MECHANICAL ENGINEERING

USF UNIVERSITY OF SOUTH FLORIDA

EML3041: Computational Methods

Title: Deflate Gate: Loss of pressure in a football.

Points: 40

Due Date: Wednesday, February 11, 2015 at 2:00 PM

Format for Submission: http://www.civil.utah.edu/files/2013/01/Homework-Requirements.pdf (Page 5 & 6)

What to Submit: Handwritten solutions in a professional manner.

Background: Deflate Gate is a great lesson in why jumping to conclusions is a bad idea and seeing the relevance of thermodynamics to a practical problem. I am also giving this problem with incomplete data so that you develop skills for formulating a problem. See this TED video on Math Needs a Makeover.

Physicist Neil deGrasse Tyson did not change gauge pressure to absolute pressure; Bill Nye, a mechanical engineer, who calls himself the science guy, did not give convincing arguments and took off 15% from the gauge pressure for his calculations; others did not change temperature to absolute temperature; other variables like water vapor pressure, and temperature of compressed air (compressed air is hot) to inflate balls, and time interval between when balls were inflated to when balls were taken to field were not accounted for.

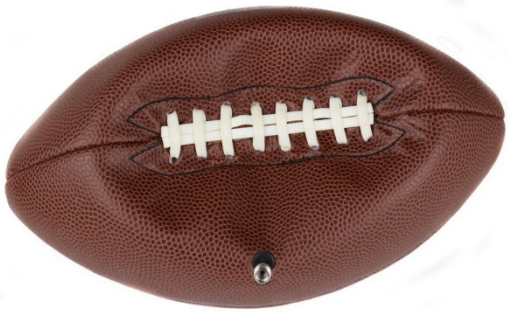

Figure: Deflated Football (Courtesy: http://bostinno.streetwise.co/2015/01/23/nfl-deflate-gate-statement-full-text-of-nfls-statement-on-deflategate-investigation/)

Questions:

1. Do the following problem by hand using TI30Xa calculator. Do the problem on a fresh sheet of paper (college ruled, printer paper or engineering paper). Find the

decrease in pressure expected in an NFL football if it was inflated in a room at 80°F, left in the room for a while, and brought to field at 40°F, and left there for a while. Use the ideal gas law to find the decrease in pressure as a number in psi. The ideal gas law is given by

$$pv = RT$$

where p is the pressure, v is the specific volume, R is the universal gas constant, and T is the absolute temperature. If any numbers for variables are needed, go to your favorite internet source or books. You should seek the least numbers needed.

2. Do the following problems by hand using TI30Xa or MATLAB or programmable calculator. Do not submit MATLAB code but all steps need to be shown by hand. At intermediate steps, you can write, "From MATLAB, I got…." but do not write this for the whole problem, "I got everything through MATLAB and here is my answer". Do the problem on a fresh sheet of paper. Use the equation given by Johannes Diderik van der Waals to do the same problem as given in #1. The ideal gas law equation is only accurate for a limited range of pressure and temperature. Johannes Diderik van der Waals came up with an empirical equation that was accurate for larger ranges of pressure and temperature given by

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

where a and b are empirical constants dependent on a particular gas. If any numbers for variables are needed, go to your favorite internet source or books. You should seek the least numbers needed.

3. Use a gauge pressure of air of 12.5 psi in the football, and a room temperature of 80°F, find the specific volume of the air in the football using the ideal gas law as well as the van der Waals' equation. Use MATLAB or programmable calculator to find the answer. Do not submit MATLAB code but all steps need to be shown by hand. At intermediate steps, you can write, "From MATLAB, I got…." but do not write this for the whole problem, "I got everything through MATLAB and here is my answer". Do the problem on a fresh sheet of paper.