3/4 B.Tech. SIXTH SEMESTER

AE6T3 **Aerospace Propulsion – II** **Credits: 4**

Lecture: 4 periods/week **Internal assessment: 30 marks**
Tutorial: ---- **Semester end examination: 70 marks**

Objectives:

1. To understand basic geometry and idealized component performance of both air breathing and non- air breathing engines, to estimate the thrust and specific impulse of a gas turbine and a rocket engine from fluid and thermodynamic principles.
2. Describes the principal figures of merit for aircraft engine and rocket motor performance and explains how they are related to vehicle performance.
3. Provide overview of analytical techniques and design issues for space propulsion systems and missions including detailed studies of chemical rockets, nuclear, electric, and advanced rocket concepts.

Learning Outcomes:

At the end of course the students will be able to:

1. Explain high speed propulsion systems, its operating principles and constructional features
2. Able to solve numerical problems eg. (sample design calculations and relative performance characteristics of ramjets and scramjets), Explain the process of combustion under various modes of operations
3. Derive rocket thrust equation and ability to solve numerical problems and relative performance characteristics of non-air breathing engines eg,.(specific impulse, specific thrust, total impulse, mass ratio, propellant mass fraction, actual velocity, effective exhaust velocity, characteristic velocity, propellant consumption, weight flow coefficient, thrust coefficient).
4. Make design choices between solid and liquid rockets propulsion systems by comparing its advantages and disadvantages, applications based on mission requirements
5. Analyze the thermodynamic performance of simple chemical and electrical rocket cycles and compute relevant performance parameters. equipped to evaluate new space propulsion cycles, and appreciate the directions and promise of upcoming developments in space propulsion concepts

Pre-requisites

The Jet Propulsion Principles, Mass, Momentum, and Energy Balances. Thermodynamics of Gases, Gas Mixtures. Review of One-Dimensional Flow of a Perfect Gas.

UNIT – I

FUNDAMENTALS OF TRANS-ATMOSPHERIC AND SPACE PROPULSION

Hypersonic transport vehicles, military missiles, space launch vehicles, spacecraft- role, types, mission profile, trajectories, operating conditions- gravity, atmosphere.

High speed propulsion systems- types, construction, operating principles- sources of energy, generation of power, momentum, propellants and applications

UNIT – II

RAMJET PROPULSION

Ramjet operating principle - Subcritical, critical and supercritical operation - Combustion in ramjet engine - Ramjet performance - Sample ramjet design calculations –- Numerical problems.

UNIT – III

SCRAMJET PROPULSION

Ramjets at high speeds – Limitations, Need for supersonic combustion, Introduction to SCRAMJET - Preliminary concepts in supersonic combustion , Combined Cycle Engines -Integral Ram Rocket (IRR), Air Turbo Rocket (ATR).

UNIT – IV

FUNDAMENTALS OF ROCKET PROPULSION

Operating principle – Thrust equation - - Rocket nozzle classifications – Rocket and propellant performance parameters –(specific impulse, specific thrust, total impulse, mass ratio, propellant mass fraction, actual velocity, effective exhaust velocity, characteristic velocity, propellant consumption, weight flow coefficient, thrust coefficient), Numerical problems.

UNIT – V

SOLID PROPELLANT ROCKET MOTORS

Solid propellant rockets - Selection criteria of solid propellants - Internal ballistics, important hardware components of solid rockets – Propellant grain design considerations

UNIT – VI

LIQUID PROPELLANT ROCKET ENGINES

Liquid propellant rockets- important hardware components, Cooling in liquid rockets, hybrid rockets –hardware components,Multi-staging concept,Limitations of hybrid rockets - Relative advantages of liquid rockets over solid rockets.

UNIT – VII

ELECTRIC PROPULSION

Electro-thermal thrusters-(Resistojet, arcjet), Electrostatic thrusters, Electromagnetic thrusters - magneto plasma dynamic (MPD) - pulsed plasma (PPT) - Hall effect and variable ISP thrusters. Operating principles, components, system parameters, performance, applications, Current technology of electric propulsion engines, applications- overview

UNIT - VIII

NUCLEAR PROPULSION

Nuclear fission- basics, sustainable chain reaction, calculating criticality, reactor dimensions, neutron leakage, control, reflection, prompt and delayed neutrons, thermal stability. Nuclear propulsion- history, operating principles, components, applications, Development status of nuclear engines, alternative reactor types, safety issues

Learning resources

Text books:

1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Ed., 1993.
2. Philipa Hill and Carl Peterson, “Mechanics and Thermodynamics of Propulsion”, Addison Wesley Longman Inc, 1999

References:

1. MarclBacareet. al.,“Rocket Propulsion”, Elsevier Pub Co, 1960
2. Zucrow M J, “Aircraft & Missile Propulsion”, John Wiley & Sons, N.Y, 1964
3. Gorden, C.V., “Aerothermodynamics of gas turbine and Rocket Propulsion”, AIAA
4. Education Series, New York, 1986
5. Oates G. C, “AeroThermodyanamics of Aircraft Engine Components”, AIAA Edn.
6. Services, N.Y, 1986
7. Rolls- Royce, “Jet Engine”, Rolls- Royce Publishers Ltd., 3rd edition, 1983.
8. Cohen. H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., “Gas turbine theory”, Longman Co., ELBS Ed., 1989
9. Ganesan V, “Gas Turbines”, TMGH Pub Co & Ed, Delhi, 1999
10. Mathur, M. L, and Sharma, R.P., “Gas Turbines and Jet Rocket Propulsion”, Standard Publishers, New Delhi, 1988
11. S M Yahya, “Fundamentals of Compressible Flow with Aircraft and Rocket propulsion”, New Age International Pub, Delhi, 2003.