INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

<table>
<tr><th colspan="10">ORBITAL MECHANICS</th></tr>
<tr><td colspan="10">VI Semester: AE</td></tr>
<tr><td>Course Code</td><td>Category</td><td colspan="3">Hours / Week</td><td>Credits</td><td colspan="3">Maximum Marks</td></tr>
<tr><td rowspan="2">AAED31</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>40</td><td>60</td><td>100</td></tr>
<tr><td>Contact Classes: 48</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 48</td></tr>
<tr><td colspan="9">Prerequisite: Aircraft Propulsion</td></tr>
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I. COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of Orbital mechanics or astro-dynamics is the application of ballistics and celestial mechanics to the practical problems concerning the motion of rockets and other spacecraft. The motion of these objects is usually calculated from Newton's laws of motion and law of universal gravitation. A number of problems/examples will be cited to enhance the understanding of the subject matter and besides, many unsolved problems will be provided with answers to further learning.

II. COURSE OBJECTIVES:

The students 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 rigorous vector analysis of rotational kinematics, Review of the basic Newtonian dynamics and Analysis of spacecraft altitude dynamics.

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

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

III.COURSE OUTCOMES:

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

CO 1 Understand the basic fundamental principles and definitions, problem of two bodies, Equation of motion in inertial frame.

CO 2 Construct the equations of relative motion, angular momentum and the orbit formulas.

CO 3 Determine the preliminary orbit by using different methods and under different conditions.

CO 4 Know the different orbital maneuvers and method of canonical transformations, Gravitational perturbations, Atmospheric drag and its effects.

CO 5 Apply the Kepler 's equation and Lambert 's theorem for Inter planetary transfer orbits and orbital maneuvers.

CO6 Make use of orbital linearization to assess relative motion of the interplanetary trajectory for impulsive transfer maneuvers by using gravity assist swing byte.

IV. COURSE CONTENT:

MODULE-I: INTRODUCTION TO ORBITAL MECHANICS (10)

Fundamental principles and definitions, problem of two bodies, Kepler ‘s equation; Equation of motion in inertial frame, equations of relative motion, angular momentum and the orbit formulas; Central orbits, circular orbits, elliptical orbits

MODULE-II: ORBITAL POSITION AND ORBITS IN THREE DIMENSIONS (11)

Time since periapsis, parabolic trajectories, hyperbolic trajectories, geocentric right ascension-declination frame, state vector and the geocentric equatorial frame, orbital elements and the state vector; Coordinate transformation, transformation between geocentric equatorial and perifocal frames; Effects of the Earth ‘s oblateness.

MODULE-III: PRELIMAMINARY ORBIT DETERMINATION (09)

Gibbs method of orbit determination from three position Lambert ‘s problem, sidereal time top centric coordinate system, top centric equatorial coordinate system, top centric horizon coordinate system.

Orbit determination from angle and range measurements angles only, preliminary orbit determination; Gauss method of preliminary orbit determination.

MODULE-IV: ORBITAL MANEUVERS AND PERTURBATIONS (09)

Introduction, Impulsive maneuver, Kepler ‘s equation and Lambert ‘s theorem, force model, fundamentals of perturbation theory, perturbation in the elements, Lagrange ‘s and Hamilton's equations, the method of canonical transformations, the general integrals of the problem of n-bodies, the problem of three bodies, restricted three-body problem, periodic and quasi-periodic orbits, Poincare surface sections. Gravitational perturbations, Atmospheric drag and its effects, Radiation pressure, other perturbations and corrections. Advanced techniques for dealing with gravitational and non-gravitational perturbations. Analytical and numerical methods for perturbed orbits

MODULE-V: RELATIVE MOTION AND RENDEZVOUS WITH INTERPLANTORY TRAJECTORIES (09)

Approximations to Relative motion in orbit Linearization of the equations of relative motion in orbit Clohessy-Wiltshire equations two-impulse rendezvous maneuvers Relative motion in close-proximity circular orbits. Patched-conic approximation, Interplanetary transfer orbits, Gravity assists and swing-byes. Non-impulsive maneuvers: Continuous thrust and low thrust trajectories, Optimal trajectory design, advanced mission planning and optimization technique

V.TEXT BOOKS:

1. Curtis, Howard D, “Orbital Mechanics for Engineering Students”, Butterworth Heinemann, Elsevier series, 3rd Edition, 2010.
2. Bate, Roger R.; Mueller, Donald D.; White, Jerry E. “Fundamentals of Astro-dynamics”. Dover Publications, 1st Edition 1971

VI. REFERENCE BOOKS:

1. Jerry J.; Astore, et al., “Understanding Space an Introduction to Astronautics”, McGraw Hill, 2nd Edition,2004.
2. Bryson, A.E, “Control of Aircraft and Spacecraft”, Princeton University Press, 1994.
3. Thomson, William T, “Introduction to Space Dynamics”, New York: Wiley, 3rd Edition, 1963.

VII. ELECTRONICS RESOURCES:

1. https://soaneemrana.org/onewebmedia/introduction%20to%20space%20dynamics1
2. https://projectehermes.upc.edu/Enginyeria_Aeroespacial/4A/Enginyeria%20espacial/Teoria/Extra/Orbital%20Mechanics%20for%20Engineering%20Students.pd
3. https://worldcat.org/title/introduction-to-space dynamics/oclc/867680515

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