

AAE 552 – NDE of Structures and Materials

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office hours for on-campus students: MF 10:00 – 11:00 AM EST, W 4:00 – 5:00 PM EST

office hours for distance students: MWF 5:00 – 6:00 PM EST

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Course Description

Overview the physics, principles, and methods employed for nondestructive evaluation (NDE) of structures and materials. Major NDE techniques covered include radiographs, ultrasonics, eddy currents, penetrants, magnetic flux, and visual/optical methods. An introduction to structural health monitoring (SHM) is also provided.

Prerequisites

Basic knowledge of mechanics of materials, elasticity, fatigue, fracture, linear algebra, and differential equations.

Course Goals and Learning Objectives

The objective of this course is to give students an understanding of the importance of NDE, the underlying physics of common NDE and SHM techniques, and the processes by which these techniques are applied.

Required Text

Fundamentals of Structural Integrity by Alten F. Grandt, Jr.

Policies

Exams

There will be no in-class exams and one final exam. The final exam will be worth 25% of your overall grade. Reasonable accommodations will be made for students having exceptional circumstances preventing them from taking exams during the scheduled times. However, requests for such accommodation must be made as soon as possible. The instructor reserves the right to use his discretion regarding this, and conflicts will be mediated through the college/university. See also **Grief Absence Policy for Students**, **Students with Disabilities**, and **Academic Dishonesty**.

Remote students are responsible for arranging a proctor and testing site for their exams. There is a process by which proctors are vetted through Purdue Engineering Professional Education. More information can be found via the following link.

<https://engineering.purdue.edu/ProEd/student-resources/taking-exams/exam-process>

Homework

Homework sets will be assigned corresponding to each major topic in the course. Homework is collectively worth 35% of your overall grade. Late homework will not be accepted. Working with classmates is encouraged, but simply copying answers will be considered cheating and receive no credit. The grader may use his or her discretion in the aforementioned. See also **Grief Absence Policy for Students, Students with Disabilities, and Academic Dishonesty.**

All assignments (homework and term paper assignments) must be submitted via Blackboard with the following file names. **All submissions must be received no later than 11:59 PM EST on the due date.**

firstname_lastname_AAE552_HW#	for homework assignments
firstname_lastname_AAE552_proposal	for term paper proposal
firstname_lastname_AAE552_references	for term paper references
firstname_lastname_AAE552_outline	for term paper outline
firstname_lastname_AAE552_term_paper	for final term paper

Term Paper

A term paper examining a case study, industrial practice, or research-based NDE or SHM is due at the end of the semester and worth 25% of your grade. Supporting documents leading up to the term paper are worth an additional 15% of your grade. The term paper must follow templates provided online. Grading of the term paper will be discussed in class.

Grading

- 5% - half-page proposal of term paper topic
- 5% - list of 6 references and relevance to term paper
- 5% - outline of term paper
- 35% - homework
- 25% - term paper
- 25% - final exam

A+ \geq 96.67% (note that both an A+ and an A are worth 4.0)
96.67% > A \geq 93.33%
93.33% > A- \geq 90%

90% > B+ \geq 86.67%
86.67% > B \geq 83.33%
83.33% > B- \geq 80%

80% > C+ \geq 76.67%
76.67% > C \geq 73.33%
73.33 > C- \geq 70%

70% > D+ \geq 67.67%
67.67% > D \geq 63.33%
63.33% > D- \geq 60%

F < 60%

The instructor reserves the right to curve or to not curve the class.

Academic Dishonesty

Purdue prohibits “dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty.” [Section B.2.a, Code of Student Conduct] Furthermore, the University Senate has stipulated that “the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest.” [University Senate Document 72-18, December 15, 1972]

The instructor reserves the right to reprimand cheating at a level commensurate with the offense. This includes up to reporting to the college/university and failing the course.

More information on academic integrity can be found at www.purdue.edu/odos/osrr/academic-integrity-brochure.

Purdue Honor Pledge

The Honor Pledge Task Force, a student organization responsible for stewarding the mission of the Honor Pledge and encouraging a culture of academic integrity, asks all instructors to prominently include the student-initiated Purdue Honor Pledge on their syllabus. The statement as written by our own Purdue students is, “**As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together – we are Purdue.**”

Use of Copyrighted Materials

Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally considered to be “derivative works” of the instructor’s presentations and materials, and they are thus subject to the instructor’s copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

Grief Absence Policy for Students

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

Students with Disabilities

Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

If you have a disability that requires special academic accommodation, please make an appointment to speak with the instructor within the first three weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications.

Mental Health Syllabus Statement

If you find yourself beginning to feel undue stress, anxiety, and/or feeling slightly overwhelmed, try WellTrack, <https://purdue.welltrack.com>. If you need support and information about options and resources, please see the Office of the Dean of Students, <http://www.purdue.edu/odos>.

Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, contact Counseling and Psychological Services (CAPS) at (765)494-6995 and <http://www.purdue.edu/caps/> during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent behavior impedes such goals. Therefore, violent behavior is prohibited in or on any university facility or while participating in any university activity.

Emergencies

In the event of a major campus emergency, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone.

Additional information on general emergency preparedness and the emergency plan for the Seng-

Liang Wang Hall can be found via the following link.

https://engineering.purdue.edu/ECE/Safety/WANG_BEP_2014-2015.pdf

Nondiscrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

Class Schedule

A tentative schedule is provided below with required readings. All required readings are from Fundamentals of Structural Integrity unless otherwise indicated. Next to the date of each week is a short summary of the topics covered.

Week 1 – Introduction to NDE

Required reading: chapters 1 and 4

- Syllabus discussion
- NDE definition and applications
- Case studies
- Mordfin's axioms/NDE myths
- Discontinuities – classifications and origins
- Overview of common NDE
- Acceptance criteria
- Inspection reliability
- Probability of detection
- Inspection period
- Discussion on term paper

Week 2 Brief Review of Linear Elasticity

Required reading: chapter 2

- Index notation
- Infinitesimal strain

- Cauchy stress tensor
- Principal stresses and directions
- Maximum shear stress
- Constitutive relations
- Equilibrium
- Yield criteria

Week 3 – Brief Review of LEFM and Fatigue Crack Growth

Required reading: chapter 3

- K -controlled fracture
- Stress intensity factor
- Crack tip stresses
- Mixed-mode fracture
- Fatigue crack growth

Week 4 – Visual and Dye-Penetrant Methods

Required reading: chapter 10

- Visual inspection
 - History and development
 - Theory and principles
 - Equipment and accessories
 - Applications and techniques
 - Advantages and limitations
- Dye-penetrant methods
 - History and development
 - Basic method
 - Fluid flow via capillary action
 - Techniques and equipment
 - Advantages and limitations

Weeks 5 and 6 – Magnetic Particle Methods

Required reading: chapter 14

- History and development
- Basic method
- Review of electromagnetism and ferromagnetism
- Techniques and equipment
- Advantages and limitations

Weeks 7 and 8 – Radiographic Methods

Required reading: chapter 11

- History and development
- Basic method
- Overview of radiation and nuclear physics
- Techniques and equipment
- Advantages and limitations

Week 9 – Ultrasonic Methods

Required reading: chapter 12

- History and development
- Basic method
- Properties of sound waves

Week 10 – Ultrasonic Methods, Continued

Required reading: chapter 12

- Techniques and equipment
- Advantages and limitations

Weeks 11 and 12 – Eddy Current Methods

Required reading: chapter 13

- History and development
- Basic method
- Electromagnetic principles
- Techniques and equipment
- Advantages and limitations

Week 13 – Other NDE Methods

Required reading: chapter 15

- Acoustic emission inspection
- Thermal inspection
- Advanced optical techniques

Week 14 – Introduction to SHM and Dynamic Methods

Suggested reading: chapters 1-3 of Health Monitoring of Structural Materials and Components by Douglas E. Adams and chapter 4 of Structural Health Monitoring of Aerospace Composites by Victor Giurgiutiu

- Basics of SHM
- Comparison to NDE
- Technical areas of SHM
- Overview of techniques
- Vibration-based SHM

Week 15 – Embedded Sensor SHM

Suggested reading: chapters 7 and 8 of Structural Health Monitoring of Aerospace Composites by Victor Giurgiutiu

- Fiber-optic sensors
- Self-sensing materials
- Review for final exam