SPACE MECHANICS

VII Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAE016	Core	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

COURSE OBJECTIVES:

The student will try to learn:

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 using various methods.

COURSE OUTCOMES:

CO1 Summarize the basic concepts in Space Mechanicsfor describing the solar system, reference frames and coordinate systems.

CO2 Describethe many body problems and the Lagrange-Jacobi identityfor identification of liberations points and relative motion in the N-body problem.

CO3 Derivethe Equations of motion and characteristics of orbits using the relations between position and time for different orbits.

CO4 Demonstrate the dependence of orbital parameters on in plane injection parameters, launch vehicle performances, and orbit deviations using the relation between orbital elements and position, velocity and Launch vehicle ascent trajectories.

CO5 Compare the perturbed satellite orbit and its various implications usingthe methods of Cowell’s method, Encke’s method, variations of orbital elements and the general perturbations approach.

CO6 Illustrate the 3D interplanetary trajectoriesfor the launching of interplanetary spacecraft and identifying trajectory of the target planet.

CO7 Outlinethe boost phase, the ballistic phase, trajectory geometry and optimal flights using Ballistic Missile Trajectories.

CO8 Illustrate the time of flight and the re-entry phase, impact point and the influence coefficientsusing the techniques of . Ballistic Missile Trajectories.

CO9 Summarize the concept of interplanetary missions and achieving the escape velocity techniques, concept of gravity turns with the equations of motion.

CO10 Demonstratethe mission performance parameters and analysis of interplanetary missions and ICBMwith help of constant radial thrust acceleration, constant tangential thrust (Characteristics of the motion), linearization of the equations of motion and Performance analysis.

CO11 Classify the ICBM phases with suitable sketchesfor low thrust trajectories.

UNIT-I	INTRODUCTION TO SPACE MECHANICS

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, Liberation points, Relative Motion in the N-body problem.

UNIT-II	TWO BODY PROBLEM
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**
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**
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**
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, 3rdEdition,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, 2ndEdition 2007.
4. David A. Vellado, ―Fundamentals of Astrodynamics and Applications‖, Springer, Germany, 3rdEdition, 2007