Home work #2

Problems 2-21, 2-24, 2-26, 3-8, 3-26 from the book and

#1

The tension in a wire is increased quasi-statically and isothermally from \( \tau_1 \) to \( \tau_2 \). If the length of the wire, \( L \), the cross-sectional area, \( A \), and isothermal Young’s modulus, \( Y \), of the wire remain practically constant, show that the work performed by the wire is

\[
W = -\frac{L}{2AY} (\tau_2^2 - \tau_1^2).
\]

#2

Derive the equation for adiabatic compressibility, \( \kappa_{ad} = -\frac{1}{v} \left( \frac{\partial v}{\partial p} \right)_{ad} \), when an ideal gas is quasi-statically and adiabatically compressed. The speed of sound is given by \( c = \sqrt{\frac{dp}{d\rho}} \) (\( \rho \) is the density). Consider this derivative as adiabatic derivative and calculate the speed of sound in air at pressure of 1 atm and temperature of 0 degrees Celsius.

Hint: Consider air as diatomic ideal gas with average molar weight of 28.9 gram/mole, think about Poisson’ equation for adiabatic process in ideal gas and think how density is related to volume.

#3

A mole of ideal gas at pressure \( p_1 \) and volume \( V_1 \) is freely (adiabatically) expanded to volume \( V_2 \). Then it is quasi-statically compressed to a volume \( V_1 \), while maintaining the pressure at \( p_2 \). Finally, this gas is heated quasi-statically until its pressure returns to \( p_1 \), while the volume remains at \( V_1 \). This cycle is called Mayer’s cycle. Prove Mayer’s relation \( c_p = c_v + R \) using this cycle, assume constant specific heats.

*Note that we have already proven the relation based on a very formal mathematical approach. This time I am looking for a physical proof based on the use of the Mayer’s cycle.*