SPACE PROPULSION

VI Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAE012	Core	3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

COURSE OBJECTIVES:

The course should enable the students to:	
I	Appraise various space missions, parameters to be considered for designing trajectories and rocket mission profiles.
II	Classify the different chemical rocket propulsion systems, types of igniters and performance considerations of rockets.
III	Discuss the working principle of solid and liquid propellant rockets and gain basic knowledge of hybrid rocket propulsion.
IV	Illustrate electric propulsion techniques, ion and nuclear rocket and the performances of different advanced propulsion systems.

COURSE OUTCOMES (COs):

The course should enable the students to:	
CO 1	Evaluate various space missions, parameters to be considered for designing trajectories and rocket mission profiles.
CO 2	Classify the different chemical rocket propulsion systems, types of igniters and performance considerations of rockets.
CO 3	Discuss the working principle of solid propellant rockets, propellant grain designs and combustion.
CO 4	Demonstrate the working principle of liquid propellant rockets, feed systems and gain basic knowledge of hybrid rocket propulsion.
CO 5	Illustrate electric propulsion techniques, ion and nuclear rocket and the performances of different advanced propulsion systems.

COURSE LEARNING OUTCOMES (CLOs):

1. Demonstrate the basic principles of space propulsion and its applications in different types of orbits.
2. Describe the concept of orbital elements and basic orbital equations.
3. Adapt the concepts of vertical takeoff and landing for space applications and launch trajectories.
4. Explain the operating principle of rocket engine and demonstrate the rocket equation.
5. Discuss the different Newton's laws of motion and the relation of thrust generation to different laws of motion
6. Describe the different types of propulsion systems and preliminary concepts in nozzle less propulsion and air augmented rockets.
7. Demonstrate the salient features of solid propellants rockets and estimate the grain configuration designs suitable for different missions.
8. Understand the erosive burning, combustion instability and burners
9. Remember the applications and advantages of solid propellant rockets
10. Recognize the salient features of liquid propellants rockets, various feed systems and injectors.
11. Understand the thrust control cooling, heat transfer problems, combustion instability in liquid propellant rockets

12. Understand the peculiar problems associated with operation of cryogenic engines in different missions.
13. Recognize the standard and reverse hybrid systems, combustion mechanism, applications and limitations.
14. Understand the different types of Electric, Ion and Nuclear propulsion systems.
15. Identify the future applications of electric propulsion system

Unit-I	PRINCIPLES OF ROCKET PROPULSION	Classes: 10

History of rockets, Newton's third law, orbits and space flight, types of orbits, basic orbital equations, elliptical transfer orbits, launch trajectories, the velocity increment needed for launch, the thermal rocket engine, concepts of vertical takeoff and landing, SSTO and TSTO, launch assists.

Unit-II	FUNDAMENTALS OF ROCKET PROPULSION	Classes: 09

Operating principle, Rocket equation, Specific impulse of a rocket, internal ballistics, Rocket nozzle classification, Performance characteristics of rockets, air augmented rockets, pulse rocket motors, static testing of rockets and instrumentation, safety considerations.

Unit-III	SOLID ROCKET PROPULSION	Classes: 10

Salient features of solid propellant rockets, selection criteria of solid propellants, estimation of solid propellant adiabatic flame temperature, propellant grain design considerations.

Types of igniters, Erosive burning in solid propellant rockets, combustion instability, strand burner and T-burner, applications and advantages of solid propellant rockets.

Unit -IV	LIQUID AND HYBRID ROCKET PROPULSION	Classes: 08

Salient features of liquid propellant rockets, selection of liquid propellants, various feed systems and injectors for liquid propellant rockets, thrust control cooling in liquid propellant rockets and the associated heat transfer problems, combustion instability in liquid propellant rockets, peculiar problems associated with operation of cryogenic engines, introduction to hybrid rocket propulsion, standard and reverse hybrid systems, combustion mechanism in hybrid propellant rockets, applications and limitations.

Unit -V	ADVANCED PROPULSION TECHNIQUES	Classes: 08

Electric rocket propulsion, types of electric propulsion techniques, Ion propulsion, Nuclear rocket, comparison of performance of these propulsion systems with chemical rocket propulsion systems, future applications of electric propulsion systems, Solar sail.

Text Books:

1. Turner, M.J.L., Rocket and Spacecraft Propulsion, 2nd Edition, MIT Press, 1922.
2. Sutton, G.P., "Rocket Propulsion Elements" John Wiley & Sons Inc., New York, 5th Edition, 1993
3. PHill, P.G. and Peterson, C.R., Mechanics and Thermodynamics of Propulsion, 2nd Edition, Addison Wesley, 1992.

Reference Books:

1. Mathur, M.L., and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers and Distributors, Delhi, 1988.
2. Tajmar, M., Advanced Space Propulsion Systems, Springer 2003
3. Hieter and Pratt, Hypersonic Air breathing propulsion th Edition, 1993.

Web References:
1. https://nptel.ac.in/courses/112106073/ 2. https://www.udemy.com/rocket-science/ 3. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-522-space-propulsion-spring-2015/
E-Text Books:
1. https://ebooks.benthamscience.com/book/9781608052707/ 2. https://www.springer.com/in/book/9781461406068