PHYS 301
Thermodynamics and Statistical Mechanics

Worksheet #17
Thursday April 23 2026

Question 1.

Let's consider a non-Carnot heat engine — call it Ivor — operating between the two temperatures T_H and T_C. Ivor performs work W by absorbing Q'_H from the hot reservoir and depositing Q'_C into the cold. Then we can couple Ivor to a Carnot engine set to reverse. The work W performed by Ivor now goes into driving the Carnot engine, which takes Q_C from the cold reservoir and deposit Q_H into the hot one.

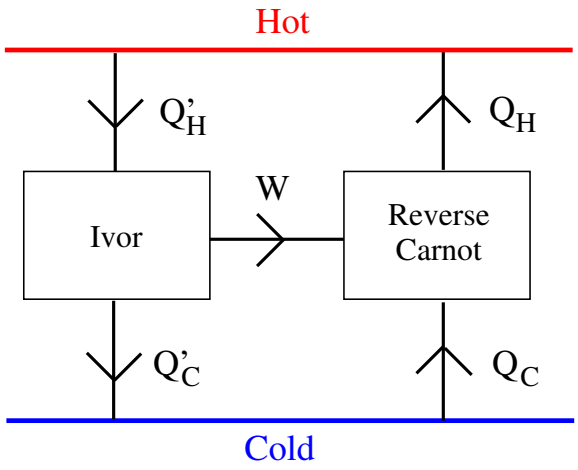

Figure 1: Coupling a non-Carnot engine to a Carnot engine.

(a) What is the net heat absorbed from the hot reservoir by the two engines? What is the net heat dumped into the cold reservoir by the two engines? What does energy conservation tells you about the relationship between the net heat absorbed to the net heat dumped?

(b) Use Clausius's statement of the second law to argue that we must have $Q'_H \geq Q_H$.

(c) Compute the efficiency of the Ivor engine

$$\eta_{\text{Ivor}} = 1 - \frac{Q'_C}{Q'_H}, \tag{1}$$

and show that we must have $\eta_{\text{Ivor}} \leq \eta_{\text{Carnot}}$.