**AE 3330-Introduction to Aerospace Vehicle Performance**

**Catalog Description** (25 words or fewer):

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 2403 Differential Equations

AE 3030 Aerodynamics (with concurrency)

**textbooks:**

Padilla, *Optmimizing Jet Transport Efficiency, Performance, Operations and Economics*, McGraw-Hill, 1996

and class notes.

**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, and
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)