THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Aerospace Engineering and Engineering Mechanics

ASE 372K Attitude Dynamics
Fall 2018

SYLLABUS

Unique Number:	13350
Instructor:	Renato Zanetti WRW 401D, 512-471-5145, renato@utexas.edu
Time:	TTh 2:00pm – 3:30pm
Location:	BUR 108
Teaching Assistant.:	TBD
Web Page:	Canvas (https://courses.utexas.edu)

Catalog Description:
Vehicle attitude descriptions, attitude determination, attitude control systems, attitude perturbations, and vehicle attitude design considerations. Three lecture hours a week for one semester.

Course Objectives:
The main objective is to understand the characterization and motion of the orientation (attitude) of a vehicle, with emphasis on spacecraft applications and hardware. This completes the six degrees of freedom of motion associated with an object. This course provides more depth on topics of rigid body dynamics than has been covered previously in the curriculum. A method for analyzing dynamic problems is presented through examples. An intuitive understanding is sought for the motion of objects (usually space objects in this course) about their center of mass.

Prerequisites: ASE 366K (Spacecraft Dynamics)

Knowledge, Skills, and Abilities Students Should Have Before Entering This Course:
Students should already have some ability to formulate basic forces acting on particles from fundamental physics. Some ability to write down equations of motion from inspection of dynamics problems is assumed. Some ability to write and solve ordinary differential equations is assumed. Prior instruction is assumed to be at the level of Dynamics (EM 311M). Students should also have a basic understanding of principles of orbit mechanics, such as is covered in Spacecraft Dynamics (ASE 366K).

Knowledge, Skills, and Abilities Students Gain from this Course (Learning Outcomes):
Students taking this course will gain knowledge of intermediate attitude dynamics: representations of the orientation of a rigid body, rotational equations of motion, calculation of the inertia tensor and the principal axis directions, and simple descriptions of rotational motion and stability. Students will gain more practice in differentiation of vectors in rotating systems. Students will also learn to model and select common sensor and actuator complements for attitude determination of rigid spacecraft. System design considerations will be presented for typical spacecraft.

Impact on Subsequent Courses in Curriculum:
This is an upper level undergraduate course in the Space Flight Aerospace Engineering Area of Study. The course will prepare students for problems in vehicle dynamics that may occur in graduate school and/or in a professional career in aerospace engineering. Although the course is intended for spacecraft problems, the material covered is of value to the analysis of any type of vehicle dynamics, including aircraft and other vehicles.

Relationship of Course to Program Outcomes:
This course contributes to the following ABET Criterion 3 outcomes and those specific to the EAC accredited program.

Outcome	√	Outcome	√
a. An ability to apply knowledge of mathematics, science, and engineering	√	g. An ability to communicate effectively	
b. An ability to design and conduct experiments, as well as to analyze and interpret data		h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	√	i. A recognition of the need for and an ability to engage in life-long learning	
d. An ability to function on multi-disciplinary teams		j. A knowledge of contemporary issues	
e. An ability to identify, formulate, and solve engineering problems	√	k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice	√
f. An understanding of professional and ethical responsibility			

ABET Program Criteria Achieved:
Program criteria are unique to each degree program and are to be compiled from the program criteria given for each degree program and listed in table format below. The faculty should check which of the program criteria are achieved in the course.

Criterion	√	Criterion	√	Criterion	√
A. Aerodynamics		G. Orbital Mechanics	√	M. Preliminary/Conceptual Design	
B. Aerospace Materials		H. Space Environment	√	N. Other Design Content	
C. Structures		I. Attitude Determination and Control	√	O. Professionalism	
D. Propulsion		J. Telecommunications		P. Computer Usage	
E. Flight Mechanics		K. Space Structures			
F. Stability and Control		L. Rocket Propulsion			

Topics:
1. Attitude Basics (2) (a,e,k)
2. Kinematic Equations of Motion (2) (a,e,k)
3. Inertia Tensor, Euler's Equations, Angular Momentum, Kinetic Energy (5) (a,e,k)
4. Attitude Representations (4) (a,e,k)
5. Attitude Dynamics (4) (a,c,e,k)
6. Attitude Determination and Control (4) (a,e,k)
7. Spacecraft Sensor and Actuator Models (2) (a,c,e,,k)
8. Gravity Gradient Stability and Special Topics (3) (a,c,e,k)

Professionalism Topics:
None.

Design Assignments:
None, however the final project requires making some design choices.

Laboratory Assignments:
None, although computer homework assignments may be given.

Computer:
1. Solution of Homework Problems – PC or Mac / Matlab or another equivalent software tool.
2. Final Project – PC or Mac / Simulink (recommended) or another equivalent software tool.
2. Investigation of Contemporary Space Internet Sites, Research – PC or Mac / Any Web Browser

Text:
(Required) Howard D. Curtis, *Orbital Mechanics for Engineering Students,* 3rd edition*,* Elsevier, 2013.

Class Format:
Traditional lecture format.

Class Schedule:

First Class	Thursday, August 30, 2:00 pm-3:30 PM
Midterm 1	Thursday, October 4, 2:00 pm-3:30 PM
Midterm 2	Thursday, November 8, 2:00 pm-3:30 PM
Last Class	Thursday, December 6, 2:00 pm-3:30 PM
Final Project Due	Thursday, December 6
Final Exam	Default final time (Probably: Saturday, December 15, 9:00 am-12:00 pm)

Class Outline:
Week 1, Vectors, Cross Product, Rotations, Angular Velocity.
Week 2, Kinematic Equations of Motion.
Week 4, Inertia Tensor, Principal Axes.
Week 5, Euler's Equations, Angular Momentum, and Kinetic Energy.
Week 6, Successive Rotations, Quaternions.
Week 7, Direction Cosine Matrices, Euler Angles, other representations.
Week 8, Torque Free Motion and Stability.
Week 9, Dual-spin, Nutation Dumper, and Actuators.
Week 10, Attitude Determination and Control.
Week 11, Spacecraft Sensors and Actuators.
Week 12, Perturbations and Gravity Gradient Stabilization.
Week 13, Special Topics and Course Review.

Grading:

Homework	10%
Midterm 1	20%
Midterm 2	20%
Final Project	20%
Final Exam	30%

Plus and minus letter grades (e.g. A-) will be assigned in this class for the final grade. Participation in class may be used to provide up to a half letter grade adjustment in some cases.

Homework Policy:
Homework will be posted in the class Canvas website, and is due electronically on Canvas by the posted due date. Late homework will not be accepted. Submitted homework should be legible, complete, and professional. Working together on assignments is permitted; however, every student must turn in their own original work.

Examinations:
There will be 2 in-class midterms (20% each) and 1 final exam (30%). Each test will be closed book and closed notes. All examinations are individual work.

Attendance:
Regular attendance is expected. Attendance and participation in class may be used to determine grades in borderline cases. Medical and professional (e.g., job interview) absences may be excused with proper documentation. Contact the instructor if you have any questions about absences. The student should always notify the instructor of any planned absences before that class if at all possible.

Office Hours:
The Instructor's office hours are on Tuesday and Friday, 3:30-4:30pm, WRW 401D, or by appointment. Email is welcome anytime. The TA's office hours are TBD. Course announcements and assignments will be posted on the class Canvas website. Students are responsible for any information that has been posted on the website for 24 hours.

Important Dates:

First day of classes	August 29
Labor Day holiday	September 3
Last day of add/drop period	September 4
Last day to drop class without penalty	September 14
Thanksgiving holiday	November 21-24
Last day of classes	December 10
Final Examination	Probably: Saturday, December 15, 9:00 am-12:00 pm

Special Notes:
The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the Cockrell School of Engineering Director of Students with Disabilities at 471-4321.

Evaluation:
The standardized Measurement and Evaluation Center forms for the College of Engineering will be used during the last week of class to evaluate the course and the instructor.

Prepared by: Renato Zanetti Date: August 16, 2018