VEERMATA JIJABAI TECHNOLOGICAL INSTITUTE
(VJTI)
MATUNGA, MUMBAI 400 019

(Autonomous Institute affiliated to University of Mumbai)

Curriculum
(Scheme of Instruction & Evaluation and Course contents)

For
Multi-Disciplinary Minor
in
Aerospace Technology

Implemented for the batch admitted in Academic Year 2023-24

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in

Aerospace Technology

Credit Framework for

Multi-Disciplinary Minor

in

Aerospace Technology

Sr.	Semester	Course Code	Course Name	L	T	P	Hr	Cr	Examination Weightage in %		
									TA	MST	ESE
1	III	R5ME2203T	An Introduction to Aerospace Engineering	2	0	0	2	2	20	30	50
2	IV	R5ME2206T	Flight and Space Mechanics	2	0	0	2	2	20	30	50
3	V	R5ME3202T	Aircraft Structures	3	0	0	3	3	20	30	50
4	VI	R5ME3204T	Aerodynamics	3	0	0	3	3	20	30	50
5	VII	R5ME4203T	Aerospace Propulsion Systems	3	1	0	4	4	20	30	50
			Total					**14**			

Abbreviations: **L** Lecture, **T** Tutorial, **P** Practical, **TA** Teacher Assessment / Term work Assessment, **MST** Mid Semester Test, **ESE** End Semester Written Examination,

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – III
Course Code	**R5ME2203T**	
Course Title	**An Introduction to Aerospace Engineering**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:
1. Interpret simple aerodynamic systems like airfoils, aircrafts and its control surfaces
2. Analyze Rocket engines, Nozzles, Air-breathing engines
3. Evaluate Performance of aircrafts, Navigation of missiles, and working of Radar systems
4. Identify Futuristic aerospace technologies

Course Contents

Atmosphere
Properties and characteristics of the atmosphere

Basic Components of Fixed-Wings Airborne Systems
The fixed wings, control surfaces – ailerons and rudders, their functionality and basic working principles

Introductory Fluid Mechanics & Aerodynamics
Concept of Pressure; A primer on Conservation Laws – Mass, Momentum and Energy. Bernoulli's Principle; A primer on viscous flows and concept of skin-friction; Basic Principle of Lift generation, airfoils – symmetric and cambered; Irrotational flows: Sink, source, doublet & irrotational vortex

Introduction to Propulsion Systems
Primer on the thermodynamic cycles of aircraft engines – ideal and real cycles; Axial Compressors and Turbines; Turbofan, turboprop, turbojet engines; An historical perspective of engines; Rocket engines – the principle of thrust generation with converging-diverging nozzles

Aircraft Performance
Mechanics of flight; Flight stability - considerations of stability in commercial and fighter aircrafts; Glide, climb, ceiling, turn and pull-up; V-n diagram; Range and Endurance

Navigation, Guidance & Control
Brief introduction to radar; Guided missiles, simplified missile guidance laws

Futuristic Aerospace Technologies

Electric propulsion; Hydrogen combustion engines; Supersonic & hypersonic Ramjet/Scramjet engines; AI assisted designs; Smart Materials etc.

Reference Books

1. Robert W. Fox, Alan T. McDonald, Philip. P. Pritchard, Introduction to Fluid Mechanics, 6th Edition, Wiley, 2003.
2. Frank M. White, Fluid Mechanics, Tata McGraw-Hill, 7th Edition, 2012
3. J.D. Anderson Jr., Introduction to Flight, McGraw-Hill, 8th Edition, 2012.
4. Saeed Farokhi, Aircraft Propulsion, John Wiley & Sons, 2nd Edition, 2014.
5. Merill I. Skolnik, Introduction to Radar Systems, Tata McGraw-Hill, 3rd Edition, 2001.
6. P. Zarchan, Tactical and Strategic Missile Guidance, AIAA, 7th Edition, 2019.

Recommended Reading

1. P.K. Kundu and I.M. Cohen, Fluid Mechanics, Elsevier Academic Press, 3rd Edition, 2004
2. M. van Dyke, An Album of Fluid Motions, The Parabolic Press, Only Edition, 1982
3. Prof. D. Ghose, Navigation, Guidance and Control, Lecture notes NPTEL, 2013
4. On Rocket Engines/Motors: https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/rocket-engines/
5. Album of Fluid Motions
6. R. M. O'Donnel, Introduction to Radar Systems, MIT OpenCourseWare https://www.ll.mit.edu/outreach/radar-introduction-radar-systems-online-course
7. S. Corda, Introduction to Aerospace Engineering with a Flight Test Perspective, Wiley, 1st Edition, 2017.

Programme Name	*Bachelor of Technology in Mechanical Engineering*	*Semester – IV*
Course Code	**R5ME2206T**	
Course Title	**Flight and Space Mechanics**	
Prerequisites		

COURSE OUTCOMES

After completing this course, students will be able to:
1. Evaluate performance of aircrafts
2. Analyze Stability of aircrafts
3. Analyze manoeuvrability and control of aircrafts, missiles, drones etc.
4. Apply orbital mechanics fundamentals to space/interplanetary flights

Course Contents

Atmosphere
Properties and characteristics of the atmosphere

Lift and drag on 3D Geometries
3D Wings; Starting, Bound & Wingtip vortices; Induced Drag; Different kinds of Drag, Center of pressure, Center of Moments.

Performance of Aircrafts
Performance: Level flight, cruise and climb, optimal cruise trajectories, Vn-diagrams; Performance comparison of jet and propeller driven engines.

Stability of Aircrafts
Static longitudinal, directional and lateral stability and control, Stick-fixed and Stick-free stability, Hinge moments, Trim-tabs, Aerodynamic balancing

Manoeuvrability and Control
Longitudinal, lateral Control, Control Surface configurations for control, Stall Recovery, Airplane Spin

Space Mechanics
Conic Sections and Central force motion; Orbital Mechanics & Kepler's Laws; Lambert's Problem; Non-Keplerian motion; Orbit Manoeuvres – Hohmann transfer, inclination change bi-elliptic manoeuvres; Lunar/Interplanetary trajectories- sphere of influence.

Reference Books

1. J.D. Anderson Jr., Introduction to Flight, McGraw-Hill, 8th Edition, 2012
2. E. L. Houghton, P.W. Carpenter, Aerodynamics for Engineering Students, Butterworth-Heinemann, 5th Edition, 2003.
3. J Katz, A Plotkin, Low-Speed Aerodynamics, Cambridge University Press, 2nd Edition, 2001.
4. P. Zarchan, Tactical and Strategic Missile Guidance, AIAA, 7th Edition, 2019.

Recommended Reading

1. W. F. Phillips, Mechanics of Flight, John Wiley & Sons, 2nd Edition, 2009
2. B.W. McCormick, Aerodynamics, Aeronautics and Flight Mechanics, John Wiley & Sons, 1st Edition, 1979
3. R. Battin, Lectures and Lectures Notes – Astrodynamics, MIT OpenCourseWare, 2008
4. Prof. D. Ghose, Navigation, Guidance and Control, Lecture notes NPTEL, 2013
5. B. Etkin, Dynamics of Atmospheric Flight, John Wiley & Sons, 1st Edition, 1971

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – V
Course Code	**R5ME3202T**	
Course Title	**Aircraft Structures**	
Prerequisites		

COURSE OUTCOMES

After completion of course, the student should be able to -

1. Grasp the fundamental concepts of aircraft structural design and analysis.
2. Understand the behavior of aircraft structures under various loading conditions.
3. Develop skills in analyzing and designing aircraft components and systems.
4. Familiarize students with the materials and manufacturing techniques used in aircraft structures.

Course Contents

Introduction to Aircraft Structures

Overview of aircraft structural components: fuselage, wings, empennage, landing gear, etc; types of aircraft structures: semi-monocoque, monocoque, and truss structures; Loads acting on aircraft structures: aerodynamic, inertial, ground, and pressure loads; Material selection for aircraft structures: aluminum alloys, composites, titanium, and steel.

Stress and Strain Analysis

Review of stress and strain concepts; Bending, shear, and torsion in beams; Stress-strain relationships for isotropic and anisotropic materials; Mohr's circle for stress and strain transformation.

Structural Load Analysis

Airworthiness requirements and design criteria; V-n diagram (flight envelope); Load factors and limit loads; Shear force and bending moment diagrams for aircraft wings and fuselage.

Analysis of Thin-Walled Structures

Thin-walled pressure vessels; Shear flow in thin-walled beams; Torsion of thin-walled closed and open sections; Bending and shear stress distribution in thin-walled beams.

Structural Stability and Buckling

Euler's buckling theory; Buckling of columns and plates; Local and global buckling in aircraft structures; Post-buckling behavior and design considerations.

Fatigue and Fracture Mechanics

Fatigue loading and S-N curves; Crack initiation and propagation; Stress concentration factors;

Damage tolerance and fail-safe design principles.

Composite Materials in Aircraft Structures

Introduction to composite materials: fibers, matrices, and laminates; Mechanical properties of composites; Failure theories for composite materials; Design and analysis of composite structures.

Structural Dynamics and Vibration

Free and forced vibrations of aircraft structures; Natural frequencies and mode shapes; Aeroelasticity: flutter, divergence, and control reversal; Vibration testing and analysis.

Aircraft Structural Design

Design philosophy: safe-life, fail-safe, and damage-tolerant design; Structural joints: riveted, bolted, and bonded joints; Finite Element Analysis (FEA) in aircraft structural design; Case studies of aircraft structural failures and lessons learned.

Manufacturing and Maintenance of Aircraft Structures

Manufacturing techniques for metallic and composite structures; Non-destructive testing (NDT) methods: ultrasonic, radiographic, and eddy current testing; Repair and maintenance of aircraft structures; Corrosion prevention and control.

Reference Books

1. Megson, T.H.G., Aircraft Structures for Engineering Students, Elsevier, 7th Edition, 2020.
2. **Sun, C.T.**, *Mechanics of Aircraft Structures*, Wiley, 2nd Edition, 2006.
3. **Donaldson, Bruce K.,** *Analysis of Aircraft Structures: An Introduction*, Cambridge University Press, 2nd Edition, 2008.

Recommended Reading

1. Baker, Alan; Dutton, Stuart; Kelly, Donald, Composite Materials for Aircraft Structures, AIAA Education Series, 2nd Edition, 2004.
2. **Alderliesten, René,** *Introduction to Aerospace Structures and Materials*, Delft University Press, 1st Edition, 2018.

Programme Name	Bachelor of Technology in Mechanical Engineering	Semester – VI
Course Code	**R5ME3204T**	
Course Title	**Aerodynamics**	
Prerequisites		

Course Outcomes

The student should be able to –

1. Grasp the fundamental principles of fluid mechanics and aerodynamics.
2. Understand the generation of lift, drag, and moments on aerodynamic bodies.
3. Analyze subsonic, supersonic, and hypersonic flows.
4. Apply aerodynamic theories to the design and analysis of aircraft and spacecraft.

Course Contents

Introduction to Aerodynamics

Basic fluid properties: density, viscosity, compressibility, and thermal conductivity; Flow characteristics: laminar and turbulent flow, steady and unsteady flow; Continuity, momentum, and energy equations; Dimensional analysis and Buckingham Pi theorem.

Incompressible Flow Over Airfoils

Airfoil nomenclature and geometry; Pressure distribution over airfoils; Lift, drag, and moment coefficients; Thin airfoil theory; Kutta condition and circulation.

Finite Wing Theory

Vortex filament and Biot-Savart law; Downwash and induced drag; Prandtl's lifting line theory; Elliptical lift distribution and wing efficiency.

Compressible Flow

Thermodynamics of compressible flow; Speed of sound and Mach number; Isentropic flow relations; Normal and oblique shock waves; Expansion waves (Prandtl-Meyer flow).

High-Speed Aerodynamics

Subsonic, transonic, supersonic, and hypersonic flow regimes; Critical Mach number and drag divergence; Wave drag and area rule; Shock-expansion theory for supersonic airfoils.

Boundary Layer Theory

Boundary layer concept and characteristics; Laminar and turbulent boundary layers; Boundary layer separation and control; Drag due to skin friction and pressure drag.

Wind Tunnel Testing

Wind tunnel types and their applications; Similarity parameters: Reynolds number, Mach number, and Strouhal number; Measurement techniques for lift, drag, and pressure distribution; Flow visualization techniques.

Reference Books

1. J.D. Anderson Jr., Introduction to Flight, McGraw-Hill, 8th Edition, 2012.
2. **Anderson, John D.,** *Fundamentals of Aerodynamics,* McGraw-Hill Education, 6th Edition, 2017.
3. **Katz, Joseph; Plotkin, Allen**, *Low-Speed Aerodynamics*, Cambridge University Press, 2nd Edition, 2001.
4. **Houghton, E.L.; Carpenter, P.W.; Collicott, S.H.; Valentine, D.T.**, *Aerodynamics for Engineering Students,* Elsevier, 7th Edition, 2020.
5. **Bertin, John J.; Cummings, Russell M.**, *Aerodynamics for Engineers*, Pearson, 6th Edition, 2013.

Recommended Reading

1. P.K. Kundu and I.M. Cohen, Fluid Mechanics, Elsevier Academic Press, 3rd Edition, 2004
2. Robert W. Fox, Alan T. McDonald, Philip. P. Pritchard, Introduction to Fluid Mechanics, 6th Edition, Wiley, 2003.
3. Frank M. White, Fluid Mechanics, Tata McGraw-Hill, 7th Edition, 2012

Programme Name	***Bachelor of Technology in Mechanical Engineering***	***Semester – VII***
Course Code	**R5ME4203T**	
Course Title	**Aerospace Propulsion Systems**	
Prerequisites		

COURSE OUTCOMES

Upon successful completion of the course, students should be able to -

1. Explain the fundamental principles of air-breathing and rocket propulsion systems.
2. Analyze the performance characteristics of turbojets, turbofans, ramjets, and chemical rocket engines.
3. Evaluate advanced and futuristic propulsion technologies.
4. Apply propulsion system design principles to solve practical engineering problems, conduct preliminary design studies, and assess mission-specific propulsion requirements for aircraft and spacecraft.

Course Contents

Fundamentals of Propulsion

Introduction to aerospace propulsion: historical overview and modern classifications. Basic thrust equation and propulsive efficiency. Comparison of air-breathing and non-air-breathing engines. Review of relevant thermodynamics (First and Second Laws, isentropic flow) and compressible fluid mechanics (shock waves, Mach number, stagnation properties). Performance parameters: specific thrust, specific impulse, total efficiency, and specific fuel consumption.

Air-breathing Engine Cycles

The Brayton cycle: ideal and real cycle analysis for gas turbine engines, including effects of irreversibilities and component losses. Detailed thermodynamic cycle analysis for: Ramjet engines (ideal and real cycles, performance at high Mach numbers); Turbojet engines (with and without afterburner, specific thrust optimization); Turbofan engines (separate and mixed exhaust streams, bypass ratio selection); Turboprop and turboshaft engines (power balance, propeller efficiency); Operating principle and thermodynamic cycle of scramjet engines with stress on supersonic mixing and flameholding, thermal management, high-temperature materials, and ground testing. Performance comparison across engine types and flight regimes.

Engine Component Analysis

Air Intakes: subsonic and supersonic diffuser design, pressure recovery, performance parameters, and modes of operation (critical, subcritical, supercritical). Combustion Chambers: gas turbine combustor types (can, annular, can-annular), flame stabilization mechanisms, combustion efficiency, pressure loss, and exit temperature distribution. Afterburners: design principles, thrust augmentation, and operational limitations. Nozzles: convergent and convergent-divergent (C-D) nozzles, flow choking, under-expanded and over-expanded flows, nozzle efficiency, and thrust vectoring concepts.

Fundamentals of Combustion

Combustion thermochemistry: stoichiometry, fuel-air ratio, enthalpy of formation, and adiabatic flame temperature calculations. Introduction to propellants: conventional aviation fuels, cryogenic fuels, and emerging sustainable alternatives.

Chemical and Electric Propulsion

Introduction to rocket propulsion systems and their classification. Rocket thrust equation, effective exhaust velocity, specific impulse, characteristic velocity (c*), and thrust coefficient (Cf). Nozzle flow theory for rockets: isentropic expansion, area-Mach number relationship, and optimum expansion ratio. Solid & Liquid propellant rockets; Electrostatic & Electromagnetic thrusters;

Preliminary Design Applications

Case studies: Turbofan engine for a business jet, solid rocket motor for a small satellite launch vehicle, electric propulsion subsystem for a geostationary communication satellite.

Reference Books

1. J.D. Mattingly, Elements of Propulsion: Gas Turbines and Rockets, AIAA Education Series, 2nd Edition, 2016.
2. S. Farokhi, Aircraft Propulsion, John Wiley & Sons, 2nd Edition, 2014.
3. M.J.L. Turner, Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, Springer, 3rd Edition, 2009.
4. P.G. Hill and C.R. Peterson, Mechanics and Thermodynamics of Propulsion, Pearson, 2nd Edition, 1992.
5. G.P. Sutton and O. Biblarz, Rocket Propulsion Elements, John Wiley & Sons, 9th Edition, 2016.
6. D. Musielak, Scramjet Propulsion: A Practical Introduction, John Wiley & Sons, 2022.
7. D.M. Goebel and I. Katz, Fundamentals of Electric Propulsion: Ion and Hall Thrusters, Wiley/JPL/NASA, 2008.

Recommended Reading

1. N. Cumpsty and A. Heyes, Jet Propulsion: A Simple Guide to the Aerodynamics and Thermodynamic Design and Performance of Jet Engines, Cambridge University Press, 3rd Edition, 2015.
2. G.C. Oates, Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA Education Series, 3rd Edition, 1997.

3. R.D. Flack, Fundamentals of Jet Propulsion with Applications, Cambridge University Press, 1st Edition, 2005.
4. V. Yang, Liquid Rocket Thrust Chambers: Aspects of Modeling, Analysis, and Design, AIAA Progress in Astronautics and Aeronautics, Vol. 200, 2004.
5. Prof. A. Kushari, Jet and Rocket Propulsion, NPTEL Lecture Notes, IIT Kanpur.
6. Prof. D.P. Mishra, Fundamentals of Combustion, NPTEL Lecture Notes, IIT Kanpur, 2018.
7. R.G. Jahn, Physics of Electric Propulsion, Dover Publications.
8. E.T. Curran and S.N.B. Murthy, Scramjet Propulsion, AIAA Progress in Astronautics and Aeronautics, Vol. 189, 2000