Problem Set 12: Kinetic Theory, Temperature and Internal Energy and Work Done by Ideal as, Second Law of Thermodynamics, Mechanical Equivalent of Heat

Design Engineering Challenge: "The Big Dig" 2.007 Contest
Pneumatic Energy Storage Strategies

PROBLEM 1:

Assuming the Ideal Gas Law where n,R, and T are constant and the volume is reduced by a factor of four:

$$P_1V_1 = P_2V_2$$

$$V_2 = \frac{V_1}{4}$$

$$\Rightarrow P_2 = 4P_1$$

PROBLEM 2:

The amount of Energy comes from the amount of work done by the system:

$$Work = Force \cdot Displacement$$

$$Work = \Delta PAx$$

$$Work = (P_2 - P_1)A\left(\frac{V_1 - V_2}{A}\right)$$

$$Work = (4P_1 - P_1)\left(\frac{3}{4}V_1\right)$$

$$Work = \frac{9}{4}P_1V_1$$

PROBLEM 3:

$$PV = nR\Delta T$$

$$\Delta T = \frac{9}{4}\frac{P_1V_1}{nR}$$

PROBLEM 4:

Assuming the change in pressure is negligible:

$$\frac{V_2}{T_2} = \frac{{}_3V_3}{T_3}$$

$$\Rightarrow V_3 = \frac{V_2 T_3}{T_2}$$

PROBLEM 5:

At steady state the temperature and volume are known. The Ideal Gas Law becomes:

$$P_3 = \frac{nRT_3}{V_3}$$

The amount of energy is

$$Work = \frac{9}{4} P_1 V_1$$