16.20 Structural Mechanics
Course Information
Spring 2013

Instructors:
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and the occasional kind participation of Prof. Emeritus John Dugundji

Teaching Assistant(s):

Class meetings: Mondays, Wednesdays 9:30-11:00am, Fridays 9:00-10:00am, Rm 33-116.

Recitations: Fridays 10:00-11:00am, Rm 33-116

Office Hour: Wednesday 4:00-5:00pm, Seamans Lounge

Course web site: http://web.mit.edu/16.20/homepage

Remote connection to class sessions: https://isn.adobeconnect.com/st13-16-20. Click on "Enter as Guest", write your name and then click on "Enter Room".

Learning objectives

16.20 is a junior and senior level course which provides the fundamental knowledge to understand, analyze and design load-bearing structures. Although the focus is on aerospace applications, the theory and the majority of the applications are equally relevant in other areas of structural analysis. The first part of the course provides an in-depth study of three-dimensional elasticity theory, including the concepts of stress and strain, equilibrium, compatibility and elastic constitutive laws and anisotropic materials. The second part focuses on classical analytical solution procedures of the boundary value problem of isotropic linear elasticity in situations of important practical application. This includes states of plane strain, plane stress and torsion. This is followed by the analysis of structural elements with an increasing level of complexity: simple beam theory, combined bending, shear, and torsion of thin-wall shell beams, and buckling.

Students who successfully complete 16.20 will have the ability to:

1. **formulate** and **apply** appropriate mathematical and numerical models to predict the state of stress and deformation of one, two and three-dimensional aerospace structures.

2. **explain** the limitations of the models, **assess** their applicability to realistic configurations and estimate the errors resulting from their application.

3. **apply** the concepts learned in the course to **assess** and **explain** the possibility of failure in aerospace structural components and systems.

Measurable Outcomes

Module-specific measurable outcomes are provided at the beginning of each module notes.

Pedagogy

16.20 and 16.90 are being offered with a new pedagogic approach this semester. While there are some differences in the details of the organization of 16.20 and 16.90, our goals for changing the pedagogy are the same.

The basic objective of the new approach is to de-emphasize the role of traditional lectures in favor of a much more active student participation and instructor-student engagement. Class sessions will adopt a *tutoring style*, where we are going to learn the subject matter by solving problems together. This is sometimes known as the apprentice model of learning. To do this in an effective manner, a number of conditions need to be satisfied:

- student attendance in person or via remote access is primordial.
- student preparation through a thoughtful advance reading of the material assigned and the attempted advance solution of the problems given.
- student preparation of questions prior to each session and proactive inquiry and discussion with instructors and peers during class.

While this approach places increased demands on students before and during class sessions, it is hoped that much more efficient learning will be achieved and that homework assignments and test preparation will require less time.

In order to facilitate the process of recalling class discussions, all the material presented and discussed will be recorded and made available online via Webex or AdobeConnect.

In order to encourage students to respond to this format, an important part of the grade (20%) will be attributed to class participation. This will be assessed on an individual and daily basis.

In addition, students will be allowed the flexibility to participate in the class activities remotely via live broadcast of the class sessions. The hope is to create an environment that provides some flexibility for students to participate in activities that may require some time away from the classroom (e.g. participating in an engineering competition; presenting at a conference; etc).

If as the semester proceeds you have suggestions for how we can better meet these goals, please let us know!

Remote Access

16.20 will broadcast the instructor's computer and voice during class sessions through a Webex or AdobeConnect. This will allow students that cannot be in the classroom to observe most and engage in many of the classroom activities if they have access to the Internet. As well, movies of each Webex session will be made available typically within a day of the session. Details for participating in a Webex class session and accessing the movies of past class sessions will be available on the course web site.

While these options for remote access will be available, we believe the best opportunity for learning will be in the classroom and so we encourage students to attend class whenever possible.

Office Hours

All office hours will be held in the Seamans Lounge (lounge area on the first floor of Building 33). During these office hours, the faculty and TA will be available on Skype. However, it is possible that we will be busy helping students in the Lounge, and may not be able to respond to a Skype request.

Students can also set up appointments (in person or via Skype) with the faculty and TA. Please send an email to the person you would like to schedule an appointment with.

Homework: Reading Assignments & Problem Sets

Homework will include:

- Required advance **reading assignments** from a set of notes available on the course website and suggested reading from the course textbook. **Due: the class following that in which the assignment is given**.

- Required advance answer of **concept questions** and attempted solution of **introductory-level exercises** which are included in the notes as part of the reading assignments. The exercises are designed to improve your understanding of the material *while* you are reading. **Due: the class following that in which the assignment is given**.

- **Problem sets** given most weeks, will consist of problems designed to be more challenging and will include a combination of look-ahead and look-back problems. Look-ahead problems will be based on material that we have not yet discussed in class (though you will have had a reading assignment on the material). Look-back problems will be based on material that we have discussed in class. **Due: on Fridays at 9:00am in class**

Late homework submission will *not* be accepted.

Homework and Project Collaboration

While discussion of the homework and projects is encouraged among students, the work submitted for grading must represent your understanding of the subject matter. Significant help from other students or other sources should be noted in writing (at the top of your assignment).

Exams

There will be two exams: an oral midterm and an oral final. Midterm exams will be scheduled for March 20–23, i.e., during the week preceding spring break. The final exam will be held during final exam week, May 21–25. Individual times for the midterm will be scheduled 2–3 weeks prior based on preferences from each student. Individual times for the final exam will be determined within 3 weeks of the Institute's final exam schedule being announced.

Each exam will be assigned a letter grade based on the standard MIT letter grade descriptions.

Discussing any aspect of an oral exam (whether content or style) outside of the examination room is strictly prohibited!

Course Grade

The subject total grade will be based on the numeric grades obtained in the following three categories: **Class Participation, Problem Sets and Exams**. The weighting of the individual numeric grades is as follows:

- **Class Participation (20%)**. Class participation will be assessed daily on an individual basis at each table by the table tutor. The assessment will be based on: evidence of advance reading, attempt to solve look-ahead problems, proactive question posing and active engagement with tutor, peers and rest of the course instructors. Students are encouraged to provide any written evidence (e.g. own derivations, drawings, answers to concept questions and problems) that may help in participation assessment.

  In order to provide participation opportunities for students connecting remotely, students will be asked to provide a skype userid so that they can be contacted by course staff during class sessions to join a specific table group. It is expected that these students participating remotely will engage at the same level as those physically present.

  It should be emphasized that attendance per se whether physical or virtual will not be considered as part of the assessment.

- **Problem Sets (20%)**
- **Midterm exam (30%)**.

- **Final exam (30%)**.

The final numeric grade will be converted into a final subject letter grade. For the subject letter grade, we adhere to the MIT grading guidelines which give the following description of the letter grades:

A: Exceptionally good performance demonstrating a superior understanding of the subject matter, a foundation of extensive knowledge, and a skillful use of concepts and/or materials.

B: Good performance demonstrating capacity to use the appropriate concepts, a good understanding of the subject matter, and an ability to handle the problems and materials encountered in the subject.

C: Adequate performance demonstrating an adequate understanding of the subject matter, an ability to handle relatively simple problems, and adequate preparation for moving on to more advanced work in the field.

D: Minimally acceptable performance demonstrating at least partial familiarity with the subject matter and some capacity to deal with relatively simple problems, but also demonstrating deficiencies serious enough to make it inadvisable to proceed further in the field without additional work.

Textbooks

(BC) Structural Analysis with Applications to Aerospace Structures, O. A. Bauchau and J. I. Craig, Springer, 2009. http://www.springerlink.com/content/978-90-481-2516-6 (**Recommended**) This is the main textbook of the class. It is written by a former student of Prof. Dugundji who is a Professor at Georgia Tech.

We encourage you to purchase this book. Its contents are also available at the link above from the MIT network.

(TG) *Theory of Elasticity* Timoshenko and Goodier, McGraw-Hill (1970).

(R) *Theory and Analysis of Flight Structures* Rivello, McGraw-Hill, 1969.

(M) *Aircraft Structures for Engineering Students* Megson, Halsted (1990).

(T) *Theory of Elastic Stability* Timoshenko (and Gere), McGraw-Hill, 1961.

(G) *Mechanics of Materials* 4th edition, Gere (and Timoshenko), PWS, 1997.

(Reddy) Energy and Variational Methods in Engineering, J. N. Reddy, John Wiley & Sons, 2003.