DAYANANDA SAGAR UNIVERSITY SCHOOL OF ENGINEERING

SCHEME & SYLLABUS

BACHELOR OF TECHNOLOGY (B. Tech) –2022

Aerospace Engineering

(With effect from 2023-24)

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	22AS2301	Transforms and Numerical	MAT	3	0	0	0	3	60	40	100	**3**
2	101	22AS2302	Thermodynamics and Heat Transfer	ASE	3	0	0	0	3	60	40	100	**3**
3	101	22AS2303	Introduction to Aerospace	ASE	2	0	0	0	3	60	40	100	**2**
4	101	22AS2304	Fluid Mechanics	ASE	3	0	2	0	3	60	40	100	**4**
5	101	22AS2305	Aerospace Structural Mechanics	ASE	3	0	2	0	3	60	40	100	**4**
6	101	22AS2306	Aerospace Materials	ASE	3	0	2	0	3	60	40	100	**4**
7	101	22AS2307	Special Topics - I	Any Dept.	1	0	0	0	1	60	40	100	**1**
8	101	22AS2308	Skill Enhancement Course – I	ASE	0	0	2	0	2	60	40	100	**1**
			Total		19	0	8	0	27	480	320	800	**22**

IV SEMESTER													
S. N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practica	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	101	22AS2401	Probability and Statistics	MAT	3	0	0	0	3	60	40	100	**3**
2	101	22AS2402	Aerospace Manufacturing	ASE	3	0	2	0	3	60	40	100	**4**
3	101	22AS2403	Introduction to Space Technology	ASE	3	0	0	0	3	60	40	100	**3**
4	101	22AS2404	Aircraft Propulsion	ASE	3	0	0	0	3	60	40	100	**3**
5	101	22AS2405	Low-speed Aerodynamics	ASE	3	0	0	0	3	60	40	100	**3**
6	101	22AS2406	Introduction to Computational Fluid Dynamics	ASE	2	0	2	0	3	60	40	100	**3**
7	101	22AS2407	Special Topics -II	Respective Dept.	1	0	0	0	1	60	40	100	**1**
8	101	22AS2408	Skill Enhancement Course – II	Respective Dept.	0	0	2	0	2	60	40	100	**1**
			Total		15	0	6	0	21	480	320	800	**21**

V SEMESTER													
S.N	Program Code	Course Code	Course Name	Teaching Department	Teaching Hours / Week				Examination				Credits
					Lecture	Tutorial	Practical	Project	Duration in Hours	CIE Marks	SEE Marks	Total Marks	
					L	T	P	J					
1	101	22AS3501	High Speed Aerodynamics	ASE	3	0	0	0	3	60	40	100	3
2	101	22AS3502	Aircraft Performance and Design	ASE	3	0	0	2	3	60	40	100	**4**
3	101	22AS3503	Space Flight Mechanics	ASE	3	0	0	0	3	60	40	100	**3**
4	101	22AS3504	Drives and Actuators	ASE	2	0	2	0	3	60	40	100	**3**
5	101	22AS3505	Introduction to Finite Element Analysis	ASE	2	0	2	0	3	60	40	100	**3**
6	101	22AS35XX	Professional Elective – I	ASE	3	0	0	0	3	60	40	100	**3**
7	101	22AS3506	Model Based System Engineering (MBSE)	ASE	1	0	2	0	2	60	40	100	2
8	101	22AS3507	Skill Enhancement Course – III	ASE	0	0	2	0	1	100	--	100	**1**
9	101	22AS3508	Cognitive and Technical Skills-I		0	0	4	0	1	100	--	100	**2**
			Total		16	0	12	2		620	280	900	**24**

Professional Elective - I

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

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

Professional Elective – II

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

Open Elective – I

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

HIGH SPEED AERODYNAMICS

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

SEMESTER – V

Subject Code	: 22AS3501	**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. 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.

Course Content

UNIT – I	**06 Hours**

One-Dimensional Compressible Flow:

Basic concepts of compressible flow continuity, energy and momentum equations. One dimensional inviscid flow; Stagnation quantities; Isentropic conditions. Speed of sound and Mach number; Isentropic relations; Area-velocity relation, Area Mach number relation.

UNIT – II	**10 Hours**

Normal Shock Waves and Flow through Ducts:

Normal shock waves: Rankine – Huguenot relations, Flow through the convergent-divergent nozzle, and Performance under various back pressures.

Flow through constant area duct with friction (Fanno flow) and Flow through constant area duct with heat addition (Rayleigh flow).

UNIT – III	**08 Hours**

Oblique shocks and Expansion waves:

Oblique shock relations, Supersonic flow past wedges and cones, strong, weak and detached shocks, Shock-interactions and reflections. Flow past convex corners, Prandtl –Meyer expansion, Shock Expansion Theory-Application to supersonic airfoils.

UNIT – IV	**08 Hours**

Steady State Compressible Flows:

Basic potential equations for compressible flow, Linearization of potential equation-small perturbation theory, Linearised supersonic flow, linearised supersonic pressure coefficient, application to supersonic airfoils, Lift, drag and center of pressure of supersonic profiles.

UNIT – V	**07 Hours**

Measurements in High-Speed Flow:

Types of subsonic and Supersonic wind tunnels - characteristic features, their operation and performance. Shock tubes and 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	**Explain** isentropic compressible flows in variable area ducts and **apply** them in the analysis of nozzles and diffusers	L2 & L3
2	**Use** normal shock relations to **calculate** flow properties across the shock wave.	L2 & L3
3	**Solve** for compressible flow characteristics with friction and heat transfer.	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

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	3	3		1	2								3	
CO3	3	3			1								2	
CO4	3	2		1	2								2	
CO5	3	3	1	2	1					1			3	2
CO6	3	2	1		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:

1. https://nptel.ac.in/courses/112103021
2. 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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AIRCRAFT PERFORMANCE AND DESIGN

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

SEMESTER – V

Course Code	:	22AS3502	**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 aircraft performance in steady unaccelerated and accelerated flight.
2. Understand the airplane performance parameters.
3. Acquire the knowledge on aircraft maneuver performance

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	**08 Hours**

THE EQUATIONS OF MOTION STEADY UNACCELERATED 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	**09 Hours**

STEADY PERFORMANCE – LEVEL FLIGHT, CLIMB & GLIDE

Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absoluteceiling, 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 angleof glide.

Fundamental Airplane Performance Parameters The fundamental Parameters: Thrust – to – weight ratio, Wing loading, Drag polar, and lift-to – drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to-drag ratio.	
UNIT – III	**08 Hours**
RANGE AND ENDURANCE Propeller driven Airplane: Physical consideration, Quantitative formulation, Breguet equation forRange and Endurance, Conditions for maximum range and endurance. Jet Airplane: Physical consideration, Quantitative formulation, Equation for Range and Endurance, Conditions for maximum range and endurance, Effect of head wind tail wind.	
UNIT – IV	**07 Hours**
AIRCRAFT PERFORMANCE IN ACCELERATED FLIGHT Take-off Performance: Calculation of Ground roll, Calculation of distance while airborne to clearobstacle, Balanced field length Landing Performance and Accelerated Climb: Calculation of approach distance, Calculation of flaredistance, Calculation of ground roll, ground effects. Acceleration in climb.	
UNIT – V	**07 Hours**
MANEUVERER PERFORMANCE Turning performance: Level turn, load factor, Constraints on load factor, Minimum turn radius,Maximum turn rate. Pull-up and Pull-down maneuvers: (Turning rate, turn radius). Limiting case for large load factor. The V-n diagram.	

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	Understand Equations of motion for unaccelerated steadyflight.	L2 & L3
2	Develop the equation for the steady performance of level, climb and glide flight	L3&L4
3	Calculate the Range and Endurance of propeller driven and jetdriven airplanes	L2 & L3
4	Enumerate aircraft performance like takeoff, and landing of accelerated Flight	L3 & L4
5	Understand the V-n diagram and calculate the Maneuver performance of the accelerated Flight	L2 & L3
6	Understand the different phases of weight estimations required for designing of aircrafts	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	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 InternationalEditions, 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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SPACE FLIGHT MECHANICS

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

SEMESTER – V

Course Code	:	22AS3503	**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 basic concepts of space mechanics and the general N- body.
2. Study satellite injection and satellite orbit perturbations.
3. Acquire the knowledge of interplanetary and ballistic missile trajectories

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
2. *type of teaching methods* may be adopted to develop the course outcomes.
3. ***Interactive Teaching:*** *Adopt* ***Active learning*** that includes brainstorming, discussing, group work, focused listening, formulating questions, note taking, annotating, and roleplaying.
4. Show ***Video/animation*** films to explain the 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 theclass.
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 student's understanding.

Course Content

UNIT – I	**8 Hours**

Introduction of Space Flight Mechanics: Overview of major contents of universe, Introduction to space flight, Introduction to two-body problem, Equations of motion, Kepler's Laws, Conic sections, types of orbits, Conservation of energy and angular momentums, The three-body problem-Lagrange and Euler cases, The n-body problem.

UNIT – II	**08 Hours**

Orbital elements: Coordinate systems- Geocentric right ascension-declination frame , Heliocentric and Geocentric equatorial system, Orbital elements and its determination from position and velocity vector, Effect of oblateness of Earth, Sidereal time, Topocentric coordinate system.

UNIT – III	**10 Hours**

Orbital Maneuvers: In-plane orbit changes, Impulsive maneuvers, Hohmann transfer, Bi-elliptical transfer, plane change maneuvers.

Interplanetary Trajectories: Intercept and Rendezvous, Relative motion in orbit, Two-dimensional interplanetary trajectories, concept of sphere of influence, Planetary departure, Planetary rendezvous, Planetary flyby.

UNIT – IV	**07 Hours**

Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

UNIT – V	**06 Hours**

Satellite Attitude Dynamics: Rigid body dynamics, Principal body axis frame, Parallel axis theorem, Euler's angles, The general torque-free rigid body, Attitude Control: Spinning and Nonspinning spacecrafts,

Satellite Launch Vehicle Motion: Vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging.

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course, the student will be able to:		
1	Apply the basic concepts of space mechanics and the general N-body.	L3&L4
2	Understand different coordinate systems, classify different types of orbits, properties of an orbit.	L3 & L4
3	Use space mechanics laws to summarize different orbital maneuvers.	L3 & L4
4	Distinguish between interplanetary and ballistic missile trajectories	L3 & L4
5	Discuss and compare Satellite launch vehicle trajectories and effect of gravity.	L3 & L4

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

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

Text Books:

1. William E. Wiesel , *Spaceflight Dynamics*, Aphelion Press (2010).
2. Howard Curtis, *Orbital Mechanics For Engineering Students,* Elsevier, 2005.

REFERENCE:

1. Van de Kamp, P., "Elements of Astromechanics", Pitman, 1979
2. Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition ,2010,ISBN-13: 978-1452879598
3. George P. Sutton and Oscar Biblarz, Rocket Propulsion Elements, Wiley India Pvt Ltd, 7th edition, 2010, ISBN-13: 978-8126525775.

DRIVES AND ACTUATORS

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

SEMESTER – V

Subject Code	:	22AS3504	**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 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**

INTRODUCTION:

Introduction to Fluid power, Advantages and Applications, Fluid power systems, Types of fluids, Properties of fluids and selection, Basics of Hydraulics, Pascal's Law, Principles of flow, Friction loss, Work, Power and Torque Problems, Sources of Hydraulic power: Pumping Theory, Pump

Classification, Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of Linear and Rotary, Fixed and Variable displacement pumps.	
UNIT – II	**05 Hours**
Module -2: Aircraft systems Aircraft Hydraulic & Pneumatic Systems Components of a typical Hydraulic system, Working of Hydraulic system, Power packs, Hydraulic actuators. Aircraft, Landing gear and Wheel Braking and Anti-Skid & Shimmy System. Pneumatic system and its components	
UNIT – III	**06 Hours**
MODULE -3: **HYDRAULIC ACTUATORS AND CONTROL COMPONENTS** Hydraulic Actuators: Cylinders, Types and construction, Application, Hydraulic cushioning , Hydraulic motors, Control Components : Direction Control, Flow control and pressure control valves, Types, Construction and Operation, Servo and Proportional valves, Applications	
UNIT – IV	**05 Hours**
Module -4: PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS Properties of air, Perfect Gas Laws, Compressor, Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Cascade method, Electro Pneumatic System, Elements, Ladder diagram, Introduction to fluidics and pneumatic logic circuits	
UNIT – V	**05 Hours**
MODULE -5: HYDRAULIC AND PNEMATIC CIRCUITS Design of hydraulic and Pneumatic circuits, Accessories : Reservoirs, Pressure Switches ,Applications	

Course Outcome	**Description**	**Bloom's Taxonomy Level**
At the end of the course the student will be able to:		
1	Describe the advantages, applications, and basic principles of hydraulics, including pump classifications.	L2 & L3
2	Illustrate the components and functions of aircraft hydraulic and pneumatic systems, such as power packs, actuators, and braking systems.	L2 & L3
3	Analyze the construction, types, and uses of hydraulic actuators and control components, including servo and proportional valves.	L2 & L3
4	Design and implement complex pneumatic and electro-pneumatic systems, focusing on air properties, gas laws, and system components	L2 & L3
5	Develop hydraulic and pneumatic circuits, incorporating accessories like reservoirs and pressure switches for various applications.	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	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	:	22AS3505	**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 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	**05 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	**05 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	**05 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	**06 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	**05 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 EXERCISES

1. Geometry clean-up and defeaturing
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 Non linear capability exploration – material, contact or geometry

Professional Elective I

ROCKETS AND MISSILES

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

SEMESTER – V

Subject Code	: 22AS3509	**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. Comprehend fundamentals of rocket and missile systems, functions and disciplines and the full spectrum of rocket systems, uses and technologies.
2. Classify various types of chemical rocket propulsion systems and their various parameters governing them and understand differences between systems built as weapons and those built for commerce.
3. Determine aerodynamic forces acting on the rocket and missiles.
4. Acquire knowledge of launch vehicle dynamics and attitude control.
5. Explain the requirements of the test facilities for the rocket propulsion system and the selection of materials for rockets and missiles.

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	**06Hours**

Introduction: Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous

space launch vehicles and strategic missiles.

UNIT – II	10 Hours

Solid Propellant Rocket Motor Systems: Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II) the Arienne SRB.

Liquid Propellant Rocket Motor Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build-up, system calibration, integration and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer.

UNIT – III	08 Hours

Electrical Propulsion System: Principles of electric propulsion, Electric thrusters: Electrothermal thrusters, Arc-jet thrusters, Electromagnetic thrusters, Plasma thrusters, Low-power electric thrusters, Applications of electric propulsion.

Nuclear Propulsion System: The principle of nuclear thermal propulsion, fuel elements, exhaust velocity of a nuclear thermal rocket, the nuclear thermal rocket engine, applications.

UNIT – IV	08 Hours

Aerodynamics of Rockets and Missiles: Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through the atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.

UNIT – V	07 Hours

Rocket Testing: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, and post-accident procedures. Description of a typical space launch vehicle launch procedure.

Materials: Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for
pressure vessels.

Course Outcome	Description	Bloom's Taxonomy Level
At the end of the course, the student will be able to:		
1	**Classify** launch vehicles and missiles	L2
2	**Analyse** chemical rocket and missile propulsion systems and **compare** their performance.	L3&L4
3	**Analyse** non chemical rocket and missile propulsion systems and **compare** their performance.	L3&L4
4	**Calculate** aerodynamic forces and moments on rockets and missiles.	L2 & L3
5	**Explain** ground testing facilities for launch vehicles and **Compare** different types of materials used.	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										3	
CO2	3	2			2								3	2
CO3	3	2			2								3	2
CO4	3	2	1		2				1	1			2	2
CO5	2	2					2			1			3	

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

TEXT BOOKS:

1. Turner, M.J.L., 'Rocket and Spacecraft propulsion', Springer,3rd edition, 2010, ISBN-13: 978-3642088698..
2. Jack N Neilson, 'Missile Aerodynamics', AIAA,1st edition, 1988, ISBN-13: 978-0962062902
3. Cornelisse, J.W, Schoyer H.F.R. and Wakker, K.F., Rocket Propulsion and Space-Flight Dynamics, Pitman, 1979, ISBN-13: 978-0273011415

REFERENCE BOOKS:

1. George P Sutton and Oscar Biblarz, 'Rocket Propulsion Element', John Wiley and Sons Inc,7th edition, 2010, ISBN-13: 978-8126525775
2. SS. Chin, 'Missile Configuration Design', McGraw Hill, 1961
3. Parker, E.R., 'Materials for Missiles and Spacecraft', McGraw Hill, 1982.
4. Ramamurthi, K, 'Rocket Propulsion', 2nd Edition, Trinity Press of Laxmi Publications Private Limited, India, 201614

E-Resources:

1. https://nptel.ac.in/courses/101106082
2. https://www.mooc-list.com/tags/rockets

Activity-Based Learning (Suggested Activities in Class)

1. Use of software tools like Rocket Modeler, Kite Modeler, Rocket Simulation
2. Demonstration of the solution to a problem through programming.

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MEASUREMENT TECHNIQUES

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

SEMESTER – V

Subject Code	:	22AS3510	**Credits**	:3	
Hours / Week	:	03 Hours	**Total Hours**	:	39 Hours
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	**07 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 – VI

Subject Code	:	22AS3511	**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. James R. Wertz, David F. Everett, and Jeffery J. Puschell, "Space Mission Engineering: The New SMAD", Microcosm Press, 2015
2. Gregory E. Chamitoff and Srivinas Rao Vadali, "HUMAN SPACEFLIGHT OPERATIONS Lessons Learned from 60 Years in Space", American Institute of Aeronautics and Astronautics, Inc., Reston, Virginia, 2021
3. Florian Sellmaier, Thomas Uhlig, Michael Schmidhuber, "Spacecraft Operations", Springer Nature Switzerland AG 2022

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. Don Edberg and Willie Costa, "Design of Rockets and Space Launch Vehicles", AIAA EDUCATION SERIES, 2022.

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	:	22AS3512	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	00 Hours
L–T–P	:	0–0–0			

Course learning objectives

1. To understand the principles and challenges of manufacturing in space environments.
2. To explore different materials and manufacturing processes suitable for space.
3. To study the impact of space conditions such as vacuum, microgravity, and radiation on manufacturing processes.
4. To design and analyze space manufacturing systems and processes.
5. To investigate the current and future applications of space manufacturing

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**

Overview and Importance of Space Manufacturing

Overview and Importance of Space Manufacturing, History and Development of Space Manufacturing, Key Challenges and Opportunities in Space Manufacturing, Applications of Space Manufacturing

UNIT – II	**08 Hours**

Properties and Selection of Materials

Properties of Materials in Space, Selection of Materials for Space Manufacturing, Composite Materials and Their Applications, Impact of Space Environment on Material Properties

UNIT – III	**07 Hours**

Additive Manufacturing and Advanced Processes

Additive Manufacturing in Microgravity, Extrusion and Molding Techniques for Space, Friction and Explosive Welding in Space, In-Situ Resource Utilization (ISRU)

UNIT – IV	**08 Hours**

Spacecraft and Space Habitat Design Spacecraft and Space Habitat Design for Manufacturing, System Integration and Testing Simulation and Modelling of Space Manufacturing Processes, Automation and Robotics in Space Manufacturing	
UNIT – V	**08 Hours**
Emerging Technologies and Future Directions Emerging Technologies in Space Manufacturing, Economic and Social Impacts of Space Manufacturing, Space Tourism and Colonization, Ethical and Legal Considerations	

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

DATA ANALYSIS AND INTERPRETATION

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

SEMESTER – V

Subject Code	:	22AS3513	**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. 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 : Introduction to Data Analysis	**08 Hours**
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: Data Pre-processing and Cleaning	**06 Hours**
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: Exploratory Data Analysis (EDA)	**09 Hours**
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: Statistical Analysis and Inference	08 Hours
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: Data Visualization and Interpretation	08 Hours
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 pre-process 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		1									
CO2	3	2	2		2									
CO3	3	2	2		2									
CO4	3	2	2		2									
CO5	3	2	2		2									

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

TEXT BOOKS:

1. "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**

MODEL BASED SYSTEM ENGINEERING (MBSE)

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

SEMESTER – V

Subject Code	:	22AS3506	**Credits**	:	03
Hours / Week	:	03 Hours	**Total Hours**	:	13+26 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

SYLLABUS

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
CO1	3	2	2	1		3						1	2	1
CO2	3	2	2	1		3						1	2	1
CO3	3	2	2	1		3						1	2	1
CO4	3	2	2	1		3						1	2	1
CO5	3	2	2	1		3						1	2	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

VI Semester

AVIONICS

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

SEMESTER – VI

Subject Code	:	22AS3601	**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.	1, 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.	3,4
CO5	Identify and select the appropriate avionics system architecture along with applicable standards	3, 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**
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.

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

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

SEMESTER – VI

Subject Code	:	22AS3602	**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.

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

UNIT – I	**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		1
CO3	3	2		3	3							1	1	
CO4	3	2	1	2	1							2	2	1
CO5	3	3			2							1	1	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	:	22AS3603	**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 of 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

TEXT BOOKS:

1. Singiresu S. Rao, "Mechanical Vibrations", 6th Edition, Pearson,2018
2. Gene F. Franklin, J. David Powell, Abbas Emami-Naeini., "Feedback Control of Dynamic Systems", 8th Ed., Pearson, 2022.
3. Norman S. Nise., "Control Systems Engineering", Wiley India, 2018

REFERENCE BOOKS:

1. S. Graham Kelly, "Mechanical Vibrations – Theory and Applications", Cengage Learning, 2012
2. Katsuhiko Ogata, Modern Control Engineering, 5th Ed., Pearson Education, 2015
3. M.Gopal, Control Systems Principles and Design, TMH, 4th edition, 2012
4. Rao V. Dukkipati, "Analysis and Design of Control Systems using MATLAB", 2nd Edition, New Age Science Ltd, 2009.
5. Farid Golnaraghi and Benjamin C. Kuo, "Automatic Control Systems", 9th edition, Wiley, 2014

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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Artificial Intelligence and Machine Learning

As per credit based system (CBCS)
Semester: VI

Subject Code	:	22AS3604	**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 Visualization	
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)												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1									1		
CO2	3	2	3	1								1	1	1
CO3	2	2		1								1	1	1
CO4	3	3		1								1	1	2
CO5	2	2		1	3				1		2	1	2	1

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

Text Books

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

Reference Books

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

Professional Elective II

HEAT TRANSFER FOR AEROSPACE APPLICATIONS

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

SEMESTER -VI

Subject Code	: 22AS3607		**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:

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. Different Modes of Heat Transfer, Material and Transport Properties in Heat Transfer.

Heat Conduction: 1 D Steady Conduction: Plane walls, radial systems, heat transfer from extended surfaces. 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 Reentry 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	L2
2	Calculate the convective heat transfer rate in free and forced convection by using semi-empirical correlations for different types of flows and geometries.	L2 & L3
3	Evaluate emissive and spectral emissive power for a black and grey surface, and determine radiation heat transfer between enclosures.	L2
4	Evaluate different active and passive heating/cooling mechanisms	L2 & 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)

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SYSTEMS ENGINEERING

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

SEMESTER – VI

Subject Code	:	22AS3608	**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.

SYLLABUS

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
CO2	**Identify** and **formulate** the requirements that influence the overall system functionality and performance	4
CO3	Given the requirements and constraints, **design** and **develop** the System Architecture and Design	4
CO4	**Perform** the System Development, Testing and Optimisation for engineering applications	4
CO5	**Synthesise** the requirements, constraints, and designs, achieving the overall system functionality and performance	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
CO1	3	2	2	1								1	2	1
CO2	3	2	2	1								1	2	1
CO3	3	2	2	1								1	2	1
CO4	3	2	2	1								1	2	1
CO5	3	2	2	1								1	2	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:

INCOSE Systems Engineering Handbook, Version 5

1. 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 SYSTEM DESIGN

SEMESTER – VI

Subject Code	:	22AS3609	**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	**07 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	**07 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	:	22AS3610	**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)**

Text Books:

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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INDUSTRY 4.0

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

SEMESTER –VI

Subject Code	: 22AS3611		**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	**09 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)**

TEXT BOOKS

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

WEBLINKS

http://www.mqtt.org
https://opcfoundation.org/about/opc-technologies/opc-ua/
https://www.profibus.com/pi-organization/about-pi/organization-communitu/
https://www.ethercat.org/default.htm

Open Elective I

INTRODUCTION TO AEROSPACE ENGINEERING

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

Subject Code	:	22OE0053	**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.

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, 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 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, private players in the aerospace industry, space explorations, space debris, Reusable Rockets, Space telescopes, AI & Digital twin technology	

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
CO1	3	3		2	3							2		
CO2	3	3	2	3	3							2		
CO3	3	3		3	3		1					1		
CO4	3	3	2	2	3							2		
CO5	3	3			2		1					1		

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 IN AEROSPACE

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

SEMESTER – VI

Subject Code	:	22OE0054	**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.

SYLLABUS

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	3
5	Identify and select appropriate modern operational concepts including digital manufacturing	3

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

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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FLIGHT PHYSICS LABORATORY

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

Subject Code	: 22AS3605			**Credits**	:	01
Hours / Week	:2	02 Hour		**Total Hours**	:	26 Hours
L–T–P	: 1–0–1					

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 over objects using smoke flow and tuft-flow visualization techniques

LIST OF EXPERIMENTS

1. Calibration of subsonic wind tunnel: Test section static and total pressure distribution
2. Measurement of pressure distribution over aerofoils
3. Measurement of pressure distribution over a bluff body
4. Flow visualization using smoke and tuft techniques
5. Flow over flat plate
6. Smoke flow visualization studies on a two dimensional circular cylinder at low speeds.
7. Flow visualization on a wing model at different angle of incidence at low speeds: Identify zones of attached and separated flows.
8. Force measurement
9. Experimental study of flow over objects that students can design and develop, as a part of the Course on Wind-Tunnel testing