Deflategate
Module 3 Day 2

Learning Objectives
- Describe the relationships between temperature, pressure, and volume of gases
- Use the combined gas law to analyze the properties of gases

Learning Activities
1. Watch: [Deflate-Gate, the Latest Scandal to Plague NFL](#) (Watch 0:00 - 1:45)

   Summarized NFL Rules about the pressure in footballs:
   a. Each team shall provide 12 footballs 2.5 hours before the start of the game to be approved by the officials
   b. Each football must be inflated to a pressure between 12.5 and 13.5 psi. This is gauge pressure, meaning that the football must be inflated to 12.5 - 13.5 psi *above* atmospheric pressure (typically around 14.7 psi)

2. Brainstorm: What are some factors that could affect the pressure inside a football?

3. What was the actual pressure inside one of the Patriot's football if the atmospheric pressure is 14.70 psi and the pressure gauge reading is 12.5 at 22 °C? (Hint: See #1b)

4. Using your previous calculation, what would be the new pressure inside the football if it was moved from the warm locker room (22 °C) to the football field (9°C)?
   remember temperature must be in Kelvin

5. What would you anticipate the pressure gauge reading to be for the football in question 4 if the atmospheric pressure is 14.7 psi?

6. Here are the halftime measurements of the pressure in the Patriots' and Colts' footballs:

Table 1: Halftime measurements of the pressure in the Patriots footballs.

Patriots Ball	Pressure Measured with Gauge 1 (psi)	Pressure Measured with Gauge 2 (psi)
1	11.50	11.80
2	10.85	11.20
3	11.15	11.50
4	10.70	11.00
5	11.10	11.45
6	11.60	11.95
7	11.85	12.30
8	11.10	11.55
9	10.95	11.35
10	10.50	10.90
11	10.90	11.35

Table 2: Halftime measurements of the pressure in the Colts footballs.

Colts Ball	Pressure Measured with Gauge 1 (psi)	Pressure Measured with Gauge 2 (psi)
1	12.35	12.70
2	12.30	12.75
3	12.95	12.50
4	12.15	12.55

6. Based on your calculations in #5 and the data provided in #6, what conclusions can you draw? (be sure to use evidence to support your claim).

7. At the start of half-time, the pressure of the Patriots' footballs were immediately measured. *After* this was complete, the Colt's footballs were measured.

    a. How would this approach impact the data that was collected?

    b. How could the data collection methods have been improved?

Gas Law Practice Problems

1. Sometimes leaving a bicycle in the sun on a hot day will cause the tires to blowout. Explain this phenomenon.

2. The pressure underwater increases with depth. While scuba diving, a diver will release air bubbles. Explain what happens to the volume of these bubbles as they rise to the surface (assume they remain intact).

3. A can of spray paint is used until it is empty, except for the propellant gas which as a pressure of 1344 torr at 23°C. If the can is then thrown into a fire (T = 475 °C), what will the pressure be in the hot can?

4. A high-altitude weather balloon is filled with 1.41×10^4 L of hydrogen gas at a temperature of 21°C and a pressure of 745 torr. What is the volume of the balloon at a height of 20km, where the temperature is -48°C and the pressure is 63.1 torr?

5. A balloon that is 100.21 L at 21°C and 0.981 atm is released and just barely clears the top of Mount Crumpet in British Columbia. If the final volume of the balloon is 144.53 L at a temperature of 5.24 °C, what is the pressure experienced by the balloon?

Extra Practice Problems:

1. https://www.physicsclassroom.com/calcpad/launch/CPGL3

2. https://www.physicsclassroom.com/calcpad/launch/CPGL4

3. https://www.physicsclassroom.com/calcpad/launch/CPGL5

4. https://www.physicsclassroom.com/calcpad/launch/CPGL6

Rubric for Quantitative Literacy (from AAC&U Quantitative Literacy VALUE Rubric)

	Capstone 4	Milestone 3	Milestone 2	Benchmark 1
Calculation	Calculations attempted are essentially all successful and sufficiently comprehensive to solve the problem. Calculations are presented clearly and concisely.	Calculations attempted are essentially. All successful and sufficiently comprehensive to solve the problem	Calculations attempted are either unsuccessful or represent only a portion of the calculations required to comprehensively solve the problem	Calculations are attempted but are both unsuccessful and are not comprehensive
Application/Analysis	Uses the quantitative analysis of data as the basis for deep and thoughtful judgments, drawing insightful, carefully qualified conclusions from this work	Uses the quantitative analysis of data as the basis for competent judgments, drawing reasonable and appropriately qualified conclusions from this work	Uses the quantitative analysis of data as the basis for basic judgments, drawing plausible conclusions from this work	Uses the quantitative analysis of data as the basis for tentative, basic judgments, although is hesitant or uncertain about drawing conclusions from this work