AE470 - 01: Orbital Mechanics

Spring 2025
Monday 4:00pm - 6:30pm
178 CAMP Building

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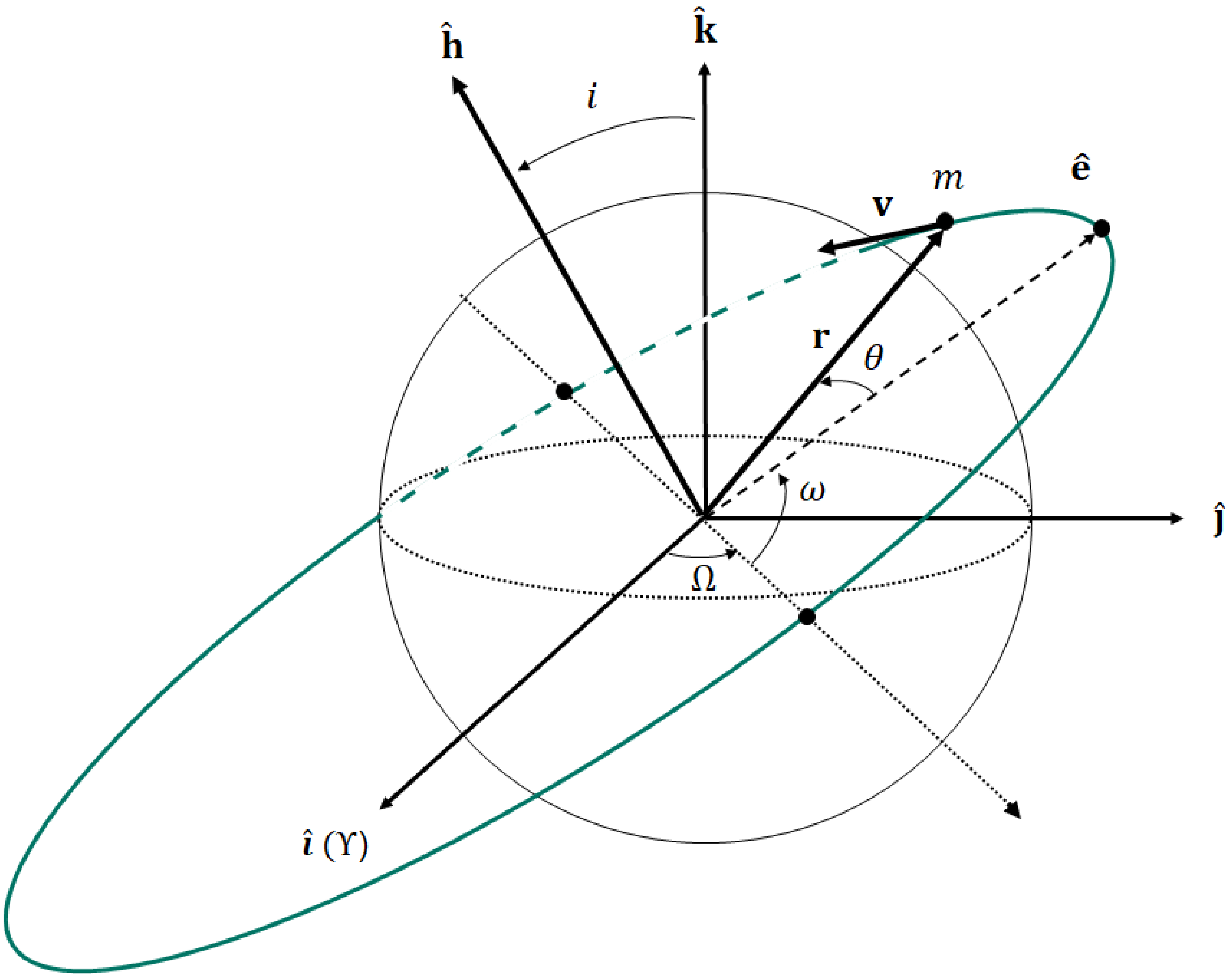

Course Description

This course provides an overview of the fundamentals of orbital mechanics. Beginning from kinematics and rigid body dynamics, students are introduced to topics in orbital and attitude dynamics and control. In orbital dynamics and control, core topics covered include: the two-body problem, orbital motion, Kepler's Laws, orbital elements, orbital perturbations, orbital maneuvers, interplanetary trajectories, and the restricted three-body problem. In attitude dynamics and control, core topics covered include: attitude stabilization, torques on a spacecraft, torque-free motion, spin and dual-spin stabilization, gravity-gradient stabilization, and active attitude control.

Units

3 credits

Prerequisites

ES 223: Rigid Body Dynamics
AE/ME 324: Dynamical Systems
MA 232: Elementary Differential Equations

Textbook

H.D. Curtis; Orbital Mechanics for Engineering Students; Butterworth-Heinemann, 4th Ed, 2021.

References

R.R. Bate, D.D. Mueller, J.E. White, W.W. Saylor; Fundamentals of Astrodynamics, Dover, 2nd Ed, 2020.

R.H. Battin; Introduction to the Mathematics and Methods of Astrodynamics, AIAA, Rev. Ed, 1999.

H.D. Curtis; Orbital Mechanics for Engineering Students; Butterworth-Heinemann, 4th Ed, 2021.

A.H.J. de Ruiter, C.J. Damaren, J.R. Forbes; Spacecraft Dynamics and Control: An Introduction; Wiley, 2013.

V.G. Szebehely; Adventures in Celestial Mechanics; University of Texas Press, 1989.

Course Objectives

CO1: Apply mathematical concepts from kinematics and rigid body dynamics to describe the position, attitude, and equations of motion of a rigid spacecraft, expressed in arbitrary reference frames.

CO2: Analytically solve problems in orbital dynamics and control, particularly with respect to two-body orbital motion, orbit determination, orbital maneuvers, orbital perturbations and interplanetary trajectories.

*CO3: Analytically solve problems in attitude dynamics and control, particularly with respect to attitude stabilization, disturbance torques, torque-free attitude motion, and active spacecraft attitude control.

Topics

1. Introduction
2. Vector and Matrix review
    1. Vector Arithmetic
    2. Dot Product
    3. Cross Product
    4. Rotation Matricies
3. Numerical Integration
4. Kinematics Review
5. Time and Coordinate Systems

6. The Two-Body Problem
    1. Newton's Laws
    2. Equations of Motion
    3. Constants of Motion
    4. Kepler's Laws
    5. Orbital Elements
7. Orbit Determination
8. Orbital Maneuvers
9. Interplanetary Trajectories
10. Orbital Perturbations
11. Restricted Three-Body Problem

Topic Schedule and Assignments

- This calendar is tentative.

Week	Date	Topics	Graded Activity
1	Jan 13	Introduction, Python Environment, Vector and Matrix Review	
2	Jan 20	Numerical Integration, Two-Body EOM	
3	Jan 27	Two-Body Constants of Motion	
4	Feb 3	Keplerian Orbits, Two-Body Orbital Elements	Assignment #1 - Numerical Integration
5	Feb 10	Keplerian Orbits, Time of Flight	STK - Level 1
6	Feb 17	Orbit Determination	Assignment #2 - p,v <=> Orbital Elements
7	Feb 24	Orbital Maneuvers	Assignment #3 - Orbit Determination
7	Feb 28	**Test #1 Due**	Test #1
8	Mar 3	Interplanetary Trajectories	Assignment #4 - Orbit Maneuvers
9	Mar 10	Orbital Perturbations	Assignment #5 - Interplanetary Trajectories
10	Mar 17	*Spring Recess (No Class)*	
11	Mar 24	Restricted Three-Body Problem	Assignment #6 - Orbital Perturbations

Week	Date	Topics	Graded Activity
12	Mar 31	Project Discussion	
13	Apr 7		
14	Apr 14	Project Presentations	STK - Mission
14	Apr 18	**Test #2 Due**	Test #2
15	Apr 21	Project Presentations	STK - Mission
16	May 6	**Project Write-Up Due**	STK - Mission

Grading

Graded Activity	Percent of Final Grade	Part Percent
Assignments (x6)	60%	
Project	20%	
STK - Level 1		5%
STK - Mission		15%
Tests (x2)	20%	