Handout #01

BOSTON UNIVERSITY
Department of Mechanical Engineering

ME 305 Mechanics of Materials: A2 Fall 2020

# 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 Flexibility and uncertainty

Flexibility in the face of uncertainty will be a theme this semester. Our solids are flexible, and must be we. Circumstances may require us all to adapt as the semester progresses, and we will. We must all be prepared to exercise flexibility related to any part of the class requirements, *except academic rigor:* I promise you the opportunity for a full, engaging, and rigorous education in mechanics of solids.

## 1.2 Mutual support: We support ourselves by supporting each other

This[1] is an extremely difficult time to be a college student and to be making decisions that may impact your health (and that of your loved ones) as well as your educational future. I empathize with these challenges and will be working to support you to the best of my ability. Please reach out at any time if I can be of help. I care about your health and well-being and that of our community, just as I care about your learning in this course. I promise to be - and encourage you to be - vigilant about public health standards and to follow the extensive safety protocols BU has put in place, including testing and physical distancing measures. We owe it to ourselves and our classmates as much as we expect it from our classmates.

If you do test positive for COVID or find yourself required to quarantine, I encourage you to be in touch with me, just as I would ask you to let me know of any illness or life circumstance that would impact your learning in the course. I will be better able to support you and make course accommodations as needed if I know. Your faculty and ENG advisors would also welcome the opportunity to support you. I believe that the COVID-19 pandemic demands that we be as transparent as possible with each other about our health and any risks of infection we might pose to others. This has always been true, of course, and the pandemic has heightened our awareness to our collective vulnerabilities to illness and our obligations to each other. I hope that in our course, in ENG, and beyond, we can foster a culture of mutual care and respect.

## 1.3 Learning objectives for the class

Dealing with uncertainty is topical at present and also an essential part of engineering. A key tool in dealing with uncertainty in engineering is being able to estimate quantities that are unknown, and being able to use those estimates in application. Therefore, estimation in the face of uncertainty will be a theme reinforced throughout the semester.

[1] Adapted from Prof. Carrie Preston, Kilachand Honors College, with permission.

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.

### 1.4 Devices, textbooks, and other required course materials

**Devices** The hybrid structure will require that *all* students have use of a laptop or tablet, *even students attending in-person 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.

Headphones with a microphone are recommended but not required.

**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.
- **Recommended; Not 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 materials:** The LfA labs for this class were designed to be conducted with materials you and/or your lab mates have at home or can obtain easily (e.g. a paper copy of a magazine or soft cover book.)

### 1.5 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/fall2020/me305a2/home
Blackboard (for handouts, assignments, etc): http://learn.bu.edu
Gradescope (for grades and grading): https://www.gradescope.com/courses/177054

**Teaching Assistants**
Andre Gutierrez Marty gutier@bu.edu.
Fatemeh Sharifi fatima94@bu.edu.

**Instructor** Paul E. Barbone. Weekly Zoom Hours: Tuesday 4:00-5:00 pm, or by appointment. Appointments can be scheduled by email: barbone@bu.edu.

## 2 Logistics

Quote from an email sent by Stephen Burgay, BU Senior VP, External Relations (sent August 27, 2020):

> *Under guidelines that came from the Governor earlier this month, institutions of higher education that comply with a number of Covid-19 health and safety requirements are permitted to have more than 25 students in a class space. Those requirements include that the space be large enough to allow for a minimum of six feel [sic] between attendees, face coverings, enhanced hygiene and regular deep cleaning, accommodations for high risk individuals, etc. BU has filed its so-called Covid-19 Control Plan with the state to establish it has these steps and safety requirements in place, and in classrooms where these criteria are met, the state allows us to exceed the 25 student per classroom limit as a result.*

We are scheduled to meet in GSU-219A, a ballroom large enough to accommodate the entire class, even under Covid-19 restrictions.

### 2.1 Modes of attendance for Lecture Section

#### 2.1.1 COVID 19 & BU Community Health Expectations

Masks are required and face coverings must be worn over the mouth and nose at all times when in public spaces on campus, including classrooms. Students should be prepared to show proof that

they are compliant with health attestations and testing in order to attend class. All students are expected to follow all university guidelines with respect to daily symptom checks, testing, social distancing, and mask wearing when they leave their dorm or home. For a detailed description of official BU policies regarding COVID, please visit: http://www.bu.edu/dos/policies/lifebook/covid-19-policies-for-students/

#### 2.1.2 Remote attendance

Those attending remotely will be expected to attend synchronously to allow group interactions. Significant time-zone incompatibility or connectivity problems will be accommodated on a case-by-case basis. Please visit during my office hours or email me barbone@bu.edu to let me know of your circumstances. Class sessions will be recorded and posted.

#### 2.1.3 In-person attendance

The hybrid structure will require that *all* students have use of a laptop or tablet *even those 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. Headphones and a microphone will also be helpful.

We will establish 3 different conditions for meeting in-person and adapt to them as needed throughout the semester.

1. Best case scenario: All BU-campus-approved instructors and students who wish to attend in-person may do so. This is our current mode of operation.
2. Restricted scenario: If circumstances require limiting classroom attendance, then the in-person attendees will be divided into groups to attend in-person alternate days/meetings.
3. All remote scenario: If this happens, let's hope it is short term only.
4. Prof at home scenario: In the event health restrictions bar me (the instructor) from campus, class will be held over zoom. Students who desire to gather in the classroom during the class session may do so.

### 2.2 Modes of attendance for Discussion Sections

Room capacity limits attendance to about 1/2 the enrolled students in each Discussion section. Therefore, we will break each Discussion into two groups, who will alternate attending either in-person or remotely. You need not attend your scheduled discussion until you are assigned to a group for the semester.

### 2.3 Group work and interaction

The class period will be divided into segments of teaching and group work. Both will require 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.

### 2.4 Do-at-home labs

We have developed all new Learn-*from*-Anywhere (LfA) labs for this course. These you will do in groups at "home", or wherever you choose to work. Lab groups will be formed based on materials availability and timezones as assessed by polling the class.

### 2.5 Assessments & Evaluations

Due to the hybrid nature of the class, all assessments will be accessible on-line. To help avoid issues around anxiety and academic integrity, emphasis on examinations is being minimized. Instead, we will emphasize many low-stakes quizzes, at-home lab exercises, at-home project assignments, and class *participation.* Participation will be measured in a variety of ways including group work, on-line attendance, and short questions related to watched videos.

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

| | |
|---|---|
| Participation: | 10% |
| Midterm exam(s): | 10% |
| Final Exam: | 15% |
| Design and Project Assignments: | 20% |
| Laboratory Assignments: | 25% |
| 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). That asks 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 its virtual extension) to be a place where you will be treated with respect. By reciprocity (a well-known scientific principle as well as a sociological principle), that means that you will treat all other members of the class with respect. ALL individuals are welcome. All members of this class are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class.

### 3.2 Attendance

Participation in group activities during the class period is expected. Therefore attendance in person or remotely 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 Deadlines and late work

Deadlines 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 deadlines 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.[2] 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.

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

### 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 must 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 exercises due approximately weekly. There will be 1 midterm exam (during the week of Oct 25) and three (small) project assignments throughout the semester.

Tentative schedule, subject to revision as the semester proceeds:

| Week | Topic | Reading and Assignments | Quiz day: topic |
|---|---|---|---|
| 1 | Estimation | Ex Set 1 | |
| 2 | Intro to $\sigma$ & $\epsilon$ | Handouts & Ex Set 2 | 10-11 Sept: Estimation |
| 3 | Elastic energy; $1D$ material behavior; $1D$ Theory of solid deformation | Chapter 2; Ex Set 3 | 17-18 Sept: Structures with 1D elements |
| 4 | Elementary theory of bending | Sections 8.1-8.3; Ex Set 4 | 24-25 Sept: $1D$ BVP |
| 5 | Stress | Chapter 3; Ex Set 5 | 1-2 Oct: Bending 1 |
| 6 | Strain | Chapter 4; Ex Set 6 | 8-9 Oct: Stress |
| 7 | Constitutive equations | Chapter 5; Ex Set 7 | 15-16 Oct: Strain |
| 8 | Energy Methods | Chapter 11; Ex Set 8 | 22-23 Oct: Hooke's law |
| 9 | Perspectives on Stress & Strain | Chapter 9; Ex Set 9 | midterm this week |
| 10 | Torsion | Chapter 6; Ex Set 10 | 5-6 Nov: Mohr quiz |
| 11 | Bending revisited | Sections 8.3-8.4; Ex Set 11 | 12-13 Nov: Torsion |
| 12 | Bending revisited | Sections 8.3-8.4; Ex Set 12 | 19-20 Nov: Bending 2 |
| 14 | Buckling & geometric instability | Chapter 12; Ex Set 13 | 3-4 Dec: Buckling |
| 15 | Combined loadings | Chapter 9; Ex Set 14 | |