AE 6320 – Structural Dynamics

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Basic Course Information

Credit Hours: 3

Lecture Hours and Location: Tuesday and Thursday, 2-3:15 PM, Allen 110 and DL

Office Hours and Location:

- Tuesday and Thursday: 4:30-6 PM
- By email appointment (same-day appointments not guaranteed)

I hold office hours in Weber 210C or Zoom: https://gatech.zoom.us/j/5459482388. If you plan to attend via Zoom, please let me know so I can start the meeting and coordinate with in-person attendees. If these office hours do not work for you, email me and we will find a mutual time.

Catalog Description: https://catalog.gatech.edu/coursesaz/ae/

Dynamic response of single-degree-of-freedom (SDOF) systems; Lagrange's equations; modal decoupling; vibrations of Bernoulli and Timoshenko beams, membranes, and plates.

Prerequisites: AE 3140 – Structural Analysis; AE 3530 – System Dynamics and Vibrations.

Important Dates:

08/22: First day of classes
08/26: Registration change deadline
10/17: Fall break
10/18: Fall break
10/29: Withdrawal deadline
11/24: Thanksgiving
12/05: Final instructional days
12/06: Final instructional days (last day of classes)
12/08: Start of final exams
12/15: End of final exams
12/19: Grade submission deadline
12/20: Grades available

Course Objectives and Learning Outcomes

In this course, you will learn how to solve for the dynamic responses of SDOF systems; how to derive the governing equations for multi-degree-of-freedom (MDOF) systems and solve for their dynamic responses using modal decoupling; how to derive the governing equations and boundary conditions for one-dimensional (1D) and two-dimensional (2D) continuous structures (beams, shells, and plates) and solve for their vibrations.

At the end of this course, you will be able to:

1. Formulate and solve structural dynamics problems for SDOF and MDOF systems;
2. Formulate and solve vibration problems for beams, shells, and plates;
3. Master assumptions and limitations of the models and methods learned;
4. Critically interpret and discuss problem solutions.

Course Resources

Course Materials

The slides and lecture recordings will be the primary source of information. Additionally, there are many textbooks that can be consulted for more details, such as (non-inclusive list):

- Meirovitch, *Principles and Techniques of Vibrations*, Prentice Hall, 1997
- Meirovitch, *Fundamental of Vibrations*, Waveland Press Inc., 2010
- Inman, *Engineering Vibrations,* Pearson, 2013

Related topics taught in AE 4220 – Structural Dynamics and Aeroelasticity are reported in Hodges and Pierce, *Introduction to Structural Dynamics and Aeroelasticity,* Cambridge, 2011. The related course slides and assignments from AE 4220 are distributed as extra materials in Canvas.

I share course materials (syllabus, slides, etc.), homework assignments, and take-home exams through Canvas. I also use Canvas for announcements. It is your responsibility to check Canvas and keep up to date with any available resources or information, including submission deadlines.

Questions

You are welcome to ask questions in class, office hours, and/or Piazza (you can ask anonymous questions on Piazza). I do not provide individualized explanations via email.

Our class Piazza signup link is: piazza.com/gatech/fall2022/ae6230q

While I try to answer Piazza questions promptly, my schedule may not always allow me to do so. Please do not ask questions right before a deadline expecting immediate response. I encourage everyone to answer classmates' questions and add to my answers.

Evaluation Criteria

I evaluate learning based on:

- Four homework assignments: 30%
- Take-home midterm exam: 35%
- Take-home final exam: 35%
- Participation: ±5% adjustment

Homework assignments and exams are attributed up to 100 points following the rubric below:

- Complete and correct process, right result: 100%
- Complete and correct process, wrong result: 80%
- Complete and partially correct process, wrong result: 20%
- Missing, incomplete, or wrong process, regardless of the result: 0%

Please read the evaluation criteria and let me know about any concerns by the first week of class. After that, I will assume that everyone agrees with these criteria.

Homework Assignments

Homework solutions must be developed in Word, LaTeX, etc. or be in clear handwriting and are due a week after released. If you need an extension, you should request it before the deadline. I do not need to know why you need the extension, as long as it does not become a habit.

When solving homework assignments and exams, remember to pay attention to these points:

- Justify all steps your solution, including any assumptions or simplifications
- Check for typos when copying equations to another line or page
- Substitute any numerical values into equations only at the end of the process
- Clearly define all mathematical symbols in the text or using a figure
- Include units for any dimensional quantities (and check dimensions)
- Include labels and units in plots

If homework assignments involve writing code, the code must be submitted with the solution so I can check it if I have doubts on your results. However, the submission main body should contain all steps, results, and plots. I will not run submitted code to recover pieces of the solution.

I release the points a week after the due date and upload the solution to Canvas before releasing the points, discussing common errors in class as needed. If you do not understand the solution or have concerns on the evaluation, please ask questions in class, office hours, and/or Piazza.

I consider reevaluation requests within a week after points are released. Every request should come with an explanation of why you believe your points should be revisited.

Midterm and Final Exams

The midterm and final exams will be take-home, open-book, open-notes exams.

The midterm exam will cover SDOF and MDOF systems. A detailed list of topics will be provided one week before the scheduled date. The exam will be due a week after assigned.

The final exam will cover the entire course with an emphasis on the second part and on any topics that appeared difficult to master based on class performance. The final exam will be distributed on 12/1, a week before the scheduled final exam date for our class (12/8). The final exam deadline is 12/8, 5:30 PM and is a hard deadline as defined by the GT Final Exam matrix.

While homework assignments involve longer developments, midterm and final exams will be designed to be completed in 2-3 hours (assuming one knows what to do).

Exam evaluation and release of points follow the same policies as for homework assignments.

I will include 15-20 extra-credit points in the final exam to help recover from difficulties. This means that if the final exam includes 15 extra-credit points, an exam solution that is complete and correct in all parts will earn 115 points instead of 100.

Consulting Materials and Colleagues

You can consult any materials for solving homework assignments and exams. For the homework assignments, you can discuss solution approaches with colleagues, but you should develop your own solution. For the exams, I ask you do not consult with colleagues.

Final Grade

The letter grade will be determined based on the weighted average of the points attributed to homework assignments and midterm and final exams, following from the ranges below:

- Above 90% → A
- 89-80% → B
- 79-70% → C
- 69-60% → D
- Below 59% → F

Participation makes for a ±5% adjustment, which *may* change the final grade, if the adjustment brings the weighted point average to the next range.

Please keep in mind that the participation adjustment is not an automatic +5% bump—it must be earned like everything else. Please do not ask for the participation adjustment before I have evaluated the final exams and released the weighted point average.

Some possible ways to demonstrate participation are:

- Engaging in class discussions
- Asking questions in class, during office hours, and/or on Piazza
- Answering questions from peers in class, during office hours, and/or on Piazza
- Submitting very well-prepared homework assignment and exam solutions
- Providing constructive feedback on the course
- Any other way that demonstrates some level of engagement with the content

Class Attendance

I encourage you to attend classes (in person or DL) if that is helpful for your learning, but I do not require it. You can manage your own attendance and recordings will be available to all.

Final Note on Evaluation Criteria

I list the evaluation criteria so you can have a sense of how you are doing with the class and if you are on track to pass the class. It is your responsibility to seek help if you are having difficulties. I cannot arbitrarily bump grades or assign individualized make-up work at the end of the course. Please do not make unreasonable last-minute requests.

Feedback

I always welcome constructive feedback on the course. You can provide feedback during office hours or send me an email.

Please take the time to complete the CIOS survey at the end of the term. The results will help me understand what to keep and what to change the next time I teach the class.

Tentative Schedule

1	08/23	Introduction, course information	First class
2	08/25	Response of SDOF systems to initial excitations	
3	08/29	Response of SDOF systems to harmonic excitations	
4	09/01	Damping models	
5	09/06	Responses of SDOF systems to periodic excitations	HW1 out
6	09/08	Fourier series, Laplace transforms	
7	09/13	Convolution and Duhamel's integrals	HW1 due
8	09/15	Fourier integrals and transforms	
9	09/20	The Newtonian method	HW1 points
10	09/22	Work, energy, and Lagrange's equations	
11	09/27	Work, energy, and Lagrange's equations – cont'd	
12	09/29	Matrix eigenvalue problems	HW2 out
13	10/04	Two-degree-of-freedom (2DOF) systems	
14	10/06	Eigenvalues and eigenvectors, rigid-body modes	HW2 due
15	10/11	Response of MDOF systems	
16	10/13	Response of MDOF systems – cont'd	HW2 points, midterm out
	10/18		No class
17	10/20	Hamilton's principle and calculus of variations	Midterm due on 10/22*
18	10/25	Vibrations of strings	
19	10/27	Vibrations of rods in extension and torsion	Midterm points
20	11/01	Bending vibration of Euler-Bernoulli beams	HW3 out
21	11/03	Bending vibration of Euler-Bernoulli beams – cont'd	
22	11/08	Initial-value problems for strings, rods, and beams	HW3 due
23	11/10	Membranes and plates	
24	11/15	Rayleigh's quotient, Stodola-Vianello method	HW3 points, HW4 out
25	11/17	Rayleigh-Ritz and Galerkin's methods	
26	11/22	Bending-shear vibration of Timoshenko beams	HW4 due
	11/24		Thanksgiving, no class
27	11/29	Bending-shear vibration of Timoshenko beams – cont'd	HW4 points
28	12/01	Strings revisited	Final available
29	12/06	Beams with axial force, rotating beams, Beck's problem	Last class
	12/08	Final exam day	Final due
	12/15	End of final examination period	
	12/19		Final points
	12/20		Grades available

*Midterm due 9 days after release to accommodate Fall break.

The schedule is *tentative* and may be subject to changes (such as wrapping up a topic in the next class or starting the following topic if we finish a class early). However, I will keep the listed dates for homework assignments and exams unless we mutually agree on a change.

Georgia Tech School of Aerospace Engineering Values

Honesty

The AE School values honesty and integrity of all members of our community. An important element of this value is the academic honor code.

Georgia Tech Honor Challenge Statement:
I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

Honor Code:
http://policylibrary.gatech.edu/student-affairs/academic-honor-code#Article_I:Honor_Agreement

Well Being

The AE School values the complete well-being of all members of its community, which includes professional, physical, spiritual, emotional, and social dimensions. There are many resources to support the health and well-being of all members of our community:

https://gatech.instructure.com/courses/108574

Mental Health Resources

Emergencies:
Call 911 or Campus Police at 404.894.2500 http://www.police.gatech.edu/

Center for Assessment, Referral, & Ed. (CARE):
https://care.gatech.edu/ or call 404.894.3498 (Counselor On-Call)

Counseling Center:
https://counseling.gatech.edu/ or call 404.894.2575

Stamps Health Services:
https://health.gatech.edu/ or call 404.894.1420

Student Life and Dean of Students:
https://studentlife.gatech.edu/content/get-help-now or call 404.894.6367

Victim-Survivor Support (VOICE):
https://healthinitiatives.gatech.edu/well-being/voice or call 404-385-4464/(or 4451)

National Suicide Prevention Lifeline: call 1.800.273.TALK (8255)

Georgia Crisis and Access Line: call 1.800.715.4225

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your needs and to obtain an accommodations letter. Please also email me as soon as possible to discuss your learning needs.

COVID-19 Safety: Vaccinate, Mask, Test

GT Safety Guidelines: https://health.gatech.edu/tech-moving-forward

Social Justice

The School of Aerospace Engineering values social justice for all members of the Georgia Tech community and the larger society. Social justice means that everyone's human rights are respected and protected. We stand committed in the fight against racism, discrimination, racial bias, and racial injustice. Our shared vision is one of social justice, opportunity, community, and equity. We believe that the diversity and contributions from all of our members are essential and make us who we are. We believe that our impact must reach beyond the classroom, research labs, our campus, and the technology we create, but must also improve the human condition where injustice lives. We will continue to work to understand, value, and celebrate all people and create an inclusive educational and work environment that welcomes all.

As a matter of policy, Georgia Tech is committed to equal opportunity, a culture of inclusion, and an environment free from discrimination and harassment in its educational programs and employment. Georgia Tech prohibits discrimination, including discriminatory harassment, on the basis of race, ethnicity, ancestry, color, religion, sex (including pregnancy), sexual orientation, gender identity, national origin, age, disability, genetics, or veteran status in its programs, activities, employment, and admissions.

http://policylibrary.gatech.edu/equal-opportunity-nondiscrimination-and-anti-harassment-policy