MAE 180A

Spacecraft Guidance I (4 units)

Class/Laboratory Schedule: four hours of lecture, eight hours of outside preparation.
12 hours/week total

Course Coordinator(s): M. Yousef Bahadori, William M. McEneaney

Textbooks/Materials:

1. Fundamentals of Astrodynamics, Roger R. Bate, Donald D. Mueller, and Jerry E. White; Dover Publications, 1971

Catalog Description: Astrodynamics, orbital motion, perturbations, coordinate systems and frames of reference. Geosynchronous orbits, stationkeeping. Orbital maneuvers, fuel consumption, guidance systems. Observation instrument point, tracking, control. Basic rocket dynamics. Navigation, telemetry, re-entry, and aero-assisted maneuvers. Mission design. Students perform analyses based on mission requirements.

Prerequisites: upper division standing in physics, mathematics, or engineering department

Course Type: Required

Performance Criteria:

Objective 1
1.1 Students will demonstrate understanding of the fundamentals of orbital mechanics

Objective 2
2.1 Students will demonstrate ability to apply principles of analysis to formulate and solve problems involving the trajectory equation for circular, elliptical, parabolic, and hyperbolic orbits

Objective 3
3.1 Students will demonstrate ability to analyze coordinate transformation problems applied to geocentric/topocentric, geocentric/perifocal, and topocentric/perifocal coordinate systems

Objective 4
4.1 Students will demonstrate understanding of orbital elements, calculation of these elements from known position- and velocity-vectors, orbit determination from a given set of elements, and evaluation of the time-of-flight using orbit properties and other parameters

Objective 5
5.1 Students will demonstrate ability to perform comprehensive analyses for interplanetary transfers, Lunar orbits, ballistic-missile trajectories, intercept, rendezvous, orbit-plane changes,

re-entry, fly-by, and aero-assisted maneuvers, where some of these analyses require knowledge of Hohmann transfer, non-Hohmann transfer, patched-conic approximation, or other methods

Objective 6
6.1 Students will demonstrate understanding and capability to integrate the theory and methods learned in this course in the design of specific orbits, and perform detailed mission analysis

Course Objectives:
(Numbers in parentheses refer to the specific MAE Program Outcomes)

1. Provide students with basic principles of orbital mechanics and astrodynamics (1, 2, 7, ME10, ME11, AE13, AE14)

2. Provide students will the ability to analyze, formulate, and solve problems associated with the characteristics and properties of different orbit types (1, 7, ME10, ME11, AE13, AE14)

3. Provide students will the knowledge to distinguish between orbits based on the specific reference frame under consideration and transfer the coordinates to obtain relevant orbit parameters (1, 7, ME10, ME11, AE13, AE14)

4. Provide students with the ability to accumulate a complete set of orbital elements and parameters based on a limited set of available data, and hence, identify the orbit and its specific properties (1, 4, 6, 7, ME 8, ME10, ME11, AE12, AE13, AE14)

5. Provide students with the background and understanding to analyze and solve problems associated with different types of orbits, missions, transfers, maneuvers, applications, and goals (1, 2, 4, 6, 7, ME 8, ME10, ME11, AE12, AE13, AE14)

6. Provide students with the knowledge to design missions with given specific requirements, then justify the plan, and perform comprehensive data analysis and model validation considering available resources, timelines, and other factors associated with the particular design (1, 2, 4, 5, 6, 7, ME 8, ME10, ME11, AE12, AE13, AE14)

Course Topics:
1. Fundamentals of astrodynamics; Kepler's laws; Newton's laws of motion; Newton's law of universal gravitation: the two-body equation of motion and the trajectory equation.
2. Conic sections: circular, elliptical, parabolic, and hyperbolic orbits; degenerate conics.
3. Canonical units.
4. Geocentric, topocentric, perifocal, and heliocentric coordinate systems.
5. Coordinate transformations.
6. Orbital elements and their relation to Euler angles.
7. Orbit determination from various observations; the Gibbs method.
8. Special Earth orbits; intercept and rendezvous; orbital maneuvers; in-plane orbit changes.

9. Lunar, interplanetary, and ballistic-missile trajectories.
10. Hohmann and bi-elliptic transfers; patched-conic approximation.
11. Time-of-flight determination; the Kepler's equation.
12. Perturbations.
13. Re-entry, fly-by, and aero-assisted maneuvers.
14. Propulsion requirements; fuel consumption; the delta-V budget.
15. Mission analysis and design.

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