

PHYS310: Sample Midterm Exam

1. A (non-insulated) cylinder with a movable piston initially contains air with density, ρ_1 , and pressure, P_1 . The piston is slowly raised simultaneously decreasing the density, ρ , and increasing the pressure, P , with heat passing through the walls of the cylinder so that at every instant P and ρ are related by the equation

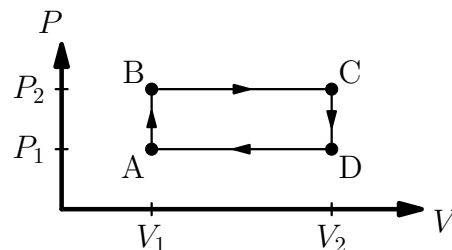
$$P = k/\rho,$$

in which k is a constant.

- Write an expression for the initial temperature of the gas, T_1 .
[Give your answer in terms of P_1 , ρ_1 , and R_a .]
- Express the constant k in terms of P_1 , T_1 , and R_a .
- Find an expression for the temperature when the density has halved to $\rho_1/2$.
[Give your answer in terms of T_1]

2. As a radiosonde balloon rises, it finds the temperature is constant (T_0) as the pressure changes from P_1 to $P_2 < P_1$. What is the vertical distance between the two pressure levels, P_2 and P_1 ?
[Give your answer in terms of T_0 , P_1 , P_2 , R_a and g .]

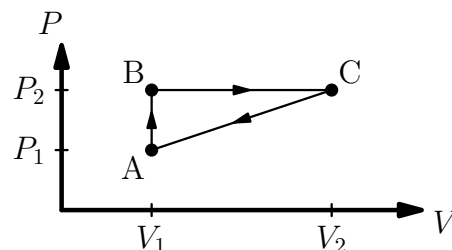
3. Suppose an ideal gas operates in a heat engine with a 4-step cycle: isochoric for $A \rightarrow B$ and $C \rightarrow D$; isobaric for $B \rightarrow C$ and $D \rightarrow A$. Its PV diagram is shown to the right. The pressure along BC is twice the pressure along DA : $P_2 = 2P_1$. The volume along CD is three times the volume along AB : $V_2 = 3V_1$.



- What is the total work performed by this engine?
- What is the total heat input to the engine?
- Evaluate the efficiency of this engine.

[Give your answers in terms of any or all of P_1 , V_1 and the adiabatic constant γ .]

4. Consider the triangular PV cycle shown to the right. Here, $P_2 = 2P_1$ and $V_2 = 3V_1$.



Find the change in entropy over each part of the cycle.

I.e. find ΔS_{AB} for $A \rightarrow B$, ΔS_{BC} for $B \rightarrow C$, and ΔS_{CA} for $C \rightarrow A$.

[Give your answers in terms of C_v and the adiabatic constant γ .]