AE 522: Dynamic Response of Materials
Spring 2026

Instructor: Prof. John Lambros, 306B Talbot Lab, lambros@illinois.edu

Class Hours: Monday and Wednesday 10 am-11:50 am, 403A Engineering Hall

Office Hours: Will be held online. Time(s) to be determined

Prerequisites: TAM 451 or TAM 551 (or equivalent). A knowledge of 3D linear elasticity with use of indicial notation and tensor analysis is required. Some knowledge of plasticity is helpful though not required.

Canvas site: Copies of the slides presented during the lectures can be found on the course Canvas site (https://canvas.illinois.edu/courses/66706). You are encouraged to download and/or print them prior to the lectures. The slides contain primarily the theoretical part of the course. Examples will be solved in class on the board.

Required book: There is no required textbook.

Recommended:
H. Kolsky, "Stress waves in solids", Dover, New York, 1963.
J.D. Achenbach, "Wave propagation in elastic solids", North-Holland, Amsterdam, 1990.
M.A. Meyers, "Dynamic behavior of Materials", Wiley, New York, 1994.
Zukas et al., "Impact dynamics", Krieger, Malabar, FL, 1992.

References:
W.W. Chen and B. Song, "Split Hopkinson (Kolsky) Bar: Design, Testing and Applications", Springer, New York, NY, 2010.
B.A. Auld, "Acoustic fields and waves in solids", Wiley, New York, 1973
A.H. Nayfeh, "Wave propagation in layered anisotropic media", North-Holland, Amsterdam, 1995.
L. Cagniard, "Reflection and refraction of progressive seismic waves", McGraw-Hill, New York, 1962.
M.J.P. Musgrave, "Crystal acoustics; introduction to the study of elastic waves and vibrations in crystals", Holden-day, San Francisco, 1970.
V.F. Nesterenko, "Dynamics of Heterogeneous Materials", Springer-Verlag, New York, 2001.
L B. Freund, "Dynamic fracture mechanics", Cambridge University Press, Cambridge, 1990.

Homework: A series of homework problems will be handed out approximately every second week for the first half of the semester. You are expected to do the homework and submit it online through Canvas in in a timely fashion. Please submit your homework as a single scanned PDF file. Please do not submit multiple files or image files. You may work in groups toward the solution of the homework exercises, but each student must hand in their own homework that they themselves have put together on their own (i.e., you cannot directly copy someone else's homework!).

Exam: An in-class exam will be scheduled tentatively around two thirds of the way through semester. The exam will cover everything up to and including Chapter 9 (probably).

Lab report: I will try to arrange a demo of a split Hopkinson (Kolsky) bar laboratory experiment some time during the second half of the semester. Each student will then be provided with a set of experimental data and will prepare a lab report using these data. If a demo cannot be arranged, we will use historical data sets to complete the report. More details will be given later in the semester.

Grading:

Homework	35%
Exam	40%
Lab Report	25%

Course Outline

1. Introduction: Definition, applications and uses.

2. Uniaxial stress waves: Equation of motion, x-t diagrams, Reflection at boundaries, Impedance mismatch.

3. Uniaxial strain waves: Transverse stress, Method of characteristics.

4. Bulk waves (2D/3D): Longitudinal and shear waves, Rayleigh, Stoneley waves
Plane waves in 2D, Reflection and refraction.

5. Wave guides: Dispersion, Phase and group velocities, Vibrating beams,
Love waves, Plate problems,
3D bar problems (Pochhammer-Chree).

6. Spherical waves: Impact of half spaces (Boussinesq and Lamb problems),
Impact of quarter spaces (unloading waves).

7. Inelastic waves: Elastic-plastic wave propagation, Hugoniot elastic limit,
Wave propagation in rate dependent solids,

8. Shock waves: One dimensional shock waves,
Rankine-Hugoniot relations, Equation of State (EOS).

9. Dynamic testing techniques: Split Hopkinson Bars, Plate impact technique,
Recovery and Pressure-Shear tests,
Other methods (Taylor test, Expanding ring etc.).

10. Strain rate dependence: Metals, Polymers, Glasses/Ceramics, Empirical relations,
Physically based relations.

11. Adiabatic shear bands: Thermomechanical coupling, 1D models, Thermoelasticity,
Thermoplasticity, Hyperbolic heat conduction.

12. Waves in anisotropic media: Bulk waves in anisotropic solids, The Christofel equation,
Material symmetry, Slowness and energy flow surfaces,
Interaction with a boundary (Snell's law), Rayleigh waves,
Reflection and refraction,
Strain rate effects in composite materials,

13. Waves in granular media: Solitary wave propagation in granular media.

14. Dynamic fracture: Review of near tip fields, initiation and growth criteria,
Equation of state, Crack branching, Terminal speed,
Plasticity.