Engineering Faculty Document No.: 3-00
Date: September 18, 2000

TO: Faculty of Schools of Engineering

FROM: Faculty of the School of Aeronautics and Astronautics

SUBJECT: New Course

The Faculty of the School of Aeronautics and Astronautics has approved the new undergraduate course listed below to be effective the Spring 2001 semester. This action is now submitted to the Engineering Faculty with a recommendation for approval.

AAE 440 Spacecraft Attitude Dynamics
Sem. 2, class 3, cr. 3.
Prerequisite: AAE 340, AAE 364.

Description of orientation, angular velocity, and angular acceleration in terms of direction cosines, Euler parameters, and angles. Forces and moments acting on space vehicles. Attitude stability of various types of satellites in circular and elliptic orbits. Spin stabilization and gravity gradient torques. Gyroscopic devices and energy dissipation. Introduction to attitude control.

Reason: This course is a necessary part of the School's astronautics initiative. It has been taught once under a temporary number AAE 490C, in the Spring 2000 semester, with an enrollment of 16. Students must take either AAE 440 or AAE 421 to fulfill the B.S.A.A.E. degree requirements.

Thomas N. Farris, Professor and Head
School of Aeronautics and Astronautics

APPROVED FOR THE FACULTY
OF THE SCHOOLS OF ENGINEERING
BY THE COMMITTEE ON
FACULTY RELATIONS

CFR Minutes #929

Date 10/11/00

Chairman CFR G. D. Sutton

AAE 440

Spacecraft Attitude Dynamics

Description:

Description of orientation, angular velocity, and angular acceleration in terms of direction cosines, Euler parameters, and angles. Forces and moments acting on space vehicles. Attitude stability of various types of satellites in circular and elliptic orbits. Spin stabilization and gravity gradient torques. Gyroscopic devices and energy dissipation. Introduction to attitude control.

Format: 3 hrs lecture per week.

Credit Hours: 3

Status: Students must take either AAE 440 or AAE 421 to fulfill the B.S.A.A.E. degree requirements.

Offered: Spring

Prerequisite: AAE340, AAE 364

Course Instructor: K. Howell

Textbook: none

Assessment Method: Homework 15%, Two Exams 30%, Projects 40%, Final Exam 15% Grading Policy is Instructor option and may vary from year-to-year.

Course Objective:

The development of spacecraft rigid body equations of motion in terms of quaternions, with external torques. Determination of the attitude stability of the resulting rotational motion of the spacecraft. Stabilization techniques presented and the impact determined through numerical simulations.

Necessary Background:

1. Calculus and differential equations through ODEs
2. Rigid body dynamics and vibrations
3. Stability analysis for nonlinear systems
4. Numerical simulation using MATLAB or other suitable package

Topics:

1. (1.5 weeks) Introduction to modern spacecraft dynamics (background and motivation).
2. (4 weeks) Fundamental concepts including the mathematical formalism of dyadics and the mechanics of energy and angular momentum; rotational kinematics including direction cosines, Euler angles, and Euler parameters (quaternions) as kinematic variables; coordinate systems and transformations, angular velocity and kinematic differential equations.

3. (3 weeks) External torques on a spacecraft; gravitational interactions between particles and bodies; center of gravity and centrobaric bodies.
4. (6.5 weeks) Simple spacecraft (axisymmetric and unsymmetric) and dynamic differential equations. Torque-free rotational motion; stability analysis; impact of external torques; spin stabilization; gravity gradient stabilization; dual-spinners; mass movement and momentum exchange techniques (momentum wheels, reaction wheels, control moment gyros); three-axis stabilization, attitude control.