CE 570: Advanced Structural Mechanics

HOMEWORK 8

Part 1: Due ONLINE on blackboard on at 11:30am Saturday, Nov 11, 2017

Part 2: Due ONLINE on blackboard **and** in class at 11:30am Monday, Nov 13, 2017

Part 1 guidelines:

- Work your solution **independently** and **neatly,** on **one side** only on college-rule / engineering paper.
- You may use any combination of mix of **black / blue / green** pens or pencils (but not red).
- Start every problem on a **new** page.
- All **diagrams** must be drawn **neatly** using a straight edge.
- All work should be presented in a **logical sequence**.
- **Scan & submit your homework online** on Blackboard as a **single pdf-file**.
- **Do not email** your homework to the instructor.
- Make sure that your **scan is good quality** and your pdf-file is **clearly readable.** Cell-phone / camera pictures of your homework will **not** be accepted / graded. Illegible or light scans will **not** be graded**.**
- All the scans must be in a **single pdf-file**. To edit, combine or create pdf-files you may use any of the following freely software programs:
    - *PDF Architect* and/or *PDF Creator* (`http://www.pdfforge.org/`)
    - *Primo-pdf* (`http://www.primopdf.com`)

  Try to make sure that your pdf-file size is not more than 5MB (Maximum 10MB).
- The **file name** of your scan must be in the format "`HW??-FirstLast-1.pdf`" where "`??`" is the HW number, "`First`" and "`Last`" `are` your first and last names, and the "`-1`" denotes Part 1. e.g. `HW01-ArunPrakash-1.pdf`.

Part 2 guidelines: (Work in red pen only)

- The solutions will be posted online at 5pm on Friday (on the due date for Part-1).
- Based on the posted solutions:
    - Correct any errors in your work and revise your solution. If you made any errors, comment why you think you made the error(s) and how you will avoid such error(s) in the future.
    - For each problem, list the most important concepts that you learned.
    - Briefly comment how you may be able to verify / cross-check your revised solution and the posted solution. Also comment, if you think that the posted solution is incorrect.
- You may add pages if necessary, but do **not** submit an entirely new homework file for Part 2.
- **Scan & submit your revised homework online** on Blackboard as a **single pdf-file**.
- The **file name** of your scan must be in the format "`HW??-FirstLast-2.pdf`"

Grading & Solutions:

- **Part 1**: 10 points = 3 problems x 3 points each + 1 presentation point
    - For Part-1, we will grade based only on your effort: You can get full 3 points for a problem, if you made an **honest independent effort** (even if your solution was incorrect!).
- **Part 2**: 5 points (for revisions and comments)
- Total: **15 points**

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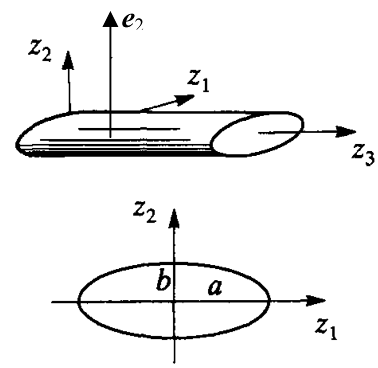
HW Guidelines:

- Read Chapters 4 and 5 from *Fundamentals of Structural Mechanics* by KD Hjelmstad.
- Work your solution neatly, starting all the problems on a new page.
- Be **very precise** with notation. You will lose ½ point for every notational error that you make. So, if you make 10 notational errors in 1 question, you will receive a *zero* score even though your solution may have the right idea.

Problem 1: (5 points)
Solve Problem 126 from the textbook:

126. A bar of length ℓ has an elliptical cross section. The equation of the ellipse is $b^2 z_1^2 + a^2 z_2^2 = a^2 b^2$, where a and b are the major and minor semi-axis dimensions. The bar experiences the following displacement map:

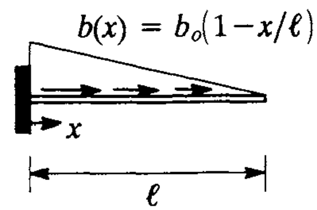


$$\mathbf{u}(\mathbf{z}) = -\beta z_2 z_3 \mathbf{e}_1 + \beta z_1 z_3 \mathbf{e}_2 - \beta c z_1 z_2 \mathbf{e}_3$$

where β and c are constants. Find the stress tensor associated with this motion, assuming that the material is linear, isotropic, and elastic with moduli λ and μ. Find the body force required for equilibrium. What value must the constant c have in order that the lateral surface of the bar be traction-free?

Problem 2: (5 points)
Solve Problem 130 from the textbook:

130. Consider the uniaxial rod shown below, fixed at $x = 0$, free at $x = \ell$, and subjected to the linearly varying body force indicated. The rod is made from a composite material with a variable elastic modulus $C(x) = C_o(2 - x/\ell)$, making it twice as stiff at $x = 0$ as it is at $x = \ell$. The governing differential equation for a rod with variable modulus is



$$\big(C(x)u'\big)' + b(x) = 0$$

where a prime indicates differentiation with respect to x. Find the exact (classical) solution to the problem by directly integrating the governing equations.

Problem 3: (5 points)
Solve Problem 131 from the textbook:

131. Consider the rod of unit length and modulus $C(x)$ that varies as shown in the sketch. The rod is fixed at the left end, is free at the right end, and is subjected to a linearly varying body force $b(x)$ as shown. Consider the following displacement map: $u(x) = a\big(x^3 + 2x^2 - 3x\big)$ where a is some constant. Is the displacement map a solution to the given problem? Why or why not?