DAYANANDA SAGAR UNIVERSITY

SCHOOL OF ENGINEERING

2023-27 Batch

BACHELOR OF TECHNOLOGY (B. Tech) –2023
Aerospace Engineering

(With effect from 2025-26)

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

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	23AS2301	Transforms and Numerical Techniques	MAT	3	0	0	0	3	60	40	100		**3**
2	101	23AS2302	Thermodynamics and Heat Transfer	ASE	3	1	0	0	3	60	40	100		**4**
3	101	23AS2303	Introduction to Aerospace Engineering	ASE	2	0	0	0	3	60	40	100		**2**
4	101	23AS2304	Fluid Mechanics	ASE	3	1	0	0	3	60	40	100		**4**
5	101	23AS2305	Aerospace Structural Mechanics	ASE	3	0	2	0	3	60	40	100		**4**
6	101	23AS2306	Aerospace Materials	ASE	3	0	2	0	3	60	40	100		**4**
7	101	23LSXXXX	Liberal Studies/MOOC	Any Dept.	1	0	0	0	1	100	--	100		**1**
8	101	23AS2307	Skill Enhancement Course - I	ASE	0	0	2	0		100	--	100		**1**
9	101	23AS2308	Cognitive and Technical Skills-I		0	0	4	0	-	100	--	100		**2**
			Total		18	2	10	0		660	240	900		**25**

IV 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	23AS2401	Probability and Statistics	MAT	3	0	0	0	3	60	40	100	**3**	
2	101	23AS2402	Aerodynamics	ASE	3	1	0	0	3	60	40	100	**4**	
3	101	23AS2403	Aircraft Propulsion	ASE	3	0	0	0	3	60	40	100	**3**	
4	101	23AS2404	Space Flight Mechanics	ASE	3	0	0	0	3	60	40	100	**3**	
5	101	23AS2405	Aerospace Manufacturing	ASE	3	0	2	0	3	60	40	100	**4**	
6	101	23AS2406	Introduction to Computational Fluid Dynamics	ASE	1	0	2	0	2	60	40	100	**2**	
7	101	23AS2407	Skill Enhancement Course - II	ASE	0	0	2	0		100	--	100	**1**	
8	101	23AS2408	Cognitive and Technical Skills -II		0	0	4	0	-	100	---	100	**2**	
			Total		16	1	10	0		560	240	800	**22**	

	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	23AS3501	Aircraft Performance and Design	ASE	3	0	0	2	3	60	40	100	4
2	101	23AS3502	Artificial Intelligence and Machine Learning	ASE	3	0	0	0	3	60	40	100	**3**
3	101	23AS3503	Aircraft Systems	ASE	2	0	2	0	3	60	40	100	**3**
4	101	23AS3504	Introduction to Finite Element	ASE	3	0	2	0	3	60	40	100	**4**
5	101	23AS35XX	Professional Elective Course – I	ASE	3	0	0	0	3	60	40	100	**3**
6	101	23AS3505	Product Design and Development	ASE	1	0		2	2	60	40	100	2
7	101	23AS3506	Flight Physics Lab	ASE	0	0	2	0	2	100	--	100	**1**
8	101	23AS3507	Cognitive and Technical Skills -III						-		---	100	**P/ F**
			Total		17	0	4	4		460	240	700	**20**

Professional Elective – I

Sl. No	Course Code	Course Name
1.	23AS3508	High-Speed Aerodynamics
2.	23AS3509	Measurement Techniques
3.	23AS3510	Space Flight Operations
4.	23AS3511	Advanced Manufacturing
5.	23AS3512	Industry 4.0
6.	23AS3513	MOOC

	VI SEMESTER													
S.N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours /				Examination					Credits
					Lecture L	Tutorial T	Practical P	Project J	Duration in	CIE Marks	SEE Marks	Total Marks		
1	101	23AS3601	Avionics	ASE	2	0	2	0	3	60	40	100		**3**
2	101	23AS3602	Aircraft Stability and Control	ASE	3	0	0	0	3	60	40	100		**3**
3	101	23AS3603	Vibration and Control	ASE	3	0	2	0	3	60	40	100		4
4	101	23AS3604	Unmanned Aerial Systems	ASE	3	0	0	0	3	60	40	100		**3**
5	101	23AS36XX	Professional Elective Course –II	ASE	3	0	0	0	3	60	40	100		**3**
6	101	23OEXXXX	Open Elective – I	ASE	3	0	0	0	3	60	40	100		**3**
7	101	23AS3605	Model Based System Engineering (MBSE)	ASE	1	0	2	0	2	60	40	100		**2**
8	101	23AS3606	Cognitive and Technical Skills -IV						-		---			**P/F**
			Total		18	0	10	2		420	280	700		**21**

Professional Elective – II

Sl. No	Course Code	Course Name
1.	23AS3607	Heat Transfer for Aerospace Applications
2.	23AS3608	Systems Engineering
3.	23AS3609	Space Vehicle Design
4.	23AS3610	Aircraft Maintenance, Repair and Overhaul
5.	23AS3611	Data Analysis and Interpretation
6.	23AS3612	MOOC

Open Elective – I

Sl. No	Course Code	Course Name
1.	23OE0030	Introduction to Aerospace Engineering
2.	23OE0031	Operations Management for Aerospace
3.	23OE0032	Introduction to Satellite Technologies
4.	23OE0033	MOOC

	VII 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		Principles of Management & Economics for Engineers	ASE	3	0	0	0	3	60	40	100		**3**
2	101		Satellite Technologies	ASE	3	0	0	0	3	60	40	100		**3**
3	101		Professional Elective Course -III	ASE	3	0	0	0	3	60	40	100		**3**
4	101		Professional Elective Course -IV	ASE	3	0	0	0	3	60	40	100		**3**
5	101		Open Elective -II	ASE	3	0	0	0	3	60	40	100		**3**
6	101		Capstone Project Phase I	ASE	0	0	0	6	1	60	40	100		**3**
			Total		15	0	0	6	23	360	240	600		**18**

Professional Elective – III

Sl. No	Course Code	Course Name
1.		Rockets and Missiles
2.		Aircraft Design
3.		Spaceflight Navigation and Guidance
4.		Airport Operations
5.		Augmented Reality & Virtual Reality
6.		MOOC

Professional Elective – IV

Sl. No	Course Code	Course Name
1.		Space Propulsion
2.		Advanced Structural Mechanics
3.		Space Communication Systems
4.		Airworthiness and Certification
5.		Urban Air Mobility
6.		MOOC

Open Elective – II

Sl. No	Course Code	Course Name
1.		Introduction to Space Technology
2.		Introduction to Unmanned Aerial Systems
3.		MOOC

	VIII 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		Internship	ASE	0	0	0	0	--	100	--	100		**3**
2	101		Capstone Project Phase II	ASE	0	0	0	22	1	60	40	100		11
			Total		3	0	0	22	4	120	80	200		**14**

AIRCRAFT PERFORMANCE AND DESIGN

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

SEMESTER – V

Subject Code	:	23AS3501	**Credits**	:	04
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P–J	:	3–0–0–2			

Course Learning Objectives:

This course will enable students to:

1. Understand the aircraft performance in steady un-accelerated and accelerated flight.
2. Understand the airplane performance parameters.
3. Understand fundamental concepts of airplane design

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* ***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 student's understanding.

Course Content

UNIT – I	8 Hours

The Equations of Motion and Steady Flight:

Introduction, Four forces of flight, General equation of motion, Power available and power-required curves. Thrust available and thrust required curves. Conditions for power required and thrust required minimum. Thrust available and maximum velocity, Power available and maximum velocity, Altitude effects on power available and power required; thrust available and thrust required.

UNIT – II	12 Hours

Steady Performance – Level Flight, Climb and Glide:

Fundamental Airplane Performance Parameters: Thrust–to–weight ratio, Wing loading, Drag polar, and lift–to–drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to-drag ratio.

Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absolute ceiling, Service ceiling, Time to climb – graphical and analytical approach, climb performance

graph (hodograph diagram), Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.	
UNIT – III	**06 Hours**
Airplane Performance- Accelerated Flight: Level turn, pull-up and pulldown maneuvers, the limiting case for a large load factor, and the V-n diagram. Takeoff and Landing performance.	
UNIT – IV	**06 Hours**
Philosophy of Airplane Design: Phases of airplane design – conceptual design, preliminary design, detail design. The seven intellectual pivot points for conceptual design.	
UNIT – V	**07 Hours**
Airplane Design: Estimation of airplane weight, critical performance parameters, configuration layout, and performance analysis. Design Case Studies – The Wright Flyer, The Douglas DC-3, Boeing 707	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course, the student will be able to:		
1	Develop Equations of motion for un-accelerated steady flight and determine the maximum thrust and power required.	L2 & L3
2	Analyse the airplane performance at level, climb and glide steady flight.	L3&L4
3	Calculate the Range and Endurance of propeller driven and jet driven airplanes	L2 & L3
4	Calculate the performance of accelerated flight using V-n diagrams	L3 & L4
5	Understand airplane design parameters.	L2 & L3
6	Estimate airplane weight, critical performance parameters and draw configuration layout.	L3 & L4

COs	**Program Outcomes (POs)**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
CO1	2	1	1										3	
CO2	2	2			1								3	2
CO3	2				2								2	2
CO4	3	1	1		1					1			2	2
CO5	2	2					1			1			3	
CO6	3	1					1			1			2	2

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

Text Books:

1. John D. Anderson, Jr. "Aircraft Performance and Design", McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 1999.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 2000.

Reference Books:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.

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Artificial Intelligence and Machine Learning

As per credit-based system (CBCS)

Semester: V

Subject Code	: 23AS3502		**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:
The course aims to provide a foundation in artificial intelligence techniques for planning, with an overview of the wide spectrum of different problems and approaches, including their underlying theory and their applications.

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 Data Science and AI & ML, Data Science, AI & ML, Essential Concepts in AI and ML Data Understanding, Representation and Visualisation	
UNIT – II	**08 Hours**
Machine Learning: Linear Methods, Linear Regression, Multiple Linear Regression, Non-Linear Regression, Clustering, Forecasting models, Perceptron and Neural Network, Decision Trees, Support Vector Machines	
UNIT – III	**06 Hours**
Probabilistic Models, Dynamic programming and Reinforcement Programming, Evolutionary Algorithms, Time Series Models, Deep Learning, Emerging Trends in ML, Unsupervised Learning	
UNIT – IV	**09 Hours**

Foundations for AI, AI Basics, AI Classification, Supervised Learning, Feature Engineering Regression, Model Selection, Model Performance, Ranking	
UNIT – V	**08 Hours**
Introduction to ML with R and using Python, Python and R for Artificial Intelligence, Machine Learning, and Data Science, AI/ML in aerospace industry.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Demonstrate understanding of essential concepts in data science, artificial intelligence, and machine learning, including data visualization, representation, and analysis	2
2	Design, implement, and assess machine learning models using techniques such as regression, clustering, neural networks, decision trees, and support vector machines for real-world problem-solving	2
3	Utilize probabilistic models, dynamic programming, reinforcement learning, evolutionary algorithms, and deep learning approaches to address complex data-driven challenges	3
4	Analyze model performance through feature engineering, model selection, and performance evaluation, while exploring emerging AI/ML trends and their applications in aerospace systems.	3
5	Develop AI and ML solutions using Python and R programming languages, focusing on their applications in the aerospace industry and related engineering fields	3

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

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

<u>Text Books</u>

1. Machine Learning and Artificial Intelligence, Ameet V Joshi, Springer, Microsoft(USA), Redmond, ISBN 978-3-030-26621-9

2. Artificial Intelligence and Machine Learning fundamentals, Zsolt Nagy,Pact Publishing, UK, ISBN 978-1-78980-165-1

<u>Reference Books</u>

1. Artificial Intelligence and Machine Learning, Vinod Chandra SS , PHI, ISBN 978-81-203-4934-6
2. Basics of Artificial Intelligence and Machine Learning, Dheeraj Mehrotra,Notion Press, eISBN 978-1-64587-283-2

AIRCRAFT SYSTEMS

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

SEMESTER – V

Subject Code	:	23AS3503	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	26 + 26 Hours
L–T–P	:	2–0–2			

Course Learning Objectives:

This Course will enable students to:

1. Develop comprehensive knowledge of fluid power systems, including fluid properties, hydraulic principles, and pump classifications.
2. Build an advanced understanding of aircraft hydraulic and pneumatic systems, focusing on critical components, operational principles, and applications.
3. Develop specialized knowledge of hydraulic actuators and control components, including direction, flow, and pressure control valves.
4. Innovate in Pneumatic Systems by enabling the design and analysis of advanced pneumatic and electro-pneumatic systems, focusing on air properties, gas laws, and pneumatic logic circuits.

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	05 Hours

Aircraft Control and Auxiliary Systems

Overview of conventional and modern airplane control systems: mechanical linkages, fully powered systems, power-augmented and fly-by-wire controls. Digital flight control, autopilot systems, and active control technologies. Auxiliary systems: Basic and evaporative air cycle systems, vapor cycle cooling systems. Aircraft fire protection, de-icing, and anti-icing systems.

UNIT – II	05 Hours

Aircraft Engine and Fuel Systems

Fuel systems for piston and jet engines: tank configuration, pumps, valves, and distribution systems. Multi-engine configurations. Lubrication systems in piston and jet engines. Starting and ignition systems: magnetos, spark plugs, exciter systems. Case studies and examples of typical configurations in general aviation and commercial aircraft.	
UNIT – III	**05 Hours**
Hydraulic Actuation and Control Systems Fluid power principles, types and construction of hydraulic actuators, motors, and cushioning mechanisms. Hydraulic control valves: direction, pressure, and flow control. Proportional and servo valves. Lab: Assembly and testing of hydraulic circuits, actuator performance assessment, valve function demonstrations.	
UNIT – IV	**06 Hours**
Pneumatic and Electro-Pneumatic Systems Compressor operation, air treatment (filters, regulators, lubricators), control valves, pneumatic actuators, quick exhaust and shuttle valves. Electro-pneumatic control using solenoids, sensors, timers, and logic circuits. Lab: Pneumatic circuit implementation, ladder diagrams, testing of automated sequences.	
UNIT – V	**05 Hours**
PLC Integration with Fluid Power Systems PLC programming for aerospace actuation systems, logic development for safety interlocks and feedback control. Hydraulic and pneumatic sequencing using ladder logic. Lab: PLC-based automation of actuator operations, troubleshooting and interfacing with electro-pneumatic elements.	

Course Outcome	Description	Bloom's Taxonomy Level
	At the end of the course the student will be able to:	
1	Describe various aircraft control, engine, and auxiliary systems and their operational principles.	L1 & L2
2	Interpret the architecture of hydraulic and pneumatic systems used in aerospace applications.	L2
3	Analyze the working of hydraulic actuators, control valves, and electro-pneumatic elements in aircraft systems.	L4
4	Design and simulate hydraulic/pneumatic circuits for aircraft subsystems using standard components.	L3
5	Develop PLC-based control logic for integrated aircraft fluid power systems and demonstrate automation sequences.	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											1		
CO2	3	3			1								1		
CO3	3	3			1				3	3			1		
CO4	3	3							3				1		
CO5	3	3							3				1		

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

TEXT BOOKS:

1) Hydraulics and Pneumatics: A technician's and engineer's guide; Author, Andrew Parr; Edition, revised; Publisher, Elsevier, 2013
2) Cengel, Y.A., Cimbala,J. M., "Fluid Power with Applications", 2nd Ed., Tata McGraw Hill, 2010

REFERENCE BOOKS:

1. P.N. Modi and S.M. Seth (1999), "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Naisarak, Delhi

E-Resources:

1. https://archive.nptel.ac.in/courses

Total Contact Hours: 26

The following are experiments to be carried out:

1) Extending a cylinder by operating a push button
2) Signal storage by electrical self-locking, setting and resetting using a momentary-contact switch
3) Mechanical locking by means of momentary-contact switch contacts Exercise 4 Electrical locking by means of contactor contacts
4) Signal storage by means of contactor contacts Accumulator, applications
5) Pressure switches and proximity switches Exercise 8 : Advance control with time-dependent intermediate stop
6) Direct and indirect control of a single-acting cylinder, double-acting cylinder with pushbutton
7) Signal storage by means of contactor contacts, Holding-element control of a double-acting cylinder with impulse valve, directly controlled
8) Displacement-dependent control of a double-acting cylinder, impulse valve, cylinder switch
9) Sequential control of 2 double-acting cylinders with impulse valves and signal overlapping spring return valves and step sequence.

INTRODUCTION TO FINITE ELEMENTAL ANALYSIS

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

SEMESTER – V

Subject Code	:	23AS3504	**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. Develop Expertise in equilibrium equations in elasticity, stress-strain relations, and the foundational principles, applications, and limitations of the finite element method (FEM).
2. Master Advanced Methods such as the principles of virtual work and minimum potential energy, and various stiffness matrix formulation techniques including Rayleigh-Ritz and Galerkin's methods.
3. Acquire Proficiency in interpolation polynomials and the analysis of Constant Strain Triangle (CST) elements, including shape functions, nodal load vectors, strain displacement matrices, and Jacobians.
4. Engineer Solutions for complex problems involving 1-D bars, trusses, beams, and steady-state heat transfer, utilizing FEM principles and techniques.

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: Equilibrium equations in elasticity subjected to body force, traction forces, and stress- strain relations for plane stress and plane strains. General description of finite element method, application and limitations, types of elements based on geometry. Node numbering.

UNIT – II	**08 Hours**

Basic Methods in FEM Principle of virtual work, principle of minimum potential energy, Raleigh's Ritz method. Direct approach or stiffness matrix formulation of bar element and Galerkin's method.		
UNIT – III	**06 Hours**
Interpolation polynomials- linear, quadratic and cubic. CST elements-shape functions and nodal load vector, strain displacement matrix and Jacobian for triangular and rectangular element. Shape function of 2-D quadrilateral element-linear, quadric element Isoparametric, sub parametric and super parametric elements.	
UNIT – IV	**09 Hours**
Solution of 1-D Bars: Solutions of bars and stepped bars for displacements, reactions and stresses by using penalty approach and elimination approach. Gauss-elimination technique. Trusses: Stiffness matrix of truss element. Numerical problems	
UNIT – V	**08 Hours**
Types of Beams & Heat Transfer Beams: Hermite shape functions for beam element, Numerical problems of beams carrying concentrated, UDL and linearly varying loads. Heat transfer: Steady state heat transfer, 1D heat transfer in thin fins.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Apply equilibrium equations and stress-strain relations to solve plane stress and strain problems using FEM techniques.	L2 & L3
2	Implement virtual work and energy methods to derive stiffness matrices for bar elements through advanced mathematical techniques.	L2 & L3
3	Develop interpolation polynomials and calculate shape functions for CST triangular and rectangular elements.	L2 & L3
4	Compute nodal load vectors and strain displacement matrices for these elements.	L2 & L3
5	Analyze 1-D bar and stepped bar problems using penalty and elimination methods, constructing stiffness matrices for truss elements.	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	3				2			1	1	1
CO2	3	2	1	1	3				2			1	1	1
CO3	3	2	1	1	3				2			1	1	1
CO4	3	2	1	1	3				2			1	1	1
CO5	3	2	1	1	3				2			1	1	1

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

Text Books:

1) T.R. Chandrupatla and A.D Belegundu , Finite Elements in Engineering, 3rd Ed PHI.

2) S.S. Rao, Finite Element Method in Engineering,4th Edition, Elsevier, 2006.

Reference Books:

1) R.D. Cook D.S Maltus, M.E Plesha and R.J.Witt, Concepts and applications of Finite Element Analysis, Wiley 4th Ed, 2009
2) J.N.Reddy, Finite Element Method, McGraw -Hill International Edition

LIST OF EXPERIMENTS

1. Geometry clean up and de-featuring
2. 2D meshing and pre-processing for beam bending
3. 3D meshing and pre-processing for propeller shaft
4. Solution Parameter Selection and Input Deck for asymmetric beam bending
5. Deflections and stresses of connecting rod assembly
6. Factor of safety and joint integrity of bolted joint assembly
7. Thermal clearance estimation in aero-engine under steady state thermal conditions
8. Implementation of Temperature dependent properties
9. Convergence studies based on solution parameters
10. Open Experiment – Any one Nonlinear capability exploration – material, contact or geometry

PRODUCT DESIGN AND DEVELOPMENT

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

SEMESTER – V

Subject Code	:	23AS3505	**Credits**	:	02
Hours / Week	:	03 Hours	**Total Hours**	:	13 + 26 Hours
L–T–P–S	:	1–0–2			

Course Learning Objectives:

1. This course provides a comprehensive understanding of the product design and development process.
2. It covers the methodologies, tools, and techniques used to create innovative products from initial concept to market introduction.
3. Students will learn about design thinking, market analysis, user-centered design, prototyping, and sustainability.
4. The course emphasizes practical applications and teamwork in multidisciplinary environments.

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 Product Design and Development: Overview of the product design and development process, Importance of innovation and creativity in product design, Design Thinking methodology, TRIZ, Case studies of successful product designs	
UNIT – II	**06 Hours**
Market Analysis and User Research: Techniques for market research and competitive analysis, identifying user needs and requirements. User personas and journey mapping, Translating user insights into design opportunities	
UNIT – III	**09 Hours**
Concept Development and Evaluation: Ideation techniques and brainstorming sessions, Concept generation and sketching, concept evaluation	

overview, evaluation techniques based on 1) feasibility judgment, 2) GO-NO-GO screening,3) Technological readiness, 4) basic decision matrix (Pugh's Method). Time value of money, cost comparison, profitability of investment, sensitivity and break-even analysis.	
UNIT – IV	**08 Hours**
Detailed Design and Prototyping: Creating detailed product specifications, CAD modeling and digital prototyping, Advanced prototyping techniques (3D printing, CNC machining, etc.), Iterative testing and refinement of prototypes	
UNIT – V	**08 Hours**
Ergonomics, Aesthetics, and User Experience: Principles of ergonomics and human factors, designing for aesthetics and visual appeal, Enhancing user experience through design, Usability testing and feedback incorporation	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	**Apply** Design Thinking principles and methodologies to create innovative product solutions.	L3
2	**Analyze** market needs, user requirements, and competitive landscapes to inform product design decisions.	L2 & L3
3	**Evaluate** various design concepts and prototypes using criteria such as usability, feasibility, and viability.	L3
4	**Develop** detailed product specifications, including materials, dimensions, and manufacturing processes	L2 & L3
5	**Integrate** principles of ergonomics, aesthetics, and user experience into product 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
CO1	3	2	2		3									
CO2	3	2	2		3									
CO3	3	2	2		3									
CO4	3	2	2		3									
CO5	3	2	2		3									

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

TEXT BOOKS:

1"Product Design and Development" by Karl T. Ulrich and Steven D. Eppinger
Comprehensive guide to the product design and development process.

2"Design Thinking: Integrating Innovation, Customer Experience, and Brand Value" by Thomas Lockwood
Explores the principles and practices of Design Thinking.

3• “Engineering Design: A Project-Based Introduction" by Clive L. Dym, Patrick Little, Elizabeth J. Orwin, and Richard G. Murray
Focuses on the engineering aspects of product design with a project-based approach.

4• "Design for Manufacturability and Assembly: Concepts, Architecture and Implementation" by James Bralla
Covers principles and practices for designing products that are easy to manufacture and assemble.

REFERENCE BOOKS:

1. "The Lean Product Playbook: How to Innovate with Minimum Viable Products and Rapid Customer Feedback" by Dan Olsen

Provides a step-by-step guide to lean product development and innovation.
2. "Ergonomics in Product Design: A Design Guide" by SendPoints
Focuses on integrating ergonomics into product design.

3. "Sustainable Design: A Critical Guide" by David Bergman
Discusses principles and practices for sustainable product design.

4 **"CAD for Product Design and Development" by Alan Pipes**

- Guide to using CAD software for product design and development.

E-Resources:

1. **Product Design and Development, https://onlinecourses.nptel.ac.in/noc21_me83/preview**
2. **Product Design and Manufacturing, https://onlinecourses.nptel.ac.in/noc21_me66/preview**

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FLIGHT PHYSICS LABORATORY

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

SEMESTER –V

Subject Code	:	23AS3506	**Credits**	:	01
Hours / Week	:	02 Hours	**Total Hours**	:	26 Hours
L–T–P–S	:	0–0–2			

Course Learning Objectives:

This course will enable students to:

1. Conduct experiments in a low-speed wind tunnel on standard test specimens such as airfoils and circular cylinders.
2. Conduct experiments to calibrate the wind tunnel test section.
3. Use multi-tube manometers to measure pressure distributions.
4. Understand data reduction and analyses methods to obtain aerodynamic coefficients

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Understand the operation of a wind tunnel
- Understand the use of pitot and static tubes to measure steady pressure and velocity
- Understand the method of aerodynamic force measurements using a 3-component balance
- Understand and interpret the flow flow over objects using smoke flow and tuft-flow visualization techniques

LIST OF EXPERIMENTS

1. Measurement of pressure distribution over an airfoils
2. Measurement of pressure distribution over a bluff body
3. Flow visualization using smoke and tuft techniques
4. Force measurement
5. Flow over flat plate
6. Experimental study of flow over objects that students can design and develop, as a part of the Course on Wind-Tunnel testing

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Profession Elective I

HIGH SPEED AERODYNAMICS

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

SEMESTER – V

Subject Code	:	23AS3508	**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. Derive the governing equations of compressible fluid flow.
2. Explain the characteristics of normal and oblique shock waves and expansion waves.
3. Analyze high-speed aerodynamics and its effects on the design and operation of aircraft.
4. Understand the measurements of fluid properties and calculate aerodynamic coefficients in high-speed flows.

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.

UNIT – I	**08 Hours**

One-Dimensional Compressible Flow:

Review of basics of compressible flows, Basic concepts of compressible flow, continuity, energy and momentum equations. Normal and Oblique shock waves, Flow through constant area duct with friction (Fanno flow) and Flow through constant area duct with heat addition (Rayleigh flow).

UNIT – II	06 Hours
Compressible Flow Through Nozzles and Diffusers: Governing Equations for Quasi-One-Dimensional Flow, Discharge through a reservoir, maximum velocity, Nozzle Flows, Diffusers, Supersonic Wind Tunnels, Shock Tunnels	
UNIT – III	**10 Hours**
Oblique shocks and Expansion waves: Oblique shock relations, Supersonic flow past wedges and cones, strong, weak and detached shocks, shock-polar, Shock-interactions and reflections. Flow past convex corners, Prandtl – Meyer expansion, Shock Expansion Theory- Application to supersonic airfoils. Hypersonic flows, aerodynamic heating, blunt versus slender bodies in hypersonic flows.	
UNIT – IV	**08 Hours**
Steady State Compressible Flows: Velocity potential equation, linearized velocity potential equation, critical Mach number, The Sound Barrier, The Supercritical Airfoil, The Blended Wing Body, High-Speed Airfoils, Linearized Supersonic Flow, Linearized Supersonic Pressure Coefficient, Application to Supersonic Airfoils, Lift and drag of supersonic profiles. Hypersonic flows, real gas effects.	
UNIT – V	**07 Hours**
Measurements in High-Speed Flow: Types of subsonic and Supersonic wind tunnels - characteristic features, their operation and performance. Shock tubes flows, Shock tunnels. Free flight testing - Measurements of pressure, velocity and Mach number –Flow visualization methods of subsonic and supersonic flows.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	**Use** normal shock relations to **calculate** flow properties across the shock wave.	L2 & L3
2	**Solve** for compressible flow characteristics with friction and heat transfer.	L2 & L3
3	**Explain** isentropic compressible flows in variable area ducts and **apply** them in the analysis of nozzles and diffusers	L2 & L3
4	**Analyze** oblique shock and expansion waves	L3 & L4
5	**Determine** aerodynamic coefficients in supersonic flows	L3 & L4
6	**Explain** the working of wind tunnels and shock tunnels under various flow conditions.	L2 & L3

COs	Program Outcomes (POs)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3			2								3	
CO2	3	3			2								3	
CO3	3	3			1								2	
CO4	3	2			2								2	
CO5	3	3		2	1					1			3	2
CO6	3	2			1					1			2	

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

TEXT BOOKS:

1. John D Anderson, “Fundamentals of Aerodynamics”, Mc Graw Hill, 6th edition, 2017, ISBN 978-1-259-12991-9.
2. Ethirajan Rathakrishnan., “Gas Dynamics”, Prentice Hall of India, 5th edition, 2014, ISBN-13: 978-8120348394

REFERENCE BOOKS:

1. John D Anderson, “Modern Compressible Flow”, Mc Graw Hill,3rd edition, 2012, ISBN-13:978-1259027420.
2. Ethirajan Rathakrishnan., “Applied Gas Dynamics”, John Wiley & Sons Ltd, 2nd edition, 2019, ISBN 9781119500452
3. Ascher. H. Saphiro, “Dynamics and Thermodynamics of Compressible fluid flow”, John Wiley&Sons, 1st edition, 1977, ISBN-13: 978-0471066910.
4. Yahya, S.M., “Fundamentals of Compressible flow”, NEW AGE, 2009, ISBN-13: 978-8122426687.
5. H.W. Liepmann and A. Roshko, “Elements of Gas Dynamics”, Dover Publications Inc, 2003, ISBN-13: 978-0486419633.

E-Resources:

2. https://nptel.ac.in/courses/112103021
3. https://nptel.ac.in/courses/101106044

Activity-Based Learning (Suggested Activities in Class)

1. Use of online calculators/software to calculate isentropic properties, normal and oblique shock relations, aerodynamic coefficients and flow visualization (https://devenport.aoe.vt.edu/aoe3114/calc.html, https://www.grc.nasa.gov/www/k-12/rocket/ieisen.html).
2. Demonstration of the solution to a problem through programming.

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MESUREMENT TECHNIQUES

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

SEMESTER – V

Subject Code	:	23AS3509	**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. To provide an overview of the different types of sensors and instruments flown on spacecraft.
2. To provide students with an appreciation and understanding of the development of the design processes involved for different instruments.
3. To explain, how the sensors and instruments interface with the spacecraft platform.

Teaching-Learning Process (General Instructions)

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

Lecture method for this course includes presentation which includes **chalk and talk for all modules.**

Interactive Teaching: *The* ***adoption of Active learning via brainstorming***

The concept in each and every module consists of **video animations**

The **collaborative learning**

The **Critical thinking** is adopted considering

Adopt ***Problem Based Learning***

Different methods of **solving**

Discuss how every ***concept can be applied to the real world***

UNIT – I	07 Hours

INTRODUCTION

Scientific Background – Parameters to be observed – Sensing platforms (rocket engine, satellites) – introduction to various sensors and instrumentation needed for satellite mission function.

UNIT – II	08 Hours

MEASUREMENTS OF CHARGED AND NEUTRAL PARTICLES

Pulse and Current modes – Pulse height spectra and analysis – Counting curves and plateaus – Energy resolution - Detector efficiency – Dead time – Analysers: Electrostatic, Magnetic-field, Time-of-flight – Detectors: Solid state, Scintillation counters, Electron multipliers – Actual instruments – Analog or pulse height spectroscopy electronics – Digital techniques – Impact of microprocessors on inflight data processing units – Power supplies – Neutral particle imagers.

UNIT – III	08 Hours

MEASUREMENT OF MAGNETIC AND ELECTRIC FIELDS

Fluxgate magnetometer – Search coil magnetometer – Optical absorption magnetometer. Electric Fields: Double probe technique – Beam experiments – Observation of electric fields parallel to the magnetic field.

UNIT – IV	08 Hours

PHOTON COUNTING SENSORS AND IMAGERS

Auroral imagers: Optical, UV, X-ray – X-ray sensors and imagers - Detection techniques, Grazing incidence optics – Charged Coupled Devices – Other imaging techniques – tomography

UNIT – V	08 Hours

SPACECRAFT SYSTEMS AND SATELLITE ORBITS

Subsystems – Testing and Qualifications – Trade-offs – Role of orbit to investigation –

Unusual orbital techniques: L1 orbit, double lunar swing-by.

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Explain how mathematics, physics, and engineering-based concepts are used to develop and design a sensor which complies with a set of specific requirements.	L2
2	Discuss essential topics such as cost estimation, signal processing, noise reduction, filters, phased arrays, radars, optics, and radiometers used in space operation	L2 & L3
3	ANALYSE a range of typical sensors used in the spacecraft industry such as infrared, passive microwave, radars and space-based GPS sensors.	L2 & L3
4	ANALYZE and EVALUATE Spacecraft Sensors is an invaluable resource for engineers, technical consultants	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**
CO1	3	3										2	3	
CO2	2	3	2										2	
CO3	2	3			1									
CO4	2	2			1									

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

TEXT BOOKS:

1. Abid, Mohamed M., "Spacecraft Sensors", Chichester, England; Hoboken, NJ: J. Wiley, 2005.
2. Kohichiro Oyama, Chio-Zong Cheng, "An introduction to space instrumentation", Tokyo, Japan: Terrapub, 2013.

REFERENCE BOOKS:

1. Yuri Surkov, "Exploration of Terrestrial Planets from Spacecraft: Instrumentation, Investigation, Interpretation", Wiley-Praxis Series in Astronomy & Astrophysics, Ellis Horwood Ltd, 2nd Ed., 1990.

SPACE FLIGHT OPERATIONS

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

SEMESTER – V

Subject Code	:	23AS3510	**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 the terminology associated with space flight operations
2. Develop technical resource budgets, spanning mass, power, thermal, telecommunications, science data return
3. Understand the roles and processes involved in operating a mission
4. Familiarize with mission planning methods and metrics
5. Identify and mitigate mission risks
6. Understand best practices for space mission design, management, and operations

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: Space mission engineering, history of space flight, space flight technology, space flight economics. Space Mission Engineering – history, evolution, characteristics and functions of mission engineering. Mission objectives and constraints, estimation of mission needs, requirements and constraints.

UNIT – II	**06 Hours**

Launch and Operations: Launch vehicle selection, mechanics of launch, launch environment, and available vehicles. Worldwide launch sites and launch restrictions, launch site preparations, launch site access and training, launch site processing, launch day, post-launch and early orbit operations.

UNIT – III	07 Hours
Ground System Operations: Antenna services, data accounting and distribution services, ground system requirements and sizing, mission examples, technology trends, telemetry, tracking and command operations.	
UNIT – IV	09 Hours
Mission Planning and Operations: History of mission planning, Mission planning and operations development, mission execution, mission termination and post mission activities, process improvement and best practices, future mission operations	
UNIT – V	09 Hours
Human Space Flight Operations: Basic Considerations, Planning Teams, Concept of Crew Flexibility, Planning Phases Overview, Planning Products and Processes, Planning Tools	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Perform preliminary assessment of mission operations requirements for a given space mission	L2
2	Analyze parameters affecting the selection of launch vehicles and launch sites.	L2 & L3
3	Analyse the performance of ground systems.	L2 & L3
4	Obtain a historical perspective on how space missions have employed different approaches to achieve their mission operations objectives.	L2 & L3
5	Analyze various factors involved in human space flight operations.	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		1								2	2
CO5	3	2	2										2	1

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**

ADVANCED MANUFACTURING

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

SEMESTER – V

Subject Code	:	23AS3511	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course learning objectives

1.To provide students with an in-depth understanding of Manufacturing Planning and Control (MPC) systems, forecasting, capacity planning, and modern industry trends including AI and Industry 4.0.

2. To familiarize students with the evolution of Industry 4.0 to Industry 5.0, covering IoT/IIoT, AI, robotics, automation, additive manufacturing, and human–machine collaboration

3. To familiarize students with the fundamentals of space manufacturing, including lunar

and Martian environmental conditions, human needs, and utilization of local resources.

4. To impart knowledge on machining, assembly, and maintenance processes in space environments, including extreme condition tool materials and mining techniques.

5. To develop an understanding of in-space manufacturing using local resources, containerless processes, ultrahigh vacuum processing, and robotic operations under extreme conditions.

Teaching-Learning Process (General Instructions)

- These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
- ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show ***Video/animation*** films to explain functioning of various concepts.
- Encourage ***Collaborative*** (Group Learning) Learning in the class.
- To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
- 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.
- Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
- 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 manufacturing planning and control (MPC) Types and characteristics of manufacturing systems – Operations planning and productivity – Product development and design - Forecasting - Process planning - Capacity planning – Facility location and layout - Aggregate planning - Master production schedule - materials requirement planning (MRP) and MRP-II – Scheduling in manufacturing systems - Assembly line balancing - Inventory planning and control - Quality management and control – Enterprise resource planning - JIT and lean systems – Introduction to industry 4.0 – Role of Artificial intelligence in MPC - case studies.	
UNIT – II	**08 Hours**
Introduction, Historical Context, General framework, Application areas, Dissemination of Industry 4.0 and the disciplines that contribute to its development, Artificial intelligence, The Internet of Things and Industrial Internet of Things, Additive manufacturing, Robotization and automation, Current situation of Industry 4.0. Introduction to Industry 4.0 to Industry 5.0 Advances	
UNIT – III	**06 Hours**
AI for Manufacturing: Overview of AI in manufacturing, application of machine learning for industrial planning and decision making, The concept of modelling and virtual representations of physical worlds, understanding of the concept of Digital Twin for manufacturing, Measurement and data generation, Predictive maintenance with Digital Twin, Tools for data exploration, analysis and visualisation, Characteristics of the physical system to implement digital twin, Enablers for implementation of Cyber-Physical systems in manufacturing, Use of digital twin for implementation of sustainable manufacturing principles	
UNIT – IV	**1. Hours**
Additive Manufacturing for Digital Transformation: Review of fundamentals of Additive manufacturing methods, Material selection, Manufacturing, Post processing, Additive manufacturing technologies and processes. 3D Printing Software, 3- D printers, Standard interface to convey geometric description from CAD package to Rapid prototyping system, Stereo Lithography (STL)file, Initial Graphics Exchange Specification (IGES)file, Hewlett-Packard Graphics Language (HP/GL) file. Lab exercises on 3D printing.	
UNIT – V	**08 Hours**
Space Manufacturing: Lunar/Martian topography, Petrology, Solar cycle, Abundance/scarcity of energy, Impacts and volcanism, Asteroids/meteoroids, Extreme conditions, Identification and fulfilment of human needs, Space-food, Extreme condition habitats, Spacesuits, Physiological and psychological health, Utilization of local resources. Vacuum conditions, Reduced/micro/quasi-absent/zero gravity, Gaseous environments, Radiation, Meteoritic impacts, Solar storms, Space objects, Physical/chemical/mineralogical properties of rocks, Simulating space environment on earth.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand the significance and evolution of space manufacturing in the context of engineering and society.	L2
2	Analyse suitable materials and understand their behavior in space environments.	L4
3	Apply additive manufacturing techniques in the context of space manufacturing.	L3
4	Design spacecraft and space habitat systems suitable for manufacturing in space.	L3
5	Evaluate the economic and social impacts of space manufacturing.	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	2	1	-	2	2	-	-	-	-	-	-	-		3
CO2	3	1	2	1	3	-	1	-	-	2	-	-		2
CO3	3	1	-	1	2	-	2	-	-	-	-	1		3
CO4	3	1	3	1	3	-	1	-	-	-	-	2		2
CO5	3	1	-	1	2	-	-	-	-	-	2	1		3

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

TEXTBOOKS:

1. Manufacturing Techniques for Space Environments by Deepak G. Pant, Publisher: Springer, Year: 2013, ISBN: 978-3642377077
2. Materials in Space by Roger D. Launius, Publisher: Springer Praxis, Year: 2016, ISBN: 978-3319261706
3. Additive Manufacturing for Space by Brian Derby, Publisher: Springer, Year: 2018, ISBN: 978-3319724666

REFERENCE BOOKS:

1. Space Systems Engineering by Peter Fortescue, Graham Swinerd, John Stark

ISBN: 978-0470750124, **Publisher:** Wiley, **Publication Year:** 2011, **Edition:** 3rd Edition

2. The Economics of Space: Value, Risk, and Policy by Henry R. Hertzfeld, Wiley J. Larson **ISBN:** 978-1884989180, **Publisher:** Microcosm Press, **Publication Year:** 2006, **Edition:** 1st Edition

INDUSTRY 4.O

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

SEMESTER –V

Subject Code	:	23AS3512	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	3–0–0			

Course learning objectives

1. Understand the fundamentals of Industry 4.0 and its relevance to aerospace manufacturing.
2. Apply advanced manufacturing technologies such as additive manufacturing and robotics in aerospace contexts.
3. Utilize digital tools and simulations for quality assurance and process optimization in aerospace manufacturing.
4. Develop strategies to enhance competitiveness and sustainability in aerospace manufacturing using Industry 4.0 concepts.
5. Analyze and optimize aerospace supply chain management leveraging digital supply network principles.

Teaching-Learning Process (General Instructions)

- These are sample new pedagogical methods, where teacher can use to accelerate the attainment of the various course outcomes.
- ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show ***Video/animation*** films to explain functioning of various concepts.
- Encourage ***Collaborative*** (Group Learning) Learning in the class.
- To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
- 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.
- Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
- 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 Industry 4.0

Concept, Globalization and emerging issues, The Fourth Revolution, LEAN manufacturing, Smart and connected business perspectives, Smart factories

UNIT – II	**08 Hours**

Automation

Programable Logic Controller (PLC) and its Programming software, Communication of different devices with PLC, Sensor, Smart Sensor, HMI design, Cyber Physical System – key components, ISA-95 architecture, CPS-5C architecture, Concept of Digit Twin

UNIT – III	**06 Hours**

Communications

Protocols – MQTT, OPC UA, EtherNet/IP, Profinet, EtherCAT, etc; MQTT – History, MQTT broker, Message types, Quality of Service (QoS), Application; OPC UA – History, Specification, Client, Server, Programming with – Free and open-source software, Propriety software; Augmented Reality

UNIT – IV	9. Hours
IoT Platform Data Modelling, IoT platforms – Thing, basic functionalities, Abstract definition of Thing, Networks, etc; IoT Gateway, Machine interfaces – Cloud-based Mosquitto brokers, Programming with – Free and open-source software, Propriety software	

UNIT – V	08 Hours
Machine Learning Foundation Learning algorithms – Supervised, Unsupervised, Self learning, Feature learning, etc. Models – Artificial Neural Networks, Decision trees, Regression analysis, Genetic algorithms, etc.; Programming with – Free and open-source software, Propriety software	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Introduce concept of Industry 4.0 for Smart Manufacturing.	L2
2	Analyse various hardware used in Smart Manufacturing.	L3
3	Evaluate the need of various communication protocols. hardware and software, IoT Layers and their relative importance.	L3
4	Integrate cloud-computing IoT platform for Smart Manufacturing.	L4
5	Develop machine learning to make smart factories.	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	2	1	-	1	-	1	-	1	-	-	-		3
CO2	3	3	3	2	2	2	1	-	1	1	-	-		
CO3	3	3	3	2	2	2	1	-	1	1	-	-		3
CO4	3	3	3	2	3	2	1	3	1	1	1	3		3
CO5	3	3	3	2	3	2	1	3	3	1	1	3		3

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

References:

1. Christoph Jan Bartodziej, "The Concept Industry 4.0 – An Empirical Analysis of Technologies and Application in Production Logistics", Spinger Gabler, 2015
2. Alasdair Gilchrist, "Industry 4.0 – The Industrial Internet of Thigs", Springer Link, 2016
3. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications.
4. Michahelles, "Architecting the Internet of Things", ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer.
5. Hakima Chaouchi, "The Internet of Things Connecting Objects to the Web" ISBN : 978-1- 84821-140-7, Willy Publications.

6. Olivier Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things: Key Applications and Protocols", ISBN: 978-1-119-99435-0, 2nd Edition, Willy Publications
7. W. Botton, "Programmable Logic Controllers", Fourth Edition, Elsevier, 2006
8. P. Juahs, K. Molnar, "Key Components of the Architecture of Cyber-physical manufacturing systems", International Scientific Journal "Industry 4.0", 2017, issue 5, 205-
207
9. Jen-Ruey Jiang, "An improved cyber-physical systems architecture for Industry 4.0 smart factories", Advances in Mechanical Engineering, 2018, Vol. 10(6) 1-15
10. http://www.mqtt.org
11. https://opcfoundation.org/about/opc-technologies/opc-ua/
12. https://www.profibus.com/pi-organization/about-pi/organization-communitu/
13. https://www.ethercat.org/default.htm

AVIONICS

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

SEMESTER – VI

Subject Code	: 23AS3601		**Credits**	:	03
Hours / Week	:	04 Hours	**Total Hours**	:	26 + 26 Hours
L–T–P	:	2–0–2			

Course Learning Objectives:

This course will enable students:

1. To **analyse** the integrated requirements of power management, instrumentation, communication, navigation and control system requirements
2. To **explain** evolution of the avionics systems architectures
3. To **describe and interpret** the Federated and Integrated Avionics System Architectures

Teaching-Learning Process (General Instructions)

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

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

UNIT – I	**05 Hours**

Introduction:

Need for avionics in civil and military aircraft. Power Distribution System: Bus Bar, split bus bar system, special purpose cables, Electrical diagram and identification scheme., Circuit controlling devices. Power utilisation-typical application to avionics.

UNIT – II	**06 Hours**

Inertial Navigation System and Flight Controls:

Gyroscopic versus Inertial platform. Structure of stable platform.

Inertial navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing. Electronic flight control system: fly-by-wire system -basic concept and features. Pitch and Roll rate-command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common modes of failure and effects analysis.

UNIT – III	**05 Hours**

Electronic Flight Instrument Systems and Communication:

Display-units, presentation, failure, and annunciation. Display of air data.

Introduction to avionics sub-systems and electronic circuits: Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.	
UNIT – IV	**05 Hours**
Principles of Digital Systems: Digital Computers, Microprocessors, Memories. Flight Deck and Cockpits: Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI) Civil cockpit and military cockpit: MFDS, HUD, MFK, and HOTA	
UNIT – V	**05 Hours**
Avionics Systems Integration: Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic, Warfare, and fire control system. Avionics system architecture, Data buses, MIL-STD1553B, ARINC429, ARINC629, RS232, RS422	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
CO1	Analyse the requirements and specifications for power distribution elements for typical military and civil aircraft. They will be able to draw, interpret and identify the aircraft electrical circuitry with respect to generation, distribution and utilisation.	2
CO2	Compare and identify the navigation system - inertial navigation, electronic flight control and fly-by-wire	3
CO3	Identify and use installed sensors, communication, flight instrument and displays systems in civil / commercial aircraft	3
CO4	Select and design the digital avionics architectures and systems for control, communication, displays and electronic warfare in military / civil aircraft.	4
CO5	Identify and select the appropriate avionics system architecture along with applicable standards	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	2	1								1	3	2	
CO2	3	2	1	1								1	3	2	
CO3	3	2	1	1	2							1	3	2	
CO4	3	3	1									1	3	2	
CO5	3	2	1									1	3	2	

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

TEXT BOOKS:

1. Introduction to Avionics Systems R.P.G. Collinson Springer 3rd edition, 2011

2. Aircraft Systems: Mechanics, Electrical and Avionics Subsystems Integration Ian Moir, Allan Seabridge Wiley 3rd Edition, 2012

REFERENCE BOOKS:

1. Middleton,D.H.,Ed.,"AvionicsSystems,LongmanScientificandTechnical", Longman Group UK Ltd.,England, 1989,ISBN-13:978-0582018815.
2. Spitzer, C.R.," Digital Avionic Systems", McGraw HillInc.,US,2ndedition,1992,ISBN-13:978-0070603332.
3. Mike Tooley and David Wyatt, Aircraft Communications and Navigation Systems, Butterworth Heinemann,2007.

E-Resources:

1.Virtual Reality 360 degree cockpit videos-Swiss Air Airbus 320 Flight in Youtube
2.Virtual Aerospace Museums with cockpit views
3.Demonstration in Avionics Laboratory of the key driver software in Flight Simulator

Activity Based Learning (Suggested Activities in Class)

1.Role Play-Primary and Secondary Power Management -Role plays with students playing the characters/avatars around primary and secondary and battery power generation with essential, non-essential and vital consumers. Students enact scenarios when primary generator fails, what happen etc.

2.Action based demonstration in class of GPS and Instrumented Landing System

AVIONICS LAB

Total Contact Hours: 26

Following experiments to be done at the Avionics Laboratory:

1. Studying and verifying the truth table of logic gates
2. Establishing a direct communication link between Uplink Transmitter and Downlink Receiver using Tone Signal and Voice Signal
3. Transmitting and receiving PC data, Function Generator Waveforms through Satellite link
4. Sending tele-command and receiving Intensity of light and Temperature from satellite
5. Familiarization of Raspberry pi and setting up ETS IoT Trainer Kit
6. Interfacing LED/Buzzer with Raspberry pi to blink and control RGB LED with a specified time delay and verify the output on the ETS IoT Kit
7. Associating OLED display and print a message and verify the output on the ETS IoT Kit
8. Monitoring Temperature & Humidity, Acceleration using sensors using ETS IoT Trainer Kit
9. Familiarization of digital storage oscilloscope for observing and measuring electronic signals
10. Analysing wave shapes, measurement of frequency and voltage values at different ac. inputs.
11. Familiarization with Flight Simulator (open ended experiment)

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AIRCRAFT STABILITY AND CONTROL

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

SEMESTER – VI

Subject Code	:	23AS3602	**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 basics of aircraft stability and control.
2. Understand the static longitudinal and static directional stability.
3. Acquire the knowledge on dynamic lateral and directional stability.

Teaching-Learning Process (General Instructions)

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

- ***Lecture method*** means it includes not only traditional lecture method, but different *type of teaching methods* may be adopted to develop the course outcomes.
- ***Interactive Teaching:*** *Adopt the* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, notetaking, annotating, and roleplaying.
- Show ***Video/animation*** films to explain functioning of various concepts.
- Encourage ***Collaborative*** (Group Learning) Learning in the class.
- To make ***Critical thinking***, ask at least three Higher order Thinking questions in the class.
- 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.
- Show the ***different ways to solve*** the same problem and encourage the students to come up with their own creative ways to solve them.
- 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**

Historical perspective, Aerodynamic Nomenclature, Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- e Introduction, Trim condition. Static margin, Stick fixed neutral points. Longitudinal control, Power by wire system and EHA

UNIT – II	**08 Hours**

Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing, Restriction on forward C.G. range. Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim

tabs, Stick-free Neutral point, Stick force gradient in un accelerated flight, Restriction on aft C.G.	
UNIT – III	**06 Hours**
Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin, one engine inoperative condition, Weather cocking effect.	
UNIT – IV	**09 Hours**
Introduction, definition of roll stability, estimation of dihedral effect. Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects, Aileron reversal. Definition of Dynamic longitudinal stability.	
UNIT – V	08 Hours
Types of modes of motion: long or phugoid motion, short period motion, Airplane Equations of longitudinal motion. Aerodynamic force and moment representation, Routh's criteria, Factors affecting period and damping of oscillations. Effect of wind shear, flying qualities in pitch, Cooper-Harper Scale. Sideslip excursion. Dutch roll and Spiral instability. Auto- rotation and spin.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand the contribution of various airframe components on longitudinal static stability in stick fixed condition and responses required from control surfaces to overcome sudden aerodynamic unbalancing.	L2 & L3
2	Evaluate stick force required at stick free condition and understand the basic concepts of static directional stability.	L2 & L3
3	Predict aileron control forces and flying modes such as Dutch roll, spiral roll, phugoid, long period oscillation with the help of Routh's criterion, for a given stability equation.	L2 & L3
4	Estimate the dynamic derivatives for forward speed, pitching velocity, time rate of change of angle of attack, rolling rate and yawing rate.	L2 & L3
5	Develop various inter-coupling effects with the motion of aircraft and Examine the response of an aircraft	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. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.

Reference Books:

1. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.

VIBRATION AND CONTROL

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

SEMESTER – VI

Subject Code	:	23AS3603	**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. Model and analyze simple vibratory systems
2. Calculate transient and steady-state responses for a vibratory system
3. Design a vibratory system to reduce the amplitude of vibration and/or transmitted forces
4. Develop a mathematical model of a control system
5. Analyze a control system to determine its transfer function and characteristic equation
6. Predict system stability and performance
7. Design controllers to meet stability and performance goals
8. Use modern computational tools such as MATLAB for analysis and 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	**09 Hours**

Introduction: Degree-of-freedom, Classification of vibration, Vibration terminology, Harmonic Motion, Periodic Motion.

Undamped and Damped Free Vibrations: Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, Spring, and Mass elements. Types of damping Single degree of freedom damped vibrations, logarithmic decrement.

UNIT – II	**06 Hours**

Forced Vibration: Single degree of freedom system, magnification factor, rotating unbalance, support harmonic excitation, critical speed of shafts, vibration measuring instruments, vibration isolation and transmissibility.

UNIT – III	**09 Hours**

Concepts of automatic control: Open loop and closed loop systems, Concepts of feedback, and requirements of an ideal control system. Mathematical Models: Transfer function models – Mechanical, electrical, thermal, and fluid systems. Introduction to State space representation. System modelling using Block diagrams and Signal Flow Graphs. Poles and Zeros, Stability analysis – Routh-Hurwitz Criterion.	
UNIT – IV	**08 Hours**
Time Response: System response, standard test signals. Response of I and II order systems for step and impulse inputs. Transient response specifications. Poles and Zeros, effect of additional poles and zeros on the system response. Root locus plots.	
UNIT – V	**07 Hours**
Frequency Response: Frequency Response of Closed-Loop Systems, Frequency-Domain Specifications, Effects of Adding Poles and Zeros, Nyquist Stability Criterion. Controllers: Proportional, Integral, Derivative, PI and PID controllers, feedforward control.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course, the student will be able to:		
1	Analyze free undamped and damped vibrations of single-degree-of-freedom systems.	L3
2	Analyze forced vibrations of single-degree-of-freedom systems	L2 & L3
3	Apply physical laws to derive transfer function and state space models of mechanical, electrical, thermal and fluid systems.	L3
4	Analyze the time response of I and II order systems for impulse and step inputs and calculate the transient response specifications.	L2 & L3
5	Compute the stability and relative stability of the control system in the time and frequency domain using Routh stability, root locus and Nyquist plots.	L3
6	Use hardware and software tools (like MATLAB) to do the calculations required for (1) to (5) above, and use graphical documentation for these analyses.	L3,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	2	2		2								1	1
CO2	3	2	2		2								2	2
CO3	3	2	2		2								2	1
CO4	3	2	2		2								2	2
CO5	3	2	2		2								2	
CO6	3	1			3				3	2		2	3	2

E-Resources:

1. https://nptel.ac.in/courses/107106081
2. https://archive.nptel.ac.in/courses/108/106/108106098/
3. https://ocw.mit.edu/courses/2-04a-systems-and-controls-spring-2013/pages/lecture-notes-labs/

Activity-Based Learning (Suggested Activities in Class)

1. Design and analysis of control systems using software tools like MATLAB.,
2. Demonstration of the solution to a problem through programming.

Vibration and Control - Lab

Total Contact Hours: 26

Following exercises can be done using hardware/software tools like MATLAB

1. Determinations of natural frequencies of beams under boundary conditions
2. Free vibration of undamped and damped systems
3. Critical speed of shafts
4. Familiarization of MATLAB environment, entering commands, arithmetic operations
5. Programming with MATLAB – script files, if statement, for loops, matrix operations.
6. Analysis of response of I and II order system for step, ramp and impulse inputs, effect of additional poles and zeros on the system response.
7. Stability analysis using root locus and Nyquist plots.
8. Familiarisation with the SIMULINK environment.
9. Design and analysis of PI, PD and PID controller.
10. Design of satellite's attitude control.
11. Lateral and Longitudinal control of Boeing 747.
12. Control of Quadrotor drone.

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UNMANNED AERIAL SYSTEMS

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

SEMESTER – VI

Subject Code	:	23AS3604	**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	**7 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	**9 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	**9 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	**07 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	**07 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.

MODEL BASED SYSTEM ENGINEERING

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

SEMESTER – VI

Subject Code	:	23AS3605	**Credits**	:	02
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P	:	1–0–2			

Course Learning Objectives:

This Course will enable students to:

- **Integrate** the advanced Model Based Systems Engineering Concepts into aircraft design process
- **Apply** MBSE tools methods and protocols for aerospace systems.
- **Perform** simulations for validating aircraft system functionalities
- **Synthesise** modular system designs towards meeting assessment, validation and certification goals

Model based system Engineering overview:

- Systems Engineering and Model Based Systems Engineering (MBSE)
- Need for MBSE and the role of modern tools
- Key features, advantages and functionalities in MBSE tools

Landing Gear overview

- What is Landing Gear and its function
- Types of Landing Gear
- Different parts of a Modern Landing Gear
- Different parts of a Modern Landing Gear Shock Strut.

Landing Gear Operation

- Steering System
- Brakes
- Uplock & Downlock
- Retraction & Extension
- Emergency lowering of Landing Gear

MBSE in LG Design – Requirements and Functional Design

- Introduction to MBSE Process in LG Design Process
- Requirement Management Theory
- Requirement Management Lab
- Functional Architecture, Mapping Requirements and Functional Components
- Practice sessions

MBSE in LG Design – Mathematical, Logical and Physical Designs

- Introduction to Mathematical modelling & Design of a DC motor
- LG Detail Design Process Practice session
- Logical Architecture Definition
- Physical CAD Integration
- Mapping Functional and Logical Components
- Test Case Validation and Impact Analysis

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	**Relate** the concepts of MBSE for Landing Gear Design	3
CO2	**Identify** and **formulate** the requirements for LG in line with the Concept of Operations	4
CO3	**Determine** the steps and processes required to achieve functional, logical and physical designs	4
CO4	**Design and perform** simulations to verify and validate requirements for LG	4
CO5	**Synthesise** MBSE tools, methods and processes for LG design	5

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	1		3						1	2	1	1
CO2	3	2	2	1		3						1	2	1	1
CO3	3	2	2	1		3						1	2	1	1
CO4	3	2	2	1		3						1	2	1	1
CO5	3	2	2	1		3						1	2	1	1

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

TEXT BOOKS :

- MBSE Course material prepared by K.Tech – Government of Karnataka

REFERENCES:

- INCOSE Systems Engineering Handbook, Version 5

Professional Elective - II

HEAT TRANSFER FOR AEROSPACE APPLICATIONS

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

SEMESTER -VI

Subject Code	: 23AS3607		**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** the different heat transfer mechanisms.
2. **Formulate and apply** the general heat conduction equations.
3. **Understand** the mechanism of convective heat transfer and radiative heat transfer
4. **Understand** various devices used for thermal management of aerospace systems.
5. **Analyse** various thermal protection 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	**08 Hours**

Conduction:

Importance of Heat Transfer in Aerospace Applications, Different Modes of Heat Transfer. Introduction: Importance of Heat Transfer in Aerospace Applications, Different Modes of Heat Transfer, Governing Equations of Fluid Dynamics and Heat Transfer, Material and Transport Properties in Heat Transfer.

Heat Conduction: Steady and Transient Heat Conduction, Lumped Heat Capacitance Method,

UNIT – II	**08 Hours**

Convective Heat Transfer:

Natural Convection, External/Internal Forced Convection for Laminar and Turbulent Flows, Transport Properties of Gases at High Temperatures, Thermal Boundary Layers, High Speed Aerodynamic Heating	
UNIT – III	**08 Hours**
Radiation: Stefan-Boltzmann law, Spectral Energy Density, Spectral Absorptivity and Emissivity, Kirchoff's Law, Surface Radiation, Problems on Surface Radiation, Radiation Pressure, Radiation through Participating Media, Shock Layer Radiation, Equilibrium and Non- Equilibrium Thermal Radiation, Bound-Bound Thermal Radiation (Including Rotational and Vibrational Transitions)	
UNIT – IV	**08 Hours**
Thermal Management of Aerospace Systems: Active and Passive Heating/Cooling Mechanisms, Heat Sinks, Thermal Interface Materials, Radiative Cooling, Phase Change Materials, Heat Pipes, Film Cooling, Heat Exchangers (Recuperative and Regenerative Type)	
UNIT – V	**07 Hours**
Thermal Protection System (TPS) Design and Analysis: Different kinds of Insulation used in Aerospace Applications, Mechanisms of TPS (Ablative and Non-ablative), TPS for High-Speed Vehicles (missiles), TPS for Re-entry Space Capsules, Design and One-dimensional Numerical Analysis of TPS **Introduction to the Thermo-Structural Aspects of High-Speed Vehicles**: Thermal Stresses, Structural Properties at Elevated Temperatures, Thermo-structural Design of Aerospace Systems Introduction to the Experimental Investigation of High-Speed Flows: Shock Tunnel, Arc-jet Tunnel, Plasma Wind Tunnel	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Solve steady and unsteady heat conduction problems with different boundary conditions, and assess the performance of fins	L3
2	Calculate the convective heat transfer rate in free and forced convection by using semi-empirical correlations for different types of flows and geometries.	L3
3	Evaluate emissive and spectral emissive power for a black and grey surface, and determine radiation heat transfer between enclosures.	L3
4	Evaluate different active and passive heating/cooling mechanisms	L3
5	Analyse various thermal protection systems used in aerospace vehicles.	L2 & L3
6	Analyse structural properties at elevated temperatures in aerospace systems.	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
CO1	3	2	1	1	2							1	3	
CO2	3	2	2	1	2							1	2	
CO3	3	2	2	1	2							1	2	
CO4	3	2	1		1		1			1				2
CO5	3	3	2		1		1			1			2	2
CO6	3	1	2		1		1			1			3	2

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

TEXT BOOKS:

1. Heat Transfer in Aerospace Applications, Bengt Sunden and Juan Fu, Academic Press, 2017
2. Fundamentals of Heat and Mass Transfer, Incropera, Devitt, Bergmann, Lavine, 6th Edition, Wiley India Pvt. Ltd., 2006.

REFERENCE BOOKS:

1. Heat Transfer, Alan J. Chapman, 4th Edition, The Macmillan Company, 1984.
2. Thermal Radiation Heat Transfer, J.R. Howell, R. Siegel, M.P. Menguc, 5th Edition, 2010.
3. Ablative Thermal Protection Systems Modelling, Georges Duffa, AIAA Education Series, 2012.

E-Resources:

1. https://www.coursera.org/learn/thermodynamics-intro
2. https://nptel.ac.in/courses/127106135

Activity-Based Learning (Suggested Activities in Class)

SYSTEMS ENGINEERING

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

SEMESTER – VI

Subject Code	:	23AS3608	**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:

- **Integrate** the basic concepts of Systems Engineering into engineering applications including aerospace.
- **Apply** systems engineering methodologies to design, optimize, and manage aerospace systems.
- **Develop** use cases, scenarios, and technical parameters of performance, requirements, architectures, behaviours, specifications, verifications and tests for an engineered system.
- **Synthesise** methods, handbooks, standards, practical software and diagrams (including SysML) for meeting system requirements.

UNIT – I	08 Hours

Introduction to systems engineering.

Introduction to the field of systems engineering. Systems engineering processes and lifecycle models, Role of systems engineering in aerospace industry, Basics of MBSE (model-based systems engineering), frameworks, and tools

UNIT – II	08 Hours

Requirements Management and Problem definition.

Understanding and eliciting requirements, Defining the problems and requirements with context and environment, SysML and Graphical models / diagrams to specify requirements Requirements analysis and management, Verification and validation of requirements, Traceability and impact analysis

UNIT – III	07 Hours

System Architecture and Design

System decomposition, Architecture frameworks: functional, physical, Functional analysis and allocation, Interface definition and management, Trade-off analysis and decision-making in system design

UNIT – IV	08 Hours

System Development, Testing and Optimisation

Logical and physical designs, Use of modelling and simulation tools, Overview of Standards DO178C, DO254, SAE-ARP4754A, SAE-ARP4761, System dynamics and behaviour modelling, Integration planning and execution, System testing, verification and validation

UNIT – V	08 Hours

Systems Engineering in Practice

Aerospace acquisition and contracts, Systems engineering in Space Missions, Systems engineering in Commercial Aerospace – balancing cost, performance, and market demands Agile methodologies

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
CO1	**Relate** the concepts of systems engineering processes and lifecycle for engineering applications	3-Apply
CO2	**Identify** and **formulate** the requirements that influence the overall system functionality and performance	4-Analyse
CO3	Given the requirements and constraints, **design** and **develop** the System Architecture and Design	4-Analyse
CO4	**Perform** the System Development, Testing and Optimisation for engineering applications	4-Analyze
CO5	**Synthesise** the requirements, constraints, and designs, achieving the overall system functionality and performance	5-Synthesize

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	1								1	2	1	1
CO2	3	2	2	1								1	2	1	1
CO3	3	2	2	1								1	2	1	1
CO4	3	2	2	1								1	2	1	1
CO5	3	2	2	1								1	2	1	1

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

TEXT BOOKS :

1. Kossiakoff, Alexander; Seymour, Samuel J.; Flanigan, David A; & Biemer, Steven M. (2020). *Systems Engineering Principles and Practice* (3rd Ed.). Hoboken, NJ: John Wiley & Sons ISBN: 9781119516668
2. Buede, Dennis M. and Miller, William D., The Engineering Design of Systems: Models and Methods (Wiley Series in Systems Engineering and Management) 3rd Edition ISBN 978-1-119-02790-4

REFERENCES:

1. INCOSE Systems Engineering Handbook, Version 5
2. Andrew P. Sage, James E. Armstrong Jr. Introduction to Systems Engineering, Wiley, ISBN: 978-0-471-02766-9

WEBLINK:

https://www.nasa.gov/reference/systems-engineering-handbook

SPACE VEHICLE DESIGN

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

SEMESTER – VI

Subject Code	:	23AS3609	**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 examine design of spacecraft and launch vehicles. Students will learn how to analyze a space mission and evaluate critical requirements iteratively. Students will also learn to understand parameters of spacecraft structures, their strength and their applications based on the constraints applied.

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**

Space Mission Analysis and Design process: The space mission life cycle, Definition of mission objectives, Preliminary estimate of mission needs, requirements and constraints.
Mission Characterization: Identifying alternate mission concepts, Identifying Alternative Mission Architectures, Identifying System Drivers, Characterizing the Mission Architecture.
Mission Evaluation: Identification of Critical Requirements, Mission analysis, Mission utility, Mission Concept Selection.

UNIT – II	**08 Hours**

Spacecraft Structures: Design requirements, Design process, Material selection, Analysis, Design verification, The future of space structures.
Attitude Control: The aircraft attitude responses, Torques and torquers, Attitude measurement,

UNIT – III	**08 Hours**

Electrical Power Systems: Estimation of electrical power requirements, Power system analysis, Power management and distribution, Power system sizing, Types of power system, selection of power systems.

UNIT – IV	08 Hours
Thermal Control System: Thermal design environments, Thermal design constraints, Estimation of temperature requirements, types of thermal transfer: Conduction, Convection and Radiation, Need for thermal control, Thermal control types, Coatings and paints, Thermal balance, Thermal isolation, Examples of satellite thermal design.	

UNIT – V	08 Hours
Communications: Techniques of radio communications, The communications payload, Typical spacecraft communication architecture. **Telemetry, Command, Data Processing & Handling:** System architecture, Telemetry data formatting, Telecommand, Communication techniques and protocols.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Estimate the mission requirement and iteratively design a space mission.	L2 & L3
2	Differentiate between different structural components used on a spacecraft.	L2 & L3
3	Estimate electrical power requirements and design a power system based on the mission requirements.	L2 & L3
4	Understand thermal design environments and constraints, types of thermal transfers, thermal control and its types.	L2 & L3
5	Evaluate Communication requirements, learn to apply data processing and handling to smoothen the process.	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	3							1	1	1
CO2	3	2	1	1	3							1	1	1
CO3	3	2	1	1	3							1	1	1
CO4	3	2	1	1	3							1	1	1
CO5	3	2	1	1	3							1	1	1

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

Text Books:

1) Fortescue, P., Swinerd, G., and Stark, J., *Spacecraft Systems Engineering*, J. Wiley & Sons, 2011.

2) Wiley Larson, James Wertz, *Space Mission Analysis and Design*, Microcosm Press, 2005.

Reference Books:

1) Pisacane, V. L., *Fundamentals of Space Systems*, Oxford University Press, 2005.

AIRCRAFT MAINTENANCE, REPAIR AND OVERHAUL

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

SEMESTER – VI

Subject Code	:	23AS3610	**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 the types of maintenance and aviation certification requirements, including FAA and DGCA standards.
2. Utilize maintenance manuals and comply with standards such as FAR and ATA.
3. Explore aviation management, maintenance operations, and servicing procedures.
4. Develop skills in safety regulations and material management.

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 1	26 Hours
Types of maintenance, Redesign, Failure rate pattern, other maintenance considerations. Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Powerplant, Avionics courses.	

UNIT – II	08 Hours
Documentation for Maintenance Manufacturers documentation, Airplane maintenance manual, Fault insulation manual, illustrated parts catalogue, structural repair manual, wiring diagram manual, Master minimum equipment, Federal Aviation regulation (FAR), Advisory	

circulars, Airworthiness direction ATA document standards, technical policies and procedure manuals (TPPM), calibration manual, Directorate General of Civil Aviation (DGCA)	
UNIT – III	**05 Hours**
Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control center flight line (preflight & post flight), Aircraft Logbook, daily check on major components of aircraft depending on airframe (flying) hours or calendar life, Maintenance crew skill requirements. First Flight Servicing (FFS), Turn Round Servicing (TRS), Last Flight Servicing (LFS), Types of maintenance bases	
UNIT – IV	**06 Hours**
Introduction, organization of hanger maintenance, Non- routine item, parts availability, cannibalization, Types of shops- sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop, ground support equipment and ground handling equipment, outsourcing of shop maintenance work, operation of overhaul shops, Material support, Material management inventory control, Support functions of material, Parts ordering, Storage, Issue, control and handling, Parts receiving quality control, calibration program, stock level adjustments, shelf life, exchanges, warranty & modifications of parts, spares management, approved bonded stores for airborne items.	
UNIT – V	**06 Hours**
FOD, Safety regulations, Role of ATC. Tarmac discipline and management, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, repeated snags, rectifications, modifications on aircraft and release of mod leaflets, Knowledge of malfunctions.	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course, the student will be able to:		
1	Understand maintenance types and certification requirements for aviation courses.	L2
2	Apply maintenance manuals and comply with regulatory standards.	L2 & L3
3	Analyze aviation management and perform daily aircraft component checks.	L2
4	Utilise safety regulations and manage materials for efficient operations.	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	2	2	2								1		1	1
CO2	2	1	3								1		1	1

CO3	3	1											1	2
CO4	2	1	3								1		1	1

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

<u>Text Books:</u>

1. Harry A Kinnison, Tariq Siddiqui, Aviation Maintenance Management, Mc Graw Hill education (India) Private Ltd 2013.
2. Kroes, Watkins, Delp, 'Aircraft maintenance and repair', Mc Graw Hill, 2013.

Reference Books:

1. Larry Reithmaier "Aircraft Repair Manual Palmar Books, Marquette, 1992.
2. Brimm. DJ, Bogges, HE, Aircraft Maintenance, Pitman publishing corp, London, 1952.

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DATA ANALYSIS AND INTERPRETATION

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

SEMESTER – VI

Subject Code	:	23AS3611	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
L–T–P–S	:	3–0–0–0			

<u>Course Learning Objectives:</u>

This course will enable students to:

1. Understanding of data analysis techniques, tools, and methodologies.
2. Students will learn how to collect, clean, analyze, and interpret data to make informed decisions.
3. Know practical applications and real-world examples to develop skills in statistical analysis, data visualization, and the use of software tools for data analysis.

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 Data Analysis: Definition and importance of data analysis, Types of data (quantitative vs. qualitative), Data collection methods, Introduction to data pre-processing, Overview of data analysis process

UNIT – II	**06 Hours**

Data Pre-processing and Cleaning: Data cleaning techniques (handling missing values, outliers), Data transformation (normalization, scaling), Data integration and reduction, Data quality assessment, Introduction to data pre-processing tools (e.g., Python libraries, Excel)

UNIT – III	**09 Hours**

Exploratory Data Analysis (EDA): Descriptive statistics (mean, median, mode, standard deviation), Data visualization techniques (histograms, scatter plots, box plots), Identifying patterns and trends in data, Correlation analysis, Introduction to EDA tools (e.g., Pandas, Matplotlib, Seaborn)

UNIT – IV	**08 Hours**

Statistical Analysis and Inference: Hypothesis testing (t-tests, chi-square tests), Analysis of variance (ANOVA), Regression analysis (linear and logistic regression), Time series analysis, Introduction to statistical software (e.g., R, SPSS)

UNIT – V	**08 Hours**

Data Visualization and Interpretation: Principles of effective data visualization, Advanced data visualization techniques (heatmaps, geospatial maps), Dashboard creation and data

storytelling, Communicating findings to non-technical audiences, Tools for data visualization (e.g., Tableau, Power BI)

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	Apply various data analysis techniques to real-world datasets.	L3
2	Evaluate and preprocess data to ensure accuracy and reliability.	L2 & L3
3	Perform statistical analysis to extract meaningful insights from data.	L3
4	Utilize data visualization tools to present data effectively.	L2 & L3
5	Interpret and communicate the results of data analysis to support decision-making	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. "Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking" by Foster Provost and Tom Fawcett
2. "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython" by Wes McKinney
3. "Data Visualization: A Practical Introduction" by Kieran Healy

REFERENCE BOOKS:

1. "Storytelling with Data: A Data Visualization Guide for Business Professionals" by Cole Nussbaumer Knaflic
2. "Applied Predictive Modeling" by Max Kuhn and Kjell Johnson
3. "Introduction to Statistical Learning" by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani

E-Resources:

1. Data Analytics with Python, IIT Roorkee, https://nptel.ac.in/courses/106107220
2. Introduction to Data Analytics, https://archive.nptel.ac.in/noc/courses/noc17/SEM2/noc17-mg24/
3. Data Interpretation Made Easy | Mastery Course, https://www.udemy.com/course/data-interpretation-made-easy-8-hours-mastery-course/?--=&gad_source=1&gclid=Cj0KCQjwsaqzBhDdARIsAK2gqneQqGFj1_SjLs9gME090wW_3sAjdxXpJCIw6qmFYMigadi6xi0J-zIaAh47EALw_wcB&couponCode=IND21PM.

Open Elective I

INTRODUCTION TO AEROSPACE ENGINEERING [As per Choice Based Credit System (CBCS) scheme] SEMESTER –VI					
Subject Code	:	23OE0030	**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 History and Development of Aviation**: Students will gain knowledge of the history of aviation, including the key milestones, influential figures, and significant technological advancements that shaped the field.
2. **Comprehend Aerodynamic Principles and Aircraft Performance:** Students will learn the fundamental principles of aerodynamics and their application to aircraft design.
3. **Familiarize with Aerospace Systems and Technologies:** Students will be introduced to various aerospace systems and technologies, including flight control surfaces, engines (piston, jet, and rocket engines), flight and navigation instruments, hydraulic and pneumatic systems, electrical systems, and fuel, fire, ice, and rain protection systems.
4. **Familiarize with Aerospace Systems and Technologies:** Students will be introduced to various aerospace systems and technologies, including flight control surfaces, engines (piston, jet, and rocket engines), flight and navigation instruments, hydraulic and pneumatic systems, electrical systems, and fuel, fire, ice, and rain protection systems.

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	08 Hours

INTRODUCTION TO AEROSPACE ENGINEERING

Introduction to Aerospace Engineering: History of aviation, Atmosphere, Classification of aircraft, Aircraft Nomenclature, Flight control surfaces, Modern developments in Aviation Aerospace industry and career opportunities, Applications, Global need for aerospace engineers Introduction to Space Flight: Space and its properties, History of Space Flight & spacecraft technologies, Types of orbits and Introduction to orbital mechanics

UNIT – II	08 Hours

FUNDAMENTALS OF FLIGHT AERODYNAMICS

Fundamentals of Flight Aerodynamics: Basics of Aerodynamics, Basics of Aerodynamics, Lift and Drag, Monoplane, Biplane and Triplane, Advantages and Disadvantages, Nomenclature of Airfoils, Aerodynamic Force and Moment Coefficients, lift and drag variations, types of drag, factors affecting lift and drag, Centre of pressure and aerodynamic centre, Basic characteristics of airfoils, Reynolds number, Significance of speed of sound, Propagation of sound, Mach number, Features of subsonic, transonic, supersonic, hypersonic flows.

UNIT – III	06 Hours

AIRCRAFT PROPULSION & ROCKET PROPULSION

Introduction, Piston engines and Jet engines, Brayton cycle, Components of the basic jet engine and performance characteristics, Principles of operation of Turboprop, turbojet and turbofan engines, P-V and T-S Diagrams of the basic cycle, Intercooler, Regeneration and Reheat, Thermal efficiency, Introduction to ramjets and scramjets, Principles of rocket propulsion, Classification of Rockets, Specific impulse

UNIT – IV	09 Hours

AIRCRAFT INSTRUMENTS & AIRCRAFT SYSTEMS

Introduction to Flight and Navigation Instruments, Basic Air data systems & Probes, Mach meter, Airspeed indicator, Vertical speed indicator, Altimeter, Gyro based instruments. Introduction to Hydraulic, Pneumatic and Electrical systems on aircraft, Air Conditioning and Cockpit pressurization system, Generation and distribution of electricity on board the aero plane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System.

UNIT – V	08 Hours

ADVANCEMENTS IN THE AEROSPACE INDUSTRY

Applications of lasers, Advancements in the aerospace industry**,** Introduction to Satellite Systems, applications and use cases, Miniaturized Satellite Systems, Drone Technology and Applications, Heli taxi, cargo and future aviation industry, defence sector, Submarines and UVSs, CubeSat Mission Planning and Operations, revenue model, country economy, private players in the aerospace industry, space explorations, space debris, Reusable Rockets, Space telescopes, AI & Digital twin technology, Super pressure Balloons, case studies

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course the student will be able to:		
1	**Outline** historical developments in the aerospace industry and **classify** aircrafts and spacecraft	L2 & L3
2	**Calculate** aerodynamic coefficients and **classify** different flow regimes	L2 & L3
3	**Compare** the working of different aircraft and rocket propulsion systems.	L2 & L3
4	**Asses** various aircraft instruments and systems	L2 & L3
5	**Outline** recent advances in aerospace industry	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	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	

TEXTBOOKS:

1. John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 8th edition, 2015, ISBN: 978-0078027673.
2. E Rathakrishnan, Theoretical Aerodynamics, 2013 Edition, John Wiley & Sons, Singapore

REFERENCE BOOKS:

1. Ian Moir, Allan Sea bridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206.
2. Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition, 2016, ISBN: 9781118753910.
3. A.C. Kermode, "Flight without formulae", Pearson Education India, 5th edition, 1989, ISBN: 9788131713891.
4. Nelson R.C., "Flight stability and automatic control", McGraw-Hill, 2nd edition, 1998, ISBN: 9780071158381.
5. T.H.G Megson "Introduction to Aircraft Structural Analysis", Elsevier Exclusive Publications, 2nd edition, 2014, ISBN 13: 978-9351071860.

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OPERATIONS MANAGEMENT FOR AEROSPACE

[As per Choice Based Credit System (CBCS) scheme] 2023

SEMESTER – VI

Subject Code	: 23OE0031		**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.

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INTRODUCTION TO SATELLITE TECHNOLOGY

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

SEMESTER – VII

Subject Code	:	23OE0032		**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

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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