San José State University
Aerospace Engineering Department
AE199: Advanced Dynamics and Simulation
Fall 2020

Instructor:	Prof. J.M. Hunter
Office Location:	Engineering 272F
Email:	jeanine.hunter@sjsu.edu
Office Hours:	To be announced
Class Days/Time:	MW 4:30 – 5:45pm
Prerequisites:	AE30, AE140
Co-requisite:	none

Course Format

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

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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 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

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 Text

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

References

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

Course Requirements and Assignments

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

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.

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

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.