San José State University
Aerospace Engineering Department
AE138: Vector-Based Dynamics for Aerospace Applications
Fall 2022

Instructor:	Prof. J.M. Hunter
Office Location:	Link for office hours: https://sjsu.zoom.us/j/96580183367
Email:	jeanine.hunter@sjsu.edu
Office Hours:	MW 12:00 – 1:00pm
Class Days/Time:	MW 9:00 – 10:15am and MW 1:30 – 2:45pm
Prerequisite:	Grade of C or better in Math 32 and Physics 50
Co-requisite:	AE 112

Course Format

Class Website: https://sjsu.instructure.com Under the courses tab, select this course.

For issues related to Canvas, please contact the eCampus Help Desk. The Help Desk can give technical support for issues encountered in Canvas Courses. Phone: (408) 924-2337
Submit a help ticket using the following URL: https://isupport.sjsu.edu/ecampus/ContentPages/Incident.aspx.

Course Description

Vector mechanics of aerospace vehicle center of mass (three degree-of-freedom particle motion). Particle kinematics, reference frames and rotational relative motion. Two degree-of-freedom aerospace vehicle (rigid body) motion, moments/products of inertia. Equations of motion and numerical time histories of the vehicle's center of mass & rigid body motions (attitude dynamics).

Course Goals

1. *To provide a fundamental knowledge of vector dynamics for aerospace applications.*
2. *To establish the basics of reference frame mechanics and relative motion.*
3. *To provide the fundamentals of aerospace vehicle center of mass (particle) kinematics of using Newtonian methods.*
4. *To write center of mass (three-dimensional) equations of motion using vector mechanics.*
5. *To understand the influence of vehicle moments/products of inertia on rigid body rotational motion.*
6. *To develop physical intuition about aerospace vehicle motion by examining the connection between the differential equations (equations of motion) and their time history solution.*

Course Learning Outcomes

1. *Combine and solve for vectors using the operations of vector algebra.*
2. *Find area using vector algebra.*
3. *Set up aerospace-vehicle-fixed basis vectors and use them to express and solve for cm (particle) position.*
4. *Set up a direction cosine matrix relating the planar orientation of two reference frames.*
5. *Express and resolve vectors (position, velocity, acceleration) into reference frames related by direction cosine matrices.*
6. *Differentiate scalars representing vehicle states; differentiate vectors in arbitrary reference frames.*
7. *Express vehicle angular velocity/acceleration and relate these concepts to the direction cosine matrix.*
8. *Solve kinematic (position/velocity/acceleration) problems when multiple reference frames are involved.*
9. *Express particle and rigid body constraints for rolling and sliding (slipping) situations.*
10. *Calculate mass center of a system of particles and of a rigid body.*
11. *Calculate aerospace vehicle model (rigid body) mass moments/products of inertia (mass properties). Intuitively understand the relationship between mass properties and rigid body motion.*
12. *Write the linear/angular momentum vectors of a dynamic system.*
13. *Inertially differentiate linear/angular momentum vectors, set them equal to applied forces/moments and thereby write the equations of motion of the system.*
14. *Write the total kinetic energy and use it to solve for the motion/reaction forces, etc. of a dynamic system.*
15. *Use MotionGenesis or Matlab to model the equations of motion of a dynamic system.*
16. *Pose an end-of semester dynamics question and carry out a team project which answers the question.*

Correlation of AE138 Course Learning Objectives with ABET Outcomes

AE138 CLO	A	B	C	D	E	F	G	H	I
1 - 14	++								x
15	++			x	x				x
16	++			x	x				x

+: Skill level 1 or 2 in Bloom's Taxonomy
++: Skill level 3 or 4 in Bloom's Taxonomy
+++: Skill level 5 or 6 in Bloom's Taxonomy
x: Skill addressed but not assessed

Required Text

Mitiguy: Dynamics of Mechanical, Aerospace and Biomechanical Systems, MotionGenesis, Inc.

References

Greenwood: Principles of Dynamics
Kane: Dynamics
Hunter: AE140 Course Reader
Thomson: Introduction to Space Dynamics
Anderson: Introduction to Flight

Course Requirements and Assignments

Homework	10%
Quizzes	30%
Daily Problem Team Participation	10%
Daily Problems	10%
Project	25%
Oral Final Exam	15%

Reading assignments will be posted for most classes and should be completed before coming to class. Homework problems will be assigned every week or two. These homework sets are essential to your understanding. Allow 8 – 10 hours per week for homework. Often we will work problems in groups during the class period, sometimes for credit, sometimes not. As homework is graded and returned to you, I will post the solutions on Canvas and work selected problems on the board. If there is a particular problem that you would like to see worked out, please let me know and I will be sure to make time to do this.

Determination of Grades

Grading Scale: 100 – 97% A plus; 96.9 – 93% A; 92.9 – 90% A minus; 89.9 – 87% B plus; 86.9 – 83% B; 82.9 – 80% B minus; 79.9 – 77% C plus; 76.9 – 73% C; 72.9 – 70% C minus; 69.9 – 67% D plus; 66.9 – 63% D; 62.9 – 60% D minus; < 59.9% F.

Late Homework Policy: Homework is due at the beginning of class, either on Canvas or as a paper submission (as specified). Late homework will be accepted for 70% credit on Canvas until 11:59pm on the due date.

Course Schedule

Lecture	Lecture Outline
1	Class Overview
2	Vector dynamics review
3	Vector basis
4	Position vectors and vector geometry
5&6	Direction cosine matrices
7&8	Vector differentiation and integration
9&10	Angular velocity & angular acceleration
11&12	Particle equations of motion; Newton's second law
13&14	Constraints
15	Linearized second order systems; Introduction to vibrations
16	Forced motion; Resonance
17	Mass, center of mass, centroid
18&19	Moments / Products of inertia
20&21	Inertia dyadic; dyadic algebra
22&23	Rigid bodies, force and momentum
24 - 26	Moments and torque; Angular momentum principle
27&28	2D Rigid body equations of motion
29	Final exam review

University Policies

Dropping and Adding Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's Catalog Policies section at http://info.sjsu.edu/static/catalog/policies.html. Add/drop deadlines can be found on the current academic calendar web page located at http://www.sjsu.edu/academic_programs/calendars/academic_calendar/. The Late Drop Policy is available at http://www.sjsu.edu/aars/policies/latedrops/policy/. Students should be aware of the current deadlines and penalties for dropping classes. Information about the latest changes and news is available at the Advising Hub at http://www.sjsu.edu/advising/.

Academic Integrity Your commitment as a student to learning is evidenced by your enrollment at San Jose State University. The University's Academic Integrity policy, located at http://www.sjsu.edu/senate/S07-2.htm, requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a *failing grade for the course* and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include your assignment or any material you

have submitted, or plan to submit for another class, please note that SJSU's Academic Policy S07-2 requires approval of instructors.

Campus Policy in Compliance with the American Disabilities Act If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the Disability Resource Center (DRC) at http://www.drc.sjsu.edu/ to establish a record of their disability.

Time Required Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of forty-five hours over the length of the course (normally 3 hours per unit per week with 1 of the hours used for lecture) for instruction or preparation/ studying or course related activities.