San José State University
Department of Aerospace Engineering
AE251, Structural Vibrations for Aerospace Applications, Spring 2021

Course and Contact Information

Instructor:	Maria Chierichetti
Office Location:	E272C - virtual
Telephone:	408-924-4329 – not available
Email:	Maria.chierichetti@sjsu.edu
Office Hours:	Monday morning & at the end of each class
Class Days/Time:	MW 7:30-8:45pm
Classroom:	Online
Prerequisites:	Graduate standing in AE/ME or instructor consent

Course Format

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on on Canvas Learning Management System course login website at http://sjsu.instructure.com. You are responsible for regularly checking with the messaging system through MySJSU on Spartan App Portal http://one.sjsu.edu (or other communication system as indicated by the instructor) to learn of any updates.

Course Description

This class introduces the analysis of vibrations of very flexible bodies encountered as elements of aircraft wings and space structures. Topics include: free and forced vibrations of single- and multi-degree of freedom systems, simplified analysis of vibrations induced by flutter, free and forced vibrations of wings in bending and torsion, signal processing techniques for time-varying signals, forced and ground vibration testing of aerospace components, finite element analysis for wings and space structures, spacecraft and aircraft dynamic design loads.

Course Goals

1. To review vibrations of single- and multi-degree-of-freedom systems
2. To review the design principles of vibration absorbers for aircraft and space elements
3. To become familiar with analytical models to analyze the vibrations of one-dimensional aerospace components, such as wings
4. To show the application of numerical and experimental techniques for vibration testing and modal analysis
5. To analyze the dynamic loads to which aircraft and space components are subject to
6. To provide a fundamental knowledge of flutter

Course Learning Outcomes (CLO)

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

1. Derive equations of motion of aerospace components modeled with multi degree of freedom lumped parameter systems, and compute the free- and forced-vibration response
2. Design a simplified system for vibration suppression for aeronautical (i.e. landing gear, control surfaces) and space components (i.e. deployable panels)
3. Determine the equation of motion of a one-dimensional flexible system (i.e. aircraft wing, helicopter rotor blade, solar panel, deployable boom, ….) and compute its modal properties
4. Model a wings and/or spacecraft component using finite element analysis and correlate to experimental measurements
5. Analyze the design dynamic loads of aerospace structures
6. Design experiments for vibration testing of aerospace components
7. Analyze situations in which aerodynamic loads and vibrations create an unstable system
8. Compute the free- and forced-response of an aerospace component
9. Analyze and improve finite element models of wings and space structures based on ground/forced vibration testing

Required Texts/Readings

Textbook

Engineering Vibrations, *D. J. Inman*, Pearson, 4th Edition, 2014 (recommended)

Other Readings

1. "Introduction to Structural Dynamics and Aeroelasticity", *D. H. Hodges, G. A. Pierce*, Cambridge University, 2nd Edition, 2011
2. Concepts and Applications of Finite Element Analysis, *R. D. Cook, D. S. Malkus, M E. Plesha, R J. Witt*, Wiley, 2001
3. Spacecraft Structures, *J. Wijker*, Springer, 2008

Course Requirements and Assignments

Grading for this class will be based on 6-7 homework assignments, 2 midterms and a final project to be presented to the class.

"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 practica. Other course structures will have equivalent workload expectations as described in the syllabus."

Final Examination or Evaluation

Students will submit a final project in place of a final examination, that will consist in a brief report and in class presentation

Lecture and in-class participation

In-class participation is very important since lectures will be interactive and collaborative. In-class demonstrations, examples and group activities are meant to develop understanding of concepts and problem solving skills.

Students are asked to have access to Matlab during classes. Students will be assigned group instruction using breakout rooms, and will need to actively participate in the assigned work. Students will need to submit their completed work through Canvas. Students will submit their initial draft of their work at the end of class, and will submit a final version of their work on Thursday of the same week.

Homework assignments
Assignments are assigned every two weeks, unless specified otherwise. Students are allowed to work in collaboration for the solution of an assignment as long as each student turns in their own work. It is expected that the assignments will present a clean and organized thought process and methodology to solve the problem at hand.

Midterms
Students will be assigned 2 midterms to be submitted individually through Canvas. Midterms will be synchronous during class times, with tentative dates as below. Students will be required to connect to the zoom class meeting during exams, with camera on and unmuted to allow for proctoring of exam. Please let me know if there are any concerns or difficulties.

Final project
Students will be required to complete an end-of-semester group project. The project will be assigned after the first midterm. Students will present the results of their project to the class and submit a concise final report of their work.

Grading Policies

Homework assignments	20%
Midterm 1	25%
Midterm 2	25%
In class assignments – extra credit	3%
Final project	30%

Grading Information

The grading policy is described in the table below.

Grade	*Points*	*Percentage*
A plus	*960 to 1000*	*96 to 100%*
A	*930 to 959*	*93 to 95%*
A minus	*900 to 929*	*90 to 92%*
B plus	*860 to 899*	*86 to 89 %*
B	*830 to 859*	*83 to 85%*
B minus	*800 to 829*	*80 to 82%*
C plus	*760 to 799*	*76 to 79%*
C	*730 to 759*	*73 to 75%*
C minus	*700 to 729*	*70 to 72%*
D plus	*660 to 699*	*66 to 69%*
D	*630 to 659*	*63 to 65%*
D minus	*600 to 629*	*60 to 62%*

Class Policies

- Zoom meeting:
  - Please upload a picture in your zoom account
  - Students will need to login to the class meeting in zoom using their SJSU credentials

- Group work assigned using breakout rooms. It is imperative that you login to the meeting with SJSU credentials to allow a seamless participation to breakout rooms.

University Policies

Per University Policy S16-9 *(http://www.sjsu.edu/senate/docs/S16-9.pdf)*, relevant information to all courses, such as academic integrity, accommodations, dropping and adding, consent for recording of class, etc. is available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/".

The AE Program policies can be found at http://www.sjsu.edu/ae/programs/policies/

AE 251, Structural Vibrations for Aerospace Applications,

Fall 2020, Course Schedule

Course Schedule

Week	Date	Topics, Readings
1	1/27	Review of free vibrations of single degree of freedom systems
2	2/1	Review of free vibrations of single degree of freedom systems
2	2/3	One-degree-of-freedom flutter
3	2/8	Free vibrations of multi-degree-of-freedom systems
3	2/10	Forced vibrations of multi-degree-of-freedom systems
4	2/15	Two-degree-of-freedom flutter
4	2/17	Design of vibration suppression systems for landing gears
5	2/22	Design of vibration suppression systems for space components
5	2/24	Signal processing and representation of time-varying signals (FFT & PSD)
6	3/1	Spacecraft design loads (dynamic and shock loads)
6	3/3	Aircraft design loads (ground vibrations, buffeting, flutter)
7	3/8	Review
7	**3/10**	**Midterm 1**
8	3/15	Uniform wing torsional dynamics (modes and frequencies)
8	3/17	Uniform wing torsional dynamics (forced response)
9	3/22	Uniform wing bending dynamics (modes and frequencies)
9	3/24	Uniform wing bending dynamics (forced response)
10	*3/29 – 3/31*	*SPRING BREAK – no class*
11	4/5	Vibrations of wings in coupled bending and torsion

Week	Date	Topics, Readings
11	4/7	Flutter analysis for a uniform wing
12	4/12	Dynamic testing: hardware
12	4/14	Dynamic testing: harmonic and random excitations
13	4/19	Modal analysis in dynamic testing: mode shapes and natural frequency extraction
13	4/21	Review
14	**4/26**	**Midterm 2**
14	4/28	Finite element modeling in dynamics: stiffness matrix for a wing or cubesat structure
15	5/3	Finite element modeling in dynamics: mass and damping matrices of a wing or cubesat structure
15	5/5	Finite element modeling in dynamics: computing modal parameters of a wing or cubesat structure
16	5/10	Finite element modeling in dynamics: forced response of a wing or cubesat structure
16	5/12	Finite element modeling in dynamics: model reduction methods of a wing or cubesat structure
17	**5/17**	**Final project presentations**