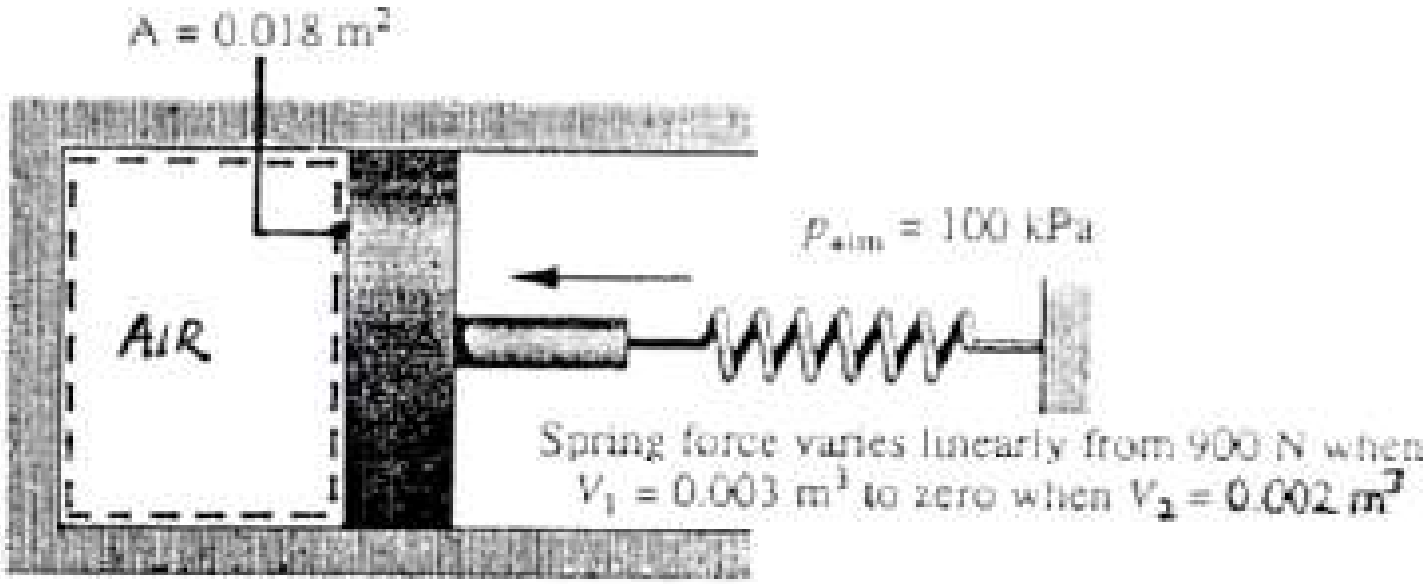
Problem Statement

- Warm air is contained in a piston-cylinder assembly oriented horizontally. The air cools slowly from an **initial volume** of **0.003 cubic meter** to a **final volume** of **0.002 cubic meter**. During the process, the spring exerts a force that varies **linearly** from an **initial value** of **900 N** to a final **value of zero**. The atmospheric pressure is **100 kPa**, and the area of the piston face is **0.018 square meter**. Friction between the piston and the cylinder wall can be neglected. For the air, determine the initial and final pressures, in kPa, and the work in kJ.

Figure

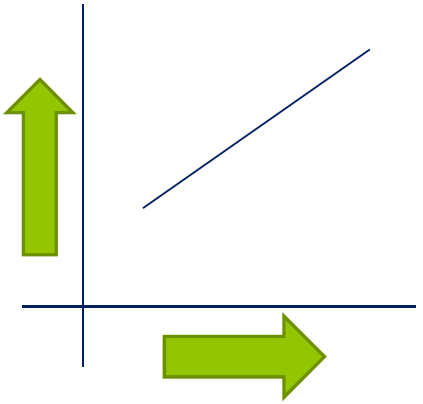

A = 0.018 m²
AIR
p_{atm} = 100 kPa
Spring force varies linearly from 900 N when
V_1 = 0.003 m³ to zero when V_2 = 0.002 m³

Solution

- Initially :
- $P_{inside} = P_{atm} + \frac{F_{spring}}{A_{piston}}$
- $P_{inside} = 100 * 10^3 + \frac{900}{0.018} = 150\ kPa$
- Similarly for the relaxed state:
- $P_{inside} = 100\ kPa$

Work done

- $\int pdv = work\ done$
- $P_{atm} + \frac{F_{spring}}{A_{piston}}$ is the pressure general expression for this system.
- Spring force varies linearly from 900 to 0 Newton and the volume goes down from 0.003 to 0.002
- $900 = k0.003, 0 = k0.002, F = kv$
- Therefore $\frac{900}{0.001} = k, \frac{F}{(v-0.002)} = k$
- $F = \frac{900(v-0.002)}{0.001}$



Work done

- $p = 100 * 10^3 + \frac{900(v-0.002)}{0.018*0.001}$
- $\int_{0.003}^{0.002}(100 * 10^3 + \frac{900(v-0.002)}{0.018*0.001})\,\mathrm{dv} = -0.125\ \mathrm{kJ}$