AME 101 Fall 2018
Lecture homework #3
Assigned: 10/5/2018
Due: 10/12/2018, 4:30 pm, in the drop box in OHE 430N (back room of the OHE 430 suite of offices, where the Xerox machine is located) (Note this is a different box than my personal mailbox in the same room).

Problem #1 (20 points)

The "Fat Man" atomic bomb dropped on Nagasaki in 1945 used 14 lbm of plutonium (Pu) that was in a "subcritical" state (meaning, it would not explode) at its density at ambient pressure but would go "critical" under the immense pressure (thus increased density) created by squeezing it very rapidly with conventional high explosives. The density (ρ) of Pu at ambient pressure is 16.9 g/cm^3, Poisson's ratio (ν) is 0.21 and the modulus of elasticity (E) is 96.5 x 10^9 Pa.

(a) What was the volume (= mass/density) of the Pu at ambient pressure?
(b) If the Pu was in the shape of a cylinder with equal diameter (d) and length (L), what was the diameter (in cm) at ambient conditions?
(c) If the Pu needs to be compressed to 24.4 g/cm^3 to explode, what strain ($\varepsilon = \Delta L/L$) is needed to obtain this density?
(d) What normal stress (σ) (in lbf/in^2) is required to produce this amount of strain?
(e) What force (in lbf) is required to produce this normal stress?

Problem #2 (20 points)

A 4340-HR steel pipe is filled with steam at a pressure of 1000 lbf/in^2 higher than the outside (atmospheric) pressure. The pipe has an inside diameter of 1 inch and a wall thickness of 1/16 inch.
(a) What is the hoop stress in the pipe?
(b) What is the longitudinal stress in the pipe?
(c) What is the maximum shear stress in the pipe?
(d) If the pipe had welded end caps made of 4340-HR steel with the same 1/16 wall thickness, what would the maximum normal stress in the end caps be?

Problem #3 (20 points)

(a) If the pipe of problem 2 is 5 ft long and is pinned at one end with a roller at the other end, and a 50 lbf load is applied to middle of the pipe (*i.e.*, treat the pipe as a beam with an applied point load):
   i. What is the maximum tensile stress caused by this point load?
   ii. What is the maximum compressive stress caused by this point load?
   iii. What is the maximum shear stress caused by this point load?
(b) What is the maximum deflection (Δ) of the beam?
(c) Repeat parts (a) and (b) if instead of a 50 lbf point load, this same total load were distributed uniformly over the entire pipe, that is, w = 50 lbf / 5 ft = 10 lbf/ft.

Problem #4 (10 points)

If the stresses of problems 2 and 3 were combined (that is, the pipe had both internal pressure and the point beam load) what would the maximum shear stress in the pipe be?

Problem #5 (10 points)

If this pipe were used instead as a column, with no pressure inside and no point or distributed beam load, what applied force would cause the column to buckle? Assume both ends are tightly clamped.

Problem #6 (20 points)

(a) Do an experiment to estimate the stress at failure of a piece of spaghetti. (You'll need to do this type of test anyway with PLA for the 2nd group project). Get a strand of spaghetti, measure its dimensions, suspend it between two tables, hang a uniform load from it, and add weight until it fails. From the formulas given in the lecture notes, calculate the maximum of the moment M(x) in the beam, and determine the stress that it causes from using the moment of inertia calculated from the formula for a round cross-section. Try to load the "beam" as uniformly as possible to match the assumptions made in the analysis. Note that you don't have to use a full-length strand of spaghetti; if you want a larger weight at failure, use a shorter piece of spaghetti. You can estimate the weight on the spaghetti without a scale by using a paper cup filled with a measured volume of water (mass = density x volume) and hung on the spaghetti with a string.

(b) Repeat part (a) for a point load in the middle of your strand of spaghetti. Do the two experiments give the same result for the stress at failure?