'Aunt Ada's Treehouse'

Introduction

Quick glance:

This is a project-based learning experience that spans approximately one-third of a standard, 14-week semester; as designed, it is a partially individual and partially team-based experience. Collectively, it accounted for 10% of a student's grade in the course. It was designed for use in a Strength of Materials class; however, students in the class must have exposure to introductory 1D finite element analysis. If this is not covered in Strength of Materials, this module may instead be suitable for use in a finite element analysis class.

Note that, if an instructor is interested in using this module, it is recommended to also download Webb's module, "Uncle Asa's Urban Abode", as this represents a highly adapted/modified version of this project idea.

What is this project about?

In this project-based learning experience, students are asked to design and optimize an artificial tree trunk to support an "epic" treehouse for a fictitious, eccentric but innovative, Aunt Ada. Upon completion of this learning module, students will have experiential learning in the following course objectives:

1) Determine both normal and shearing stresses in simple beam and beam like structures; utilize stress analysis information to design application specific beam cross-sections (here, normal stress only),
2) perform 1D stress/strain analysis utilizing the finite element method,
3) construct a computer code to implement a finite element solution for a one-dimensional rod of varying cross-section
4) compute critical buckling load for columns subject to different fixations (i.e. boundary conditions),
5) account for column weight in computing critical buckling load.

In what class has this been implemented?

This was one of two major projects in our Strength of Materials course; in this module submission, the Fall 2015 deployment of the project is primarily addressed (i.e. the original deployment).

In addition to Mechanical Engineering & Mechanics majors who typically take this class in the second term of their second year, all Bioengineering majors and some Materials Science & Engineering majors take this class. The latter two populations tend to be third or fourth year students. Because this was deployed during a Fall term, the Mechanical Engineering & Mechanics majors were either second year students who were ahead of the typical schedule or later year students who were re-taking the class (e.g. to obtain a proficient grade).

There were 52 students in the class during this deployment; student teams were mostly comprised of three students with a few four-person teams.

Why is this project important?

Strength of Materials is a notoriously challenging class that is nonetheless intrinsic to many engineering design activities. The course has traditionally been taught via lecture format with relatively minimal active-collaborative learning techniques incorporated. This project provides a platform for exploration of some of the course learning objectives in an experiential format; furthermore, a number of in-class active-collaborative exercises support the project and further enhance the course content. Contextualization of the exercise around helping a distant relative advance a rather whimsical solution provides a strong "hook" for the project, drawing on a growing engineer's desires to solve problems while also sparking some interesting creativity.

How is the project different from current methods of teaching inherent concepts?

For the learning objectives outlined above, traditional lecture format with follow-on homework is augmented by in-class activities germane to the project (and to the learning objectives), collaborative team work outside of class, individual contextualized activities outside of class, and team-based interaction with the course instructor outside of class. The experience provides multiple facets through which the learning objectives are encountered and explored.

Who should implement this project?

Strength of Materials is a core course for Mechanical Engineering and Civil Engineering majors that is typically taught during the second year of study. Column buckling is a topic that is typically covered near the end of this course. Any instructor of Strength of Materials can implement this as a major project in the course. Even if finite element methods is not a topic covered in one's offering of the course, that part of the project can be introduced as a discretized numerical solution technique for computing complex integrals (in this case, displacement of a body with non-trivial cross-section loaded in one dimension). See Instructor Reflections for more on this.

How much time was spent on this project?

For calibration of times quoted in what follows, our offering of Strength of Materials is three times per week, with a 50-minute lecture for each meeting. Furthermore, the specific assignments that are the various "parts" of the project discussed below are provided in the "Delivery" document of this module. Parts (a) and (c) of the project were individual assignments while Parts (b), (d), and (e) were team exercises.

Part (a) of this experience was introduced during the second week of classes and due one class session later (~10 minutes of class was consumed discussing Part (a) of the project and the project as an entity). On the day that Part (a) was submitted, students first used their submissions to do a Think-Pair-Share exercise that consumed ~20 minutes of class; Part (b) was assigned that same day (~5 minutes to discuss) and was again due two class sessions later (that included a weekend). On the day that Part (b) was due, part (c) was assigned; this again consumed ~10 minutes of class to discuss. Part (c) was due two class sessions after it was assigned, which again included a weekend. Following the same pattern, Part (d) was assigned (and discussed for 10 minutes) on the same day that Part (c) was due. For Part (d), student teams were given almost two weeks (it was due 5 lectures later); for each of the first three of those 5 lectures between when Part (d) was assigned and due, ~10 minutes of lecture was used for active-collaborative activity around Part (d) of the project. This was mostly in the form of "think-team-share" discussions. Because of hourly exams, there was a somewhat longer than desired gap between

when Part (d) was submitted and when the final Part (e) was assigned. Once it was, student teams were given nearly two weeks (it was due 5 lectures later, which included two weekends). In one of the interim lectures (between the Part (e) assignment and due date), ~25 minutes were dedicated to a "Just in Time" lecture on buckling. Please see Instructor Reflections for suggested changes that impact the time consumed by the project.