GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3160102

FUNDAMENTALS OF JET PROPULSION

6th SEMESTER

Type of course: Engineering Science.

Prerequisite: Aircraft Science, basic thermodynamic cycles and compressible flow machines

Rationale: Jet Propulsion signifies the need of each component of jet engines and their physical significance which offers to students the knowledge required to understand the working of jet engines and rocket engines in aircraft industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE(E)	PA (M)	ESE (V)	PA(I)	
3	0	2	4	70	30	30	20	150

Course Content:

Sr. No	Topics	Teaching Hrs.
1.	**Introduction to Aircraft Power Plant:** Air breathing and non- air breathing propulsion systems. **Turbojet engine Cycle:**Thermodynamic cycle and h-s diagram, component efficiencies, thrust equation, thermal efficiency, propulsive efficiency, overall efficiency, TSFC, Specific impulse etc., factors affecting thrust developed, matching of compressor with turbine in turbojet engines, comparison of real cycle turboprops, turbofans, turbojets and ramjets. Blade materials **Turbofan engine cycle:** Turbofan thrust, The ideal turbofan cycle, The fan bypass stream, The core stream, Turbine-compressor-fan matching, The fuel/air ratio, Maximum specific impulse and thermal efficiency **The Turboprop cycle:** Propellor efficiency, Work output coefficient and Power balance. **Numericals**	**10**
2.	**Inlets/ Intakes and Propelling Nozzles:** **Inlets/Intakes:** Introduction to inlets, Requirements of an Intake, subsonic and supersonic inlets, Diffusers,Axi-symmetric and Asymmetric Intakes, Aircraft Intake design considerations and Performance **Nozzle Theory:** Basic review of thermodynamics and one dimensional isentropic flow, Area –Mach	**10**

	relation and types of nozzle, Exhaust velocity of nozzle, Mass flow rate through nozzle and choking of nozzle, Area ratio of nozzle, Effect of back pressure, Optimum expansion, under expansion and over expansionnozzle,Variousnozzleconfigurations,DifferentTypesofNozzle, Actual mass flow rate through nozzle and equilibrium conditions	
3	**Gas Turbine Combustion Chamber/Burner:** Introduction and types of burners – Can burner, Annular burner, Cannular burner, Relative advantages and disadvantages of different types of burners, zones of combustion chamber, requirements of combustion chamber, design criteria of combustion chamber, Combustion Mechanism and Important Combustion parameters like pressure losses, combustion intensity and combustion efficiency, Fuel injection systems, flame stabilization and flame holder, Combustion Emissions, Greenhouse Gases, Low- Emission Combustors,	**08**
4	**Ramjet Propulsion:** Introduction and operating principle, Advantages, disadvantages, limitations and comparison with jet engines, Ramjet flow field, The ideal ramjet cycle, Subcritical, critical and super critical operation, Ramjet performance, Simple design calculation of ramjet engine, Introduction to scramjet engine, Numericals	**06**
5	**Pulse Jet Engine:** Introduction, types of pulse jet engine: Valved and Valve less, Pulse detonation engines.	**03**
6	**Rocket Propulsion:** Introduction to rocket propulsion and operating principle, Classification of Rockets, Introduction to chemical, electric, ion and nuclear powered rockets. Chemical Propulsion systems: Solid and liquid propellant rockets, types of propellants, thrust equation and rocket performance parameters, Propellant feeding systems, Numericals	**04**
7	* **Future Fuels and Energy Sources in Sustainable Aviation:** Introduction, Alternative Jet Fuels, Biofuels, LNG and Hydrogen, Battery systems and Fuel cell * **Promising Technologies in Propulsion and Power:** Multifuel (Cryogenic- Kerosene), Hybrid Propulsion Concept, Distributed Propulsion in Modern Aviation, Aircraft Configurations Using Advanced Propulsion Systems	**04**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20%	**25%**	**20%**	**15%**	**15%**	**05%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Gas turbines and propulsive systems by P.R.Khajuria andS.P.Dubey
2. Fundamentals of compressible fluid flow byS.M.Yahya
3. Fundamentals ofJet Propulsion with Applications, Ronald D. Flack, Cambridge University Press 2005

4. Principles of Jet Propulsion and Gas Turbines, M J Zucrow, John Willey and Sons.
5. Aircraft and Rocket Propulsion, Brian J. Cantwell
6. Future Propulsion Systems and Energy Sourcesin Sustainable Aviation, 2020 John Wiley & Sons Ltd.
7. Gas turbine theory by V. V.Ganesan

Course Outcome:
After learning the course, the students will be able to demonstrate knowledge and understanding of:

Sr. No	CO statement	Marks % weightage
CO 1	Basics of jet engines, rocket engines and their thermodynamic cycles.	25
CO 2	The design and operational behavior of the major components in aircraft gas turbine engines.	15
CO 3	The factors that limit the performance of jet engine components.	20
CO 4	Aircraft Materials, aviation jet fuels and advanced propulsion techniques.	15
CO 5	Analytical and numerical solution of aircraft and airspace propulsion systems and their thermodynamic performance.	25

List of Experiments

1. Investigation of the relationship between outlet pressure and mass flow rate for a convergent nozzle
2. Investigation of the relationship between outlet pressure and mass flow rate for a convergent -divergent nozzle
3. Investigation of the pressure distribution in convergent and convergent divergent nozzles when working over a variety of overall pressure ratios.
4. Numerical/Analytical determination of pressure and velocity variation through convergent and convergent divergent nozzle.
5. Numerical/Analytical determination of pressure and velocity variation through diffuser.
6. Numerical/Analytical determination of Turbojet engine performance.
7. Numerical/Analytical determination of Ramjet engine performance.
8. Numerical/Analytical determination of Turbofan engine performance.
9. Study of aircraft combustors.
10. Study of Advances in jet propulsion techniques.

List of Open Source Software/learning website:
https://nptel.ac.in, Coding software for numerical analysis of jet engines.

Major Laboratory Equipment needed:

Jet engine or its models and/or charts, Nozzle (convergent, divergent and convergent-divergent shapes) Test rig with air as working fluid.