AE 522: Dynamic Response of Materials
Spring 2024

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

Class Hours: Monday and Wednesday 10 am-11:50 am, 410B1 Engineering Hall

Office Hours: To be determined

Textbook and Website: There is no required textbook. Copies of the slides presented during the lectures can be found on the course Canvas site (https://canvas.illinois.edu/courses/43744). 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.

Recommended Textbooks:
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, NY, 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.

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.

Homework: Handed out approximately every other week for about the first half of the course.
Midterm exam: An in-class exam will be scheduled, tentatively around 2/3 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 Hopkinson bar lab experiment some time during the second half of the semester. Each student will then be provided with a set of experimental data and write a lab report using these data.

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.

Run > Hide > Fight

Emergencies can happen anywhere and at any time. It is important that we take a minute to prepare for a situation in which our safety or even our lives could depend on our ability to react quickly. When we're faced with almost any kind of emergency – like severe weather or if someone is trying to hurt you – we have three options: Run, hide or fight.

Run

Leaving the area quickly is the best option if it is safe to do so.

- Take time now to learn the different ways to leave your building.
- Leave personal items behind.
- Assist those who need help, but consider whether doing so puts yourself at risk.
- Alert authorities of the emergency when it is safe to do so.

Hide

When you can't or don't want to run, take shelter indoors.

- Take time now to learn different ways to seek shelter in your building.
- If severe weather is imminent, go to the nearest indoor storm refuge area.
- If someone is trying to hurt you and you can't evacuate, get to a place where you can't be seen, lock or barricade your area if possible, silence your phone, don't make any noise and don't come out until you receive an Illini-Alert indicating it is safe to do so.

Fight

As a last resort, you may need to fight to increase your chances of survival.

- Think about what kind of common items are in your area which you can use to defend yourself.
- Team up with others to fight if the situation allows.
- Mentally prepare yourself – you may be in a fight for your life.

Please be aware of people with disabilities who may need additional assistance in emergency situations.

Other resources

- **police.illinois.edu/safe** for more information on how to prepare for emergencies, including how to run, hide or fight and building floor plans that can show you safe areas.

- **emergency.illinois.edu** to sign up for Illini-Alert text messages.

- **Follow the University of Illinois Police Department** on Twitter and Facebook to get regular updates about campus safety.