San José State University
Aerospace Engineering Department
AE 149, Advanced Dynamics and Simulation, Fall 2022

Course and Contact Information

Instructor(s):	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 4:30 – 5:45 pm
Classroom:	https://sjsu.instructure.com Under the courses tab, select this course.
Prerequisites:	C or better in AE30 and AE140

Course Description

Matlab scripting of Runge Kutta and stiff-ODE numerical integration algorithms. Derivation of equations of motion using Lagrange's equations (with and without a potential energy). Power/energy rate principle. Kane's equations. Analytical derivation and simulation. Multi-body dynamics. Planar two and three-body astrodynamics. Quaternions. Matlab motion animation.

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 Goals

1. To create and use different types of numerical integration techniques, understanding their differences.
2. To derive particle, single-body and multi-body equations of motion using Lagrange's Equations and Kane's Method, and compare the results with Newton's Second Law of Motion.
3. To model the particle motion created by one or two primary central force bodies.
4. To model rigid body motion with quaternions.
5. To animate particle and rigid body motion using Matlab.
6. To choose the best analysis method confidently for a particular problem.

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

1. Write the equations of motion of a double or triple particle pendulum using Lagrange's Equations of the Second Kind.
2. Derive Lagrange's Equations of the First Kind (when no potential energy exists) and use them to write the equations of non-conservative systems.
3. Compare Lagrange results with known Newtonian equations of motion and correct if necessary.

4. Write a Matlab script using the Runge Kutta numerical integration method (Taylor Series model), fourth order or above, and use it to approximate the motion of a system.
5. Write a Matlab script using an algorithm for the numerical integration of stiff ODEs, and use it to approximate the motion of a system.
6. Compare the accuracy of several numerical integration methods with the exact analog system.
7. Model a particle in Earth orbit (two-body problem).
8. Illustrate the Power/Energy Rate Principle with a Hohmann Transfer simulation and animation.
9. Using Kane's method, write the equations of motion and simulate particle, rigid body and multi-body systems.
10. Model a particle inside the spheres of influence of both the Earth and the Moon (three-body problem).
11. Derive and use quaternions to model rotational motion.
12. Use Matlab to animate particle and rigid body motion.
13. Present excellent in-class project briefings: well organized, well presented, clearly stated assumptions, professional briefing materials.

Required Texts/Readings

Textbook

Mitiguy, P., Advanced Dynamics and Motion Simulation

Other Readings

Greenwood, D.T., Principles of Dynamics, 2nd edition, ISBN 978-0137099818
Kane, T.R., Dynamics, ISBN 978-0030711602
Kane, T.R., Likins, P.W., Levinson, D.A., Spacecraft Dynamics, ISBN 978-0070378438
Thomson, W.T., Introduction to Space Dynamics, ISBN 978-0486651132
Hunter, J.M., AE140 Course Reader

Other technology requirements / equipment / material

- A computer with internet connectivity and the video conferencing software ZOOM is required. Please follow this link for more information to set it up: https://ischool.sjsu.edu/zoom

- Basic proficiency with Matlab is required. Matlab can be freely accessed from the computers in College of Engineering through VPN (for details on how to setup the Cisco VPN client on your PC use the following link: https://www.sjsu.edu/it/services/network/vpn/index.php). Microsoft Excel is part of the Office 365 package that SJSU provides for free to all students (for more details use the following link: https://www.sjsu.edu/it/services/collaboration/software/instructions.php). Additional ways of accessing the software may be available. For more information contact the IT department.

Course Requirements and Assignments

Homework	10%
Projects and Presentations	60%
Class Participation	15%
Oral Final Exam	15%

Success in this course is based on the expectation that students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practical. Other course structures will have equivalent workload expectations as described in the syllabus.

Final Examination or Evaluation

Oral final exam based on in-class examples and project work.

Grading Information

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.

Homework & project assignments are due at the beginning of the class period.

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 in teams 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.

AE149/ Advanced Dynamics and Simulation, Fall 2021, Course Schedule

Schedule is subject to change with fair notice

Course Schedule

Week	***Lecture Outline***
1	Double/triple particle pendulum; Lagrange's Equations of the Second Kind
2	Runge Kutta 4 numerical integration method
3	Lagrange examples
4	Lagrange's equations of the First Kind (when no potential energy exists)
5	Stiff ODE numerical integration methods
6	Power/energy rate principle
7	Kane's Method
8	Multi-body dynamics
9	Newton vs. Lagrange vs. Kane
10	Two-body astrodynamics
11	Hohmann transfer about Earth; application of Power/energy rate principle
12	Heliocentric Hohmann transfer for patched conic interplanetary travel
13	Quaternions
14	Three-body orbital mechanics problem: Earth-Moon transit
15	How Earth's mass distribution affects low Earth orbits
Final Exam	Venue and Time