GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT (GITAM)

(Deemed to be University)

VISAKHAPATNAM * HYDERABAD * BENGALURU

Accredited by NAAC with A^{++} Grade

GITAM School of Technology

CURRICULUM AND SYLLABUS

2 Year Postgraduate Programme
PAERO01: M.Tech. Aerospace Engineering

w.e.f. 2024-25 admitted batch

(Updated on July 2024)

GANDHI INSTITUTE OF TECHNOLOGY AND MANAGEMENT

Vision

To become a global leader in higher education.

Mission

To impart futuristic and comprehensive education of global standards with a high sense of discipline and social relevance in a serene and invigorating environment.

Quality Policy

To achieve global standards and excellence in teaching, research, and consultancy by creating an environment in which the faculty and students share a passion for creating, sharing and applying knowledge to continuously improve the quality of education.

GITAM School of Technology

Vision

To become a global leader in holistic engineering education and research

Mission

1. To impart a strong academic foundation and practical education through a flexible curriculum, state of the art infrastructure, and best learning resources

2. To actively pursue academic and collaborative research with industries and research institutions, both in India and abroad

3. To build a congenial and innovative eco system by enabling the latest technologies, thus helping the students, to solve the challenges of societal importance

4. To provide our students with the appropriate leadership, management, communication skills and professional ethics for career success and to continuously impact the global lives

REGULATIONS AND SYLLABUS

of

Master of Technology

in

Aero Space Engineering

(w.e.f 2024-25 admitted batch)

A University Committed to Excellence

M.Tech in Aero Space
REGULATIONS
(w.e.f. 2024-25 admitted batch)

1. ADMISSION

Admission into M.Tech in Aerospace Engineering program of GITAM (Deemed to be University) is governed by GITAM admission regulations.

2. ELIGIBILITY CRITERIA

A pass in B.E./B.Tech./AMIE in Aerospace Engineering or its equivalent.

Admissions into M. Tech will be based on the following:

(i) Score obtained in GAT (PG), if conducted.

(ii) Performance in Qualifying Examination/Interview.

(iii) Candidates with valid GATE score shall be exempted from appearing for GAT(PG).

The actual weightage to be given to the above items will be decided by the authorities at the time of admissions.

3. CHOICE BASED CREDIT SYSTEM

Choice Based Credit System (CBCS) is introduced in order to promote:

- Student centered Learning
- Activity based learning
- Students to learn courses of their choice
- Cafeteria approach

Learning objectives and outcomes are outlined for each course to enable a student to know what he/she will be able to do at the end of the program.

4. STRUCTURE OF THEPROGRAM

The Program Consists of

i) Core Courses (compulsory) which give exposure to a student in core subjects related area.

ii) Program Electives.

iii) Open Electives

iv) Mandatory and Audit Courses

Each course is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week.

In general, credits are assigned to the courses based on the following contact hours per week per semester.

- One credit for each Lecture / Tutorial hour per week.
- One credit for two hours of Practical per week.

The curriculum of the four semesters M.Tech. program is designed to have a total of 71 credits for the award of M.Tech. Degree.

5. MEDIUM OF INSTRUCTION

The medium of instruction (including examinations and project reports) shall be English.

6. REGISTRATION

Every student has to register for the courses in each semester at the time specified in the academic calendar.

7. ATTENDANCEREQUIREMENTS

A student whose attendance is less than 75% in all the courses put together in any semester will not be permitted to attend the semester-end examination and he/she will not be allowed to register for subsequent semester of study. He/she has to repeat the semester along with his/her juniors.

However, the Vice-Chancellor on the recommendation of the Principal/Director of the Institute/School may condone the shortage of attendance to the students whose attendance is between 65% and 74% on genuine grounds and on payment of prescribed fee.

8. EVALUATION

The assessment of the student's performance in a theory course shall be based on two components: Continuous Evaluation (40 marks) and semester-end examination (60 marks).

A student has to secure a minimum of 40% in any theory course in the two components (ref. Table.1) put together to be declared to have passed the course, subject to the conditionthat the student must have secured a minimum of 24 marks out of 60 marks (i.e. 40%) in the theory component at the semester-end examination.

Practical/ Project Work/ Viva voce/ Seminar etc. course is completely assessed under Continuous Evaluation for a maximum of 100 marks, and a student has to obtain aminimum of 40% to secure Pass Grade. Details of assessment procedure are furnished below in Table1. Audit courses are assessed through continuous evaluation for satisfactory or not satisfactory only. No credits will be assigned.

Table 1: Assessment Procedure

S.No.	Component of Assessment	Marks Allotted	Type of Assessment	Scheme of Evaluation
1	Theory Courses	40	Continuous Evaluation	i) Thirty (30) marks for mid Semester examinations. Three mid examinations shall be conducted for 15 marks each; performance in best two shall be taken into consideration. ii) Ten (10) marks for Quizzes, Assignments and Presentations. Sixty (60) marks for Semester-end examinations
		60	Semester-end Examination	
	Total	100		

2	Practical Courses	100	Continuous Evaluation	i) Fifty (50) marks for regularity and performance, records and oral presentations in the laboratory. Weightage for each component shall be announced at the beginning of the semester. ii) Ten (10) marks for case studies. iii) Forty (40) marks for two tests of 20 marks each (one at the mid-term and the other towards the end of the semester) conducted by the concerned lab teacher.
3	Technical Seminar (II Semester)	100	Continuous Evaluation	Through five periodic seminars of 20 marks each
4	Project Work (III Semester)	100	Continuous Evaluation	i) Forty (40) marks for periodic assessment on originality,innovation, sincerity and progress of the work, assessed by the project supervisor. ii) Thirty (30) marks for mid-term evaluation for defending the project, before a panel of examiners. iii) Thirty (30) marks for final report presentation and viva-voce, by a panel of examiners*.
5	Project Work (IV Semester)	50	Continuous Evaluation	i) Twenty (20) marks for periodic assessment on originality innovation, sincerity and progress of the work, assessed by the project supervisor. ii) Fifteen (15) marks for mid-term evaluation for defending the project, before a panel of examiners*. iii) Fifteen (15) marks for interim report presentation and viva-voce.
		50	Semester-end Examination	Fifty (50) marks for final project report and viva-voce examination assessed by external examiners.
	Total	100		

6	Audit Courses	100	Continuous Evaluation	Audit courses are assessed for PASS or FAIL only. No credits will be assigned to these courses. If a student secures a minimum of 40 out of 100 marks during continuous evaluation, he / she will be declared PASS, else FAIL. PASS grade is necessary to be eligible to get the degree

**Panel of Examiners shall be appointed by the concerned Head of the Department*

9. PROVISION FOR ANSWER BOOK VERIFICATION AND CHALLENGE EVALUATION

If student is not satisfied with his/her grade, the student can apply for answer book verification on payment of prescribed fee for each course within one week after announcement of results.

After verification, if a student is not satisfied with revaluation marks/grade, he/she can apply for challenge valuation within one week after announcement of answer book verification result or two weeks after the announcement of results, which willbe valued by two examiners i.e., one Internal and one External examiner in the presence of the student on payment of prescribed fee. The challenge valuation fee will be returned, if the student is successful in the appeal by securing a better grade.

10. SUPPLEMENTARY AND SPECIAL EXAMINATIONS

The odd semester supplementary examinations will be conducted after conducting regular even semester examinations during April/May.

The even semester supplementary examinations will be conducted after conducting regular odd semester examinations during October/November.

A student who has secured 'F' Grade in Project work shall have to improve his/her work and reappear for viva-voce after satisfactory completion of work approved by panel of examiners.

A student who has completed period of study and has "F" grade in final semester courses is eligible to appear for special examination.

11. MASSIVE OPEN ONLINE COURSES(MOOCs)

Greater flexibility to choose variety of courses is provided through Massive Open Online Courses (**MOOCs**) during the period of study. Students without any backlog courses up to first semester are permitted to register for MOOCs in second semester up to a maximum of 6 credits from program elective/open elective/audit courses. However, the Departmental Committee (DC) of the respective campuses has to approve the courses under MOOCs. The grade equivalency will be decided by the respective Board of Studies(BoS).

12. GRADING SYSTEM

Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given in Table 2.

Table 2: Grades and Grade Points

S.No.	Grade	Grade Points	Absolute Marks
1	O (outstanding)	10	90 and above
2	A+ (Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79
4	B+ (Good)	7	60 to 69
5	B (Above Average)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab (Absent)	0	-

A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, and is deemed to have earned the credits assigned to that course, subject to securing a GPA of 5.0 for a Pass in the semester.

13. GRADE POINT AVERAGE

A Grade Point Average (GPA) for the semester will be calculated according to the formula:

$$GPA = \frac{\Sigma [C \times G]}{\Sigma C}$$

where, C = number of credits for the course,

G = grade points obtained by the student in the course.

The Cumulative Grade Point Average (CGPA), is calculated using the above formula considering the grades obtained in all the courses, in all the semesters up to that particular semester.

CGPA required for classification of class after the successful completion of the program is shown in Table 3.

Table 3: CGPA required for Award of Class

Class	CGPA Required
First Class with Distinction	$\geq$ 8.0*
First Class	$\geq$ 6.5
Second Class	$\geq$ 5.5
Pass Class	> 5.0

* In addition to the required CGPA of 8.0 or more, the student must have necessarily passed all the courses of every semester in the first attempt.

14. ELIGIBILITY FOR AWARD OF THE M.Tech DEGREE

Duration of the program: A student is ordinarily expected to complete the M.Tech. Program in four semesters of two years. However, a student may completethe program in not more than four years including study period.

However, the above regulation may be relaxed by the Vice-Chancellor in individual cases for cogent and sufficient reasons.

A student shall be eligible for award of the M.Tech Degree if he / she fulfills all the following conditions.

a) Registered and successfully completed all the courses and project works.

b) Successfully acquired the minimum required credits as specified the curriculum corresponding to the branch of his/her study within the stipulatedperiod.

c) Has no dues to the Institute, Hostels, Libraries, NCC / NSS etc., and

d) No disciplinary action is pending against him/her.

15. DISCRETIONARY POWER

Not with standing anything contained in the above sections, the Vice Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

DEPARTMENT OF AERO SPACE ENGINEERING

Program-Specific Outcomes (PSOs)

PSO 1: Advanced Aerospace Analysis and Design Skills - Apply advanced analytical methods and design techniques to solve complex problems in the field of aerospace engineering, incorporating interdisciplinary knowledge.

PSO 2: Computational and Experimental Proficiency - Utilize sophisticated computational tools and experimental methods to simulate, model, and analyze aerospace systems, components, and structures, interpreting results for optimization.

PSO 3: Aerospace Systems Integration - Integrate knowledge from various aerospace engineering disciplines to design and analyze complete aerospace systems, considering factors such as aerodynamics, propulsion, materials, and control systems.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: Acquire adequate knowledge both in practical and theoretical domains in the field of Aerospace Technology through post graduate education.

PEO 2: Train students to have successful technical and managerial career in aerospace industries and the allied management.

PEO 3: Guide students to learn and adapt new technology developments to contribute for the current needs of the Aerospace Technology.

PEO 4: Prepare students to excel in aerospace technology with an academic environment aware of leadership and the life-long learning needed to meet out the changing industrial scenarios.

PEO 5: Possess an entrepreneurial mindset and be able to identify and pursue opportunities for innovation in the aerospace sector.

PROGRAM OUTCOMES (POS)

PO1. **Advanced Knowledge:** Demonstrate advanced understanding of fundamental principles, theories, and concepts in aerospace engineering, including aerodynamics, propulsion, structures, materials, control systems, and space science.

PO2. **Problem Solving Skills:** Apply analytical and critical thinking to solve complex problems in aerospace engineering, integrating knowledge from multiple disciplines within the field.

PO3. **Research Competence:** Conduct independent and original research in aerospace engineering, including the ability to formulate research questions, design experiments, collect and analyze data, and draw meaningful conclusions.

PO4. **Advanced Design and Analysis:** Apply advanced techniques for the design, analysis, and optimization of aerospace systems, components, and structures, taking into consideration constraints such as safety, reliability, and environmental impact.

PO5. **Computational and Experimental Skills:** Utilize computational tools and experimental methods to simulate, model, and test aerospace systems, and interpret results to enhance the understanding and performance of aerospace technologies.

PO6. **Communication Skills:** Effectively communicate complex technical concepts, research findings, and design solutions to both technical and non-technical audiences through written reports, oral presentations, and visual representations.

PO7. **Teamwork and Collaboration:** Collaborate effectively within interdisciplinary teams, demonstrating leadership and teamwork skills in solving real-world aerospace engineering challenges.

PO8. **Ethical and Professional Conduct:** Adhere to ethical standards and professional conduct in aerospace engineering practice, understanding the social, environmental, and economic implications of engineering decisions.

PO9. **Lifelong Learning:** Demonstrate a commitment to continuous learning and professional development, staying abreast of advancements in aerospace engineering and related fields.

PO10. **Global and Societal Impact:** Understand the global and societal impact of aerospace engineering, including considerations for sustainability, safety, and ethical responsibilities in the development and deployment of aerospace technologies.

M.Tech Aero Space Engineering

Department of Aerospace Engineering
Effective from academic year 2024-25 admitted batch

Credits Distribution

Category	**Credits**
Program Core (PC)	**25**
Program Elective (PE)	**12**
Mandatory Course (MC)	**5**
Open Elective (OE)	**3**
Project Work (PW)	**26**
Audit Course	**0**
Total	**71**

SEMESTER I

S.No.	Course Code	Course Title	Category	L	T	P	C
1	AERO6001	Engineering Aerodynamics and Flight Mechanics	PC	3	0	0	3
2	AERO6011	Spacecraft Propulsion	PC	3	0	0	3
3	AERO6021	Airplane and Aerospace Structures	PC	3	0	0	3
4	AEROXXXX	Program Elective 1	PE	3	0	0	3
5	AEROXXXX	Program Elective 2	PE	3	0	0	3
6	AERO6031	Experiments in Aerospace Engineering	PC	0	0	6	3
7	20EMC781	Research Methodology and IPR	MC	2	0	0	2
8	20EAC7XX	Audit Course I	AC	2	0	0	0
Total credits							20

SEMESTER II

S.No.	Course Code	Course Title	Category	L	T	P	C
1	AERO7011	Aircraft and Spacecraft Design	PC	4	0	0	4
2	AERO7001	Space Mechanics and Orbital Dynamics	PC	4	0	0	4
3	AERO7021	Aircraft Systems and Avionics	PC	4	0	0	4
4	AEROXXXX	Program Elective 3	PE	3	0	0	3
5	AEROXXXX	Program Elective 4	PE	3	0	0	3
6	20EOE7XX	Open Elective	OE	3	0	0	3
7	AERO7031	Technical Seminar	PC	0	0	4	1
8	20EAC7XX	Audit Course II	AC	2	0	0	0
9	HSMCH102	Universal Human Values -II: Understanding Harmony	MC	2	1	0	3
Total Credits							25

SEMESTER III

S.No.	Course Code	Course Title	Category	L	T	P	C
1	24PROJ7888	Project Work I	PW	0	0	26	13
Total Credits							13

SEMESTER IV

S.No.	Course Code	Course Title	Category	L	T	P	C
1	24PROJ7999	Project Work II	PW	0	0	26	13
Total Credits							13

Number of Credits

Semester	I	II	III	IV	Total
	20	25	13	13	71

Audit Course I and II

S.No.	Course Code	Course Title	Category	L	T	P	C
1	20EAC741	English for Research Paper Writing	AC	2	0	0	0
2	20EAC742	Disaster Management	AC	2	0	0	0
3	20EAC743	Sanskrit for Technical Knowledge	AC	2	0	0	0
4	20EAC744	Value Education	AC	2	0	0	0
5	20EAC745	Constitution of India	AC	2	0	0	0
6	20EAC746	Pedagogy Studies	AC	2	0	0	0
7	20EAC747	Stress Management by Yoga	AC	2	0	0	0
8	20EAC748	Personality Development Through Life Enlightenment Skills	AC	2	0	0	0
9	20EAC750	Developing Soft Skills and Personality	AC	2	0	0	0

Program Electives

S.No.	Course Code	Course Title	Category	L	T	P	C
1	AERO7041	Launch Vehicle Performance ,Design and System Engineering	PE	3	0	0	3
2	AERO7051	Launch Vehicle Guidance, Navigation and Control	PE	3	0	0	3
3	AERO7061	Launch Vehicle Integration	PE	3	0	0	3
4	AERO7071	Applied Computational Fluid Dynamics	PE	3	0	0	3
5	AERO6041	Fundamentals of Acoustics	PE	3	0	0	3
6	AERO6051	Hypersonic Flow Theory	PE	3	0	0	3
7	AERO7081	Applied Finite Element Analysis	PE	3	0	0	3
8	AERO7091	Robotics and Control	PE	3	0	0	3
9	AERO6061	Aerospace Material Characterization	PE	3	0	0	3
10	AERO7101	Aerodynamics of Turbomachinery	PE	3	0	0	3
11	AERO7111	Hydrodynamics of Rocket Pumps	PE	3	0	0	3

Open Electives

Open Electives S. No	Course Code	Course Title	Category	L	T	P	C
1	20EOE742	Business Analytics	OE	3	0	0	3
2	20EOE744	Industrial Safety	OE	3	0	0	3
3	20EOE746	Operations Research	OE	3	0	0	3
4	20EOE748	Cost Management of Engineering Projects	OE	3	0	0	3
5	20EOE752	Waste to Energy	OE	3	0	0	3

Program Core

S. No	Course Code	Program Core	L	T	P	C	Course Owner
1	AERO6001	Engineering Aerodynamics and Flight Mechanics	3	0	0	3	AE
2	AERO6011	Spacecraft Propulsion	3	0	0	3	AE
3	AERO6021	Airplane and Aerospace Structures	3	0	0	3	AE
4	AERO7001	Space Mechanics and Orbital Dynamics	4	0	0	4	AE
5	AERO6031	Experiments in Aerospace Engineering	0	0	6	3	AE
6	AERO7011	Aircraft and Spacecraft Design	4	0	0	4	AE
7	AERO7021	Aircraft Systems and Avionics	4	0	0	4	AE
8	AERO7031	Technical Seminar	0	0	4	1	AE
		Total Credits				**25**	

Program Electives

S.No.	Course Code	Course Title	L	T	P	C	Course Owner
1	AERO7041	Launch Vehicle Performance, Design and System Engineering	3	0	0	3	AE
2	AERO7051	Launch Vehicle Guidance, Navigation and Control	3	0	0	3	AE
3	AERO7061	Launch Vehicle Integration	3	0	0	3	AE
4	AERO7071	Applied Computational Fluid Dynamics	3	0	0	3	AE
5	AERO6041	Fundamentals of Acoustics	3	0	0	3	AE
6	AERO6051	Hypersonic Flow Theory	3	0	0	3	AE
7	AERO7081	Applied Finite Element Analysis	3	0	0	3	AE
8	AERO7091	Robotics and Control	3	0	0	3	AE
9	AERO6061	Aerospace Materials and Characterization	3	0	0	3	AE
10	AERO7101	Aerodynamics of Turbomachinery	3	0	0	3	AE
11	AERO7111	Hydrodynamics of Rocket Pumps	3	0	0	3	AE
		Total Credits (4 courses to be selected)				**12**	

Program Core

AERO6001	**Engineering Aerodynamics and Flight Mechanics**	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description: This course provides an in-depth study of aerodynamics and flight mechanics, focusing on the principles and concepts essential for the analysis ,design and stability of aircraft. The course integrates theoretical foundations with practical applications to foster a comprehensive understanding of the complex interactions involved in flight mechanics and dynamics.

Course Educational Objectives: In this course students should be able to:

1. Provide students with a deep understanding of aerodynamics principles, including fluid dynamics, airfoil design, and aircraft performance, to design and analyze advanced aerospace systems
2. Equip students with the skills and knowledge to analyze the principles behind the formation of shocks
3. Learn the principles of flight control systems and their role in stabilizing and maneuvering aircraft.
4. Enable students to apply computational methods and software tools to model and simulate complex Stability and performance criteria.
5. Enhance the fundamental understanding of Building and Sports aerodynamics.

UNIT 1 **9 hours**

Basic Aerodynamic Principles : Governing equations, Wing and airfoil geometry, aerodynamic force and moments, pressure distribution, aerodynamic center, center of pressure.

Thin Airfoil Theory: Vortex sheet, Kutta condition and Kelvin's circulation theorem. Classical thin airfoil theory: symmetric and cambered airfoil.

Finite Wing Theory: Downwash, induced drag, Biot-Savart's law and Helmholtz's theorem. Prandtl's classical lifting line theory, Elliptic and general lift distribution over finite unswept wings, effect of aspect ratio ,3D panel methods, Viscous Incompressible Flows:Prandtl boundary layer equation.

UNIT 2 **9 hours**

Isentropic Flows: Steady one-dimensional isentropic flow: differential equations for 1D flow, isentropic flow with area variation, area-velocity relation and its application.

Shock Theory: Normal shock concept, normal shock relations, stationary normal shocks, Oblique shocks, concept and theory, oblique shock relations.

Unit 3 **9 hours**

Aircraft Performance: Steady level flight, range, endurance, gliding, climbing flight, pull-up, pulldown, take-off, landing, accelerating climb, turning flight,V-n diagrams–optimal cruise trajectories, turning performance, horizontal and vertical turn, pull up and pull down.

Unit 4 **9 hours**

Static Stability& Control: frames of reference(body axis,wind axis), static longitudinal, directional, lateral stability and control,stick fixed and stick free stability,hinge moments,trim-tabs,aerodynamic balancing .

Dynamic Stability and control-Equations of motion and Phugoid. Dynamic stability Case study of different flights .

Unit 5 **9 hours**

Sports and Buiding Aerodynamics- sprint aerodynamics, Mathematical-physical model of running, Wind effects, Stadium aerodynamics , cycling aerodynamics, Wind-tunnel testing for single cyclist, Wind flow around buildings, Natural ventilation of buildings, Wind energy in the built environment .

Textbook:

1. J. D. Anderson, Introduction to Flight, 8/e, McGraw Hill, 2018.

2. E. L. Houghton, P. W. Carpenter, S. H. Collicott and D. T. Valentine, Aerodynamics for Engineering Students, 6/e , Elsevier, 2016.

3. J. D. Anderson, Aircraft Performance and Design, 7/e, McGraw Hill, 2016.

4. B. N. Pamadi, Performance, Stability, Dynamics, and Control of Airplane; 2/e, AIAA, 2004.

References:

1. J. J. Bertin and R. Cummings, Aerodynamics for Engineers, 6/e, Pearson, 2013.

2. A.W. Babister, Aircraft Stability and Response, Pergamon Press, 1980.

3. R. C. Nelson, Flight Stability and Automatic Control, 2/e, McGraw Hill, 2004.

4. Tom Lawson,Building Aerodynamics,2/e,Imperial college Press, 2001.

Course Outcomes:

1. Apply appropriate theoretical and numerical methods to estimate aerodynamic characteristics of an airfoil.
2. Exhibit knowledge of quantification of supersonic flow shock field concepts.
3. Apply control system and maneuvering methodologies to solve flight control problems.
4. Characterize and Quantify relevant flight Stability and the disturbances acting on an aircraft.
5. Implement the practical application of Sports and Building Aerodynamics to real world Problem.

AERO6011	Spacecraft Propulsion	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description: The course is designed with content suitable for propulsion needs of spacecrafts systems used for flying across space. It gives knowledge on the functioning of chemical, non-chemical power plants engaged in rocket, and space crafts. It brings out advanced and miniaturized propulsion engines used for variety of flying systems.

Course Educational Objectives: In this course , students should be able to:

1. Appreciates working of spacecraft nozzle and its performance estimation.
2. Learn working of liquid rocket engine, solid rocket motor and associated propellant properties.
3. Gains knowledge on variety of electrical and miniaturized propulsion systems
4. Understand functioning of solar, laser and alternate thermal propulsion systems
5. Study the working of rocket combustion systems.

UNIT – I **8 hours**

Spacecraft Nozzle Performance: Types of rocket nozzle, nozzle flow, design parameters, Characteristic velocity, exhaust velocity and effective velocity**,** Nozzle area ratio, thrust and thrust coefficient, Numerical.

UNIT – II **9 hours**

Spacecraft Rocket Engines: Liquid engine, Propellant tanks, types of propellants, valves and piping, Turbopump feed system, Gas pressurised feed system, Auxiliary feed systems: OMS and RCS systems
Spacecraft Engine Propellants: Performance of propellants, physical hazards, desirable physical properties, Liquid Oxidizers, Liquid fuels, Liquid monopropellant, and gaseous propellant
Thrust Chambers: Injectors: Types, hydrodynamics, Combustion chamber, Starting and ignition, Combustion Process, Heat transfer and cooling of rocket combustion system.

UNIT - III **9 hours**

Spacecraft Rocket Motors: Solid motor structure, function, burn rate and modifiers, Propellant grain and configurations, Grian stress and strain, Classification, characteristics and hazards, Propellant ingredients and properties.
Propellant Combustion: Liners, Insulation and Inhibitors, Propellant processing and manufacturing, Physical and chemical processes, Grain ignition and burning, Ignition hardware.

UNIT – IV **9 hours**

Laser Propulsion Systems: Introduction, Schematic, working of Laser systems, Mission requirements and applications, Laser system requirement and state of art
Solar Sails: Introduction, nomenclature, basic principles of solar sail, Basic requirements and performance parameters, Ground based solar sail technology and analysis.

UNIT – V **8 hours**

Electrical Propulsion Systems: Ion thrusters, Hall effect thrusters, Field emission thrusters

Miniaturized Propulsion: Introduction and Choice of Micro Propulsion Systems, Chemical propulsion, cold gas thrusters, Alpha thrusters, FMMR, FEEP, Technological Challenge

Textbooks

1. Rocket Propulsion Elements" by George P. Sutton and Oscar Biblarz, 9/e 2018
2. Introduction to Rocket Science and Engineering, 2/e 2017
3. Fundamentals of Electric Propulsion: Ion and Hall Thrusters" by Dan M. Goebel and Ira Katz, 1/e 2008

References

1.Rocket Propulsion by Jack D. Mattingly and Keith M. Boyer, 2/e 2017

2. Aerothermodynamics of Gas Turbine and Rocket Propulsion" by Gordon C. Oates, 3/e

3. Modern Engineering for Design of Liquid-Propellant Rocket Engines" by Dieter K. Huzel and David H. Huang

Course outcomes:

Upon completion of this course the students will be able to:

1. Gain solid knowledge on fundamentals of spacecraft propulsion and nozzle performance.
2. Appreciate significance of liquid engine, variety of fuels, and their combustion
3. Compare and judge suitability of liquid rocket engines and solid rocket motors.
4. Demonstrate knowledge on electric and miniaturized propulsion systems.
5. Appraise the significance of laser and solar propulsion systems.

AERO6021	**Airplane and Aerospace Structures**	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description

This course provides an in-depth study of the principles and methods used in the structural analysis and design of aircraft airframes. Covering both classical hand-calculation methods and modern computational techniques, the course addresses the behavior of structural elements under various loading conditions, the analysis of stress and strain, buckling, torsion, fatigue, and dynamic response of aircraft structures. Through theoretical lectures, numerical problem-solving, and case studies, students will gain a comprehensive understanding of the design considerations and challenges in the field of aerospace structural engineering.

Course Educational Objectives

1. To understand the fundamental principles of elasticity and structural analysis as they pertain to airframe design.
2. To analyze the loads acting on aircraft structures and determine the resulting stress distributions and deformations.
3. To learn the analytical methods for evaluating the strength and stability of aircraft structural components.
4. To explore modern materials and methods used in airframe construction and their influence on structural performance.
5. To apply failure theories to the design and analysis of airframe structures for ensuring safety and reliability.

UNIT 1 **10 hours**

Fundamentals of Airframe Structural Analysis: Introduction to Structure and Structural Analysis: Basic concepts of determinate and indeterminate structures, stability and elasticity principles, and Maxwell's Reciprocal Theorem. Load Analysis: Understanding different types of loads acting on aircraft and the stress analysis due to these loads. Basic Elasticity and Two-Dimensional Problems: Addressing problems in elasticity with relevance to airframe structures.

UNIT 2 **8 hours**

Airframe Structural Members and Deflection Analysis: Analysis of Structural Components: Study of beams, including slope and deflection, and application of energy methods like Castigliano's Theorem.**Perfect Pin-Jointed Frames Analysis**: Analysis of truss systems, including methods to identify zero-force members. **Shear Stress and Bending**: Calculation of shear stress due to bending, including asymmetric beams and shear flow in thin-walled structures.

UNIT 3 **10 hours**

Energy Methods and Stability Analysis : Strain Energy Concepts: Introduction to strain energy, resilience, and energy methods in structural analysis. Column Buckling: Fundamentals of column buckling analysis, including Euler's theory for long columns and Rankine formula. Failure Theories: Discussion of failure theories relevant to airframe structures, including maximum principal stress, shear stress, and strain theories.

UNIT 4 **7 hours**

Advanced Topics in Structural Analysis: Torsional Analysis of Airframe Structures: In-depth examination of torsion in round bars, thin plates, and multi-cell structures.

Buckling of Complex Structures: Advanced study of buckling in compression members, stiffened panels, and thin-walled structures.

Fatigue and Fracture Mechanics: Overview of fatigue life calculation methods and introduction to fracture mechanics as applied to airframe maintenance.

UNIT 5 **9 hours**

Dynamic Analysis of Airframe Structures: Vibration Analysis: Fundamentals of rigid body vibration, including single degree of freedom systems using equilibrium approach and energy methods. **Dynamic Load Analysis**: Understanding the effects of dynamic loads, such as sudden loads and impact loads, on the structural integrity of airframes

Textbooks

1. "Aircraft Structures for Engineering Students" by T.H.G. Megson: This textbook is an established comprehensive overview of the science and practice of airframe structural design.
2. "Analysis of Aircraft Structures: An Introduction" by Bruce K. Donaldson: This book provides a valuable resource for understanding the basics of structural analysis, including elasticity, loads, and failure analysis.

References

1. "Roark's Formulas for Stress and Strain" by Warren C. Young and Richard G. Budynas: A classic reference providing reliable formulas for computing stresses in structural members.
2. "Fundamentals of Aerodynamics" by John D. Anderson Jr.: While primarily focused on aerodynamics, this book offers insights into the loads acting on aircraft structures.

AERO7001	Space Mechanics and Orbital Dynamics	L	T	P	S	J	C
		4	0	0	0	0	4

Course Description:

Space Mechanics and Orbital Dynamics is an advanced undergraduate or graduate-level course that delves into the principles governing the motion of objects in space. This course combines theoretical concepts with practical applications to provide students with a comprehensive understanding of the dynamics of celestial bodies, spacecraft, and satellites.

Course Educational Objectives:

- Develop a deep understanding of the fundamental principles governing the motion of objects in space, including celestial bodies, spacecraft, and satellites.
- Master the mathematical models and concepts related to orbits, including Kepler's laws, conic sections, and orbital transfers.
- Learn how to plan and design space missions, including orbit determination, trajectory optimization, and rendezvous and docking procedures.
- Understand the dynamics of spacecraft, including attitude control, stabilization, and the effects of external forces like gravity and solar radiation pressure.
- Study the effects of perturbing forces on orbital motion, such as the oblateness of celestial bodies, lunar and solar gravitational effects, and atmospheric drag.

UNIT-1 **8 hours**

Introduction to Space Mechanics: Basic Concepts of Celestial Mechanics, Laws of Motion in Space, Newton's Law of Gravitation, Kepler's Laws of Planetary Motion, Orbital Parameters and Elements, Coordinate Systems in Space Mechanics

UNIT-2 **9 hours**

Orbital Dynamics: Introduction Two-Body and Multi-Body Orbital Mechanics Kepler's Equation and Its Solutions Perturbation Theory, Orbit Determination and Propagation, Orbital Maneuvers and Transfers, Orbital Perturbations: Gravitational, Atmospheric, Solar Radiation Pressure.

UNIT-3 **9 hours**

Spacecraft Attitude Dynamics and Control: Attitude Representation and Kinematics, Euler's Equations of Motion, Attitude Determination and Control Systems, Attitude Stabilization and Maneuvering, Reaction Wheel Control, Thruster Control, and Magnetorquers, Case Studies: Satellite Attitude Control Systems

UNIT-4 **9 hours**

Orbital Mechanics Applications: Launch Vehicle Dynamics and Trajectory Optimization, Interplanetary Trajectories and Mission Design, Spacecraft Formation Flying, Relative Motion Dynamics, Space Debris and Collision Avoidance, Orbital Mechanics in Satellite Constellations.

UNIT-5 **8 hours**

Astrodynamics: Classical and modern astrodynamics concepts, Kepler's equation and Lambert's problem, Attitude dynamics and control of spacecraft, Gravity assists and trajectory optimisation, Numerical methods in astrodynamics

Textbooks:

1. Orbital Mechanics for Engineering Students" by Howard D. Curtis ,2013.
2. ‘Fundamentals of Astrodynamics" by Roger R. Bate, Donald D. Mueller, and Jerry E. White ,1971.
3. Spacecraft Attitude Dynamics" by Peter C. Hughes ,2004
4. Optimal Space Trajectories" by Michel Malabre ,2011.
5. Fundamentals of Astrodynamics and Applications" by David A. Vallado ,2007.
6. Spacecraft Formation Flying: Dynamics, Control and Navigation" by Kyle Alfriend et al. ,2010

References:

1. "Introduction to Space Dynamics" by William Tyrrell Thomson (1961)
2. "Analytical Mechanics of Space Systems" by Hanspeter Schaub and John L. Junkins (2003)
3. "Spacecraft Attitude Determination and Control" by James R. Wertz and Wiley J. Larson (1982)

AERO6031	Experiments in Aerospace Engineering	L	T	P	S	J	C
		0	0	6	0	0	3

Course Description:

Experiments in Aerospace Engineering course offers demonstration of experiments in major sub-disciplines of aerospace engineering. The intent of this course is to give an overview of all the experimental facilities in the domain of Aerospace Engineering.

Course Educational Objectives:

- To know about experimental facilities in aerodynamics
- To learn computational tools in Aerodynamics and Structural domains
- To learn about the characterization of materials

List of Experiments:

1. Design and experimental analysis on the performance of aerodynamic models using wind tunnel
2. Study on flow field parameters using shock tube test facility
3. Predicting and optimizing aerodynamics and structural performance using simulation tools
4. Synthesis of alloys using High-speed ball milling
5. Study of mechanical properties AS-prepared alloys
6. Fabrication of a composite laminate using any of the conventional techniques

Course Outcomes: At the end of the course the student will be able to:

- Analyze the flow behavior for streamlined bodies
- Compute the flow parameters across the shock wave
- Gain proficiency in computational tools
- Characterize different material properties

AERO7011	Aircraft and Spacecraft Design	L	T	P	S	J	C
		4	0	0	0	0	4

Course Description

This course provides a comprehensive overview of the design processes for both aircraft and spacecraft, covering the fundamental principles, methodologies, and tools used in the field. Students will learn about the selection of airfoil and geometry for aircraft, thrust-to-weight ratios, wing loading, initial sizing, control-surface sizing, aerodynamic considerations, structural considerations, propulsion systems, fuel systems, landing gear arrangements, stability, control, handling qualities, performance, flight mechanics, cost analysis, and the design of unique aircraft concepts. For spacecraft, the course will cover systems engineering principles, design and functionality of various subsystems, including command and data handling, power and electrical, thermal, telecommunication, flight and simulation software, guidance, navigation and control, propulsion, structures and mechanisms, fault protection, assembly, integration, test, and operations.

Course Objective

1. To equip students with the foundational principles of aircraft and spacecraft design.
2. To introduce students to the critical design considerations, methodologies, and tools used in the aerospace industry.
3. To develop students' ability to apply engineering principles to the design, analysis, and operation of aerospace vehicles.
4. To foster critical thinking and problem-solving skills in addressing aerospace engineering challenges.
5. To prepare students for advanced study and careers in aerospace engineering and related fields.

UNIT 1 **10 hours**

Fundamentals of Aerospace Design Introduction to Aerospace Engineering: Historical milestones, key principles, and the distinction between aircraft and spacecraft. Aerodynamics and Astrodynamics: Basic aerodynamics for aircraft, including lift and drag, and basic astrodynamics for spacecraft, including orbit mechanics. Material Selection and Structures: Overview of aerospace materials, structural design considerations, and selection criteria. Aircraft and Spacecraft Systems: Introduction to common subsystems, including avionics and life support systems. Design Process and Methodologies: Steps from conceptual design to detailed design and prototyping, with case studies.

UNIT 2: **8 hours**

Aerodynamic and Structural Considerations Airfoil and Geometry Selection for Aircraft: Impact on performance and efficiency. Aerodynamic Considerations for Spacecraft: Design for re-entry and thermal protection. Structural Design and Analysis: Stress, strain, and load analysis for durability and efficiency, Composite Materials in Aerospace: Advantages, challenges, and applications. Vulnerability and Damage Tolerance: Design strategies for enhancing resilience.

UNIT 3 **9 hours**

Propulsion and Power Systems Aircraft Propulsion Systems: Engine types, operation, and integration, Spacecraft Propulsion Systems: Propulsion technologies and system components, Fuel Systems for Aircraft and Spacecraft: Design, management, and safety considerations**,** Power and Electrical Subsystems: Generation, distribution, and management strategies, Thermal Management Systems: Thermal control techniques and systems for aerospace vehicles.

UNIT 4 11 hours

Control and Guidance Systems Flight Control Systems for Aircraft: Stability, control surfaces, and system integration, Guidance, Navigation, and Control for Spacecraft: Techniques and technologies for precise maneuvering and orientation, Autonomy and Fault Tolerance: Strategies for enhancing reliability and mission success. **,** Telecommunication Subsystems: Design and operation of aerospace communication systems, Integration of Control Systems: Challenges and best practices in aerospace vehicle design.

UNIT 5 7 hours

Design, Testing, and Operations Design for Manufacturability and Operations: Considerations for efficient production and maintenance. Testing and Validation: Approaches for ensuring vehicle reliability and performance. Safety and Certification Processes: Standards and regulations governing aerospace vehicles. Mission Planning and Operations: Execution of aerospace missions, from planning to operational management.

Course Outcomes:

Upon successful completion of this course, students will be able to:

1. Understand the key principles and processes involved in the design of both aircraft and spacecraft.
2. Apply knowledge of mathematics, science, and engineering to the solution of complex aerospace design problems.
3. Design and conduct experiments, as well as analyze and interpret data for aerospace applications.
4. Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
5. Use the techniques, skills, and modern engineering tools necessary for engineering practice.
6. Function on multidisciplinary teams and communicate effectively.

Textbooks:

1.Aircraft Design: A Conceptual Approach , Daniel P. Raymer,2018
2. Introduction to Aeronautics: A Design Perspective, R. Stiles, B. Bertin, and S. Whitford,2nd edition ,2004.

References:

1. Spacecraft Systems Engineering" by Peter Fortescue, Graham Swinerd, and John Stark,
2.Fundamentals of Space Systems" by Vincent L. Pisacane.

AERO7021	Aircraft Systems and Avionics	L	T	P	S	J	C
		4	0	0	0	0	4

Course Description:

Launch Vehicle Guidance, Navigation, and Control is an advanced engineering course designed to provide students with a comprehensive understanding of the principles, methodologies, and technologies utilized in guiding, navigating, and controlling launch vehicles during their ascent phase into space. This course integrates theoretical concepts with practical applications to equip students with the necessary knowledge and skills required to design, analyze, and optimize launch vehicle guidance, navigation, and control systems.

Course Educational Objectives:

1. To provide students with a comprehensive understanding of the various systems that make up an aircraft, including mechanical, electrical, hydraulic, and avionics systems.
2. To develop the skills and knowledge necessary to design, install, maintain, and troubleshoot avionics systems used in modern aircraft.
3. To ensure students are aware of and understand the relevant safety regulations, standards, and certification processes related to aircraft systems and avionics.
4. To teach students how to integrate avionics systems with the overall aircraft design, including communication, navigation, and surveillance systems.
5. To equip students with the skills to diagnose and address issues in avionics systems, ensuring the safety and reliability of aircraft.

UNIT-1 **8 hours**

Introduction to Aircraft Systems Introduction to aircraft systems and avionics, Overview of aircraft electrical systems, aircraft hydraulic systems, aircraft pneumatic systems, Introduction to aircraft avionics systems, Role of avionics in modern aircraft.

UNIT-2 **9 hours**

Aircraft Communication Systems: Fundamentals of aircraft communication systems, VHF and HF communication systems, Satellite communication systems, Data link communication systems, Aircraft intercom systems, Emerging trends in aircraft communication.

UNIT-3 **9 hours**

Aircraft Navigation Systems: Basics of aircraft navigation, Inertial Navigation Systems (INS), Global Navigation Satellite Systems (GNSS), principles and advantages and disadvantages of Radio Navigation Systems (VOR, DME, ADF), Terrain Awareness and Warning Systems (TAWS), Future trends in aircraft navigation

UNIT-4 **9 hours**

Aircraft Instrumentation Systems: Principles of aircraft instrumentation, Flight instruments (Altimeter, Airspeed Indicator, Attitude Indicator, etc.), Engine instruments (Tachometer, Temperature Gauges, Pressure Gauges), Aircraft sensors and transducers, Introduction to Glass Cockpit Systems,

UNIT-5 **8 hours**

Introduction to flight control systems: Fly-by-wire (FBW) systems, Automatic Flight Control Systems (AFCS), Avionics integration and architecture, Avionics testing and validation, Future developments in flight control systems and avionics integration.

Textbooks:

1. "Introduction to Aircraft Systems" by David A. Lombardo (2009)
2. Aviation Communications" by Michael J. Kroes (2017)
3. "Aircraft Communications and Navigation Systems" by Mike Tooley (2017)"Introduction to Aircraft Navigation and Communication Systems" by Colin H. Simmons (2013)
4. "Aircraft Instrumentation and Systems" by David A. Lombardo (2012)
5. "Aircraft Flight Control Systems: Design, Analysis, and Simulation" by Wayne Durham (2015)

Course outcomes:

1. Analyze the integration and interaction of various aircraft systems.
2. Understand the principles of electrical power generation and distribution in aircraft.
3. Understand the Principles of aircraft instrumentation and measurement.
4. Analyze stability and control augmentation systems used in aircraft.
5. Understand the process of integrating avionics systems into modern aircraft.

AERO7031	Technical Seminar	L	T	P	S	J	C
		0	0	4	0	0	1

Course Description: This technical seminar is an integral component of the M.Tech Aerospace Engineering program, designed to provide students with a platform to explore and delve deep into the recent advancements in hypersonic propulsion systems. The seminar aims to enhance students' knowledge, critical thinking, and research skills in the context of cutting-edge technologies shaping the future of aerospace engineering.

Course Educational Objectives: In this course , the student will be able to

1. Develop a profound understanding of the theoretical foundations and practical applications.
2. Cultivate research and analytical skills to critically analyze recent advancements, emerging technologies, and challenges.
3. Explore the multidisciplinary nature of aerospace engineering by considering the integration of other subsystems in aircraft design.
4. Enhance oral and written communication skills through the preparation and delivery of a technical presentation on a specific topic within aerospace.
5. Foster a sense of professional development by encouraging participation in discussions, seminars, and workshops related to aerospace engineering beyond the classroom.

Course Outcomes: At the end of the course the student will be able to:

1. Demonstrate advanced knowledge of the latest developments in the aerospace engineering domain.
2. Critically analyze current and emerging technological trends in aerospace different specialization.
3. Apply theoretical knowledge to solve real-world problems related to the design, analysis, and optimization of aerospace.
4. Conduct independent research on a specific topic within aerostructures and materials and present findings in a clear and concise manner
5. Actively engage in professional networking opportunities and events related to aerospace engineering.

Note: Student has to select a topic of his/her interest in consultation with the faculty incharge of seminar. He/She can collect information from the books, journals and internet and prepare a report. Prepare for a power point presentation on the topics and present to a committee to evaluate the seminar.

Program Electives

AERO7041	Launch Vehicle Performance Design and System Configuration	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:

This course focuses on the principles and methodologies involved in the design and performance analysis of launch vehicles. Students will learn about the various aspects of launch vehicle design, including propulsion systems, structural dynamics, aerodynamics, flight mechanics, and system integration. The course also covers the evaluation of launch vehicle performance, mission planning, and optimization techniques. Through a combination of theoretical study and practical design projects, students will gain a comprehensive understanding of how to develop efficient and reliable launch systems.

Course Objectives:

1. To provide a thorough understanding of the fundamental principles governing launch vehicle design and performance.
2. To introduce students to the various subsystems of launch vehicles and their integration.
3. To develop skills in analyzing and optimizing launch vehicle performance for various missions.
4. To enhance problem-solving skills through practical design and analysis projects.
5. To prepare students for careers in aerospace engineering with a focus on launch vehicle development.

UNIT I **9 hours**

Introduction to Launch Vehicle Design Overview of launch vehicle history and types, Basic physics and mechanics of rocket flight, Introduction to launch vehicle architecture and system components, Mission profiles and requirements analysis. Overview of the launch vehicle design process.

UNIT 2 **9 hours**

Propulsion Systems Fundamentals of rocket propulsion, Liquid, solid, hybrid, and advanced propulsion systems, Propellant types, selection criteria, and propellant management, Engine integration, thrust vector control, and propulsion system testing, Performance metrics and optimization of propulsion systems.

UNIT 3 **10 hours**

Structural Design and Materials Materials selection for launch vehicles, Structural design considerations: stress, strain, and load analyses, Vibration, acoustics, and thermal protection systems, Manufacturing techniques and structures testing, Integration of structures with other subsystems.

UNIT 4 **9 hours**

Aerodynamics and Flight Mechanics Aerodynamic forces and moments on launch vehicles, Subsonic, supersonic, and hypersonic aerodynamics, Stability and control during ascent, Flight trajectory analysis and optimization, Re-entry dynamics and vehicle recovery systems.

UNIT 5 **9 hours**

System Integration and Launch Operations Integration of launch vehicle subsystems, Ground support equipment and launch pad infrastructure, Launch sequence and operational procedures, Mission planning, payload integration, and launch vehicle performance assessment,Case studies of successful and failed launches.

Course Outcomes:

Upon successful completion of this course, students will be able to:

- Understand the fundamental principles and technologies behind launch vehicle design.
- Analyze and design propulsion systems tailored to specific mission requirements.
- Apply principles of structural dynamics and materials science to develop robust launch vehicle structures.
- Conduct aerodynamic and flight mechanics analyses to ensure vehicle stability and performance.
- Integrate launch vehicle subsystems into a cohesive system and plan successful launch operations.

Textbooks:

1. Sutton, George P., and Oscar Biblarz. Rocket propulsion elements. John Wiley & Sons, 2016.
2. Thomson, W. T. (2012). Introduction to space dynamics. Courier Corporation.
3. Huzel, D. K. (1992). Modern Engineering for Design of Liquid-Propellant Rocket Engines. AIAA Press google schola, 2, 1413-1417.
4. Mishra DP. Fundamentals of Rocket Propulsion. CRC Press; 2017 Jul 20.

AERO7051	Launch Vehicle Guidance, Navigation and Control	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description :

This course covers the principles and techniques of guidance, navigation, and control (GNC) systems for launch vehicles. It explores the theoretical foundations and practical applications of GNC systems in ensuring the successful launch, trajectory management, and target attainment of space vehicles. Topics include navigation sensors, guidance algorithms, control systems, error analysis, trajectory optimization, and real-time decision-making.

Course Educational Objectives:

1. Develop a deep understanding of the fundamental principles of GNC as applied to launch vehicles, including control theory, sensors, and algorithms.
2. Analyze and design guidance systems to control the launch vehicle's trajectory, including target orbits and mission objectives.
3. Develop the ability to design and implement navigation systems that accurately determine the vehicle's position and velocity throughout the flight.
4. Design and analyze control systems that ensure the vehicle's stability and responsiveness during ascent, including thrust vector control and attitude control.
5. Understand the various sensors and data processing techniques used in GNC systems, including inertial measurement units (IMUs) and GPS.

UNIT-1 **8 hours**

Introduction to Launch Vehicle Systems-Overview of launch vehicle architecture and subsystems, Basic principles of guidance, navigation, and control (GNC) systems, Introduction to orbital mechanics and trajectory optimization, Overview of launch vehicle propulsion systems.

UNIT-2 **9 hours**

Guidance Systems for Launch Vehicles- Principles of guidance laws and algorithms, Inertial guidance systems and sensors, GPS and satellite-based navigation systems, Kalman filtering and estimation techniques for navigation.

UNIT-3 **8 hours**

Navigation Systems for Launch Vehicles- Celestial navigation and star sensors, Inertial Navigation Systems (INS), Integration of multiple navigation sensors, Error analysis and mitigation in navigation systems.

UNIT-4 **9 hours**

Control Systems for Launch Vehicles- Basics of control theory and feedback control, Dynamics and modeling of launch vehicle systems, Attitude control systems, Propulsion control and thrust vectoring.

UNIT-5 **9 hours**

Advanced Topics in Launch Vehicle GNC- Autonomous guidance and control, Fault detection and isolation in GNC systems, Re-entry guidance and control, Future trends and emerging technologies in launch vehicle GNC

Textbooks:

1. Space Vehicle Guidance, Control and Astrodynamics by Bong Wie (2011)
2. Fundamentals of Astrodynamics by Roger R. Bate, Donald D. Mueller, and Jerry E. White (1971, latest edition 1971)
3. Spacecraft Attitude Determination and Control by James R. Wertz and Wiley J. Larson (1999)
4. Introduction to Modern Navigation Systems by P. K. Kundu (2007)
5. Spacecraft Navigation and Guidance by David G. Simpson (2015)
6. Spacecraft Dynamics and Control: An Introduction by Marcel J. Sidi (1997)
7. Advanced Control of Aircraft, Spacecraft and Rockets by Ashish Tewari (2011)

Course Outcomes:

- Students will develop a comprehensive understanding of launch vehicle systems, including architecture, subsystems, and the interplay between guidance, navigation, and control systems.
- Students will acquire the skills to design effective guidance systems by applying principles of guidance law
- Students will demonstrate proficiency in utilizing various navigation techniques, such as inertial navigation systems, celestial navigation, and satellite-based navigation, for precise positioning and trajectory determination.
- Students will acquire the skills to design and implement control systems for launch vehicles, encompassing stability analysis, control algorithm implementation, and optimization techniques.
- Students will apply theoretical knowledge to solve real-world challenges in launch vehicle guidance, navigation, and control.

AERO7061	Launch Vehicle Integration	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:

This course covers the fundamental concepts, techniques, and challenges involved in the integration of launch vehicles. It addresses the technical and engineering aspects of assembling and preparing a launch vehicle for its mission, including structural assembly, propulsion system integration, payload integration, testing, and launch operations. The course also explores the critical interfaces between the launch vehicle components, system-level testing, and the management of integration processes to ensure mission success.

Course Educational Objectives:

1. To provide an understanding of the principles and practices involved in launch vehicle integration.
2. To familiarize students with the structural, mechanical, and electrical integration processes of launch vehicles.
3. To introduce students to the methodologies and tools used for system-level testing and validation of launch vehicles.
4. To develop skills in problem-solving and critical thinking through the examination of case studies on launch vehicle integration challenges and solutions.
5. To prepare students for careers in aerospace engineering with a focus on launch vehicle design, integration, and operations.

UNIT 1 **10 hours**

Introduction to Launch Vehicle Systems: Overview of launch vehicle architecture and components, Fundamentals of rocket propulsion and vehicle dynamics, Staging mechanisms and integration principles, Launch vehicle materials and structures, Safety and reliability considerations in launch vehicle design.

UNIT 2 **7 hours**

Propulsion System Integration: Integration of propulsion elements: engines, tanks, and feed systems, Propellant management and control systems, Thrust vector control mechanisms and integration, Ground support equipment for propulsion testing, Case studies on propulsion integration challenges and solutions.

UNIT 3 **8 hours**

Structural and Mechanical Integration: Structural assembly of launch vehicle components, Load analysis and stress testing of integrated structures, Integration of mechanical systems: separation mechanisms, payload adapters, and fairings, Vibration analysis and mitigation during launch, Techniques for lightweight and durable structural design.

UNIT 4 **10 hours**

Electrical and Avionics Integration: Avionics architecture and subsystem integration, Electrical power systems and distribution, Communication and telemetry systems integration, Guidance, navigation, and control systems, Environmental testing for avionics systems.

UNIT 5 **10 hours**

System-Level Testing and Launch Operations: Integration testing: static firing, vibration, and acoustic tests, Launch preparation and countdown procedures, Range safety and mission assurance practices, Post-launch analysis and performance evaluation, Future trends and technologies in launch vehicle integration.

Course Outcomes:

Upon completion of this course, students will be able to:

1. Understand the key components and systems of launch vehicles and their integration processes.
2. Apply engineering principles to the integration of propulsion, structural, mechanical, and electrical systems in launch vehicles.
3. Conduct system-level testing and validation to ensure the reliability and performance of launch vehicles.
4. Analyze and solve complex problems related to launch vehicle integration using a multidisciplinary approach.
5. Communicate effectively the processes and outcomes of launch vehicle integration projects.

Textbooks:

- Rocket Propulsion Elements , George P. Sutton and Oscar Biblarz, 2016
- Space Vehicle Design , Michael D. Griffin and James R. French, 2012
- Introduction to Space Dynamics , William Tyrrell Thomson, 2015
- Spacecraft Systems Engineering , Peter Fortescue, Graham Swinerd, and John Stark,2017.

AERO7071	Applied Computational Fluid Dynamics	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:

This course is designed for students who are aspiring to achieve in the computational fluid dynamics domain. It reviews the CFD and its applications in various fields of engineering along with the introduction of governing equations, discretization techniques. This course is designed to acquaint students with turbulence modeling, multiphase flows and real flow problems and case studies related to them.

Course Educational Objectives:

1. Understand the basic principles of fluid dynamics and the role of CFD in engineering applications.
2. Understand the importance of grid quality in CFD simulations.
3. Introduce numerical solvers for fluid flow problems and explore different solution algorithms and discretization methods.
4. Develop skills in post-processing and interpretation of CFD results.
5. Apply CFD techniques to real-world engineering problems.

UNIT I **9 hours**

Introduction to Computational Fluid Dynamics: Overview of CFD and its applications, Basic principles of fluid mechanics, Introduction to numerical methods for solving fluid flow problems, Introduction to software tools (e.g., ANSYS Fluent, Open FOAM)

UNIT II **9 hours**

Governing Equations and Numerical Methods: Continuity, momentum, and energy equations, Discretization techniques (finite difference, finite volume, finite element), Solution algorithms and iterative methods

UNIT III **9 hours**

Turbulence Modeling: Introduction to turbulence and its modeling, Reynolds-averaged Navier-Stokes (RANS) equations, Turbulence models: k-epsilon, k-omega, LES, DNS

UNIT IV **9 hours**

Heat Transfer and Multiphase Flows: Simulation of heat transfer in CFD, Modeling multiphase flows (e.g., free surface flows, boiling, condensation), heat exchanger simulations.

UNIT V **9 hours**

Case Studies and Applications: Application of CFD in aerospace, Case studies and project work, Best practices and challenges in applied CFD

Text Books:

1. John D. Anderson Jr., Computational Fluid Dynamics: The Basics with Applications, 6/e, Tata McGraw-Hill Publishing 2012
2. Suhas Patankar, Numerical Heat Transfer and Fluid Flow, 1/e, CRC Press, Taylor & Francis Group, 2018
3. David C. Wilcox, Turbulence Modeling for CFD, 3/e, DCW Industries, Inc., 2006
4. Efstathios Michaelides, Clayton T. Crowe, John D. Schwarzkopf, Multiphase Flow Handbook, 2/e, CRC Press, 2016

Course Outcomes:

At the end of this course, the student will be able to

- apply numerical methods for fluid flow problems and use software tools.
- identify different algorithms and iterative methods used for different flow problems
- identify different types of turbulence modeling applicable for different types of flow problems
- solve heat transfer and multiphase flow problems
- apply CFD for various disciplines of engineering

AERO6041	Fundamentals of Acoustics	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description: The course is designed to impart technical knowledge related to impact of sound and its influence in determining the instabilities related to flow fields in aerodynamics and aerospace propulsion. It helps students in understanding, and aerothermodynamic modulation under the influence of aero acoustics. It gives knowledge connected to controlling the detrimental impact of acoustics on various aerospace subsystems.

Course Educational Objectives:

1. Explain fundamental principle connected with aero acoustics.
2. Impart awareness related to investigate and amend performance of acoustic influence on low-speed flows.
3. Demonstrate and explain the knowledge of linear acoustics.
4. Explain different techniques to interpret acoustic on aerofoil flows.
5. Make them learn experimental methods and data measurement techniques of acoustics.

Unit - I: 8 hours
Introduction to Fundamentals of acoustics: Aeroacoustics of low Mach number flows, Sound waves and turbulence, Quantifying sound levels and annoyance. The equation of continuity, The momentum equation, Thermodynamic quantities, The role of vorticity, Energy and acoustic intensity

Unit - II 9 hours
Linear acoustics: The acoustic wave equation, Plane waves and spherical waves, Harmonic time dependence, Sound generation by small bodies in motion, Sound scattering by a small sphere, Superposition and far field approximations, Monopole, dipole and quadrupole sources, Acoustic intensity and sound power output, Solution to the wave equation using Green's functions, Frequency domain solutions and Fourier transforms.

Unit – III 9 hours
Lighthill's acoustic analogy: Lighthill's analogy, Limitations of the acoustic analogy, Curle's theorem, Monopole, dipole and quadrupole sources, Tailored Green's functions, Surfaces and sources
The Ffowcs Williams and Hawkings equation: Generalized derivatives, The Ffowcs Williams and Hawkings equation, Moving sources, Sources in a free stream, The Prantl-Glauert transformation, Ffowcs Williams and Hawkings surfaces.
Propeller and open rotor noise: Tone and broadband noise, Time domain prediction methods for tone noise from a single rotor blade, Frequency domain prediction methods for tone noise.

Unit – IV 9 hours
The surface source for thin aerofoils: Amiet's approach, The incompressible flow blade response function, The compressible flow blade response function, The acoustic far field, Blade vortex interactions in compressible flow
Flows with distortion: Goldstein's equation, Drift coordinates, Rapid distortion theory, The rapid distortion of vorticity.

Vortex sound: Theory of vortex sound, Sound from two-line vortices in free space, Surface forces in incompressible flow, Aeolian tones, Blade vortex interactions in incompressible flow, the effect of angle of attack and blade thickness on unsteady loads, RDT and aerofoil loading noise.

Unit - V **9 hours**

Experimental methods: Aeroacoustic wind tunnels, Wind tunnel acoustic corrections, Sound measurement, The measurement of turbulent pressure fluctuations, Velocity measurement

Measurement, signal processing, and uncertainty: Limitations of measured data, Uncertainty, Averaging and convergence, Measurement as seen from the frequency domain, Calculating time spectra and correlations, Wavenumber spectra and spatial correlations.

Textbooks

1. Stewart Glegg, Aeroacoustics of Low Mach Number Flows, 1/e, Matthew Deans 2023.
2. Fabien Anselmet, Acoustics, aeroacoustics and vibrations, John Wiley, 2016

References

1. Marvin E Goldstein, Aeroacoustics, McGraw-Hill International Book Co, 3/e, 2017
2. Kenneth C. Hall, Unsteady aerodynamics aeroacoustics and aeroelasticity of turbomachines, Springer, 2006

Course outcomes:

Upon completing the course, students should be able to:

- Exhibit strong command on fundamental principle connected with aero acoustics.
- Study, investigate and amend performance of acoustic influence on low-speed flows.
- Demonstrate the knowledge of linear acoustics.
- Develop different techniques to interpret acoustic on aerofoil flows.
- Exhibit command on experimental methods and data measurement techniques of acoustics.

AERO6051	Hypersonic Flow Theory	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:
This course is designed for students who are aspiring to achieve in the computational fluid dynamics domain.

Course Educational Objectives:

- To know the fundamentals of hypersonic flow and its importance.
- To learn hypersonic shock and expansion-wave relations.
- To analyze the hypersonic inviscid flow fields using approximate and exact methods.
- To apply computational fluid dynamics in hypersonic viscous flow

UNIT I **8 hours**
General Features of Hypersonic Flow Field: Characteristic features of hypersonic flow, basic equations boundary conditions for inviscid flow, shock shapes over bodies, flow over flat plate, flow over a wedge, hypersonic approximations, Prandtl-Meyer flow, axisymmetric flow over a cone.

UNIT II **9 hours**
Small Disturbance Theory: Hypersonic small disturbance theory, applications to flow over a wedge and a cone, blast wave analogy, Newtonian impact theory, Busemann centrifugal correction and shock expansion method, tangent cone and tangent wedge methods.

UNIT III **10 hours**
Approximate methods in Inviscid and Viscous flows: Approximate methods, hypersonic small disturbance equation and theory. Thin shock layer theory, Introduction to viscous flows, hypersonic boundary layers, non-equilibrium high enthalpy flows.

UNIT IV **8 hours**
Experimental test facilities in hypersonic flows: High enthalpy impulse test facilities and instrumentation.

UNIT V **10 hours**
Computational techniques: Computational fluid mechanics techniques for hypersonic flows, methods of generating experimental data for numerical code validation at hypersonic Mach numbers in hypervelocity facilities. Computational Fluid Dynamic Solutions of Hypersonic Viscous Flows

Text Books:

1. J. D. Anderson, Hypersonic and High Temperature Gas Dynamics, 3/e, AIAA Education Series, 2019.
2. P. Curtis, The Shock tube, Kindle edition, Dream Engine Interactive limited, 2014.
3. Hayes, W.D. and Problein, R.F., Hypersonic Flow Theory, Academic Press, 1959

Course Outcomes: At the end of the course the student will be able to:

- Apply knowledge of oblique and curved shock waves and shock wave structure
- Utilize Shock-Expansion theory, Surface inclination method, and Newtonian theory for the estimation of pressure distribution of simple shapes
- Solve problems related to hypersonic viscous effects
- design and test any model in shock tunnels in order to understand the high temperature effects in hypersonic flows.
- Solve computational problems for simple shapes

AERO7081	Applied Finite Element Analysis	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:

This course is designed for aerospace engineering students. It introduces the fundamental and applied principles of finite element procedure. This course is designed to acquaint the learners with finite element solutions to structural and thermal problems and deals with the realistic engineering problems.

Course Educational Objectives:

- To impart the Fundamental principles of finite element analysis procedure.
- To develop the ability to solve the governing FE equations for one dimensional and truss elements.
- To familiarize and apply finite element solutions to two dimensional, three dimensional and axisymmetric structural problems.
- To develop proficiency in the application of the finite element method (modelling, analysis, and interpretation of results) to realistic engineering problems.
- To understand the application of finite element methods in solving the heat transfer steady state and transient nature of the problems.

UNIT I **8 hours**

Fundamental Concepts: Stresses and equilibrium, strain – displacement relations, stress-strain relations, plane stress, plane strain, temperature effects, potential energy and equilibrium.

Variational and Weighted Residual Formulation- Rayleigh- Ritz method, Variational Methods ,Galerkin's method, Method of Weighted Residual, Saint Venant's principle.

UNIT II **9 hours**

One-dimensional Problems: Finite element modeling, coordinates, and shape functions. Potential energy approach. Galerkin's approach, assembly of the global stiffness matrix and load vector, treatment of boundary conditions, quadratic shape functions, temperature effects.

Truss- Plane trusses, local and global coordinate systems, direction cosines, element stiffness matrix, force terms, stress calculations.

UNIT III **8 hours**

Two-dimensional Problems using Constant Strain Triangles: Finite element modeling, constant strain triangle, problem modeling and boundary conditions, isoparametric representation, potential energy approach, element stiffness, force terms, stress calculations, strain displacement relations.

Axisymmetric Solids Subjected to Axisymmetric Loading: Axisymmetric formulation, axisymmetric triangular element, strain displacement relations, problem modeling and boundary conditions, stiffness matrix, body force terms. **Three-Dimensional Elements** -Four Node Tetrahedral Element , Eight-Node Brick Element.

UNIT IV 9 hours

Beams and Frames

Finite element formulation, load vector, boundary considerations, shears force and bending moment, plane frames.

Two-dimensional Isoparametric Elements and Numerical Integration: Four-node quadrilateral element, shape functions, element stiffness matrix, element force vector. Numerical integration, Gauss quadrature, one dimension and two-dimensional integrals, stiffness integration, stress calculations.

UNIT V 8 hours

Steady-State Thermal and Fluid Flow Analysis: Introduction ,Steady state heat transfer, one dimensional heat conduction, one dimensional heat transfer in thin fins, The Green-Gauss Theorem.Case study.

Transient and Dynamic Analysis: Introduction, Dynamic Structural Analysis, Transient Thermal Analysis, Formulation, , element mass matrices, Lumped Versus Consistent Matrices, evaluation of eigenvalues and eigenvectors, Two-Point Recurrence Schemes.

Course Outcomes:

At the end of this course, the student will be able to

- Apply the numerical methods involved in Finite Element Theory for structural problems.
- Apply the role and significance of shape functions in finite element formulations and use linear, quadratic, and cubic shape functions for interpolation
- Estimate the global, local, and natural coordinates and formulation of one dimensional elements like trusses and frames.
- Formulate two-dimensional elements, three dimensional and axisymmetric elements for practical applications.
- Identify how the finite element method expands beyond the structural domain, for problems involving dynamics, heat transfer, and fluid flow.

Textbooks

1. Tirupathi R. Chandrupatla, Ashok D. Belegundu, Introduction to Finite Elements in Engineering, 3/e, Pearson Education, 2012.
2. Reddy. J.N., “An Introduction to the Finite Element Method”, 3rd Edition, Tata McGraw-Hill, 2016.
3. Frank L. Stasa , Applied Finite Element Analysis for Engineers, 3rd Edition, Oxford University Press, 1995.

References

1. S.S.Rao, Finite Element Method in Engineering, Elsevier Butterworth-Heinemann Publications, 2013.
2. Robert D. Cook, David S. Malkus, Michael E. Plesha, Rober J. Witt, Concepts and Applications ofFinite Element Analysis, 4/e, Wiley India 2001.
3. Logan, D.L., “A first course in Finite Element Method”, Thomson Asia Pvt. Ltd., 2002

AERO7091	Robotics and Control	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description

This course introduces the fundamental concepts, methodologies, and practical applications of robotics and control systems. It covers spatial descriptions and transformations, manipulator kinematics, inverse kinematics, Jacobians, dynamics, trajectory generation, manipulator-mechanism design, and various control strategies, including linear and nonlinear control of manipulators and force control. The course also explores robot programming languages and systems, providing a comprehensive understanding of the principles and practices involved in designing and controlling robotic systems.

Course Objectives:

- To provide a solid foundation in the principles of robotics and control systems.
- To develop an understanding of spatial descriptions, transformations, and manipulator kinematics.
- To introduce inverse kinematics, Jacobians, and manipulator dynamics.
- To teach students about trajectory generation and manipulator-mechanism design.
- To explore various control strategies for manipulators and delve into robot programming languages and systems.

UNIT 1 **7 hours**

Introduction to Robotic, Spatial Descriptions and Transformations: History and Evolution of Robotics, Coordinate Frames and Representation, Rotation Matrices and Their Properties, Homogeneous Transformations and Applications, Forward and Inverse Transformations.

UNIT 2 **11 hours**

Kinematics and Dynamics: Definitions and basic concepts of kinematics and dynamics, Joint space, workspace, and degrees of freedom, Forward kinematics: position and orientation of the end-effector, Differential kinematics and velocity kinematics, Dynamic modeling and equations of motion**.**

Inverse Manipulator Kinematics: The concept of inverse kinematics in robotic systems, Analytical methods for solving inverse kinematics problems, Numerical methods for inverse kinematics solutions, Multiple solution handling and redundancy resolution, Practical applications and limitations of inverse kinematics.

UNIT 3 **10 hours**

Jacobians: Velocities and Static Forces, Definition and significance of the Jacobian matrix, Velocity mapping from joint space to Cartesian space, Static force analysis using Jacobians, Jacobian singularity and implications on manipulator control, Dexterity, and manipulability analysis using Jacobians.

Manipulator Dynamics: Fundamentals of manipulator dynamics formulation, Lagrangian dynamics for robotic manipulators, Newton-Euler dynamic modeling approach, Computational methods for dynamic simulation, Control implications of manipulator dynamics.

UNIT 4 **9 hours**

Trajectory and Mechanism Design Trajectory Generation, Manipulator-Mechanism Design, Principles of Trajectory Planning and Optimization Techniques, Spline, Polynomial, and Interpolation Methods for Path Generation, Kinematic Chains and Linkage Design for Manipulators, Actuator Selection and Placement for Mechanism Efficiency

UNIT 5 **9 hours**

Control of Manipulators: Linear Control of Manipulators, Nonlinear Control of Manipulators, Introduction to Force Control of Manipulators

Textbooks:

1. Introduction to Robotics: Mechanics and Control" by John J. Craig.2005
2. Spong, M. W., Hutchinson, S., & Vidyasagar, M. (2020). Robot modeling and control. John Wiley & Sons.
3. Dixon, Warren E. "Control of robot manipulators in joint space, R. Kelly, V. Santibáñez and A. Loria, Springer, London, UK, 2005, 426pp. ISBN: 1-85233-994-2." (2006): 945-946.
4. Vepa R. Nonlinear control of robots and unmanned aerial vehicles: an integrated approach. Crc Press; 2016 Oct 14.

Course Outcomes:

Upon successful completion of this course, students will be able to:

- Understand and apply spatial descriptions and transformations in robotics.
- Analyze and design kinematic and dynamic models of manipulators.
- Develop algorithms for inverse kinematics and trajectory generation.
- Design and implement control systems for robotic manipulators.
- Program robots using specialized programming languages and integrate robotic systems into practical applications.

AERO6061	Aerospace Materials and Characterization	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description:

This course provides an in-depth understanding of materials used in aerospace engineering and their characterization techniques. Students will explore the properties, processing methods, and performance of materials crucial for aircraft and spacecraft design. The course will also cover various methods of characterization to analyze and evaluate aerospace materials.

Course Educational Objectives:

- To familiarize students with the types, properties, and applications of materials used in aerospace engineering.
- To provide insight into the manufacturing processes and techniques relevant to aerospace materials.
- To introduce advanced characterization methods used to analyze and evaluate aerospace materials.
- To develop an understanding of the relationship between material properties and their performance in aerospace applications.
- To encourage critical thinking and problem-solving skills in selecting materials for specific aerospace applications.

UNIT I **9 hours**

Introduction to Aerospace Materials: Overview of materials used in aerospace engineering - Classification and selection criteria for aerospace materials - Importance of materials in aircraft and spacecraft design.

Metals in Aerospace:

Properties and applications of aluminum, titanium, and Magnesium alloys - Manufacturing processes for aerospace metals -Heat treatment and surface treatments.

UNIT II **9 hours**

Composites and Polymers:

Introduction to composite materials - Types of composites and their applications in aerospace - Polymer matrix composites and their manufacturing processes.

UNIT III **8 hours**

Ceramics and Advanced Materials:

Properties and applications of ceramics in aerospace - Introduction to advanced materials (e.g., carbon-carbon composites) - High-temperature applications in aerospace.

UNIT IV **10 hours**

Material Processing Techniques

Casting, forging, and machining processes for aerospace materials -Additive manufacturing (3D printing) in aerospace - Surface treatments and coatings.

Environmental Effects on Materials

Corrosion and its prevention in aerospace materials - Effects of radiation and temperature variations on materials.

UNIT V **9 hours**

Characterization Techniques: Non-destructive testing methods (ultrasonic testing, radiography, etc.) - Mechanical testing of materials (tensile, impact, hardness) - Microstructural analysis techniques (metallography, electron microscopy).

Thermal Analysis and Testing: Thermal properties of aerospace materials - Thermal testing techniques (DSC, TGA, thermal conductivity).

Textbooks:

1. Introduction to Aerospace Materials by Adrian P. Mouritz, Woodhead Publishing 2012.
2. Aerospace Materials Handbook by Sam Zhang, CRC Press, 2012.
3. Materials for Aerospace Applications by Brian Cantor,CRC Press, 2012..
4. Aerospace Materials and Material Technologies by R. C. Hendricks, CRC Press 2016.
5. Characterization of Aerospace Materials by Richard J. Fields, CRC Press, 2017.

Course Outcomes:

At the end of this course, the student will be able to

- demonstrate a comprehensive understanding of the types, properties, and applications of materials used in aerospace engineering.
- apply their knowledge of aerospace materials to select appropriate materials for specific aerospace applications, considering factors such as performance requirements, environmental conditions, and manufacturing constraints.
- gain proficiency in various manufacturing processes used for aerospace materials, including casting, forging, machining, and additive manufacturing, and understand their effects on material properties.
- develop the ability to utilize advanced characterization techniques to analyze and evaluate aerospace materials, including non-destructive testing, mechanical testing, microstructural analysis, and thermal analysis.
- recognize the effects of environmental factors such as corrosion, radiation, and temperature variations on aerospace materials and understand strategies for mitigating these effects.

AERO7101	Aerodynamics of Turbomachinery	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description: The course helps students in understanding working of variety of turbomachines used in different types of aircraft engines. It gives knowledge connected to thermodynamics and aerodynamics aspects relating to functioning of compressors and turbines. It further propels students towards designing of turbo components of different engines.

Course Educational Objectives: In this course, the students should be able to:

1. Exhibit strong command on fundamental knowledge of turbomachinery.
2. Demonstrate design knowledge of axial flow compressor.
3. Demonstrate design knowledge of centrifugal compressor.
4. Develop different types of axial radial inflow turbines for different design requirements.
5. Investigate the performance ability of different turbomachines.

UNIT – I **9 hours**

Axial Flow Compressors: Geometry structure of stage and related terminology, velocity triangles, flow behaviour, thermodynamic cycle, single and multistage, degree of reaction, stage pressure ratio and other performance characteristics, compressor pressure curve. Losses - causes, primary and secondary losses, stall, surge. Efficiencies - polytrophic, stage and adiabatic and study of performance charts.

UNIT – II **9 hours**

Centrifugal Compressors: Introduction, elements of centrifugal compressor, inlet and impeller slip factor, concept of rothalpy. Incidence and lag angles, forward lean, backward lean, velocity triangles, diffuser - vane and vaneless, volute casing centrifugal compressor characteristics, stage loses, surging, chocking.

UNIT – III **9 hours**

Axial Flow Turbines: Velocity diagrams for rotors and stators, performance computations, degree of reaction, impulse and reaction turbines, flow losses and causes, efficiencies - total to total and total to static, blade spacing,. Typical blade profiles, study of performance charts. Limitations: Materials used for blades and disks, cooling - internal, external cooling,

UNIT – IV **8 hours**

Radial Flow Turbines: Elements of radial turbines stage, stage velocity triangles, enthalpy - entropy diagrams, stage losses and efficiency, performance characteristics

Unit – V **8 hours**

Case Studies and Projects: Analysis of real-world turbomachinery systems. Case studies on performance improvement and design modifications. Project work focusing on turbomachinery design and analysis.

Textbooks

3. Baskharone, Principles of Turbomachinery in Air Breathing Engines, 2/e, Cambridge University Press, 20016.
4. R. D. Flack, Fundamentals of Jet Propulsion with Applications, 2/e, Cambridge University Press, 2018.

References

3. E. Logan Jr., Turbomachinery: Basic Theory and Applications, 2/e, Taylor and Francis limited, 1993.
4. S. A. Korpela, Principles of Turbomachinery, 2/e, John Wiley, 2018

Course Outcomes:

Upon completion of this course the students will be able to:

- Gain solid knowledge on fundamentals of aerothermodynamic aspects of turbomachinery.
- Appreciate working of axial flow compressors used in gas turbine engines.
- Understands the significance of centrifugal compressor and their contribution to enhanced engine

  performance under specific conditions.
- Demonstrate knowledge on design of axial flow turbines.
- Appraise the significance radial inflow turbines and their suitability for jet engines.

AERO7111	Hydrodynamics of Rocket pumps	L	T	P	S	J	C
		3	0	0	0	0	3

Course Description: The course is designed to impart technical knowledge related to working and design of rocket pumps used in spacecraft, rocket, and missiles. It helps students in understanding working of variety of pumps used in different types of flying systems. It gives knowledge connected to hydrodynamics and thermodynamics aspects related to functioning of variety of pumps. It encourages students towards designing of pumps and associated different components.

Course Educational Objectives:
Upon completing the course, students should be able to:

- Exhibit strong command on pump fundamental principle.
- Study, investigate and amend performance of typical turbopump.
- Demonstrate design knowledge of centrifugal pump.
- Develop different types of axial and mixed flow pumps for different design requirements.
- Incorporate advanced design features and exercise proper mechanical suitability of turbopump.

UNIT – I **8 hours**
Introduction to Turbopumps: Overview of turbomachinery and rocket pumps. Historical development of pumps. Review of fluid properties and behavior. Basic thermodynamic principles and laws. Classification of rocket pumps based on application and design. Principles of pump operation 3.2. Pump components and their functions. Fluid flow fundamentals and equations for pump analysis. NPSH and its significance, Pump performance curves.

UNIT – II **7 hours**
Centrifugal Pumps: Working principles and components of centrifugal pumps. Impeller design and performance characteristics. Cavitation and its effects on centrifugal pumps

UNIT – III **8 hours**
Axial and Mixed Flow Pumps: Operation and design principles of axial and mixed flow pumps. Blade design and performance characteristics. Applications and efficiency considerations

UNIT – IV **8 hours**
Cavitation, and flow instabilities mechanical design: Causes and effects of cavitation in pumps. Cavitation prevention and mitigation strategies. Flow instabilities and their impact on pump performance

UNIT – V **8 hours**
Case Studies and Projects: Analysis of real-world rocket pumps. Case studies on performance improvement and design modifications. Project work focusing on design of rocket pump and analysis.

Textbooks

1. Christopher E. Brennen, Hydrodynamics of Pumps, 1/e, cambridge university press, 2011
2. Robert R. Ross, Centrifugal Pumps: Design and Application, 1/e, 2017.

References

1. Rocket Propulsion Elements" by George P. Sutton and Oscar Biblarz, 9/e 2018
2. S. A. Korpela, Principles of Turbomachinery, 2/e, John Wiley, 2016

Course outcomes:

Upon completion of this course the students will be able to:

- Gain solid knowledge on fundamentals of hydrodynamic aspects of rocket pumps.
- Appreciate working of axial flow axial pumps used in rocket engines.
- Understands the significance of radial and mixed flow pumps and their contribution to enhanced engine performance.
- Recognizes the significance of cavitation and material used for rocket pumps.
- Demonstrate knowledge on design of axial radial and mixed flow pumps.

		L	T	P	C
	PROJECT WORK I	0	0	26	13

Each student is required to submit a report of first part of project work i.e. about the problem definition, literature review and methodology to be adopted including experiments and tests to be performed on topic of project as per the guidelines decided by the department. The project work is to be evaluated through Presentations and Viva-Voce during the semester.

	PROJECT WORK II	L	T	P	C
		0	0	26	13

Each student is required to submit a detailed project report about the work on topic of project as per the guidelines decided by the department. The project work is to be evaluated through Presentations and Viva-Voce during the semester and Final evaluation will be done at the end of semester as per the guidelines decided by the department from time to time. The candidate shall present/publish one paper in national/international conference/seminar/journal of repute. However, candidate may visit research labs/institutions with the due permission of chairperson on recommendation of supervisor concerned.

GITAM School of Technology

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