

## Syllabus

This syllabus is subject to change. You will be notified of any changes as far in advance as possible via an announcement on Brightspace. Monitor your Purdue email daily for updates.

### Course Information

**Course number and title:** AAE 59000 Design of Composite Materials and Structures

**Meeting days, time and location:** TR 3:00 – 4:15 pm, Wang 2599

**Live stream and recorded lectures** can be found in Brightspace under Course Tools → Kaltura Media Gallery

**Instructional modality:** In-person/distance

**Prerequisites:** AAE 352

**Credits:** 3

### Instructor Contact Information

**Instructor:** Dianyun Zhang, Ph.D.

**Office location:** ARMS 3233/CMSC 116

**Office phone number:** (765)496-5231

**Email:** [dianyun@purdue.edu](mailto:dianyun@purdue.edu)

**Office hours:** TR, 4:15 – 5:15 PM, ET, in person at ARMS 3233 and virtually on Zoom or by appointment.

**Office hour location:** ARMS 3233 or Zoom ([Meeting ID: 914 6260 9604](#); [Passcode: aae590](#))

Virtual office hours are a synchronous session through Zoom to discuss questions and/or assignments. To connect to the virtual session, please open Zoom and click “Join”. Then please enter the meeting ID, your name, and the meeting passcode. You can also find the link under “Communication” in Brightspace.

### Request help outside office hours:

- **Piazza Q&A:** This semester we will be using Piazza for class discussion. The system is highly catered to getting you help fast and efficiently from classmates and myself. I encourage you to post your questions on Piazza. If you have any problems or feedback for the developers, email [team@piazza.com](mailto:team@piazza.com).

**Piazza signup link:** <https://piazza.com/purdue/fall2023/wl202410aae59000wn5>

**Piazza class link:** <https://piazza.com/purdue/fall2023/wl202410aae59000wn5/home>

You can also find the link under “Communication” in Brightspace.

- **Email:** Emails are read 8 a.m. to 5 p.m. M-F, and will be responded to within 24 hours. Be flexible with these times before deadlines and exams. Please use your *Purdue email* with a subject line starting from AAE 590. **Emails without “AAE 590” in the subject line may not be responded.**

## Learning Resources, Technology & Texts

**Required textbook:** No required textbook. Lecture notes will be provided.

**Recommended textbook:**

- Christos Kassapoglou, Design and Analysis of Composite Structures with Applications to Aerospace Structures, Wiley, 2<sup>nd</sup> edition, 2013.
- Isaac Daniel and Ori Ishai, Engineering Mechanics of Composite Materials, Oxford University Press, 2<sup>nd</sup> Edition, 2005.
- Michael Hyer, Stress Analysis of Fiber-Reinforced Composite Materials, DEStech Publications, Inc., 2009.
- Kuen Lin, *Composite Materials: Materials, Manufacturing, Analysis, Design and Repair*, CreateSpace independent Publishing Platform, 2nd Edition, 2015.

**Brightspace learning management system (LMS):** Access the course via Purdue's Brightspace learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. It is strongly suggested that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

**Zoom:** We will use Zoom for virtual office hours. The link for the Zoom meeting can be found under "Communication" in Brightspace.

**Piazza:** We will use Piazza for Q&A discussion. Please post your questions in Piazza.

**Gradescope:** Your assignments will be submitted to Gradescope for grading. The link to Gradescope is posted in Brightspace.

**MATLAB:** <https://engineering.purdue.edu/ECN/Support/KB/Docs/MatlabToolboxes>

**cdmHUB:** Access via <https://cdmhub.org/>. Please create an account. You will find many useful information and simulation tools under Resources.

**Autodesk Helius Composite:** You will be able to download the software once you create a student account via <https://www.autodesk.com/education/students>. You may need to upload your transcript or other documents to confirm your student status. The student version is free.

## Course Description

The goal of this course is to equip students with the fundamental principles and knowledge for designing structural parts made from fiber-reinforced composite materials. Students will develop computer codes for predicting composite properties, designing composite parts, and predicting the part performance under specified loading and environmental conditions. The course begins with a brief introduction of composite materials including their constituent properties, applications, advantages and limitations, and manufacturing techniques. The theory of elasticity of anisotropic solids, micromechanics, and the Classical Lamination Plate Theory (CLPT) will be introduced, followed by the discussion of the failure behavior, vibration and buckling, and hygrothermal effects. Design of skin-stiffened and sandwich structures will also be discussed. The course concludes with a discussion on the consideration of manufacturing-induced defects for composites design.

## Learning Outcomes

On completing this course, the student shall be able to:

1. Identify the types of composite materials, the constituents, manufacturing techniques, and the applications of these materials.
2. Determine the effective composite properties based on the constituent fiber and matrix properties, microstructure, and stacking sequences.
3. Estimate manufacturing-induced residual stresses and the resulting geometrical distortions.
4. Apply design guidelines for laminated composites and determine how parameters such as ply orientation and stacking sequence affect the laminates stiffnesses and strengths.
5. Apply design guidelines for skin-stiffened and sandwich structures.
6. Perform trade studies to select the appropriate material(s) and manufacturing method for a given application.
7. Develop computer program for designing and analyzing composite structures.

### Course Outline

Module 1: Introduction to Composite Materials and Basic Concepts

Module 2: Design of Composite Materials: Microstructure

Module 3: Design of Composite Laminates

Module 4: Design of Composite Beams

Module 5: Design of Skin-Stiffened Structures

Module 6: Design of Sandwich Structures

Module 7: Hygrothermal Effects and Manufacturing-Induced Defects

Module 8: Composite Design Process & Design Guidelines

### Assignments

Your learning will be assessed through a combination of ~11 homework sets, 1 midterm, and 1 final project spread throughout the academic period. Details on these assignments and exams, including a schedule of due dates, rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

Course Components	Weight
Homework	40%
Midterm Exam	30%
Final Project	30%

#### Homework

Homework will be assigned on a weekly basis and is worth 40% of your overall grade. The lowest homework grade will be dropped at the end of the semester. The assignments must be done in a neat and presentable manner with all calculations and free-body diagrams shown. **All final answers must be boxed** and include the numeric value or expression and the units when applicable. Discussion of homework problems with your classmates is encouraged, however, you must show your own work. Simply copying answers is prohibited and will be considered violating Purdue Honor Pledge and receive no credit. See also **Academic Integrity**.

#### Midterm Exam

There will be one midterm exam. **All final answers must be boxed** and include the numeric value or expression and the units when applicable. Any in-class notes, textbooks, or other resources are allowed on the exam. However, working together is prohibited. Students must sign an honor code statement verifying that they have not worked together on the exam. The instructor reserves the right to enact punitive measures commensurate with the offense if the work-alone requirement is violated. 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 the discretion regarding this, and conflicts will be mediated through the college/university. See also **Academic Integrity**.

### Final Project

The final project includes a presentation and written report. Details will be given in the project description posted in Brightspace.

## Grading Scale

In this class, grades reflect the sum of your achievement of learning outcomes throughout the semester. You will accumulate points as described in the assignments portion above, with each assignment graded according to a rubric. At the end of the semester, final grades will be calculated by adding the total points earned and translating those percentages into the following letters.

A+  $\geq$  95.50%

95.49%  $\geq$  A  $\geq$  92.50%

92.49%  $\geq$  A-  $\geq$  89.50%

89.49%  $\geq$  B+  $\geq$  85.50%

85.49%  $\geq$  B  $\geq$  82.50%

82.49%  $\geq$  B-  $\geq$  79.50%

79.49%  $\geq$  C+  $\geq$  75.50%

75.49%  $\geq$  C  $\geq$  72.50%

72.49  $\geq$  C-  $\geq$  69.50%

69.49%  $\geq$  D+  $\geq$  65.50%

65.49%  $\geq$  D  $\geq$  62.50%

62.49%  $\geq$  D-  $\geq$  59.50%

F  $\leq$  59.49%

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

## Course Logistics

- All course due dates are identified in Brightspace. Deadlines are based on **Eastern Time**; if you are in a different time zone, please adjust your submittal times accordingly. *The instructor reserves the right to change dates accordingly as the semester progresses. All changes will be communicated in an appropriate manner.*
- All assignments are due by 11:59 p.m. ET on the due date specified in Brightspace.
- Deadlines are an unavoidable part of being a professional and this course is no exception. Course requirements must be completed and posted or submitted on or before the specified due date and delivery time deadline.
- Late Homework Submission:
  - Submission within 1 day (24 hours) past the original due date will receive a 10% grade deduction.
  - Submission within 2 days (48 hours) past the original due date will receive a 20% grade deduction.
  - Submission after 2 days (48 hours) past the original due date will not be accepted and will receive a zero.
- **Late Exam will NOT be accepted.**
- An assignment file should be appended by your username, such as "HW1-kim53.pdf". This will make it easier for me to manage assignment files."

## Attendance Policy

The University expects that students will attend classes for which they are registered. At times, however, either anticipated or unanticipated absences can occur. The student bears the responsibility of informing the instructor in a timely fashion, when possible. The instructor bears the responsibility of trying to accommodate the student either by excusing the student or allowing the student to make up work, when possible. The University expects both students and their instructors to approach problems with class attendance in a manner that is reasonable.

## Course Schedule

Week	Course Plan	Lecture Dates	Assignments
1	<b>Module 1, Introduction &amp; Basic Concepts</b> Introduction to composite materials Generalized Hooke's Law Tensor transformation	T, 8/22 R, 8/24	HW 1 assigned
2	<b>Module 2, Design of Composite Materials: Microstructure (1)</b> Effective properties of continuous fiber-reinforced composites via micromechanics models	T, 8/29 R, 8/31	HW 2 assigned HW 1 due on 9/1
3	<b>Module 2, Design of Composite Materials: Microstructure (2)</b> Constituent properties Optimization methods	T, 9/5 R, 9/7	HW 3 assigned HW 2 due on 9/8
4	<b>Module 2, Design of Composite Materials: Microstructure (3)</b> Effects of fiber orientation Effective properties of short fiber composites <b>Module 3, Design of Composite Laminates (1)</b> Constitutive behavior of a single lamina	T, 9/12 R, 9/14	HW 4 assigned HW 3 due on 9/15
5	<b>Module 3, Design of Composite Laminates (1)</b> Classical Laminate Plate Theory (CLPT) Coupling effects Effective laminate properties Special laminates	T, 9/19 R, 9/21	HW 5 assigned HW 4 due on 9/22
6	<b>Module 3, Design of Composite Laminates (2)</b> Laminar failure criteria laminate failure analysis Examples	T, 9/26 R, 9/28	HW 6 assigned HW 5 due on 9/29

7	<b>Module 3, Design of Composite Laminates (3)</b> Laminate design <b>Module 4, Design of Composite Beams (1)</b> Cross sectional properties, equivalent axial and bending stiffness Design guidelines	T, 10/3 R, 10/5	HW 7 assigned HW 6 due on 10/6
8	<b>Module 4, Design of Composite Beams (2)</b> Beam buckling & stiffener crippling Examples	R, 10/12	HW 8 assigned HW 7 due on 10/13
9	<b>Module 5, Skin-Stiffened Structures (1)</b> Equivalent stiffness of skin-stiffened structures	T, 10/17 <del>R, 10/19</del>	<b>Exam 1 assigned on 10/18, due on 10/22</b>
10	<b>Module 5, Skin-Stiffened Structures (2)</b> Equivalent stiffness of skin-stiffened structures Failure modes of stiffened panels	T, 10/24 R, 10/26	HW 9 assigned HW 8 due on 10/27
11	<b>Module 6, Sandwich Structures</b> Bending stiffness Panel buckling and face-sheet wrinkling	T, 10/31 R, 11/2	HW 10 assigned HW 9 due on 11/3
12	<b>Module 6, Sandwich Structures</b> Shear crimping & face-sheet dimpling Attaching sandwich structures <b>Module 7, Manufacturing-Induced Defects (1)</b> Introduction to composite manufacturing	T, 11/7 R, 11/9	HW 11 assigned HW 10 due on 11/10
13	<b>Module 7, Manufacturing-Induced Defects (2)</b> Hygrothermal effects Residual stress prediction	T, 11/14 R, 11/16	
14	<b>Module 8, Textile Composites (1)</b> Manufacturing & Microstructure	T, 11/21	
15	<b>Module 8, Textile Composites (2)</b> Effective properties of textile composites  <b>Module 9, Design Guidelines</b> “Good” design practices	T, 11/28 R, 11/30	HW 11 due on 12/1

16	<b>Final Project Presentation</b>	T, 12/5 R, 12/7	<b>Final report due on Sun, 12/10</b>
17	Final Exam Week	12/11–12/17	No Final Exam

### Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing [integrity@purdue.edu](mailto:integrity@purdue.edu) or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies and Statements.

### Copyright

See the University Policies and Statements section of Brightspace for guidance on Use of Copyrighted Materials. Effective learning environments provide opportunities for students to reflect, explore new ideas, post opinions openly, and have the freedom to change those opinions over time. Students and instructors are the authors of the works they create in the learning environment. As authors, they own the copyright in their works subject only to the university's right to use those works for educational purposes. Students may not copy, reproduce, or post to any other outlet (e.g., YouTube, Facebook, or other open media sources or websites) any work in which they are not the sole or joint author or have not obtained the permission of the author(s).

### Nondiscrimination Statement

Purdue University is committed to maintaining a community that 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 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. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies and Statements.

### Accessibility

**Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: [drc@purdue.edu](mailto:drc@purdue.edu) or by phone: 765-494-1247.**

### Mental Health/Wellness Statement

**If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try [WellTrack](#).** Sign in and find information and tools at your fingertips, available to you at any time.

**If you need support and information about options and resources,** please contact or see the [Office of the Dean of Students](#). Call 765-494-1747. Hours of operation are M-F, 8 a.m.- 5 p.m.

**If you find yourself struggling to find a healthy balance between academics, social life, stress, etc.,** sign up for free one-on-one virtual or in-person sessions with a [Purdue Wellness Coach at RecWell](#). Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is free and can be done on BoilerConnect.



**If you're struggling and need mental health services: 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, such individuals should contact [Counseling and Psychological Services \(CAPS\)](#) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

### Emergency Preparation

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. You are expected to read your @purdue.edu email on a frequent basis.

A link to Purdue's Information on [Emergency Preparation and Planning](#) is located on our Brightspace under "University Policies and Statements." This website covers topics such as Severe Weather Guidance, Emergency Plans, and a place to sign up for the Emergency Warning Notification System. I encourage you to download and review the *Emergency Preparedness for Classrooms document* ([PDF](#)) or ([Word](#)).

### Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday.

### Course Evaluation

During the last two weeks of the semester, you will be provided with an opportunity to give feedback on this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to 10 days to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

### Netiquette

Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea, but you are not to attack an individual. Our differences, some of which are outlined in the University's nondiscrimination statement below, will add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Monitor how much space/time you are taking up in any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the 'Send' button.



Seek and take in feedback from others; learning from other people is an important life skill.

### **Diversity & Inclusion Statement**

We strive for equity, providing equal access and opportunity, and working to maximize student potential. This requires both instructor and students to identify and remove barriers that may prevent someone from full access or full participation. You can help by:

- Contacting me, anonymously if needed, if you see a potential barrier for someone or yourself in participating fully in the class. This might be a physical barrier such as access to technology or a personal situation.
- Suggesting ways in which members of our class can support each other. Virtual study groups and discussion boards are examples, but I encourage you to be creative in your ideas.

Getting to know each other as contributing members of our learning community. Everyone has something to contribute, and while I designed the course to take advantage of the wealth of knowledge, expertise, and experience we bring together, I cannot do it well without your participation. There are many opportunities built into this course for this type of work. It is important we do it together.