Fall 2025

CEE 541. Structural Dynamics

Instructor: Henri P. Gavin, Rm. 133 Hudson Hall, henri.gavin@duke.edu

Class Time: Tu 11:30 – 1:00

Classroom: Rm 133 Hudson

Text: Clough, R.W. and Penzien, J., *Dynamics of Structures* 3rd ed., Computers & Structures, 2003.
Paz, M. and Kim, Y.H., *Structural Dynamics: Theory and Computation* 6th ed., Springer 2019.

Course Website: http://www.duke.edu/~hpgavin/StructuralDynamics

Computers: Some assignments will involve programming.

Academic Integrity: *The Duke Community Standard* applies.

Grading: Homework: 20%; Project: 30%; Midterm: 20%; Take-Home Final: 30%

BULLETIN DESCRIPTION

CEE 541. Structural Dynamics. Formulation of dynamic models for discrete and continuous structures; normal mode analysis, deterministic and stochastic responses to shocks and environmental loading (earthquakes, wind, and waves); introduction no nonlinear dynamic systems, analysis and stability of structural components (beams and cables and large systems such as offshore towers, moored ships, and floating platforms).

OUTLINE

Core Topics

1. Virtual displacements - equations of motion - generalized coordinates - buckling.
2. Simple Oscillators - Free, harmonically forced, and impuse responses - convolution in the time and frequency domains.
3. Linear Multi Degree Of Freedom (MDOF) systems - real and complex modes - modal superposition.
4. Partial differential equation models - self-adjoint systems - damping and complex p.d.e's.
5. Random vibration - power spectral density - extreme value distribution - LTI approaches - stochastic simulation.

Special Topics

1. Lagrange's equations and constraints.
2. Visco-elasticity - dynamic hysteresis.
3. Structural elements and matrix assembly.
4. Linear Time Invariant systems and numerical integration.
5. Environmental loads - wind - wave - earthquake.
6. Tuned mass dampers - base isolation.
7. Performance Based Design - Probabilistit Seismic Hazard Analysis - Incremental Dynamic Analysis - ASCE-7.

REQUIREMENTS

- **The Duke Community Standard** http://www.integrity.duke.edu/standard.html: Duke University is a community dedicated to scholarship, leadership, and service and to the principles of honesty, fairness, respect, and accountability. Citizens of this community commit to reflect upon and uphold these principles in all academic and non-academic endeavors, and to protect and promote a culture of integrity.

  To uphold the Duke Community Standard:

  - I will not lie, cheat, or steal in my academic endeavors;
  - I will conduct myself honorably in all my endeavors; and
  - I will act if the Standard is compromised.

- **Short-term illness:** If you miss a due-date because you were sick, follow the university policy for submitting the missed assignment. http://trinity.duke.edu/academic-requirements?p=policy-short-term-illness-notification

- **Communication:** I use email for course announcements. There is no Sakai site for the course.

- **Due dates:** Homework due dates are shown in the course schedule.

- **Collaboration:** The Duke Community Standard applies to all work in the course, including homework problem sets. If you collaborate with another student, indicate your collaborator's name on each problem on which you collaborate.

- **Computer-Aided Solutions:** You may use software (such as MATLAB, Mathematica, and Maple) to help solve or simplify problems. If you do so, attach a printout of your own program/commands and results.

- **Homework grading:** Each homework assignment will be scored out of 100 points.

  Fifteen of the 100 points will be awarded for following the following rules on neatness:

  - Use pencil (so you can erase). A mechanical pencil is recommended.
  - Write neatly and clearly. Our TA's may lose patience with illegible solution sets.
  - Write your first and last name, the course number, the assignment number and the due-date in the upper right corner of the first page. Write the page number on each page (e.g., 3/6, means page 3 of 6)
  - Use a straight edge (a ruler or a triangle) to draw straight lines.
  - Present solutions to problems in the same order as listed in the assignment, and begin every problem on a new page unless the next solution is so short that it can fit on the same page.
  - Partial credit will be awarded *only* if the solution leading to an incorrect answer describes your thinking in words.
  - Draw a box around your final answer and provide the units of your answer (i.e., cm, psi).
  - Scan your hand-written solution set with a good PDF scanning app (I use one called Fast Scanner.) Email your solution to `hpgavin@duke.edu` *with the subject line:* `CEE 541: <your name> HW x` and name the `.pdf` file of your solution set: `CEE541-HWx-<YourName>.pdf`

- **Late work:** Grades for assignments submitted after the due-date will be penalized ten points for each day late; late penalties are not accrued for weekends or University holidays. Assignments submitted after graded assigments are returned receive no credit. Submit late work to me in person or under my office door.

References

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