AE 3330-Introduction to Aerospace Vehicle Performance

CATALOG DESCRIPTION:
Orbital mechanics, orbit determination, and spacecraft maneuvers. Basics of airplane flight including climb, cruise, takeoff, and landing. Actuator disk theory and elements of rotorcraft performance.

PREREQUISITES:

MATH 2552 Differential Equations
With concurrency
AE 3030 Aerodynamics

COURSE OBJECTIVES:
This course introduces students to the solution of performance problems for spacecraft, fixed-wing aircraft, and rotorcraft. Emphasis is placed on the approach used to pose and solve performance problems: setting up the equations of motion, evaluating the appropriate forces, and solving for the desired performance parameters. Students are introduced to standard performance problems for all three types of aerospace vehicles (e.g., spacecraft orbital maneuvering, airplane range, rotorcraft hover performance), and the relationship between key vehicle parameters and performance capability.

LEARNING OUTCOMES:
Students will be able to pose and solve performance problems by:

1. Setting up the equations of motion
2. Evaluating the appropriate forces
3. Solving for the desired performance parameters

TOPICAL OUTLINE:

Orbital Mechanics (6 hrs)
- Newton's law of gravitation, N-body problem, Two-body problem
- Two-body orbital mechanics (Kepler's Laws, conic section orbits)
- Orbital elements
- Conservation of angular momentum and energy
- Earth orbits (LEO, GEO, etc.)

Orbit Determination (8 hrs)
- Reference frames, Time
- Determination of orbital elements from position and velocity
- Determination of position and velocity from orbital elements
- Spacecraft ground tracks and special orbits (LEO, GEO, SSO, Molyniya)
- Oblateness effects

Orbital Maneuvers (2 hrs)
- (ΔV's, Hohmann transfers)
- Orbital plane change

Space Vehicle Performance (4 hrs)
- Idealized and modified rocket equation
- Staging

Regimes and Forces of Aircraft Flight (5 hrs)
- Atmosphere
- Forces of Flight and Equations of Motion
- Two-Parameter Quadratic Drag Polar
- Brief overview of Aircraft Propulsion Systems

Canonical Maneuvers in Fixed-Wing Aircraft Performance (10 hrs)
- Thrust required and available vs. velocity, altitude, and weight
- Thrust-limited maximum speed and lift-limited minimum speed (stall)
- Steady climb, rate and angle of climb, ceilings, time to climb
- Level turn, pull-ups, loops, and level flight acceleration
- Takeoff, landing, V/STOL performance
- Cruise range and endurance equations

Rotorcraft Performance (8 hrs)
- Rotorcraft Configurations and Capabilities
- Actuator Disk Theory
- Introduction to Blade Element Theory
- Rotors in Forward Flight (swashplate, blade flapping, retreating blade stall, lead/lag hinges)
- Rotorcraft Power Required
- Elements of Rotorcraft Performance

Exams (2 hrs)