DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

SCHEME & SYLLABUS

BACHELOR OF TECHNOLOGY (B. Tech) –2022

Aerospace Engineering

(With effect from 2025-26)

Devarakaggalahalli, Harohalli, Kanakapura Road, Ramanagara Dt.,
Bengaluru 562 112, Karnataka

SCHEME 2022 – 2026 Batch

III SEMESTER													
S.N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	101	22AS2301	Transforms and Numerical	MAT	3	0	0	0	3	60	40	100	**3**
2	101	22AS2302	Thermodynamics and Heat Transfer	ASE	3	0	0	0	3	60	40	100	**3**
3	101	22AS2303	Introduction to Aerospace	ASE	2	0	0	0	3	60	40	100	**2**
4	101	22AS2304	Fluid Mechanics	ASE	3	0	2	0	3	60	40	100	**4**
5	101	22AS2305	Aerospace Structural Mechanics	ASE	3	0	2	0	3	60	40	100	**4**
6	101	22AS2306	Aerospace Materials	ASE	3	0	2	0	3	60	40	100	**4**
7	101	22AS2307	Special Topics - I	Any Dept.	1	0	0	0	1	60	40	100	**1**
8	101	22AS2308	Skill Enhancement Course – I	ASE	0	0	2	0	2	60	40	100	**1**
			Total		18	0	8	0		480	320	800	**22**

IV SEMESTER													
S. N	**Program Code**	**Course Code**	**Course Name**	**Teaching Department**	**Teaching Hours / Week**				**Examination**				**Credits**
					Lecture	**Tutorial**	**Practical**	**Project**	**Duration in Hours**	**CIE Marks**	**SEE Marks**	**Total Marks**	
					L	**T**	**P**	**J**					
1	101	22AS2401	Probability and Statistics	MAT	3	0	0	0	3	60	40	100	**3**
2	101	22AS2402	Aerospace Manufacturing	ASE	3	0	2	0	3	60	40	100	**4**
3	101	22AS2403	Introduction to Space Technology	ASE	3	0	0	0	3	60	40	100	**3**
4	101	22AS2404	Aircraft Propulsion	ASE	3	0	0	0	3	60	40	100	**3**
5	101	22AS2405	Low-speed Aerodynamics	ASE	3	0	0	0	3	60	40	100	**3**
6	101	22AS2406	Introduction to Computational Fluid Dynamics	ASE	2	0	2	0	3	60	40	100	**3**
7	101	22AS2407	Special Topics -II	Respective Dept.	1	0	0	0	1	60	40	100	**1**
8	101	22AS2408	Skill Enhancement Course – II	Respective Dept.	0	0	2	0	2	60	40	100	**1**
			Total		18	0	6	0	21	480	320	800	**21**

V SEMESTER													
S. N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	101	22AS3501	High Speed Aerodynamics	ASE	3	0	0	0	3	60	40	100	3
2	101	22AS3502	Aircraft Performance and Design	ASE	3	0	0	2	3	60	40	100	**4**
3	101	22AS3503	Space Flight Mechanics	ASE	3	0	0	0	3	60	40	100	**3**
4	101	22AS3504	Drives and Actuators	ASE	2	0	2	0	3	60	40	100	**3**
5	101	22AS3505	Introduction to Finite Element Analysis	ASE	2	0	2	0	3	60	40	100	**3**
6	101	22AS35XX	Professional Elective Course – I	ASE	3	0	0	0	3	60	40	100	**3**
7	101	22AS3506	Model Based System Engineering (MBSE)	ASE	1	0	2	0	2	60	40	100	2
8	101	22AS3507	Skill Enhancement Course – III	ASE	0	0	2	0	1	100	--	100	**1**
9	101	22AS3508	Cognitive and Technical Skills-I		0	0	4	0	1	100	--	100	**2**
			Total		17	0	12	2		620	280	900	**24**

Professional Elective - I

Sl No.	Course Code	Course Name
1	22AS3509	Rockets and Missiles
2	22AS3510	Measurement Techniques
3	22AS3511	Space Flight Operations
4	22AS3512	Advanced Manufacturing
5	22AS3513	Data Analysis and Interpretation
6	22AS3514	MOOC

VI SEMESTER													
S.N	**Program Code**	**Course Code**	**Course Name**	**Teaching Department**	**Teaching Hours / Week**				**Examination**				**Credits**
					Lecture	**Tutorial**	**Practical**	**Project**	**Duration in Hours**	**CIE Marks**	**SEE Marks**	**Total Marks**	
					L	**T**	**P**	**J**					
1	101	22AS3601	Avionics	ASE	2	0	2	0	3	60	40	100	**3**
2	101	22AS3602	Aircraft Stability and Control	ASE	2	1	0	0	3	60	40	100	**3**
3	101	22AS3603	Vibration and Control	ASE	3	0	2	0	3	60	40	100	4
4	101	22AS3604	Artificial Intelligence and Machine Learning	ASE	3	0	0	0	3	60	40	100	**3**
5	101	22AS36XX	Professional Elective Course – II	ASE	3	0	0	0	3	60	40	100	**3**
6	101	22OEXXXX	Open Elective – I	ASE	3	0	0	0	3	60	40	100	**3**
7	101	22AS3605	Flight Physics Lab	ASE	0	0	2	0	2	60	40	100	**1**
8	101	22AS3606	Cognitive and Technical Skills-II		0	0	4	0		100	0	100	2
			Total		16	1	10	0		520	280	800	**22**

Professional Elective – II

Sl. No	Course Code	Course Name
1.	22AS3607	Heat Transfer for Aerospace Applications
2.	22AS3608	Systems Engineering
3.	22AS3609	Space System Design
4.	22AS3610	Aircraft Maintenance, Repair and Overhaul
5.	22AS3611	Industry 4.0
6.	22AS3612	MOOC

Open Elective – I

Sl. No	Course Code	Course Name
1.	22OE0053	Introduction to Aerospace Engineering
2.	22OE0054	Operations Management for Aerospace
3.	22OE0055	MOOC

VII SEMESTER													
S. N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	101	22AS4701	Principles of Management & Economics for Engineers	ASE	3	0	0	0	3	60	40	100	**3**
2	101	22AS4702	Satellite Technologies	ASE	3	0	0	0	3	60	40	100	**3**
3	101	22AS47XX	Professional Elective Course -III	ASE	3	0	0	0	3	60	40	100	**3**
4	101	22AS47XX	Professional Elective Course -IV	ASE	3	0	0	0	3	60	40	100	**3**
5	101	22OEXXXX	Open Elective -II	ASE	3	0	0	0	3	60	40	100	**3**
6	101	22AS4703	Capstone Project Phase I	ASE	0	0	0	6	1	60	40	100	**3**
			Total		15	0	0	6		360	240	600	**18**

Professional Elective – III

Sl. No	Course Code	Course Name
1.	22AS4704	Urban Air Mobility
2.	22AS4705	Advanced Structural Mechanics
3.	22AS4706	Space Vehicle Design
4.	22AS4707	Operations Management
5.	22AS4708	Unmanned Aerial Systems
6.	22AS4709	MOOC

Professional Elective – IV

Sl. No	Course Code	Course Name
1.	22AS4710	Sustainable Aviation
2.	22AS4711	Aircraft Design
3.	22AS4712	Spaceflight Navigation and Guidance
4.	22AS4713	Airworthiness and Certification
5.	22AS4714	Augmented Reality & Virtual Reality

Open Elective – II

Sl. No	Course Code	Course Name
1.	22OE0067	Introduction to Space Technologies
2.	22OE0068	Introduction to Satellite Technologies
3.	22OE0055	MOOC

VIII SEMESTER													
S.N	**Program Code**		**Course Name**	**Teaching Department**	**Teaching Hours / Week**				**Examination**				**Credits**
					Lecture	**Tutorial**	**Practical**	**Project**	**Duration in Hours**	**CIE Marks**	**SEE Marks**	**Total Marks**	
					L	**T**	**P**	**J**					
1	101	22AS4801	Internship	ASE	0	0	0	6	01	100	--	100	**3**
2	101	22AS4802	Capstone Project Phase	ASE	0	0	0	22	01	60	40	100	11
			Total		0	0	0	28		160	40	200	**14**

PRINCIPLES OF MANAGEMENT AND ECONOMICS FOR ENGINEERS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –VII

Subject Code	:22AS4701		**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

1. This course presents the principles, techniques, and concepts for managerial analysis and decision-making.
2. It highlights the effective management of planning, organizing, influencing, and controlling related to the internal and external environment and issues of ethics and social responsibility.
3. The course focuses on economic and cost analysis of engineering projects, giving insights into modern techniques and methods used in economic feasibility studies relating to the design and implementation of engineering projects.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I : Introduction to Management	**08 Hours**

Nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession – Management as an Administration -Roles of Management, Levels of Management, Development of Management Thought- early management approaches – Modern management approaches. Planning: Nature, importance, and purpose of planning process Objectives - Types of plans (Meaning Only) - Decision-making Importance of planning - steps in planning & planning premises - Hierarchy of plans.

UNIT – II: Organizing and Staffing	**06 Hours**

Nature and purpose of organization Principles of organization - Types of organization - Departmentation Committees Centralization Vs Decentralization of authority and responsibility -Span of control - MBO and MBE (Meaning Only) Nature and importance of staffing--Process of Selection & Recruitment (in brief). Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co-Ordination.

Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief).	
UNIT – III: Engineering and Economics	**09 Hours**
Laws of demand and supply, Difference between Microeconomics Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, and income elasticity. Law of Returns, Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans, and EMI payment calculation with flexible interest rates, Discussion, and problems.	
UNIT – IV: Present, Future and Annual worth and Rate of Returns	**08 Hours**
Present, future and annual worth and rate of returns: Basic present worth comparisons, Present worth equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Discussions and problems.	
UNIT – V: Costing and Depreciation	**08 Hours**
Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of Management principles in project works and organizations.	L3
2	Analyze cash flows and overall economic analysis.	L2 & L3
3	Evaluate various project proposals for their feasibility and economic considerations.	L3
4	Make decisions consistent with economic and organizational standards	L2 & L3
5	Apply the financial procedures and implications of engineering economics in industries/organizations and in real life	L3

Table: Mapping Levels of COs to POs / PSOs															
COs	**Program Outcomes (POs)**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	3
CO1	3	2	2								2				
CO2	3	2	2								2				
CO3	3	2	2								2				
CO4	3	2	2								2				
CO5	3	2	2								2				

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Principles of Management by Tripathy and Reddy
2. Mechanical estimation and costing, T.R. Banga & S.C. Sharma, 17th edition 2015
3. Management & Engineering Economics, Ravi Kumar R, Sunstar Publications
4. Engineering Economy, Riggs J.L. McGraw Hill, 2002

REFERENCE BOOKS:

1. Management Fundamentals - Concepts, Application, Skill Development - Robers Lusier Thomson
2. Basics of Engineering Economy, Leland Blank & Anthony Tarquin, McGraw Hill Publication (India) Private Limited
3. Engineering Economics, R.Paneerselvam, PHI publication

E-Resources:

1. Engineering Economic Analysis, https://archive.nptel.ac.in/noc/courses/noc18/SEM1/noc18-me35/#:~:text=Course%20abstract,and%20implementation%20of%20engineering%20projects.
2. Principles of Management, https://onlinecourses.nptel.ac.in/noc23_mg33/preview
3. Principles of Management, https://archive.nptel.ac.in/noc/courses/noc20/SEM2/noc20-mg58/

****

SATELLITE TECHNOLOGIES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4702	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

Course Learning Objectives:

This course will enable students to get exposed to:

- Understand different types of satellites, payloads, and their applications.
- Gain knowledge about spacecraft bus and payload systems including their requirements and configurations.
- Learn about mainframe subsystems of spacecraft including mechanical and electrical components.
- Explore nanosatellites, rovers, and astronautics including their missions and classifications.
- Study space exploration and utilization focusing on major space agencies, space habitats, and sustainable living in space.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher Order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I **08 Hours**

TYPES OF SATELLITES & PAYLOADS, CUBESATS

Space Environment, Global Space Technologies, Space Missions, objectives, Space Mission Life Cycle Classification of satellites, Types of Orbits, Types of Payloads & Applications, Cubesat Configuration, Payloads for Cubesats, Overview of Launch and On-Orbit Operations, Life-Cycle of Satellites, Space Polices & Laws.

UNIT – II **08 Hours**

SPACECRAFT BUS AND PAYLOAD SYSTEMS

Overview, Model philosophy, Spacecraft configuration, Bus and payload systems requirements, Mechanical and Electrical requirements, Thermal requirements, Accommodation Studies and optimisation, Layouts and ILDs (Inserts Layout Drawings) generation, testing and qualification

UNIT – III **06 Hours**

SPACECRAFT MAINFRAME SUBSYSTEMS

Mainframe Subsystems-Mechanical: Structure, Propulsion, Thermal and Deployment Mechanisms; Electrical: Power, Telemetry, Telecommand, Navigation, Communication, Altitude determination and control (ADCS), Mission Software, Control Electronics, Sensors, Communication, nano propulsion, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, Deployment and ejection systems, Space entrepreneurship

UNIT – IV **09 Hours**

NANOSATELLITE, ROVERS & ASTRONAUTICS

Definition and Classification: CubeSats, Picosats, and Pocket Qubes, Key Missions: Sojourner, Spirit, Opportunity, Curiosity, Perseverance, Instruments for Geology, Atmosphere, and Surface Analysis, History of Human Space Exploration, Spacecraft Architecture: Crew Modules, Life Support Systems, Safety Features, Radiation Protection and Mitigation Strategies

UNIT – V **08 Hours**

SPACE EXPLORATION AND UTILIZATION

Overview of Major Space Agencies, Design and Architecture of Space Habitats, Technologies for Sustainable Living in Space, Space Tourism, Space Manufacturing, Additive Manufacturing (3D Printing) in Space, In-Situ Resource Utilization (ISRU), Spaceflight challenges.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Classify and describe various satellites, payloads, orbits, and their applications.	L2 & L3
2	Analyze spacecraft bus and payload systems and their requirements	L2 & L3
3	Explain the mainframe subsystems of spacecraft and their respective functions	L2 & L3
4	Identify and discuss the types and missions of nanosatellites and rovers.	L2 & L4
5	Evaluate space exploration technologies, space habitats, and space manufacturing processes	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	3		3	3							3		3	
CO2	3		3	2	2							2		2	
CO3	3	3		3	3							1		3	
CO4	3	2	3	2	2							2		2	
CO5	3	3			2							1		2	

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXTBOOKS:

1. Satellite Communications Systems: Systems, Techniques and Technology by Gerard Maral, Michel Bousquet, Publisher: Wiley, Publication Year: 2010, Edition: 5th Edition

2. Spacecraft Systems Engineering by Peter Fortescue, Graham Swinerd, John Stark, Publisher: Wiley, Publication Year: 2011, Edition: 4th Edition
3. Small Satellite Missions for Earth Observation by Rainer Sandau, Publisher: Springer, Publication Year: 2010, Edition: 1st Edition
4. Nanosatellites: Space and Ground Technologies, Operations and Economics by Rogerio Boni, Publisher: Springer, Publication Year: 2020, Edition: 1st Edition
5. Space Exploration and Astronautics by James M. Tiller, Publisher: McGraw-Hill, Publication Year: 2015, Edition: 1st Edition
6. Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: https://doi.org/10.1007/978-3-031-34818-1
7. Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018 Edition: 2 Volume: 3

REFERENCE BOOKS:

1. "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
2. "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
3. "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley.

E-Resources:

1. https://archive.nptel.ac.in/courses/101/106/101106046/
2. IEEE Xplore Digital Library
3. NASA Technical Reports Server (NTRS)
4. European Space Agency (ESA) Publications
5. SpaceX Mission Archives
6. Journal of Spacecraft and Rockets

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on a mission, satellite building, and propulsions technology
2. Site visit/Video demonstrations on the building/launching of a spacecraft
3. **Hands-On Labs and Workshops**
    a. Design and Build a Simple CubeSat or Rover Model
    b. Simulation Software: Use of STK, GMAT, for Mission Planning and Simulation
4. **Case Study Analysis**
    a. Detailed Study of Selected Nanosatellite and Rover Missions
    b. Group Discussions on Challenges and Innovations in Space Exploration.

Professional Elective III

URBAN AIR MOBILITY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4704	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P–S	:	3–0–0–0			

Course Learning Objectives:

This course will enable students to:

1. Understand of new mobility concepts.
2. Analyze the influence of Urban Air Mobility on the whole transport system.
3. Model Urban air mobility systems.
4. Understand the economics and safety aspects of future transportation systems.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teachers can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain the functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher-order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

Course Content

UNIT – I	**06 Hours**

Introduction to Future Transportation:

Introduction to existing transportation systems, importance of moving towards future transportation with respect to sustainable ecosystem. the modelling aspects in designing of control systems like PID, FOPID, aesthetics. System Dynamic Model of Urban Transportation System

UNIT – II	**10 Hours**

Deep Learning approaches for Urban Air Mobility: Object detection algorithms using deep learning techniques for urban air mobility, Deep Learning approaches such as Reinforcement Learning Network, Convolution Neural Network, Deep Queuing Network, adopted for design of control algorithms,

UNIT – III	**08 Hours**

Navigation and traffic control systems for Urban Air Mobility: Navigation and traffic control law like group coordination, Navigation, obstacle avoidance, fault identification. Trajectory Planning	
UNIT – IV	**08 Hours**
Economics of UAM and Urban Planning: Planning Process, Integration with existing systems, Potential conflict with other urban uses, Demand and Supply as Basic Theoretical Building Blocs, Basic cost, price determinants and shifters, Limits set by economic regulation, Cost structure decisions.	
UNIT – V	**07 Hours**
Safety and Security challenges in implementing Urban Air Mobility Safety aspects for the users and security challenges like network vulnerabilities, compromise the onboard systems and other catastrophic consequences for the passengers.	

TEXT BOOKS:

1. Vishnu Kumar Kaliappan, "Urban Air Mobility Intelligent, Safe and Sustainable Systems for Future Transportation", River Publishers Series in Transport Technology, ISBN: 9788770226783 e-ISBN: 9788770226776
2. Ivana Semanjski (Editor), Antonio Pratelli (Editor), Massimiliano Pieraccini (Editor.), "Urban Air Mobility (UAM)", Mdpi AG, 2023, ISBN978-3-0365-9163-6 (Hardback), ISBN978-3-0365-9162-9 (PDF)

****

ADVANCED STRUCTURAL MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4705	**Credits**	:	04
Hours / Week	:	03 Hours	**Total Hours**	:	39 + 26 Hours
L–T–P	:	3–0–2			

Course Learning Objectives:

This course will enable students to:

1. **Analyze** the behaviour of aerospace structures under different loading conditions
2. **Apply principles** of structural analysis to determine the stress, strain, and deformation of aerospace components and systems.
3. **Evaluate** the performance and safety of aerospace structures by conducting structural integrity assessments and failure analyses.
4. **Interpret** and **analyze** experimental data obtained from structural tests, such as material testing, load testing, and vibration analysis.

1. Teaching-Learning Process (General Instructions)

2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
3. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
4. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
5. Show ***Video/animation*** films to explain functioning of various concepts.
6. Encourage ***Collaborative*** (Group Learning) Learning in the class.
7. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
8. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
9. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
10. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

STRESS & STRAIN ANALYSIS IN AEROSPACE STRUCTURES: 3d stress–strain behavior in aircraft wings, fuselage frames, and thin-walled structures, principal stresses and failure-critical locations in airframes, aerospace materials: anisotropic laminates, composites, and alloys, compatibility and equilibrium for lightweight structural components

UNIT – II	08 Hours
Energy methods for aircraft structural design Virtual work and energy principles applied to wings, spars, and ribs, Rayleigh–Ritz methods for aeroelastic deformation prediction, Castiglioni's theorems for load path and deflection estimation in aircraft component, -variational approaches used in preliminary airframe optimization	
UNIT – III	**06 Hours**
Stability & Buckling in Aerospace Components column and panel buckling in wings, fuselage skins, and stiffened shells, post-buckling behaviour of, thin aerospace structures under compressive loads, lateral–torsional buckling in control surfaces and slender beams, design against instability for lightweight, high-efficiency airframes	
UNIT – IV	**09 Hours**
Structural Dynamics of Flight Vehicles Free and Forced vibration of aircraft panels, wings, and rotor blades, modal analysis for flutter, resonance, and aeroelastic coupling, damping mechanisms in aerospace structures, shock, impact, and fatigue response under real flight loading	
UNIT – V	**08 Hours**
finite element methods for aerospace structural analysis: FEM formulation of beams, shells, and composite laminates used in aircraft, stress recovery and mesh refinement for high-stress aerospace zones, nonlinear fem for large deformation and composite failure modes, application of software tools (Nastran/Abaqus/ANSYS) for airframe simulation	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	**Determine** loads on aircraft structural members and **select** appropriate material.	L2 & L3
2	**Analyze** the axial members for stress, strain and deformation	L2 & L3
3	C**onstruct** Shear force and bending moment diagrams and **calculated** bending and shear stresses in beams.	L3 & L4
4	**Analyze** the torsional members for stress, strain and deformation.	L3 & L4
5	**Determine** critical load for columns with different end conditions.	L2 & L3
6	**Apply** the theories of failure in designing the structures	L2 & L3

Table: Mapping Levels of COs to POs / PSOs															
COs	**Program Outcomes (POs)**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3		2	1								3		
CO2	3	3	2	3	2				2	2			2		
CO3	3	3		3	2				2	2		1	2		
CO4	3	3	2	2	2				2	2		1	2		
CO5	3	3		2	2				2	2		1	2		
CO6	3	3		2	2								2		

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. T.H.G.Megson, Aircraft Structures for Engineering students, Elsevier. 5th edition, 2007.
2. Lalit Gupta and O P Sharma, Fundamentals of Flight Vol-II (AIRCRAFT STRUCTURES), Himalayan Books. 2006, ISBN: 9788170020752

REFERENCE BOOKS:

1. J.B.K. Das and Dr. P.L.Srinivas Murthy , "Mechanics of Materials", Sapna, 2016.
2. Barry J Goodno, James M Gere, Mechanics Of Materials, 9th Edition, Cengage Publications

E-Resources:

1. https://archive.nptel.ac.in/courses/101/105/101105084/

SPACE VEHICLE DESIGN

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4706	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

This course will enable students to:

1. Understand the design principles, methodologies, and technologies involved in space vehicle design.
2. Understand space mission analysis and design process
3. Understand critical subsystems of space vehicles, including propulsion, structures and thermal.
4. Acquire the knowledge of spacecraft configuration and structural design

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

Introduction to Launch Vehicle: Anatomy of a Launch Vehicle, the Phases of Launch and Ascent, Typical Launch Vehicle Mission and Mission Elements, The Typical Launch Vehicle Design Process, Launch Sites, Launch Site Selection Criteria, The Space Industry, Launch Vehicle Requirements Derive from Payload and Mission, Orbits, Orbital Parameters, and Trajectories, Spacecraft Mission Orbits and Trajectories, Required Energy to Be Delivered for Orbit, Determining the Launch Vehicle Velocity Vector

UNIT – II	**06 Hours**
Propulsion: Rocket Propulsion Fundamentals, Ascent Flight Mechanics, Launch Vehicle selection, Entry flight Mechanics, Entry heating, entry vehicle design, Aero assisted orbit transfer.	
UNIT – III	**07 Hours**
Launch Vehicle Performance and Staging: The Three Categories of Launch Vehicle Mass, finding a Rocket's Speed Change in Free Space, Burnout Speed, Single-Stage-to-Orbit, Staging, Calculation of Speed Supplied by a Multistage Rocket, Payload Ratio, Unrestricted Staging, Parallel Burns and Staging, Launch Vehicle Design Sensitivities.	
UNIT – IV	**09 Hours**
Sizing, Inboard Profile, Mass Properties: Inboard Profile, Vehicle or Step Mass Calculations, Liquid Propulsion System Real-Life Additions to Mass and Volume, Other Launch Vehicle Components, Solid Propulsion System Sizing, Comments about Upper Steps and Payload Fairings, Mass Estimation Process, Calculation of Tank or Shell Thicknesses	
UNIT – V	**09 Hours**
Effect of Space Environment on Design: Introduction, Pre-operational Spacecraft Environments, Operational Spacecraft Environments, Environmental Effects on Design. Overview of Attitude control system, ACS block diagram, passive and active control, Attitude Measurement. Need for thermal control, Thermal Environment: Types of Thermal control, Thermal Balance.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	**Assess** the trade-offs and decision-making processes involved in space vehicle design.	L3
2	Analyse the launch vehicle flight during launch and reentry	L2 & L3
3	Analyse the performance of launch vehicle and determine the staging.	L3
4	Apply fundamental principles of space vehicle design to develop conceptual and detailed designs in terms of mass and sizing of the subsystems.	L2 & L3
5	Discuss the effect of space environment on design of space vehicle	L3

Table: Mapping Levels of COs to POs / PSOs														
COs	**Program Outcomes (POs)**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	3	2	2		1								1	1
CO2	3	2	2		2								2	2
CO3	3	2	2		1								2	1
CO4	3	2	2		2								2	2
CO5	3	2	2		2								2	

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1 . Don Edberg and Willie Costa, “Design of Rockets and Space Launch Vehicles”, AIAA EDUCATION SERIES, 2022.
2. Michael D. Griffin and James R. French, "Space Vehicle Design”, American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2004

REFERENCE BOOKS:

1. Thomas P. Sarafin, “Spacecraft Structures and Mechanisms : From Concept to Launch”, Springer; 1995.
2. Ronald Humble, Gary Henry, and Wiley Larson, “Space Propulsion Analysis and Design”,
3. James R. Wertz, David F. Everett, and Jeffery J. Puschell, “Space Mission Engineering: The New SMAD”, Microcosm Press, 2015

E-Resources:

1. **Introduction to Launch Vehicle Analysis and Design, IIT Bombay, https://archive.nptel.ac.in/courses/101/101/101101086/#**
2. **Space Flight Mechanics, https://onlinecourses.nptel.ac.in/noc23_ae16/preview**

****

OPERATIONS MANAGEMENT

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:22AS4707		**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

This Course will enable students to:

1. **Integrate** the various elements of operations management in the context of aerospace industry.
2. **Deploy** their knowledge and skills in scheduling and control operation to address ongoing & futuristic trends in the control of inventory.
3. **Analyse** operational elements to achieve effective materials management, lean manufacturing, quality assurance and compliance.
4. **Apply** modern methods for cost reduction, digital transformation, and operational efficiency in the context of the aerospace industry.

UNIT – I	**07 Hours**

Introduction to Operations Management in Aerospace

Overview of aerospace industry: tier – 1, tier – 2 and tier -3, Operations management in the aerospace industry - trends and issues, Importance of operations strategy, integrated product development, process design and project management in ensuring efficient production and delivery of aerospace products, Key concepts: quality, cost, delivery effectiveness and flexibility. Case studies of successful aerospace operations management practices

UNIT – II	**08 Hours**

Introduction to supply chain management in the aerospace industry

Components of the aerospace supply chain: suppliers, manufacturers, distributors, and customers Role of forecasting, procurement, sourcing, Inventory management, and logistics in the aerospace supply chain, performance measures for supply chains Challenges and opportunities in aerospace supply chain management

UNIT – III	**08 Hours**

Production facility layout, manufacturing processes

Demand forecasting, Enterprise Resource Planning, Inventory Planning and Control ,Types of production processes: make-to-order, make-to-stock, and hybrid,JIT, KANBAN and Continuous Improvement ,Material Planning, Capacity planning and resource allocation ,Techniques for scheduling and sequencing aerospace production activities, Digital Manufacturing, Industry 4.0 and Factories of the Future

UNIT – IV	**08 Hours**
Introduction to lean manufacturing principles in aerospace operations Operations Scheduling, Eliminating waste and improving efficiency in aerospace manufacturing, Quality assurance systems and certifications in the aerospace industry, regulatory, environmental, health and safety issues in operations (e.g., AS9100)Tools and techniques for quality, improvement in aerospace operations, Introduction to Six Sigma methodology and its applications in aerospace, Case studies of lean manufacturing and Six Sigma in the aerospace industry	
UNIT – V	**08 Hours**
Modern Trends Emerging trends and technologies including digital threads and block chains in aerospace operations management, Application of analytics, artificial intelligence, and automation, cobots, factories of the future, Sustainability and environmental considerations in aerospace manufacturing and operations, Future directions and career opportunities in aerospace operations management	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Integrate production planning functions towards managing manufacturing functions	3
2	Prepare schedule and sequence for simple manufacturing operations and with affordable manufacturing lead time.	3
3	Choose supply chain strategy appropriate to the aerospace product requirements	3
4	Perform material planning, capacity planning and resource allocation for simple components	4
5	Identify and select appropriate modern operational concepts including digital manufacturing	4

Table: Mapping Levels of COs to POs / PSOs															
COs	**Program Outcomes (POs)**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2	1			1					3	1	2	1	3
CO2	3	2	1			1					3	1	2	1	3
CO3	3	2	1			1					3	1	2	1	3
CO4	3	2	1			1					3	1	2	1	3
CO5	3	2	1			1					3	1	2	1	3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

Text Books:

1. B Mahadevan, Operations Management Theory and Practice, 3rd Ed. 2015, Pearson Education. ISBN: 9789332547520
2. Aswathappa K. and Sridhara Bhat, Production and Operations Management 2015, Himalaya Publishing House. ISBN: 9789350971888

Reference Books:

1. William J Stevenson, Operations Management, 13th Ed, July 2022, McGraw Hill ISBN13: 978-9355322647.
2. Chary SN, Production and Operations Management, 6th Ed Tata McGraw Hill 2019 ISBN: 978-9353164812.

****

UNMANNED AERIAL SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4708	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0-3			

Course Learning Objectives:

This course will enable students to:

1. Provide foundational knowledge of Unmanned Aircraft Systems (UAS), including history, evolution, and applications.
2. Familiarize students with design, selection, and aerodynamics of UAV platforms.
3. Develop understanding of system development, testing, and certification procedures.
4. Introduce various payloads, launch, and recovery mechanisms used in UAVs.
5. Enhance knowledge of UAV navigation, guidance, communication systems, and explore future trends in UAS.

Teaching-Learning Process (General Instructions)

1. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
2. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
3. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
4. Show ***Video/animation*** films to explain functioning of various concepts.
5. Encourage ***Collaborative*** (Group Learning) Learning in the class.
6. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
7. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
8. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
9. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**10 Hours**

Introduction to Unmanned Aircraft Systems (UAS). The Beginning The Need for Effective Control The First Modern Unmanned Aircraft; The Target Drone Some Applications of UAS, The Systemic Basis of UAS System Composition Basic Technology Control Methods. Classification of UAS Long-endurance, Long-range Role Aircraft

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

UNIT – II	10 Hours

Introduction to Design and Selection of the System Conceptual Phase Preliminary Design Detail Design Selection of the System Aerodynamics and Airframe Configurations Lift-induced Drag Parasitic Drag Rotary-wing Aerodynamics Response to Air Turbulence Airframe Configurations **Transportation:** Micro-UAV VTOL Close-range Systems HTOL Close-range Systems Medium- range Systems MALE and HALE Systems

UNIT – III	10 Hours

THE DEVELOPMENT OF UAV SYSTEMS

Introduction to System Development and Certification System Development Certification Establishing Reliability System Ground Testing UAV Component Testing UAV Sub-assembly and Sub-system Testing Complete UAV Control Station Testing Catapult Launch System Tests Documentation System In-flight Testing Test Sites Preparation for In-flight Testing In-flight Testing System Certification

UNIT – IV	08 Hours

Payloads of UAVs :

Non-dispensable Payloads- Electro-optic Payload Systems, Radar Imaging Payloads, Electronic Warfare Payloads, Dispensable Payloads and other payloads. Launch and Recovery Systems for UAVs: UAV Launch Methods for Fixed-Wing Vehicles- Rail Launchers, Pneumatic Launchers, Hydraulic/Pneumatic Launchers, Zero Length RATO Launch of UAVs, UAV Recovery Systems- Conventional Landings, Vertical Net Systems, Parachute Recovery, VTOL UAVs, Mid-Air Retrieval, Shipboard Recovery.

UNIT – V	08 Hours

UAV Navigation and Guidance Systems:
Navigation, Dead Reckoning, Inertial, Radio Navigation, Satellite– Way point Navigation, UAV Guidance, Types of guidance, UAV communication systems, Ground control station, Telemetry, UAS future.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	Explain the history, need, and classification of UAVs along with their system components.	L2
CO2	Analyze UAV design phases, airframe configurations, and aerodynamic considerations for different classes of UAVs.	L3
CO3	Demonstrate knowledge of UAV system development, ground/in-flight testing, and certification processes.)	L2
CO4	Evaluate different payloads, launch and recovery mechanisms used in UAV applications.	L3
CO5:	Apply principles of UAV navigation, guidance, communication systems, and assess emerging UAS technologies.	L4

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2	1	1	2	1	1	1	2	2	1	2	1	2	
CO2	3	2	1	1	2	1	1	1	2	2	1	2	1	1	
CO3	3	2	1	1	2	1	1	1	2	2	1	2	1	1	
CO4	3	2	1	1	2	1	1	1	2	2	1	2	1		
CO5	3	3	2	3	3	2	2	2	2	3	2	2	1		

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

Text books:

1. Reg Austin, Unmanned Aircraft systems UAVs Design, Development and Deployment, A John Wiley & Sons,Ltd.,2010.
2. Douglas M.Marshall et al., Introduction to unmanned Aircraft systems, second edition Taylor & Francis, 2016.
3. Design of Unmanned Air Vehicle Systems, Dr. Armand J. Chaput, 3rd Edition, 2001, Lockheed Martin Aeronautics Company, ISBN: 978-1-60086-843-6

Reference Books:

1. Unmanned Aircraft Systems UAV design, development and deployment, Reg Austin, 1st Edition,2010, Wiley, ISBN 9780470058190.

2.Introduction to UAV Systems, Paul G Fahlstrom, Thomas J Gleason, 4th Edition, 2012, Wiley, ISBN:978-1-119-97866-4

3 .Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy, Kimon P. Valavanis, 1st Edition,2007, Springer ISBN 9781402061141

4.Flight Stability and Automatic Control, Robert C. Nelson, 2nd Edition, October 1, 1997, McGraw- Hill, Inc, ISBN 978-0070462731.

Professional Elective IV

SUSTAINABLE AVIATION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4710	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P–S	:	3–0–0–0			

Course Learning Objectives:

This course will enable students to:

1. Have in-depth understanding of aviation fuels, their properties, production processes, and the combustion mechanisms in aviation engines.
2. Know how to evaluate fuel performance and efficiency, address environmental concerns, and innovate in the field of aviation fuel technology.
3. Appreciate emerging trends in alternative fuels, secondary fuels, electrification, and sustainability in aviation.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I : Introduction to Sustainability	**08 Hours**

What is sustainability, evaluation of sustainability, pillars of sustainability, sustainability development goals, sustainability in aviation, Aviation and Climate Change, how do aircraft impact the environment, Current situation

UNIT – II: Sustainable Aviation Fuels	**06 Hours**

Overview of aviation fuels, Types of aviation fuels (Jet A, Jet A-1, JP-4, JP-8, etc.), Properties of aviation fuels (density, viscosity, energy content, etc.), Historical development and evolution of aviation fuels

Alternate Jet fuels, biofuels, biofuel emissions, hydrogen production and storage, battery systems, electric aircraft

UNIT – III: Combustion in Aviation Engines	**09 Hours**

Basics of combustion chemistry and physics, Stoichiometry of combustion reactions, Types of combustion (diffusion flames, premixed flames, etc.), Combustion process in jet engines, Combustion efficiency and performance parameters, Flame stabilization and propagation, Advanced combustion technologies (lean burn, rich burn, staged combustion)
UNIT – IV: Hydrogen Fuels and Electrification **08 Hours**
Introduction to secondary fuels (hydrogen, ammonia, etc.), Properties and performance of secondary fuels, Infrastructure and handling of secondary fuels, Environmental impact of secondary fuel usage, Electrification of aviation: current technologies and future prospects, Hybrid-electric and fully electric aircraft, Battery technologies and energy storage solutions, Sustainable aviation fuels (SAFs) and their production processes, Life cycle assessment of aviation fuels and technologies, Regulatory framework and standards (ICAO, EPA, etc.), Strategies for enhancing sustainability in aviation
UNIT – V: Sustainable Airports **08 Hours**
Energy Management at the Airports, Aircraft noise and its effects, international regulations, control of aircraft noise, sustainable goals, energy management of airports.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply knowledge of different types of aviation fuels and their properties to real-world aviation scenarios.	L3
2	Evaluate the combustion processes in aviation engines to optimize performance and efficiency.	L2 & L3
3	Critically evaluate environmental impacts and regulations associated with aviation fuels and propose mitigation strategies.	L3
4	Investigate alternative and secondary fuel options and their potential applications in aviation.	L2 & L3
5	Examine the role of electrification in aviation propulsion and its impact on the industry	L3

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2											
CO2	3	2	2											
CO3	3	2	2											
CO4	3	2	2											
CO5	3	2	2											

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Thomas Walker · Angela Stefania Bergantino, Northrop Sprung-Much · Luisa Loiacono "Sustainable Aviation Greening the Flight Path", Palgrave Macmillan, 2020ISBN 978-3-030-28660-6

2. T. Hikmet Karakoc • C. Ozgur Colpan, Onder Altuntas • Yasin Sohret, "Sustainable Aviation", Springer Nature Switzerland AG 2019, ISBN 978-3-030-14194-3

REFERENCE BOOKS:

1. Joachim Buse, "Sustainable Aviation Fuels Transitioning Towards Green Aviation", CRC Press, 2024, ISBN 9781003440109
2. Paul Upham, Janet Maughan, David Raper and Callum Thomas, " Towards Sustainable Aviation", Earthscan Publications Ltd, 2003, ISBN: 1 85383 818 9

E-Resources:

1. **Combustion of Solid Fuels and Propellants, IIT Kharagpur,** https://nptel.ac.in/courses/101105331
2. **Fundamentals of Combustion, IIT Kanpur,** https://nptel.ac.in/courses/101104014
3. **Physics of Combustion,** https://nptel.ac.in/courses/101104014

****

AIRCRAFT DESIGN

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –VII

Subject Code	:	22AS4711	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P–S	:	3–0–0–0			

Course Learning Objectives:

4. Comprehend the flight vehicle design process.
5. Acquire the knowledge of vehicle configuration and structural components.
6. Understand the stability & control and subsystems.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

9. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
10. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
11. Show ***Video/animation*** films to explain functioning of various concepts.
12. Encourage ***Collaborative*** (Group Learning) Learning in the class.
13. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
14. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
15. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
16. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I : Overview of Design Process	**08 Hours**

Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation.

Thrust to Weight Ratio & Wing Loading: Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult takeoff, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling..

UNIT – II: Design of Structural Components	**08 Hours**

Configuration Layout & loft: Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Detectability. Crew station, Passenger, and Payload arrangements. Design of Structural Components: Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal &

Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.	
UNIT – III: Engine Selection & Flight Vehicle Performance	**09 Hours**
Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices :- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking, Spread Sheet for Take-off and Landing. Enhanced lift design -Passive & Active. Spread Sheet	
UNIT – IV: Static Stability & Control	**08 Hours**
Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Spread Sheets. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.	
UNIT – V: Design Aspects of Subsystems	**08 Hours**
Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
	At the end of the course the student will be able to:	
CO1	Calculate the thrust to weight ratio and wing loading.	L3
CO2	Compute the flight vehicle performance.	L2 & L3
CO3	Select the subsystems as per vehicle design.	L3

Table: Mapping Levels of COs to POs / PSOs

COs	**Program Outcomes (POs)**												**PSOs**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	3
CO1	3	2	1												
CO2	3	2	2												
CO3	3	2	1												

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Aircraft Design - A Conceptual Approach Daniel P. Raymer AIAA Education Series IV Edition, 2006
2. Design of Aircraft Thomas C Corke Pearson Edition. Inc. 2003

REFERENCE BOOKS:

1.Aeroplane Design J Roskam

2. Introduction to Aircraft Design John Fielding Cambridge University Press 2009

3. Standard Handbook for Aeronautical & Astronautical Engineers Editor Mark Davies Tata McGraw Hill 2010

****

SPACEFLIGHT NAVIGATION AND GUIDANCE

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4712	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

This course will introduce students to the basics of Spacecraft navigation and guidance. Students will learn different tools used in space navigation, their working mechanisms with pros and cons. Students will be able to apply linear guidance and navigation laws and will be able to estimate orbit parameters.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

Introduction to radars: Radar equation. Block Diagram and Operation; Radar Frequencies. Application of Radars; Range performance of radars. Minimum detectable signal ; Noise effects; Continuous wave and Frequency modulated radars; Doppler effect. CW-radar; Isolation between transmitter and receiver. Radial velocity; CW radar applications; Frequency modulated CW radars; MIT and Pulse Doppler radars; Description of operation.

UNIT – II	**08 Hours**

Guided missiles: Classifications; Description of tactical missiles. Guidance phases during flight; Categories of Homing and command guidance. The kinematic equations; Missile Guidance laws; Classification of guidance laws; Classical guidance laws; Modern guidance laws.

UNIT – III	**08 Hours**

Fundamentals of Satellite Navigation: Concept of Ranging Using TOA Measurements, Two-Dimensional Position Determination, Principle of Position Determination Via Satellite-Generated Ranging Signals, World Geodetic System, Determination of User Geodetic Coordinates: Latitude, Longitude, and Height, Fundamentals of Satellite Orbits, Satellite constellation design, Position determination using PRN codes.

UNIT – IV	10 Hours
Satellite Tracking and Observation Models: Tracking Systems: Radar tracking, Laser tracking, GPS tracking; Tracking Data Models: Transmitter and Receiver Motion, Angle Measurements, Range Measurements, Doppler Measurements, GPS Measurements; Media Corrections: Interaction of Radiation and Atmosphere, Tropospheric Refraction, Ionospheric Refraction. **Orbit Determination and Parameter Estimation:** Weighted Least-Squares Estimation, Numerical Solution of Least-Squares Problems, Kalman Filtering.	
UNIT – V	**06 Hours**
Satellite Navigation systems: The European GALILEO system, The Russian GLONASS system, The Chinese BeiDou Satellite Navigation System; The Japanese QZSS Program.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand observation techniques and limitations, and how navigation data is collected and assimilated	L2 & L3
2	Develop linear guidance and navigation laws.	L2 & L3
3	Develop mathematical models that characterize space vehicle dynamics.	L2 & L3
4	Understand different tracking and observation models and estimate orbit using least-square and Kalman filtering.	L2 & L3
5	Understand the intricacies of different satellite navigation systems.	L2

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3		2	3							2		
CO2	3	2	1	3	2							2		
CO3	3	2		3	3							1		
CO4	3	2	1	2	1							2		
CO5	3	3			2							1		

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

Text Books:

1. Paul Zarchan, "Tactical and Strategic Missile Guidance", AIAA Progress in Astronautics and Aeronautics, 2012.
2. MERRIL I. SKLOINK "Introduction To Radar System", McGraw-Hill Book Co., 1981.

Reference Books:

1. Elliott D. Kaplan Christopher J. Hegarty, `Understanding GPS`, Artech House Boston, 2006.

AIRWORTHINESS AND CERTIFICATION

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4713	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

1. Understand the fundamental concepts of flight safety and airworthiness as defined by international regulatory frameworks.
2. Gain familiarity with the structure and role of ICAO, EASA, FAA, and national civil aviation authorities in airworthiness certification.
3. Identify the major steps involved in the type certification, production, and continuing airworthiness of aircraft.
4. Analyze the relationship between system safety assessments and certification standards such as CS/FAR 25.1309.
5. Evaluate the impact of system design on safety, reliability, and compliance in commercial aviation.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

Flight Safety Fundamentals and Airworthiness Philosophy

Flight safety pillars (Person, Environment, Machine); ICAO definition of safety; accident causality; chain of failure; safety as regulation; operational risk; Annex 13 on aircraft accident investigation; safety culture and state safety program (SSP); aircraft limitations and operational envelopes; regulatory intent vs. practical compliance.

UNIT – II	**10 Hours**

Global Regulatory Framework and Certification Ecosystem ICAO Annexes 6, 8, 16; State responsibilities; EASA and FAA jurisdiction; DGCA (India); Certification Specifications (CS), Federal Aviation Regulations (FAR); Type Certification (TC); Supplemental Type Certificate (STC); Airworthiness Directives (ADs); bilateral agreements; Type Certificate Data Sheets (TCDS); Part 21 design approvals; Maintenance and Repair Organizations (MROs).	
UNIT – III	**10 Hours**
Type Certification, Production and Continuing Airworthiness Initial airworthiness; production organization approval (POA); Certificate of Airworthiness (CofA); flight manual and maintenance documentation; maintenance and inspection schedules; Continuing Airworthiness Management Organization (CAMO); Safety Management System (SMS); reliability programs; configuration control; aircraft ageing and structural integrity; operator and state obligations.	
UNIT – IV	**10 Hours**
System Safety Assessments and Certification Standards FAR/CS 25.1309; Acceptable Means of Compliance (AMC); Functional Hazard Assessment (FHA); Failure Mode and Effects Analysis (FMEA); Fault Tree Analysis (FTA); Development Assurance Levels (DALs); ARP 4754A, ARP 4761; risk assessment; redundancy and fail-safe concepts; fault tolerance; certification plan documentation.	
UNIT – V	**10 Hours**
Future Airworthiness Domains: UAS, Environment, and Space UAS airworthiness; risk-based certification for unmanned systems; Annex 16 – noise and emissions; carbon and NOx standards; space worthiness; reusable launch vehicles; Urban Air Mobility (UAM); electric aircraft regulations; sub-orbital flight certification; sustainable aviation compliance strategies; green airworthiness practices.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Describe the core concepts of airworthiness, safety factors, and accident causality in civil aviation.	L2
2	Illustrate the regulatory landscape and global frameworks for type certification and aircraft operations.	L2
3	Apply system safety assessment tools such as FHA, FMEA, and DAL assignment in compliance evaluation.	L3
4	Analyze the lifecycle of airworthiness from type certification through continuing operations and maintenance.	L4
5	Evaluate emerging airworthiness issues for new domains such as UAVs, spaceflight, and environmental impact.	L3

COs	Program Outcomes (POs)												PSOs		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	1	2	1							1	1	1		
CO2	2	2	2	2							1	2	1		
CO3	1	1	2	1							1	1	1		
CO4	3	3	2	2							1	1	1		
CO5	3	3	2	2							1	1	1		

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1) Airworthiness: An Introduction to Aircraft Certification, 2nd Edition, ASIN: B00519EPVU,Butterworth-Heinemann, 2010.
2) John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 2011. ISBN: 9780071108059.

REFERENCE BOOKS:

1. **Filippo De Florio**, *Airworthiness: An Introduction to Aircraft Certification and Operations*, 3rd Edition, Butterworth-Heinemann, Elsevier, 2016. ISBN: 978-0-08-100888-1
2. **Duane Kritzinger**, *Aircraft System Safety: Assessments for Initial Airworthiness Certification*, Woodhead Publishing (Elsevier), 2017. ISBN: 978-0-08-100889-8

AUGUMENTED REALITY AND VIRTUAL REALITY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22AS4714	**Credits**	:3	
Hours / Week	:	03 Hours	**Total Hours**	:	39 HRS
L–T–P	:	3–0–0			

Course Learning Objectives:

This Course will enable students to:

1. Learn the fundamental Computer Vision, Computer Graphics and Human-Computer interaction
   Techniques related to VR/AR
2. Review the Geometric Modeling Techniques
3. Review the Virtual Environment
4. Discuss and Examine VR/AR Technologies
5. Use of various types of Hardware and Software in Virtual Reality systems
6. Simulate and Apply Virtual/Augmented Reality to varieties of Applications

Teaching-Learning Process (General Instructions)

1. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
2. ***Lecture method*** for this course includes presentation which includes **chalk and talk for all modules.**
3. ***Interactive Teaching:*** *The* ***adoption of Active learning***
4. The concept in each and every module consists of **video animations**
5. The **collaborative learning** which will be group oriented
6. The **Critical thinking** is adopted
7. Adopt ***Problem Based Learning***, in this course
8. Different methods of **solving problems**
9. Discuss how every ***concept can be applied to the real world*** –

UNIT – I	**07 Hours**

Introduction to Virtual Reality (VR)

Virtual Reality and Virtual Environment, Computer graphics, Real time computer graphics, Flight Simulation, Virtual environment requirement, benefits of virtual reality, Historical development of VR, Scientific Landmark

UNIT – II	**08 Hours**

Computer Graphics and Geometric Modelling

The Virtual world space, positioning the virtual observer, the perspective projection, human vision, stereo perspective projection, Color theory, Conversion From 2D to 3D, 3D space curves, 3D boundary representation, Simple 3D modelling, 3D clipping, Illumination models, Reflection models, Shading algorithms, Geometrical Transformations: Introduction, Frames of reference,

UNIT – III	**08 Hours**

Virtual Environment

Input/Output Devices: Input (Tracker, Sensor, Digital Gloves, Movement Capture, Video- based Input, 3D Menus & 3D Scanner, etc.), Output (Visual/Auditory/Haptic Devices)

Generic VR system: Introduction, Virtual environment, Computer environment, VR technology, Model of interaction, VR Systems, Animating the Virtual Environment:

Introduction, The dynamics of numbers, Linear and Nonlinear interpolation, the animation of objects, linear and non-linear translation, shape & object in between, free from deformation, particle system Physical Simulation: Introduction, Objects falling in a gravitational field, Rotating wheels,

Elastic collisions, projectiles, simple pendulum, springs, Flight dynamics of an aircraft

UNIT – IV	08 Hours
Augmented Reality (AR) Taxonomy, Technology and Features of Augmented Reality, AR Vs VR, Challenges with AR, AR systems and functionality, Augmented Reality Methods, Visualization Techniques for Augmented Reality, enhancing interactivity in AR Environments, Evaluating AR systems	
UNIT – V	**08 Hours**
Development Tools and Frameworks Human factors: Introduction, the eye, the ear, the somatic senses Hardware: Introduction, sensor hardware, Head-coupled displays, Acoustic hardware, Integrated VR systems Software: Introduction, Modelling virtual world, Physical simulation, VR toolkits, Introduction to VRML	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Classify fundamental Computer Vision, Computer Graphics and Human-Computer Interaction Techniques related to VR/AR.	L2
2	Describe Geometric Modeling Techniques	L2 & L3
3	Recognise the Virtual Environment	L2 & L3
4	ANALYZE and EVALUATE VR/AR Technologies	L2 & L3
5	APPLY various types of Hardware and Software in Virtual Reality systems	L2

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3											3	
CO2	2	3											2	
CO3	2	3			1									
CO4	1	2												
CO5		3												

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXT BOOKS:

1. Coiffet, P., Burdea, G. C., (2003), "Virtual Reality Technology," Wiley-IEEE Press, ISBN: 9780471360896
2. Schmalstieg, D., Höllerer, T., (2016), "Augmented Reality: Principles & Practice," Pearson, ISBN: 9789332578494
3. Norman, K., Kirakowski, J., (2018), " Wiley Handbook of Human Computer Interaction," Wiley-Blackwell, ISBN: 9781118976135
4. LaViola Jr., J. J., Kruijff, E., McMahan, R. P., Bowman, D. A., Poupyrev, I., (2017), "3D User Interfaces: Theory and Practice," Pearson, ISBN: 9780134034324
5. Fowler, A., (2019), "Beginning iOS AR Game Development: Developing Augmented Reality Apps with Unity and C#," Apress, ISBN: 9781484246672
6. Hassanien, A. E., Gupta, D., Khanna, A., Slowik, A., (2022), "Virtual and Augmented Reality for Automobile Industry: Innovation Vision and Applications," Springer, ISBN: 9783030941017

REFERENCE BOOKS:

1. Craig, A. B., (2013), "Understanding Augmented Reality, Concepts and Applications," Morgan Kaufmann, ISBN: 9780240824086
2. Craig, A. B., Sherman, W. R., Will, J. D., (2009), "Developing Virtual Reality Applications, Foundations of Effective Design," Morgan Kaufmann, ISBN: 9780123749437
3. John Vince, J., (2002), "Virtual Reality Systems, " Pearson, ISBN: 9788131708446
4. Anand, R., "Augmented and Virtual Reality," Khanna Publishing House
5. Kim, G. J., (2005), "Designing Virtual Systems: The Structured Approach", ISBN: 9781852339586
6. Bimber, O., Raskar, R., (2005), "Spatial Augmented Reality: Merging Real and Virtual Worlds," CRC Press, ISBN: 9781568812304
7. O'Connell, K., (2019), "Designing for Mixed Reality: Blending Data, AR, and the Physical World," O'Reilly, ISBN: 9789352138371
8. Sanni Siltanen, S., (2012), "Theory and applications of marker-based augmented reality,"
Julkaisija –Utgivare Publisher, ISBN: 9789513874490

E-Resources:

1. Manivannan, M., (2018), "Virtual Reality Engineering," IIT Madras, https://nptel.ac.in/courses/121106013
2. Misra, S., (2019), "Industry 4.0: Augmented Reality and Virtual Reality," IIT Kharagpur, https://www.youtube.com/watch?v=zLMgdYI82IE
3. Dube, A., (2020), "Augmented Reality - Fundamentals and Development," NPTEL Special Lecture Series, https://www.youtube.com/watch?v=MGuSTAqlZ9Q
4. http://cambum.net/course-2.htm**Activity-Based Learning (Suggested Activities in Class)**

****

Open Elective - II

INTRODUCTION TO SPACE TECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22OE0067	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course Learning Objectives:

1. This course will enable students to:
2. **Analyze** the fundamentals of space technology: Students will gain a comprehensive understanding of the basic principles and concepts related to space technology,
3. **Interpret:** Students will gain an understanding of past and ongoing space exploration missions, including robotic and manned missions to planets, moons, asteroids, and other celestial bodies
4. **Identify**: Students will be introduced to the various types of **space launch systems**, such as expendable launch vehicles and reusable launch vehicles.
5. **Describe** the diverse applications of space technology, including satellite navigation systems, weather forecasting, Earth observation, and space tourism

1. Teaching-Learning Process (General Instructions)

2. These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
3. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
4. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
5. Show ***Video/animation*** films to explain functioning of various concepts.
6. Encourage ***Collaborative*** (Group Learning) Learning in the class.
7. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
8. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
9. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
10. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

SPACE ENVIRONMENT

Introduction to space technology, Milestones in Global Space Technologies, Atmosphere, Neutral atmosphere, Plasma, Solar Cycle, Solar Radiation, Radiation Belts, Earth's Magnetic field, Space Debris, Electro static charging, meteoroid impact, Effect of environment on Spacecraft, Aerodynamic drag, orbital mechanics.

UNIT – II	**08 Hours**

SPACE PROPULSION

Space Missions, objectives, Types of space travel, Principle of rocket launching, Rocket Propulsion, Staging, Solid propellant, liquid propellant and cryogenic Propulsion, Electric Propulsion, Electro-Thermal Thrusters, sounding rockets, PSLV, GSLV, Launch window, Reusable Launch Vehicle (RLV)

UNIT – III	**06 Hours**

SATELLITE & SUBSYSTEMS

Power Systems, Attitude Determination and Control system, Guidance and Navigation, Avionics, Telemetry, tracking and command, Communication, Structure and Mechanisms, Thermal System

UNIT – IV	**09 Hours**

NANOSATELLITE, ROVERS & ASTRONAUTICS

Types of spacecraft, Payload, design consideration for payloads, nano propulsion, thermal control systems, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, concepts related to Astronautics & Space entrepreneurship

UNIT – V	**08 Hours**

TESTING OF SPACE COMPONENTS AND SYSTEM

Types of Tests; Test Facilities and Safeguards; Safety and Environmental Concerns; Monitoring and Control of Toxic Materials and Exhaust Gases; Instrumentation and Data Management; Reliability and Quality Control; Flight Testing. Assembly integration test, comprehensive test & test vacuum chamber and comprehensive test & test vibration facilities

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	**Outline** the fundamental concepts and principles of space technology. They will understand the basic principles of rocketry, satellite design and operation, space exploration, and the various components and systems used in space missions.	L2 & L3
2	**Interpret:** Students will develop the ability to interpret and analyze data related to space technology.	L2 & L3
3	**Describe:** Upon completion of the course, students will be able to describe the different types of space missions and their objectives. They will be familiar with the main types of satellites, such as communication satellites, weather satellites, and scientific satellites, and will understand their specific purposes and functions	L2 & L3
4	**Identify and Explain:** Students will gain the skills to identify and explain the key components and systems involved in space technology. They will be able to identify the major parts of a rocket and explain their functions.	L2 & L3
5	**Describe:** Students will be able to describe the impact of space technology on various aspects of human life and society. They will understand how space technology is used for communication, weather forecasting, navigation, Earth observation, and scientific research..	L2

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3		2	3							2		3
CO2	3	3	2	3	3							2		3
CO3	3	3		3	3							1		3
CO4	3	3	2	2	3							2		3
CO5	3	3			2							1		3

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXTBOOKS:

1. Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: https://doi.org/10.1007/978-3-031-34818-1
2. Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018 Edition: 2 Volume: 3

REFERENCE BOOKS:

3. "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
4. "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
5. "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley

E-Resources:

https://archive.nptel.ac.in/courses/101/106/101106046/

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on a mission, satellite building, and propulsions technology
2. Site visit/Video demonstrations on the building/launching of a spacecraft

****

INTRODUCTION TO SATELLITE TECHNOLOGIES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	:	22OE0068		**Credits**	:	03
Hours / Week	:	03 Hours		**Total Hours**	:	39 Hours
L–T–P	:	3–0–0				

Course Learning Objectives:

Course Learning Objectives:

This course will enable students to get exposed to:

- Understand different types of satellites, payloads, and their applications.
- Gain knowledge about spacecraft bus and payload systems including their requirements and configurations.
- Learn about mainframe subsystems of spacecraft including mechanical and electrical components.
- Explore nanosatellites, rovers, and astronautics including their missions and classifications.
- Study space exploration and utilization focusing on major space agencies, space habitats, and sustainable living in space.

Teaching-Learning Process (General Instructions)

These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.

1. ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
2. ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
3. Show ***Video/animation*** films to explain functioning of various concepts.
4. Encourage ***Collaborative*** (Group Learning) Learning in the class.
5. To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
6. Adopt ***Problem Based Learning***, which fosters students' Analytical skills, develop thinking skills such as the ability to evaluate, generalize, and analyse information rather than simply recall it.
7. Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
8. Discuss how every ***concept can be applied to the real world*** - and when that's possible, it helps improve the students' understanding.

UNIT – I	**08 Hours**

TYPES OF SATELLITES & PAYLOADS, CUBESATS

Space Environment, Global Space Technologies, Space Missions, objectives, Space Mission Life Cycle Classification of satellites, Types of Orbits, Types of Payloads & Applications, Cubesat Configuration, Payloads for Cubesats, Overview of Launch and On-Orbit Operations, Life-Cycle of Satellites, Space Polices & Laws.

UNIT – II	**08 Hours**

SPACECRAFT BUS AND PAYLOAD SYSTEMS

Overview, Model philosophy, Spacecraft configuration, Bus and payload systems requirements, Mechanical and Electrical requirements, Thermal requirements, Accommodation Studies and optimisation, Layouts and ILDs (Inserts Layout Drawings) generation, testing and qualification
UNIT – III **06 Hours**
SPACECRAFT MAINFRAME SUBSYSTEMS Mainframe Subsystems-Mechanical: Structure, Propulsion, Thermal and Deployment Mechanisms; Electrical: Power, Telemetry, Telecommand, Navigation, Communication, Altitude determination and control (ADCS), Mission Software, Control Electronics, Sensors, Communication, nano propulsion, photovoltaic power generation, Solar array, Batteries, testing of satellites, simulation, Deployment and ejection systems, Space entrepreneurship
UNIT – IV **09 Hours**
NANOSATELLITE, ROVERS & ASTRONAUTICS Definition and Classification: CubeSats, Picosats, and Pocket Qubes, Key Missions: Sojourner, Spirit, Opportunity, Curiosity, Perseverance, Instruments for Geology, Atmosphere, and Surface Analysis, History of Human Space Exploration, Spacecraft Architecture: Crew Modules, Life Support Systems, Safety Features, Radiation Protection and Mitigation Strategies
UNIT – V **08 Hours**
SPACE EXPLORATION AND UTILIZATION Overview of Major Space Agencies, Design and Architecture of Space Habitats, Technologies for Sustainable Living in Space, Space Tourism, Space Manufacturing, Additive Manufacturing (3D Printing) in Space, In-Situ Resource Utilization (ISRU), Spaceflight challenges

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Classify and describe various satellites, payloads, orbits, and their applications.	L2 & L3
2	Analyze spacecraft bus and payload systems and their requirements	L2 & L3
3	Explain the mainframe subsystems of spacecraft and their respective functions	L2 & L3
4	Identify and discuss the types and missions of nanosatellites and rovers.	L2 & L4
5	Evaluate space exploration technologies, space habitats, and space manufacturing processes	L4

Table: Mapping Levels of COs to POs / PSOs

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3		3	3							3		3
CO2	3		3	2	2							2		2
CO3	3	3		3	3							1		3
CO4	3	2	3	2	2							2		2
CO5	3	3			2							1		2

3: Substantial (High) **2: Moderate (Medium)** **1: Poor (Low)**

TEXTBOOKS:

1. Satellite Communications Systems: Systems, Techniques and Technology by Gerard Maral, Michel Bousquet, Publisher: Wiley, Publication Year: 2010, Edition: 5th Edition
2. Spacecraft Systems Engineering by Peter Fortescue, Graham Swinerd, John Stark, Publisher: Wiley, Publication Year: 2011, Edition: 4th Edition
3. Small Satellite Missions for Earth Observation by Rainer Sandau, Publisher: Springer, Publication Year: 2010, Edition: 1st Edition
4. Nanosatellites: Space and Ground Technologies, Operations and Economics by Rogerio Boni, Publisher: Springer, Publication Year: 2020, Edition: 1st Edition
5. Space Exploration and Astronautics by James M. Tiller, Publisher: McGraw-Hill, Publication Year: 2015, Edition: 1st Edition
6. Book Title: Space Technology Author: Ignacio Chechile Publication: Springer Cham Year: 2017 Edition: 1 Volume: 1 DOI: https://doi.org/10.1007/978-3-031-34818-1
7. Book Title: Introduction to Satellite Communication Author: Bruce R. Elbert Year: 2018 Edition: 2 Volume: 3

REFERENCE BOOKS:

1. "Space Mission Engineering: The New SMAD" by James R. Wertz and Wiley J. Larson, Volume: 4th Edition, 2 volumes, Publication: Microcosm Press
2. "Introduction to Space Dynamics" by William Tyrrell Thomson, Volume: 1st Edition, 2 volume, Publication: Dover Publications
3. "Spacecraft Systems Engineering" by Peter Fortescue, John Stark, and Graham Swinerd, Volume: 4th Edition, Publication: Wiley

E-Resources:

- https://archive.nptel.ac.in/courses/101/106/101106046/
- IEEE Xplore Digital Library
- NASA Technical Reports Server (NTRS)
- European Space Agency (ESA) Publications
- SpaceX Mission Archives
- Journal of Spacecraft and Rockets

Activity-Based Learning (Suggested Activities in Class)

1. Group discussions on a mission, satellite building, and propulsions technology
2. Site visit/Video demonstrations on the building/launching of a spacecraft
3. **Hands-On Labs and Workshops**
    a. Design and Build a Simple CubeSat or Rover Model
    b. Simulation Software: Use of STK, GMAT, for Mission Planning and Simulation
4. **Case Study Analysis**
    a. Detailed Study of Selected Nanosatellite and Rover Missions
    b. Group Discussions on Challenges and Innovations in Space Exploration.