Course Syllabus

VM645

Wave Propagation in Elastic Solids

Summer 2018

Course Description:

Solid wave phenomena are ubiquitous and are found in many engineering applications, such as nondestructive evaluation (NDE), medical ultrasound imaging (including phased array ultrasound and laser ultrasonics), transient analysis of biomechanical procedures, and earthquake engineering. Emerging research/engineering topics such as ultrasonic/acoustic metamaterials and phononics may also benefit from a thorough understanding of the wave mechanics.

Detailed topics: Formulation and solution of the wave propagation problem in an unbounded isotropic medium. Study of the reflection-refraction, mode conversion problem at a plane interface. Discussion of Rayleigh, Love, and general surface waves. Wave propagation in a bounded isotropic medium. Brief touching of simulation techniques of wave procedures using analytical implementations, finite element models, and finite difference technique. Engineering applications in Nondestructive Evaluation and Structural Health Monitoring.

Instructor:

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Textbook (Author, Book Title, Publisher, Publication Year, ISBN)**:**

Graff, K. F. *Wave Motion in Elastic Solids*, Dover Publications, Inc., 1975

Auld, B. A. *Acoustic fields and waves in solids*, Wiley, New York, 1973 (Volume I and II)

Course Prerequisites:

This course will focus on conveying the fundamental concepts and theories of wave propagation. Although pre-requisite courses such as vibrations and elasticity are preferred, the instructor will carefully and systematically design the course material in the fashion of building blocks. The course is intended to be self-contained. Related fundamentals of elasticity and vibrations will be introduced in each topic to help the students pave their progress.

Objectives:

1. Grasp important concepts in wave propagation, such as dispersion, phase velocity, group velocity, acoustic impedance, mode conversion, transmission and reflection.
2. Learn analytical solutions of classical wave types, such as P-wave and S-wave in 3-D solids, pressure and flexural waves in beams, Lamb waves and shear horizontal waves in plate waveguides.
3. Acquire numerical technique to quantitatively solve and analyze wave problems using Matlab and ANSYS.

Grading Policy (Assignments %, Project, Exams, etc.):

Midterm Exam 1	15%
Midterm Exam 2	15%
Midterm Exam 3	15%
Final Exam	20%
Homework (8-10 HMWKs)	30%
Class participation	5%

Homework may consist of: mathematical proofs, problems solving, and electronic simulations-animations. Show all your steps such that partial credit can be given by the grader when appropriate.

Mathematical Proofs

Mathematical proofs should preferably be performed by hand, in pencil. The emphasis will be on the clear presentation of all the steps involved in the mathematical developments. Sketches should also be included as necessary. Homework may be also submitted in typed format, if the student prefers.

Three midterm exams and one final exam will be given. Open book, open note. A grade of zero will be given for an unexcused absence from any regularly scheduled exam. Only an official excuse will allow an exam to be made-up.

Class participation will be graded using a series of active-learning strategies. Missing three times of random attendance check without valid reasons results in an automatic F in the course grade.

Honor Code Policy:

All students in the class are presumed to be decent and honorable, and all students in the class are bound by the Honor Code of the UM-SJTU Joint Institute (visit http://umji.sjtu.edu.cn/honorcode for more details). You may not seek to gain an unfair advantage over your fellow students; you may not consult, look at, or possess the unpublished work of another without their permission; and you must appropriately acknowledge your use of another's work. Following are specific policies for different types of course assignments.

Teaching Schedule:

Week	NO.	Date	lectures and Exams	Comments
1	1	05/14	Introduction; wave equation; wave speed; D' Alembert Solution	
	2	05/16	Particle velocity; initial value problem; boundary value problem	
2	3	05/21	Wave reflection at free and fixed boundaries	
	4	05/23	Acoustic impedance; wave propagation through interfaces	
3	5	05/28	Power and energy of generic waves; harmonic waves	
	6	05/30	Harmonic waves BVP; reflections; standing waves; power and energy of harmonic waves	
4	7	06/04	Exam 1	
	8	06/06	Flexural wave equation; harmonic solution	
5	9	06/11	Flexural waves dispersion; group velocity; energy velocity	
	10	06/13	Lab demos of wave transmission and reception	
6	11	06/18	Holiday for Dragon Boat Festival (No Class)	
	12	06/20	Navier Equation; plane waves in 3D solids, pressure and shear waves	
7	13	06/25	Harmonic plane waves in 3D; wave potentials	
	14	06/27	Exam 2	
8	15	07/02	Z-invariant (plane strain) 3D waves; SH waves; P+SV waves	
	16	07/04	Normal P-wave propagation through bi-material interface	
9	17	07/09	Oblique SH wave propagation through bi-material interface	

	18	07/11	Oblique P+SV wave propagation through biomaterial interface	
10	19	07/16	Exam 3 (Cumulative)	
	20	07/18	SH guided waves; dispersion curves; wave mode shapes	
11	21	07/23	Lamb guided waves; dispersion curves	
	22	07/25	Lamb wave mode shapes; axial and flexural plate waves	
12	23	07/30	Rayleigh guided waves; Generic spherical and circular waves	
	24	08/01	Review	
13	25	08/06	Final Exam	
	26	08/08	End of Term (No Class)	