

# **AAE 552 – NDE of Structures and Materials**

Spring 2018  
MWF 9:30 – 10:20 AM EST  
WANG 2555

## **Professor Tyler N. Tallman**

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## **Teaching Assistant: TBD**

email: TBD  
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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 x-rays, 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 25% 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.**

On-campus students must submit a hard copy of their homework in class on the day that it is due. Multiple pages must be stapled together.

Remote students must send an electronic copy of their homework to the teaching assistant via email before the end of the day (11:59 PM EST) that it is due. Please submit your homework as a single .pdf file and use 'firstname\_lastname\_AAE552\_HW#' in the subject line of your email and as the file name of your submission.

### **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 25% of your grade. The term paper must follow templates provided online. Grading of the term paper will be discussed in class.

### **Grading**

7.5% - half-page summary of term paper topic

7.5% - list of 10 references, brief summary of references, and relevance to term paper

10% - outline of term paper

25% - 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+ ≥ 76.67%  
76.67% > C ≥ 73.33%  
73.33 > C- ≥ 70%

70% > D+ ≥ 67.67%  
67.67% > D ≥ 63.33%  
63.33% > D- ≥ 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.

Additional information on Purdue academic integrity can be found at [www.purdue.edu/odos/osrr/academic-integrity-brochure](http://www.purdue.edu/odos/osrr/academic-integrity-brochure).

### **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 (<http://www.purdue.edu/drc>) of an impairment/condition that may require accommodations and/or classroom modifications.

### **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](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](http://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. **Important dates are in red and boldfaced.**

### **Week 1 – Introduction to NDE**

January 8 – 12

*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
- Additional resources

### **Week 2 Review of Linear Elasticity**

January 17 – 19 (**no class January 15, MLK day**)

*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 – Review of LEFM and Fatigue Crack Growth**

January 22 – 26

*Required reading: chapter 3*

- *K*-controlled fracture
- Stress intensity factor
- Crack tip stresses
- Mixed-mode fracture
- Fatigue crack growth
- Discussion on term paper

#### **Week 4 – Visual and Dye-Penetrant Methods**

January 29 – February 2

*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**

February 5 – 16

*Required reading: chapter 14*

- History and development
- Basic method
- Review of electromagnetism and ferromagnetism
- Techniques and equipment
- Advantages and limitations
- **Half-page summary of term paper topic due 2/16**

#### **Weeks 7 and 8 – Radiographic Methods**

February 19 – March 2

*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**

March 5 – 9

*Required reading: chapter 12*

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

**No class March 12 – 16, spring vacation**

## **Week 10 – Ultrasonic Methods, Continued**

March 19 – 23

*Required reading: chapter 12*

- Techniques and equipment
- Advantages and limitations
- **List of 10 references, summaries, and relevance due 3/23**

## **Weeks 11 and 12 – Eddy Current Methods**

March 26 – April 6

*Required reading: chapter 13*

- History and development
- Basic method
- Electromagnetic principles
- Techniques and equipment
- Advantages and limitations
- **Term paper outline due 4/6**

## **Week 13 – Introduction to SHM**

April 9 – 13

*Suggested reading: chapter 1 of Health Monitoring of Structural Materials and Components by Douglas E. Adams*

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

## **Week 14 – Dynamic SHM**

April 16 – 20

*Suggested reading: chapters 2 and 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*

- Vibration-based SHM
- Guided wave SHM

## **Week 15 – Embedded Sensor SHM**

April 23 – 27

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

- Fiber-optic sensors
- Self-sensing materials
- **Term paper due 4/27**

**Week 16 – Final Exam Week**

**April 30 – May 5, final exam time and location TBD**