AME 101 Fall 2016
Lecture homework #3
Assigned: 10/7/2016
Due: 10/14/2016, 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 (25 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? (Note that as you compress it (reduce L), the diameter d increases so you need to consider Poisson's ratio to determine net change in volume and thus change in L required)
(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 (25 points)

A 6061-T6 aluminum pipe (see Table 2 of the lecture notes for properties) has a diameter of 5 cm, a wall thickness of 1/8 inch and a length of 10 feet. Assume that the aluminum has the same yield strength in tension, compression and shear.

(a) What is the maximum pressure this pipe could hold without yielding?
(b) If instead this pipe is used as a beam, what is the maximum distributed load (w, units lbf/ft) that could be applied without yielding?
(c) If **both** of the loads from parts (a) and (b) were applied simultaneously, what would the maximum shear stress in the pipe be? (Assume that somehow the pipe didn't yield).
(d) If instead of applying the loads in parts (a) and (b), the pipe were oriented vertically and used as a column, what is the maximum load (in lbf) that the pipe could support without buckling? Assume both ends of the column are tightly clamped.

Problem #3 (25 points)

Ronney Materials, Inc. has invented a new metal, called PDR™, that has **all the same properties as aluminum** (Al) except that its yield stress in compression is 3 times larger than Al and its yield stress in shear is 3 times smaller than Al (see table, property changes in shaded cells):

Material	Yield stress σ_{yield} (tension) (N/m^2)	Yield stress σ_{yield} (compression) (N/m^2)	Yield stress τ_{yield} (shear) (N/m^2)	Elastic modulus (E), (N/m^2)	Poisson's ratio (ν)
Aluminum	300×10^6	300×10^6	300×10^6	70×10^9	0.32
PDR™	300×10^6	900×10^6	100×10^6	70×10^9	0.32

If PDR™ were substituted for aluminum, how would each of the following structural properties be affected? Specifically, would the property increase, decrease or remain the same, and if there is a change, is it by less than, more than or exactly a factor of 3? **No credit without explanation!**

(a) The maximum pressure (P) that a cylindrical pressure vessel with the **high pressure inside** could withstand without the material yielding
(b) The maximum pressure (P) that a cylindrical pressure vessel with the **high pressure outside** could withstand without the material yielding
(c) The maximum bending moment (M_{max}) on a point-loaded beam
(d) The maximum uniform load (w, force/length) that a beam of round cross-section could withstand without the material yielding
(e) Maximum deflection (Δ) of a point-loaded beam of square cross-section
(f) The maximum force that a column of circular cross-section with pinned ends can withstand without buckling

Problem #4 (25 points)

(a) Do an experiment to estimate the stress at failure of a piece of spaghetti. (You'll need to do this anyway 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?