Physics 112 - Intro to Statistical and Thermal Physics - Spring 2023
Spoiler Set 03

Problem 3.1 - Equivalent Statements of the Second Law

(b) For the first step, what happens if we use the work from the super-Carnot to drive a reverse Carnot? For the second step, what happens to the net efficiency if we let some of the heat an anti-Clausius engine deposits into a hot bath provide some of the input heat for a Carnot engine?

Problem 3.2 - Entropy, Engines, and the Third Law

(a) Since we are dealing with an ideal gas and a set number of degrees of freedom we may take C_V and C_P to be temperature-independent for this problem.

(f) If we look at the derivative we have, $\left(\frac{\partial V}{\partial T}\right)_{P,N}$, we want to use the thermodynamic potential whose natural variables are T, P, and N. Note that V can now be related to a derivative of this potential with respect to one of the natural variables.

Problem 3.3 - Thermodynamic Stability

(b) Start with $\left(\frac{\partial S}{\partial U}\right)_V = \frac{1}{T}$ and take the derivative with respect to U on both sides.

(c) Recall that differences in temperature drive heat flow from hot to cold. What happens to the temperatures of the two systems if a little bit of energy gets nudged from one system to the other? Why does this lead to a cascade/runaway effect away from equilibrium?

Problem 3.4 - Thermodynamic Potentials

(a) Remember, we have temperature dependence in the entropy now! You will have to use the chain rule for the first term in F and the product rule for the second term.

(e) **Extra Part** (*Not for Credit*) We did something similar in lecture to show $U = TS - PV + \mu N$.
♦