Handout #01

BOSTON UNIVERSITY
Department of Mechanical Engineering

ME 305 Mechanics of Materials: A1 Spring 2023

Contents

1 Overview

In this class we learn how to predict the behavior of solid things when they squish, stretch, bend, or twist. Hence the class is about mechanics of flexible (or deformable) solids in contrast to the mechanics of rigid bodies studied in earlier courses.

1.1 Learning objectives for the class

At the very highest level, the learning objectives for this course are:

- Estimation methods: How to make quantitative predictions with very little information.
- How to tackle new problems by building on solid assumptions.
- Formulation, solution, and interpretation of idealized mathematical models of bits of the world around us.

In more detail at the level of content coverage, our goals include:

- Estimation methods: Fermi problems, scaling, and dimensional analysis.
- Stiffness and flexibility approaches to structural analysis.
- Understanding and interpretation of stress and strain as $3D$ tensor fields.
- Understanding the roles of kinematics, balance laws, constitutive equations, and boundary conditions in formulating engineering analysis problems.

1.2 Devices, textbooks, and other required course materials

Devices All students are expected to have use of a laptop or tablet. If you do not have access to an up-to-date laptop or tablet, *please* contact the University Service Center. They can provide confidential assistance.

Textbooks You do not need to *purchase* a book for this class, but you will need *access* to the required text below.

- **Required:** Sanjay Govindjee, **Engineering Mechanics of Deformable Solids**, Oxford; 2013. ISBN: 978-0-19-965164-1. Note: This book is available electronically through the BU Science & Engineering Library. See the *Information* section of our course website for details on linking to it.
- **Required:** WA Nash; **Schaum's outline of theory and problems of strength of materials**, 1957. Note: This book is available electronically through the BU Science & Engineering Library. See the *Information* section of our course website for details on linking to it.

Laboratory exercises: The course includes three lab exercises. They will be conducted in small groups of 2-4.

1.3 How to get your questions answered

Websites Questions posted to the Piazza website tend to get answered very quickly. Readings, videos, assignments, etc, will be distributed via Blackboard. Work will be submitted via Gradescope.

Piazza (for discussions, updates, announcements, links): https://piazza.com/bu/spring2023/me305a1
Blackboard (for handouts, assignments, etc): http://learn.bu.edu
Gradescope (to submit assignments, see grades, and grading): https://www.gradescope.com/courses/502096

Teaching Assistants
Ao Chen aochen@bu.edu

Instructor Paul E. Barbone. Weekly Office Hours: Thursday 2:00-3:00 pm, or by appointment. Appointments can be scheduled by email: barbone@bu.edu.

2 Logistics

2.0.1 Missed Classes

Inevitably and regrettably, some of us will need to miss class at some point during the semester. If you miss class:

- Let me know of your absence by email.
- Review the class notes (posted on Blackboard) and the assigned readings for the day.
- Work through the Exercise Sets with the help of your group mates, connecting virtually if necessary.
- Contact GSTs to schedule a make-up quiz.
- Attend office hours.

2.1 Group work and interaction

The class period will be divided into segments of teaching and group work. Both will require occasional use of a laptop or tablet *even in the classroom*. If you do not have access to a suitable laptop or tablet, please contact the University Service Center. They can provide confidential assistance.

Much of the class structure for this semester will be based on group work. This includes in-class working groups, at home lab groups, and project groups.

2.2 Assessments & Evaluations

We emphasize a variety of assessment methods to help you and me evaluate your progress and mastery of the material. Assessment and evaluation is through a variety of in-person exams, *many* low-stakes quizzes, several at-home lab exercises, several at-home project assignments, and class *participation.* Participation will be measured in a variety of ways including group work, attendance, and short questions.

Approximate allocations of credit for work for the semester is as follows:

Participation:	10%
Midterm exam(s):	15%
Final Exam:	20%
Design and Project Assignments:	20%
Laboratory Assignments:	15%
Quizzes (drop lowest 2):	2% each for a total of 20%

3 Class Policies: Promoting a community of learning and mutual support

We all share the responsibility for creating and maintaining a positive learning environment (e.g., participation/ discussion guidelines). Doing so requires each of us to try to present our best selves. Under our restricted living conditions, it will be difficult for us to be our best all the time. Therefore, it ALSO demands that each of us exercises compassion for others and forbearance from escalation.

3.1 Inclusion and Mutual Respect

I consider this classroom (and all its real and virtual extensions) to be a place where you will be treated with dignity and respect. By reciprocity (a well-known scientific principle as well as a sociological principle), that means that you will conduct yourself with dignity and treat all other members of the class with respect. ALL individuals are welcome. All members of this class are expected to contribute to a welcoming, inclusive, and respectful environment for every other member of our class and learning community.

3.2 Attendance

Participation in group activities during the class period is expected. Therefore attendance in person is required and will be reflected in your participation score. Excused absences for either health or religious reasons (see BU Policy on Religious Observance) will be granted provided notification is given not later than the day of the absence; exceptional circumstances will be considered on a case-by-case basis.

3.3 Due dates and late work

Due dates help keep the class working together. Mutual respect for your group mates requires that you keep up with the course. Circumstantial uncertainty, however, suggests that we won't all keep up all the time with everything. Therefore, limited flexibility will be available for assignment due dates on a case-by-case basis, but there will be no flexibility on requirements of those assignments.

3.4 Academic conduct

You are here to learn engineering, and I'm here to help you achieve your goal.[1] In the spirit of mutual respect, therefore, I expect that all your actions in completing your class work will be consistent with *your* goal of *individual* learning. Group exercises can benefit all individuals only if every individual participates. Though we will often learn together, every person learns. Academic *misconduct* may be broadly defined as actions that are inconsistent with the goal of individual learning.

Therefore, all students must conduct themselves in accordance with the BU Academic Conduct Code, and in accord with the professional ethical conduct expected of members of the Engineering Profession (c.f. Ethics section in National Council of Examiners for Engineering and Surveying (NCEES) FE Supplied-Reference Manual, available on our course website.) I regard these as *minimal standards*, and expect a much higher level of personal comport from our BU Engineering students.

Any behavior inconsistent with the Academic Conduct Code will be referred to the Academic Conduct Committee.

3.5 Accommodations

If you require accommodations, requests must be made in a timely fashion to Disability & Access Services, 25 Buick St, Suite 300, Boston, MA 02215; 617-353-3658 (Voice/TTY). Students seeking academic accommodations are expected to submit appropriate medical documentation and comply with the established policies and procedures http://www.bu.edu/disability/accommodations/

4 Calendar

The basic "rhythm" of the class throughout the semester is designed around the week. Each week there will be an exercise set assigned. (You should do the exercises and read the offered solutions, but you do not have to submit them.) There will be a quiz on those exercises during the discussion section about a week later. In addition, there will be Lab/Project exercises due approximately weekly. There will be 1 midterm exam (during week 7) and three (small) project assignments throughout the semester.

[1] If your goal is not individual learning, then you may switch to another section or preferably, to another university.

Tentative schedule, subject to revision as the semester proceeds:

Week	Dates	Topic	Reading & Assignments	Quiz topic
1	1/23-27	Intro to σ & ϵ; material behavior.	Nash 1 & Ex Set 1	
2	1/30- 2/3	Shear stress and strain; more mat props.	Nash 4 & Ex Set 2 Attend Lab 1	σ & ϵ. Material Props
3	2/6-10	$1D$ Theory of solid deformation	Govindjee 2; Ex Set 3 Lab 1 due.	τ & γ
4	2/13-17	Torsion	Govindjee 6; Nash 5; Ex Set 4	$1D$ BVP
5	2/20-24	Internal shear force & bending moments	Govindjee 8.2; Nash 6; Ex Set 5 Proj 1 due.	Torsion
6	2/27 - 3/3	Bending stress and moment of inertia	Govindjee 8.1-8.3; Nash 7; Ex Set 6	V & M
7	3/13-17 3/16	Bending stress and moment of inertia (cont)	Govindjee 8.1-8.3; Nash 7; Ex Set 6 Attend Lab 2	$\sigma_{xx} = -\frac{My}{I_{zz}}$ Midterm Exam
8	3/20-24	Area properties; shear stress in bending	Govindjee 8.6; Nash 8; Ex Set 7	I_{zz}
9	3/27-31	Beam deflection: bcs & differential eqns.	Govindjee 8.4; Nash 9,10; Ex Set 8 Lab 2 due. Attend Lab 3.	$\tau_{xy} = \frac{VQ_z}{I_{zz}b}$
10	4/3-7	Elastic instability: buckling.	Govindjee 12; Nash 12; Ex Set 9 Proj 2 due	Beam deflection
11	4/10-14	Matrix rep. of stress; pressure vessels	Govindjee 3,6.2; Nash 3; Ex Set 10	$P_{crit} = \pi^2 \frac{EI}{L^2}$
12	4/17-21	Combined loading and material failure	Govindjee 9; Ex Set 11 Lab 3 due.	Pressure Vessels and Cauchy
13	4/24-28	Matrix representation of strain; Hooke's Law	Govindjee 4,5; Ex Set 12 Proj 3 due.	Superposition and Yielding
14	5/2	Impact Loading & Energy methods	Govindjee 9; Ex Set 13	