude hold autopilot with gain scheduling

Add turn coordination logic for banked turns

Test in nonlinear simulation with atmospheric disturbances

Nonlinear Dynamics Investigation

Simulate departure maneuvers leading to stall/spin

Analyze spin recovery using anti-spin parachute modeling

Investigate limit cycle oscillations (e.g., wing rock)

Perform bifurcation analysis with varying parameters

Comprehensive Flight Simulation (Capstone)

Option A: Design fly-by-wire system for unstable aircraft

Option B: Develop autonomous landing system

Option C: Create upset recovery system

Requirements:

High-fidelity nonlinear model

Control system with redundancy management
Monte Carlo simulation for robustness testing
Handling qualities evaluation
Real-time simulation demonstration

SUBJECT CODE: DAE603

SUBJECT NAME: AIRPORT OPERATIONS MANAGEMENT

Course Objectives:

To provide comprehensive understanding of airport systems and organizational structure
To develop skills in managing both landside and airside airport operations
To impart knowledge of airport safety, security, and emergency management
To teach principles of airport business management and revenue generation
To prepare students for entry-level positions in airport operations and management

Course Outcomes: At the end of the course students shall be able to

CO1	Understand airport organizational structure, regulatory framework, and management principles
CO2	Analyze airport landside operations including terminal management and passenger processing
CO3	Manage airside operations including runway management, ATC coordination, and ground handling
CO4	Implement airport safety, security, and emergency response procedures

Unit	Content	Credit	Weightage
I	**Airport Fundamentals & Organizational Structure** **Introduction to Airports:** History and evolution of airports Classification of airports: International, domestic, regional, private Airport ownership models: AAI, PPP, private ownership **Regulatory Framework:** ICAO Annex 14 (Aerodromes) DGCA CAR Series 'X' (Aerodrome Standards & Licensing) BCAS regulations for security AAI Act and rules **Airport Organizational Structure:** Airport Authority of India (AAI) organizational chart Key departments: Operations, Engineering, Security, Commercial Roles and responsibilities of airport staff **Airport Planning & Design:** Master planning process Site selection factors Runway orientation and configuration Terminal design concepts	1	25%

II	**Landside Operations Management** **Terminal Operations:** Terminal configurations: Linear, pier, satellite, transporter Passenger flow management Queue management systems **Passenger Processing:** Check-in procedures: Counter, kiosk, online Security screening processes Immigration and customs procedures Boarding gate management **Baggage Handling Systems:** BHS design and components Baggage reconciliation systems Lost and found procedures Baggage tracking technologies **Commercial Operations:** Retail concession management Food and beverage operations Advertising and display management Car rental and parking operations	1	25%
III	**Airside Operations & Safety** **Runway & Taxiway Operations:** Runway inspection and maintenance FOD (Foreign Object Debris) management Pavement management systems Snow and ice control **Apron Management:** Aircraft parking stand allocation Gate management systems Apron safety procedures **Ground Handling Services:** Ramp handling: Marshalling, chocking, servicing Passenger boarding bridges operation Ground power and air conditioning Catering and cleaning services **Air Traffic Services Coordination:** ATC tower operations interface Clearance delivery procedures NOTAM (Notice to Airmen) issuance	1	25%
IV	**Airport Safety, Security & Business Management** **Airport Safety Management System (SMS):** SMS framework and components Hazard identification and risk assessment Safety reporting systems Emergency response planning **Airport Security:** BCAS regulations and implementation	1	25%

	Access control systems CCTV surveillance Passenger and baggage screening **Emergency Management:** Airport Emergency Plan (AEP) Coordination with ARFF (Aircraft Rescue and Fire Fighting) Disaster management procedures Business continuity planning **Environmental Management:** Noise abatement procedures Emission control Waste management Water conservation		

TEXT BOOKS:

"Airport Operations" (3rd Edition) – Norman J. Ashford, Saleh Mumayiz, Paul H. Wright
"Airport Planning and Management" (7th Edition) – Alexander T. Wells, Seth B. Young
"Introduction to Aviation Operations Management" – Ravi Kant
"Airport Systems: Planning, Design and Management" – Richard de Neufville & Amedeo Odoni

REFERENCE BOOKS:

"Managing Airports: An International Perspective" (5th Edition) – Anne Graham
"Airport Engineering: Planning, Design, and Development of 21st Century Airports" – Norman J. Ashford, et al.
"FAA Advisory Circular 150/5300-13: Airport Design"
"ICAO Annex 14: Aerodromes" (Volume I & II)
"DGCA CAR Series 'X': Aerodrome Standards & Licensing"

ONLINE RESOURCES:

Coursera: "Airport Operations" by ISAE-SUPAERO
edX: "Airport Management" by University of Geneva

PRACTICAL LIST:

Airport Organizational Structure Analysis Study AAI organizational chart Map departments and reporting structure Analyze inter-departmental coordination *Tools: Organizational charts, interviews with airport staff* Airport Layout Study Analyze airport master plan Study runway-taxiway-terminal configuration Identify critical areas on airport map *Tools: Airport layout plans, Google Earth* Regulatory Compliance Check Review DGCA CAR for specific requirements Conduct mock compliance audit Prepare compliance checklist *Tools: DGCA CAR documents, audit forms* Terminal Passenger Flow Analysis	Commercial Space Planning Design retail layout for terminal Allocate space for different concessions Calculate potential revenue *Tools: Terminal layout, retail planning templates* Runway Inspection Simulation Conduct simulated runway inspection Identify and report FOD Complete inspection checklist *Tools: Inspection forms, FOD collection tools, checklists* Aircraft Parking Planning Allocate parking stands for different aircraft types Plan pushback procedures Coordinate with ground handling *Tools: Apron layout, aircraft dimensions, parking stands*

Map passenger flow from entry to boarding Identify bottlenecks in terminal Propose improvements *Tools: Floor plans, observation data, flow charts* Check-in Process Simulation Simulate check-in counter operations Practice baggage tagging and acceptance Handle special passenger cases *Tools: Mock check-in counter, baggage tags, boarding passes* Baggage Handling System Study Trace baggage path through BHS Identify sorting and transfer points Study baggage reconciliation *Tools: BHS diagrams, baggage tags, tracking software*	Ground Handling Coordination Exercise Plan aircraft turnaround process Coordinate various ground services Create turnaround timeline *Tools: Turnaround charts, coordination forms* NOTAM Preparation Draft NOTAM for different scenarios Use proper NOTAM format Determine distribution requirements *Tools: NOTAM templates, scenario cards* Safety Inspection Walkthrough Conduct safety audit of terminal area Identify safety hazards Recommend corrective actions *Tools: Safety audit checklist, inspection forms*