SPACE MECHANICS

VII Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAE016	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. Impart the knowledge in two-body, restricted three-body and n-body problem, Hamiltoniandynamics, canonical transformations, Poincare surface sections.

II. Analyze the basic Newtonian dynamics and spacecraft altitude dynamics.

III. Provide necessary knowledge to study the satellite and interplanetary trajectories and Formal approaches for handling coordinate transformations.

IV. Solve the orbital problems related to Earth satellite orbits using Hamilton's and generate interplanetary orbits in the frame work of restricted three-body problem.

COURSE OUTCOMES (COs):

CO 1 : Understand and develop basic concepts in Space Mechanics

CO 2 : Obtain a clear understanding of the Two Body Problem.

CO 3 : Develop a clear understanding of the perturbed satellite orbit, and its various implications.

CO 4 : Develop a Complete understanding of the Ballistic Missile Trajectories

CO 5 : Describe the solar system, reference frames, and coordinate systems.

COURSE OUTCOMES (COs):

1. Explain the celestial sphere, the ecliptic, a motion of vernal equinox, sidereal time, solar time, standard time, and the Earth's atmosphere
2. Analyze the concepts of discrete and continuous random variables, probability distributions, expectation and variance.
3. Recognize and describe the circular restricted three body problem, libration points, and relative motion in the N-body problem.
4. Derive and describe the Equations of motion. Specifically, the general characteristics of motion for different orbits. Understand the relations between position and time for different orbits.
5. Define and describe the expansions in elliptic motion, and orbital elements.
6. Explain the relation between orbital elements and position and velocity. Launch vehicle ascent trajectories, general aspects of satellite injection.
7. Discuss the dependence of orbital parameters on in-plane injection parameters, and launch vehicle performances, and orbit deviations due to injection errors.
8. Explain special and general perturbations, such as the Cowell's method, & Encke's method.
9. Understand the method of variations of orbital elements, and the general perturbations approach
10. Define the two-dimensional interplanetary trajectories, fast interplanetary trajectories.
11. Understand 3D interplanetary trajectories
12. Discuss about the launch of interplanetary spacecraft, and understand the trajectory of the target planet.
13. Define and understand the boost phase, the ballistic phase, trajectory geometry and optimal flights.
14. Define the time of flight and the re-entry phase.
15. Define the position of the impact point and the influence coefficients.
16. Understand the equations of motion.
17. Understand the constant radial thrust acceleration, constant tangential thrust (Characteristics of the motion), Linearization of the equations of motion, and Performance analysis.

UNIT-I	INTRODUCTION TO SPACE MECHANICS	Classes: 10
Basic concepts: The solar system, Reference frames and coordinate systems, The celestial sphere, The ecliptic, Motion of vernal equinox, Sidereal time, Solar Time, Standard Time, The earth's atmosphere. The many body problem, Lagrange-Jacobi identity. The circular restricted three body problem, Libration points, Relative Motion in the N-bodyproblem.		
UNIT-II	**THE TWO BODY PROBLEM**	**Classes: 09**
Equations of motion-General characteristics of motion for different orbits-Relations between position and time for different orbits, Expansions in elliptic motion, Orbital Elements. Relation between orbital elements and position and velocity: Launch vehicle ascent trajectories, General aspects of satellite injection. Dependence of orbital parameters on in-plane injection parameters, Launch vehicle performances, Orbit deviations due to injection errors.		
UNIT-III	**PERTURBED SATELLITE ORBIT**	**Classes: 09**
Special and general perturbations- Cowell's Method, Encke's method. Method of variations of orbital elements, General perturbations approach. Two-dimensional interplanetary trajectories, Fast interplanetary trajectories, Three dimensional interplanetary trajectories. Launch of interplanetary spacecraft. Trajectory about the target planet.		
UNIT-IV	**BALLISTIC MISSILE TRAJECTORIES**	**Classes: 09**
The boost phase, the ballistic phase, Trajectory geometry, optimal flights. Time of flight, Re-entry phase. The position of the impact point, Influence coefficients.		
UNIT-V	**LOW-THRUST TRAJECTORIES**	**Classes: 08**
Equations of Motion. Constant radial thrust acceleration, Constant tangential thrust (Characteristics of the motion), Linearization of the equations of motion, Performance analysis.		

Text Books:

1. J. W.Cornelisse,–RocketPropulsionandSpaceflightDynamics‖,PitmanPublishing,London,1979.
2. WilliamE.Wiesel,–SpaceflightDynamics‖,McGraw-Hill,3rdEdition,NewDelhi,2010.

Reference Books:

1. VladimirA.Chobotov,–OrbitalMechanics‖,AIAAEducationSeries,USA,3rd Edition,2002.
2. Kaplan, Marshall H., –Modern Spacecraft Dynamics and Control‖, John Wiley & Sons, New York, 1976.
3. Wiesel, William E.,–Spaceflight Dynamics‖, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2nd Edition2007.
4. David A. Vellado, –Fundamentals of Astrodynamics and Applications‖, Springer, Germany, 3rdEdition,2007.

Web References:

1. https://soaneemrana.org/onewebmedia/INTRODUCTION%20TO%20SPACE%20DYNAMICS1
2. https://nptel.ac.in/courses/101105030/

E-Text Books:

1. https://store.doverpublications.com/0486651134.html
2. https://worldcat.org/title/introduction-to-space-dynamics/oclc/867680515