

# Structural Dynamics

**CES 6108, Class # 11599, Section 5327**

**Class periods:** Mon., Wed., Period 1-2 (7:25 am – 9:20 am)

**Location:** WEIL 234 (Weil Hall)

**Academic term:** Spring 2020

**Instructor:**

Dr. Gary R. Consolazio

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Office: 475-J Weil Hall

Office hours: posted next to office door.

Class website: Canvas (UF E-Learning) – CES6108

**Teaching assistant:**

None.

**Course description:**

Evaluating structural response to the effects of dynamic loads for single degree and multi degree of freedom systems. Considers seismic and wind effects, modal analysis, numerical methods, structural idealization, response spectra, and design codes, (3 credits).

**Course prerequisites/co-requisites:**

An undergraduate course in fundamental dynamics.

**Course objectives:**

The purpose of this course is to provide the student with an understanding of the response of structural systems to time-varying dynamic loads and displacements. The student will study the response of single degree-of-freedom (DOF) and multi-DOF systems to harmonic and general loading conditions so that the theoretical bases of earthquake, blast, impact, etc. structural loading specifications are understood. Solution methods for free vibration and forced vibration of single and multi-DOF systems will be studied. Response spectrum analysis for support excitation (earthquake motions) will be studied.

**Material and supply fees:**

Not applicable.

**Required notes and software:**

Required course notes: Posted to course website (Canvas) in PDF format for printing by students.

Required software: MathCad (or similar).

**Recommended textbook:**

Recommended textbook: Tedesco, J.W., McDougal, W.G., Ross, C.A., (1999), *Structural Dynamics – Theory and Applications*, Addison-Wesley

**Course Schedule:****Preliminaries**

Course overview; dynamic vs. static response; types of dynamic loading: seismic, impact, wind, blast; unit sets

**Single degree of freedom systems (SDOFs)**

- **SDOFs : Introduction**  
Idealizing structures as SDOFs; relationship between structural and load frequencies
- **SDOFs : Formulating the equation of motion**  
Undamped SDOFs; dynamic equation of motion; D'Alembert's principle; equivalent stiffness; series and parallel springs; energy method
- **SDOFs : Free vibration analysis**  
Undamped systems; initial conditions; damped systems (underdamped; critically damped; overdamped); logarithmic decrement method of determining damping
- **SDOFs : Forced vibration analysis for harmonic loading**  
Undamped systems under harmonic loading; damped systems under harmonic loading (transient and steady state components); dynamic response factors; damping at resonance; harmonic ground motion; transmissibility
- **SDOFs : Forced vibration analysis for general loading**  
Undamped systems under constant and block loading; damped systems under block loading; Duhamel's integral; numeric integration of Duhamel's integral; seismic loading (ground acceleration histories)
- **SDOFs : Introduction to explosive loads**  
Propagation and reflection of blast waves in air; incident vs. reflected pressure; pressure time-history characteristics; impulse; calculation of blast parameters
- **SDOFs : Time-step integration methods for linear-elastic systems**  
Linear acceleration method; special linear acceleration method; stability and accuracy; finite difference expressions; central difference method
- **SDOFs : Seismic response spectra**  
Response spectra parameters; response spectra relationships; tri-log plots
- **SDOFs : Introduction to nonlinear analysis**  
Source of nonlinearity; numerical approaches; material hardening models; elastic-plastic analysis; equation of motion; central difference method

**Multi-degree of freedom systems (MDOFs)**

- **MDOFs : Modal properties**  
Shear building approximation; coupled equations of motion; stiffness, mass, and damping matrices; eigen analysis (mode shapes and natural frequencies)
- **MDOFs : Model reduction**  
Reduction of model size for dynamic analysis; flexibility formation and inversion
- **MDOFs : Time-step integration using mode superposition**  
Orthogonality of eigenvectors; eigenvector normalizations; modal coordinates; uncoupled modal equations of motion; mode superposition; seismic loading (ground motion); modal mass and stiffness; effective modal mass; truncated modal superposition; approximate models of damping
- **MDOFs : Response spectra analysis**  
Response spectra analysis; SRSS and CQC combination methods
- **MDOFs : Seismic design loads**  
Building code seismic provisions; permissible methods; response spectra analysis; design spectra; ground motion maps; inelastic behavior; comprehensive example
- **Introduction to frequency domain analysis (time permitting)**  
Time domain vs. frequency domain; Fourier series; the fast Fourier transform (FFT); assessing frequency content; frequency based filtering

**Attendance:**

Students are expected to attend class regularly, however, attendance will not be formally recorded. Habitual tardiness will not be tolerated. Excused absences must be in compliance with university policies in the Graduate Catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation.

**Make-up exam policy:**

Make-up exams will not be given except in cases of valid medical emergencies (for which the student must provide written documentation) or certain other admissible emergencies. Students with questions regarding this policy are urged to consult the instructor.

**Evaluation of grades:**

Assignments: 15 %, Exam 1: 25 %, Exam 2: 25 %, Exam 3: 25 %, Final project: 10 %

**Grading policy :**

A 100-93; A- 93-90; B+ 90-87; B 87-82; B- 82-80; C+ 80-77; C 77-72; C- 72-70; D+ 70-67; D 67-62; D- 62-60. Grades may be curved at the instructor's discretion.

**Assignments:**

All assignments will be evaluated for overall degree of completion. A randomly selected subset of assignments will also be graded in detail. Solutions to assignments will be distributed by the instructor. Each student is responsible for comparing their solution to the solution posted by the instructor to determine if errors were made. Questions relating to the posted solutions should be brought to the instructor for clarification.

A due date and time will be indicated on each assignment. Assignments submitted late will be penalized as follows: 0-24 hrs late: 25% penalty; 24-48 hrs late: 50% penalty; 48+ hrs late : 100% penalty. Exceptions may be made in cases where the student has spoken to the instructor *prior* to the due date of the homework or cases where there is a valid excuse (e.g. medical emergency with written proof).

Assignments will consist of hand calculations, spreadsheet/program development, use of commercial software, or a combination of any of these components. Each problem solution submitted shall begin with a statement of the problem being solved. All hand calculations must be submitted on engineering computation paper with clear calculations, and neat sketches. Sloppy, disorganized homework will not be graded. Spreadsheets/programs must include comments documenting the procedures being implemented, variables used, degrees of freedom chosen, units, etc. Where appropriate, sketches should be included either as hand drawn supplements that are referred to in the spreadsheet printouts (e.g. "see Figure 1") or as computer sketches included directly in spreadsheet/program printouts.

**Students requiring accommodations:**

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

**Course evaluation:**

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at <https://gatorevals.aa.ufl.edu/students/>. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via <https://ufl.bluera.com/ufl/>. Summaries of course evaluation results are available to students at <https://gatorevals.aa.ufl.edu/public-results/>.

**Class honesty policy:**

Each student is expected to submit work that constitutes an independent effort on their part. While open discussion of assignments (but not exams) is acceptable and, in fact, encouraged, the written work submitted by each student must reflect that student's understanding of the topics covered. Failure to comply with this policy will result in serious consequences.

**University honesty policy:**

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (<https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

**Commitment to a safe and inclusive learning environment**

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Robin Bielling, Director of Human Resources, 352-392-0903, [rbielling@eng.ufl.edu](mailto:rbielling@eng.ufl.edu)
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, [taylor@eng.ufl.edu](mailto:taylor@eng.ufl.edu)
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, [nishida@eng.ufl.edu](mailto:nishida@eng.ufl.edu)

**Software use:**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

**Student privacy:**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <https://registrar.ufl.edu/ferpa.html>

**Campus resources:***Health and Wellness***U Matter, We Care:**

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

**Sexual Discrimination, Harassment, Assault, or Violence**

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the Office of Title IX Compliance, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, [title-ix@ufl.edu](mailto:title-ix@ufl.edu)

**Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

*Academic Resources*

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling.  
<https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process>.