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		

I. COURSE OVERVIEW:

The space mechanics focuses on conceptual understanding of planetary and solar systems, spacecraft manoeuvres, propulsion and control systems used in mission design of launch vehicles and missiles. This subject motivates to gain knowledge of the challenges related to the use of the space environments, criterion of dominating perturbing forces as a platform for scientific and practical purposes. Also, this course emphasisfor optimising mission design for rockets and missiles.

II. OBJECTIVES:

The course should enable the students to:

I The knowledge in two-body, restricted three-body and n-body problem, Hamiltonian dynamics, canonical transformations, Poincare surface sections.

II The characterization of orbital motions and their relations for evaluating the orbital parameters through transformations.

III Provide necessary knowledge for understanding satellite and interplanetary trajectories and formal approaches for handling coordinate transformations

IV The optimizing techniques for final mission of spacecrafts and missiles by usingvarious methods.

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO 1	**Utilise** the concepts of Solar system, Lagrange-Jacobi identity and N-body problem for determining the Lagrange points in the Earth Moon system.	Apply
CO2	**Demonstrate** the dependence of orbital parameters of orbit deviations using Orbital elements for Launch vehicle ascent trajectories	Understand
CO3	**Identify** the Equations of motion and characteristics of orbits using the relation between orbital elements and position for Launch vehicleperformance.	Apply
CO4	**Classify** the 2-Dimensional, 3-Dimensional interplanetary trajectories and general perturbations in Cowell's Method for launching interplanetary spacecraft and identifying trajectory of the target planet.	Analyze
CO5	**Illustrate** the boost phase, ballistic phase and trajectory geometry using the techniques of Re-entry for Ballistic Missile Trajectories.	Understand
CO6	**Demonstrate** the mission performance parameters with help of constant radial thrust acceleration, constant tangential thrust for Lowthrust trajectories.	Understand

IV. SYLLABUS:

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-body problem.

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, "Rocket Propulsion and Spaceflight Dynamics", Pitman Publishing, London, 1979.
2. William E. Wiesel, "Spaceflight Dynamics", McGraw-Hill, 3rd Edition, New Delhi, 2010.

Reference Books:

1. Vladimir A. Chobotov, "Orbital Mechanics", AIAA Education Series, 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 Edition 2007.
4. David A. Vellado, "Fundamentals of Astrodynamics and Applications", Springer, Germany, 3rd Edition, 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

Course Home Page: