TAM 514 / AE 551 Elastodynamics and Vibrations
Spring 2025, MW 1:00 – 2:50 pm, 2051 Sidney Lu MEB

Instructor: Alexander F. Vakakis, office hours Th F 12:30-1:30pm CST, 3003 MEL
Canvas Course Website: https://canvas.illinois.edu/courses/54763
Media Space Lecture recordings (only for on-line students):
https://mediaspace.illinois.edu/channel/TAM+514_AE+551+Spring+2025/366158722.

Tentative List of Contents

Review of the theory of multi-DOF linear vibrating systems: Hamilton's principle, Lagrange's equations, the eigenvalue problem, normal modes, orthogonality conditions, the expansion theorem and modal analysis.

Wave equation: Differential equation of the vibrating string – of the longitudinal vibrations of a rod – of the torsional vibrations of a shaft, initial and boundary conditions, the eigenvalue problem, normal modes, orthogonality conditions, normal modes, the expansion theorem and modal analysis, free and forced vibrations, motion of the supports, kinetic and potential energy of the vibrating string (rod), Rayleigh's quotient, Rayleigh-Ritz method, Galerkin method, examples and applications.

Beam equation: Differential equation of the lateral vibrations of a beam, initial and boundary conditions, the eigenvalue problem, normal modes, orthogonality conditions, expansion theorem and modal analysis, free and forced vibrations, motion of the supports, kinetic and potential energy of the vibrating beam, Rayleigh's quotient, Rayleigh-Ritz method, Galerkin method, examples and applications.

General Sturm-Liouville theory of eigenvalue problems: Linear homogeneous differential operators, adjoint differential expressions, Green's formulas (one or more independent variables), theorems on existence of eigensolutions, discrete and continuous eigenfrequency spectra, complete and closed bases for expansion of continuous functions in R^n, orthogonal Bessel and Legendre functions, Jacobi and Tchebycheff polynomials, Green's functions.

Vibrations of membranes and plates: The wave equation in two dimensions, rectangular and circular membranes, initial and boundary conditions, the eigenvalue problem, normal modes, orthogonality conditions and modal analysis, free and forced vibrations, nodal lines, kinetic and potential energy of the vibrating membrane, Rayleigh's quotient, Rayleigh-Ritz method; Differential equation of a vibrating plate, rectangular and circular plates, initial and boundary conditions, the eigenvalue problem, kinetic and potential energy of the vibrating plate, Rayleigh's quotient, Rayleigh-Ritz method, examples and applications.

Elements of wave propagation in strings: Waves in long strings, D'Alembert solution, reflection and transmission at boundaries, dispersive relation, free vibration of finite string, the string on an elastic base-dispersion, elastic dispersive media, phase and group velocities.

Texts

Principles and Techniques of Vibration Analysis, Leonard Meirovitch, Prentice Hall (recommended)

Vibrations of Elastic Systems with Multiphysics Applications, Edward B. Magrab, 2nd edition, Springer Verlag, 2024 (recommended)

Grading

Homeworks 45%, Attendance 5%, Final Exam 50%

Attendance Policy

Attendance of the lectures by the on-campus students is mandatory. If a student misses a total of 4 lectures during the semester, this will result in a 5% course grade reduction.

Anti-racism and inclusivity statement

There is the need to raise awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment.

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team. Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Sexual misconduct reporting obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Academic integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Disability-related accommodations
To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family educational rights and privacy act (FERPA)
Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Note regarding public safety
Emergencies can happen anywhere and at any time, so it's important that we take a minute to prepare for a situation in which our safety could depend on our ability to react quickly. Take a moment to learn the different ways to leave this building. If there's ever a fire alarm or something like that, you'll know how to get out and you'll be able to help others get out. Next, figure out the best place to go in case of severe weather – we'll need to go to a low-level in the middle of the building, away from windows. And finally, if there's ever someone trying to hurt us, our best option is to run out of the building. If we cannot do that safely, we'll want to hide somewhere we can't be seen, and we'll have to lock or barricade the door if possible and be as quiet as we can. We will not leave that safe area until we get an Illini-Alert confirming that it's safe to do so. If we can't run or hide, we'll fight back with whatever we can get our hands on. If you want to better prepare yourself for any of these situations, visit police.illinois.edu/safe. Remember you can sign up for emergency text messages at emergency.illinois.edu.