New Course EFD Template

PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document No.: 55-25
June 6, 2024

TO: The Engineering Faculty

FROM: The Faculty of the School of Mechanical Engineering

RE: New graduate course – ME 59300 Solid Mechanics I

The Faculty of the School of Mechanical Engineering has approved the following new graduate course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM (IF ALREADY OFFERED WITH TEMPORARY NUMBER):

ME 59700, Solid Mechanics I

Fall semesters

3 total credits; 3 credits-lecture

Pre-Requisites: ME 32300 Mechanics of Materials (B+ or higher), Upper Level undergraduates, Graduate Students

Previous Semesters Offered—Fall 2023 (29 residential, 33 online), Fall 2022 (32 residential, 17 online), Fall 2021 (24 residential)

TO:

ME 59300 Solid Mechanics I

Fall semesters

3 total credits; 3 credits-lecture

Pre-Requisites: ME 32300 Mechanics of Materials (B+ or higher), Upper Level undergraduates, Graduate Students

Course Description: The design of modern engineering structures is intrinsically linked to the understanding and analysis of materials and structures. This course is a foundational course on graduate level knowledge in this area of engineering. Course will cover Elements of linear elasticity, Kinematics of deformation, equilibrium conditions, and constitutive relationship of materials. Classical problems in elastostatics and general solutions for field equations in elasticity. Anisotropic elasticity, thermal elasticity.

RATIONALE:

This is an elementary course of solid mechanics and is fundamental for students who conduct research on solid mechanics and related topics. It will deliver fundamental concepts of vector and tensor-based mechanics of solid materials and structural elements in mechanical engineering, and teach elements of elasticity describing the geometry of deformation, mechanical equilibrium, and constitutive relationship. Through this course, students will define the field equations and general strategies of solving boundary value problems, define and solve problems in 2D and 3D elasticity, and solve and contrast boundary value problems in linear elasticity under mechanical and thermal load,

anisotropic material behavior, and nonhomogeneous field solutions. This course is currently serving a course waiver for the area exam of solid mechanics.

Head/Director of the School of Mechanical Engineering

Link to Curriculog entry: https://purdue.curriculog.com/proposal:28508/form

ME 597: Solid Mechanics I
Fall 2023

Lecture: MWF: 11:30-12:20. Room: BHEE222

Professor: Kejie Zhao
Office hours: T&Th 1:30 – 2:30 PM. Zoom Link. Open-door ME3166. Emails are most efficient.
Telephone: (765) 496-0224.
E-mail: kjzhao@purdue.edu
Teaching Assistants: Xixian Yang, yang1989@purdue.edu
Sameep Rajubhai Shah, shah484@purdue.edu
TA office hours: MWF 1:30-2:30PM. Zoom Link.

Prerequisites: ME323 Mechanics of Materials or equivalent.

Course Description

Elements of linear elasticity: Kinematics of deformation, equilibrium conditions, and constitutive relationship of materials.
Classical problems in elastostatics and general solutions for field equations in elasticity.
Anisotropic elasticity, thermal elasticity.

Textbook:

Elasticity: Theory, Applications, and Numerics. 4th Edition. Martin Sadd.
PDF available in Purdue library.

Grading Policy:

Homework	25%
Midterm exam	30%
Final exam	45%

Examination Dates:

Midterm exam	October 6th, 8-10PM EST on Zoom.
Final exam	TBD, Zoom.

General Information:

- All relevant materials (i.e. course syllabus, homework solutions) will be posted on Brightspace.
- Typically, one homework set will be due every week, except for weeks during which exams are given. Homework must be submitted by 11:59pm (EST) on Friday unless otherwise posted. Please submit your HW on Gradescope on the appropriate assignment link using a single PDF file (you will be asked to prescribe which page(s) each problem is on in Gradescope). Late HW will not be accepted without a personalized excuse (i.e., a generic PUSH note is not sufficient). Please review your homework submission after it has been uploaded onto Gradescope to ensure that all work has been properly submitted. If for some reason you have problems posting your HW on Gradescope, please email the instructor the PDF of your HW before the 11:59pm (EST) deadline with an explanation. Your work needs to be presented with a logical thought process and in a neat, easy-to-read style. Failure to do so can result in a loss of points in your homework grade.
- You are encouraged to work together in learning the course material (including homework). However, your submitted homework solutions should be **YOUR** work and not copied from other sources. Copying solutions from other sources will be considered to be a serious academic dishonesty. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor's discretion may result in a failing grade for the course.
- Attendance is expected for all class meetings. If you are unable to attend on any day, please contact the instructor prior to the class meeting time via email.
- Course grades will be assigned on a straight scale: 93-100 A+; 90-93% A; 87-90% A-; 84-87% B+; 81-84% B; 78-81 B-; 75-78% C+; 72-75% C; 69-72% C-; 66-69% D+; 63-66% D; 60-63% D-; <60% F.

Students With Disabilities

If you have a disability that requires special academic accommodation, please make an appointment to speak with your instructor within the first week of the semester in order to discuss any adjustments and bring your accommodation letter from the Disability Resource Center. *It is important that we are informed 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. If a student does not notify their instructor well in advance about the need for accommodations, there may not be time to arrange some accommodations.

ME 597 – SOLID MECHANICS I

Schedule for Fall 2023

PER	*DATE*	*TOPIC*	*READING ASSIGNMENT*
1 M	21-Aug	Scalar, vector, matrix, and tensor	1.1-1.3
2 W	23-Aug	Coordinate transformation and principal values/directions of 2nd order tensors	1.4-1.6
3 F	25-Aug	Algebra and calculus of tensors	1.7-1.9
4 M	28-Aug	Kinematics of finite deformation	2.1
5 W	30-Aug	Geometric construction of infinitesimal deformation	2.2
6 F	1-Sep	Strain transformation, strain compatibility, curvilinear coordinates.	2.3-2.7 (HW1 due)
M	4-Sep	***Labor Day – no class***	
7 W	6-Sep	Tractions and stresses	3.1-3.2
8 F	8-Sep	Stress transformation, principal stresses, 3D Mohr's circle	3.3-3.4 (HW2 due)
9 M	11-Sep	Equilibrium equations in Cartesian and curvilinear coordinates	3.5-3.8
10 W	13-Sep	Materials behavior – constitutive relations	4.1-4.2
11 F	15-Sep	Stiffness tensor and materials symmetry	11.1-11.2 (HW3 due)
12 M	18-Sep	Anisotropic stiffness tensors	11.1-11.2
13 W	20-Sep	Isotropic elastic materials	4.3-4.4
14 F	22-Sep	Review of field equations and boundary conditions	5.1-5.2 (HW4 due)
15 M	25-Sep	Boundary value problems and displacement formulation N-L equations	5.2-5.4
16 W	27-Sep	Stress formulation B-M equations	5.2-5.4
17 F	29-Sep	Principle of superposition and Saint-Venant's principle	5.5-5.8 (HW5 due)
18 M	2-Oct	Strain energy and bounds of elastic constants	6.1-6.2
19 W	4-Oct	Uniqueness of solution, Clapeyron's theorem, Betti's reciprocal theorem	6.3-6.4
F	6-Oct	***Mid-term examination, 8-10PM EST (no lecture)***	
M	9-Oct	***October Break – no class***	
20 W	11-Oct	Principle of virtual work	6.5-6.8
21 F	13-Oct	Principle of minimum potential and complementary energy, Rayleigh-Ritz method	6.5-6.8 (HW6 due)
22 M	16-Oct	Two-dimensional formulations: Plane strain problems	7.1
23 W	18-Oct	Plane stress and generalized plane stress	7.2-7.3
24 F	20-Oct	Airy stress function and polar formulation	7.4-7.6 (HW7 due)
25 M	23-Oct	Classical 2D elastostatic problems: Review of mechanics of materials	Appendix D, 8.1
26 W	25-Oct	Cartesian solutions using polynomials/beam problems	8.1-8.2
27 F	27-Oct	General Michell solution in polar coordinate	8.3 (HW8 due)
28 M	30-Oct	Lame problems/pressurized hole in an infinite media	8.4
29 W	1-Nov	Lame problems/stress-free hole in an infinite media under various loads	8.4
30 F	3-Nov	Wedge problems	8.4 (HW9 due)
31 M	6-Nov	Half-space problems/Flamant problem	8.4
32 W	8-Nov	Half-space problems/Notch and crack problems	8.4
33 F	10-Nov	Diametrically compressed disks and rotating disks	8.4(HW10 due)
34 M	13-Nov	Extension, torsion, and flexural of prismatic bars	9.1-9.2
35 W	15-Nov	Torsion of non-circular prismatic bars: Prandtl stress function	9.3
36 F	17-Nov	Membrane analogy and torsion solutions	9.3 (HW11 due)
37 M	20-Nov	Torsion solutions for various cross sections	9.4-9.8
W	22-Nov	***Thanksgiving – no class***	
F	24-Nov	***Thanksgiving – no class***	
38 M	27-Nov	Revisit anisotropic elasticity	11.3
39 W	29-Nov	Torsion of an anisotropic prismatic bar	11.4
40 F	1-Dec	Thermoelasticity: heat conduction and uncoupled field equations	12.1-12.2
41 M	4-Dec	Two dimensional thermoelasticity problems	12.3
42 W	6-Dec	Polar coordinate formulation of thermoelasticity	12.6-12.7
F	8-Dec	Review for final exam	HW12 due (optional)

* Textbook "Elasticity Theory, Applications and Numerics", Martin H. Sadd, 4th Edition.

ME 59300
SOLID MECHANICS I

Course Outcomes

1. Comprehend fundamental concepts of a vector and tensor-based mechanics of solid materials and structural elements in mechanical engineering. [1,2,7]
2. Comprehend the elements of elasticity describing the geometry of deformation, mechanical equilibrium, and constitutive relationship. [1,2,7]
3. Define the field equations and general strategies of solving boundary value problems. [1,2,7]
4. Define and solve problems in 2D and 3D elasticity. [1,2,7]
5. Solve and contrast boundary value problems in linear elasticity under mechanical and thermal load, anisotropic material behavior, and nonhomogeneous field solutions. [1,2,7]
6. Develop the skill to analyze problems in mechanics of materials, interpret technical literature, and write technical report about a problem in this field. [1,2,3]

Mathematical prelims (1 wk)

1. Scalar, vectors, matrix and tensors
2. Coordination transformation, principal values and directions
3. Algebra and calculus of tensors

Field equations of Elasticity (4 wks)

1. Geometry of deformation
2. Equilibrium conditions
3. Constitutive relationships
4. Boundary conditions

General solution strategies and 2D elasticity (6 wks)

1. Field equations and uniqueness of solutions
2. St Venant's principle
3. Principle of virtual work
4. General solution strategies
5. Plane strain and plane stress problems
6. Solutions in cartesian coordinate
7. Solutions in polar coordinate

Advanced Topics (3 wks)

1. Anisotropic elasticity
2. Thermoelasticity
3. Nonhomogeneous elasticity (functionally graded materials in isotropic formulation)

COURSE NUMBER: ME 59300 **COURSE TITLE:** Solid Mechanics I

REQUIRED COURSE OR ELECTIVE COURSE: Elective

TERMS OFFERED: Fall

TEXTBOOK/REQUIRED MATERIAL: Elasticity: Theory, Applications, and Numerics. 4th Edition. Martin Sadd

PRE-REQUISITES: Graduate student standing, First Semester Senior Standing or higher, ME 323 Mechanics of Materials (B+ grade required)

COORDINATING FACULTY: Solid Mechanics Area Faculty

COURSE DESCRIPTION: The design of modern engineering structures is intrinsically linked to the understanding and analysis of materials and structures. This course is a foundational course on graduate level knowledge in this area of engineering.

COURSE OUTCOMES: [Related ME Program Outcomes in brackets]:

1. Comprehend mechanics concepts of key classes engineering materials (elasticity, thermoelasticity), and be able to relate mechanics principles to real world engineering applications in design. [1,2,7]
2. Comprehend the methods for the analysis and prediction of deformation, strain and stress in engineering structures. [1,2,7]
3. Identify elasticity and thermoelasticity in the context of static and dynamic loading. [1,2,7]
4. Develop the ability to deal with elastic and thermal boundary conditions. [1,2,7]
5. Develop the skill to analyze problems of stability. [1,2,3]
6. Use solid mechanics principles to interpret and analyze the mechanical behavior of advanced engineering structures. [1,2,3,7]

ASSESSMENTS TOOLS:

1. Weekly homework.
2. Two 1-hour mid-term exam.
3. One 2-hour final exam.

PROFESSIONAL COMPONENT:

1. Engineering Topics: Engineering Science – 3 credits (100%)

NATURE OF DESIGN CONTENT: Comprehend on how to realize engineering systems by use of analysis tools in solid mechanics

RELATED ME PROGRAM OUTCOMES:

1. Engineering fundamentals
2. Engineering design
3. Communication skills
4. Ethical/Prof. responsibilities
5. Teamwork skills
6. Experimental skills
7. Knowledge acquisition

COMPUTER USAGE: Students are expected to appropriately choose from spreadsheets, symbolic math packages

COURSE STRUCTURE/SCHEDULE:

1. Lecture – 3 days per week at 50 minutes.

PREPARED BY: Solid mechanics Faculty **REVISION DATE: June 2024**