INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

SPACE DYNAMICS								
V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
		L	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
AAED22	**Elective**	3	-	-	3	40	60	100
Contact Classes: 48	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 48**		
Prerequisite: Nil								

I. COURSE OVERVIEW:

Space dynamics, also known as celestial mechanics, is a branch of astrodynamics that focuses on the study of the motion and behaviour of objects in space under the influence of gravitational forces. It involves analysing the orbits, trajectories, and interactions of celestial bodies, such as planets, satellites, and spacecraft. Mathematical models, often based on principles of classical mechanics and celestial gravitation, are employed to predict the motion and positions of celestial objects over time. Space dynamics plays a crucial role in space mission planning, satellite design, and understanding the stability and evolution of planetary systems. Its applications extend to predicting satellite launches, optimizing orbital manoeuvres, and ensuring the long-term stability of space missions.

II. COURSES OBJECTIVES:

The students will try to learn

I. The principles of classical mechanics and gravitational interactions that govern the motion of celestial bodies in space.
II. To analyze and compute orbital elements, trajectories, and orbital transfers, gaining practical skills in predicting and optimizing the motion of artificial satellites and spacecraft.
III. The knowledge and tools necessary for planning space missions, considering factors such as launch windows, orbital injection, and mission profiles.
IV. The practical applications of space dynamics in the context of space exploration, satellite deployment, and interplanetary missions, emphasizing the relevance of theoretical concepts to real-world scenarios.

III. COURSE OUTCOMES:

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

CO 1 Illustrate the ability to analyse and calculate various orbital parameters, such as eccentricity, inclination, and semimajor axis, enabling them to understand and predict the motion of celestial bodies and artificial satellites.
CO 2 Apply their knowledge to plan space missions, considering factors like launch windows, orbital transfers, and mission objectives. This outcome emphasizes the practical application of space dynamics in the field of space exploration.
CO 3 Analyze and predict long-term behaviours of orbits in the presence of various influencing factors.
CO 4 Apply proficiently in designing and implementing control systems for spacecraft.
CO 5 Apply navigation and control the motion of satellites and probes to achieve desired orbital configurations and mission goals.
CO 6 Develop problem-solving skills by applying space dynamics principles to real-world scenarios.

IV. COURSE CONTENT:

MODULE-I: INTRODUCTION TO SPACE MECHANICS (09)

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 bodies problem, Lagrange-Jacobi identity. The circular restricted three body problem, Liberation points, Relative Motion in the N-body problem.

MODULE – II: TWO BODY PROBLEM (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.

MODULE – III: PERTURBED SATELLITE ORBIT (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.

MODULE – IV: MANEUVERS AND ORBIT MAINTENANCE (09)

Orbit geometry change, transfer orbit. LEO, Geo-synchronous, Sun-synchronous orbit maintenance, Re-entry phase., Influence coefficients and critical orbit inclination, shape of earth and orbital change, programing in Python – orbital parameters to state vector and vice versa.

MODULE – V: LOW THRUST TRAJECTORIES (09)

Equations of Motion. Constant radial thrust acceleration, Constant tangential thrust (Characteristics of the motion), Linearization of the equations of motion, Performance analysis.

V. 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.

VI. 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 Dynamic", 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.

VII. ELECTRONICS RESOURCES:

1. https://www.nasa.gov/centers-and-facilities/armstrong/dynamics-and-controls/

VIII. MATERIALS ONLINE

1. Course template
2. Tutorial question bank
3. Tech talk topics

4. Open end experiments
5. Definitions and terminology
6. Assignments
7. Model question paper – I
8. Model question paper - II
9. Lecture notes
10. E-learning readiness videos (ELRV)
11. Power point presentation