San José State University
Aerospace Engineering Department
AE 149, Advanced Dynamics and Simulation, Section 01, Fall 2021

Course and Contact Information

Instructor(s):	Prof. J.M. Hunter
Office Location:	Engineering 272F
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Email:	jeanine.hunter@sjsu.edu
Office Hours:	W 12-1pm, Th 1-2pm
Class Days/Time:	MW 4:30 – 5:45pm
Classroom:	TBA
Prerequisites:	AE30, AE140

Course Description

Matlab scripting of Runge Kutta and Adams Bashforth Moulton numerical integration algorithms. Derivation of equations of motion with 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. Confirm Lagrange results with known Newtonian equations of motion.
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 Adams Bashforth Moulton numerical integration (predictor/corrector), fourth order or above, and use it to approximate the motion of a system.
6. Compare the accuracy of RK with ABM, and compare both numerical 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. Understand 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

P. Mitiguy: Advanced Dynamics and Motion Simulation, MotionGenesis, Inc. (graduate text)

Other Readings

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

Other technology requirements / equipment / material

Course Requirements and Assignments

Homework 20%
Projects & Presentations 50%
Class Participation 10%
Oral Final Exam 20%

“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

“Faculty members are required to have a culminating activity for their courses, which can include a final examination, a final research paper or project, a final creative work or performance, a final portfolio of work, or other appropriate assignment.”

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

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate
Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/

AE Department Policies and SJSU policies are posted at
http://www.sjsu.edu/ae/programs/policies/

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

Schedule is subject to change with fair notice

Course Schedule

Lecture	*Lecture Outline*
1	Class overview, form project teams
2	Double/triple particle pendulum; Lagrange's Equations of the Second Kind
3	Runge Kutta 4 numerical integration method
4-5	Lagrange examples
6-7	Lagrange's equations of the First Kind (when no potential energy exists)
8-9	Adams Bashforth Moulton 4 (predictor/corrector numerical approximation)
10-11	Power/energy rate principle
12-13	Kane's Method
14-15	Multi-body dynamics
16-17	Newton vs. Lagrange vs. Kane
18-19	Two-body astrodynamics
20	Hohmann transfer about Earth; application of Power/energy rate principle
21	Heliocentric Hohmann transfer for patched conic interplanetary travel
22-24	Quaternions
25-26	Three-body orbital mechanics problem: Earth-Moon transit
27-28	How Earth's mass distribution affects low Earth orbits
29	Final exam review
Final Exam	Venue and Time