Physics 127C – Homework Set 3 (due May 16)

Problem 1

Consider an array of n Szilard engines, each containing a one-particle gas in an unknown state. We saw in class that the work needed to reset the whole array to the zero state is $nkT\ln(2)$. Suppose instead that you are given two copies of the full array, and you need to reset both to zero. What is the corresponding work cost? Find a procedure which resets both arrays using that amount of work. Using Landauer's principle, show that there doesn't exist any better procedure.

Problem 2

Suppose that we are given an array with a very large number n of boxes, where for each box independently the particle is in the zero state with probability p and on the right side with probability $1-p$. Show that you can reset the boxes to the all zero state by using an amount of work $\approx nH(\{p,1-p\})kT$, where $H(\{p,1-p\}) = -p\ln(p)-(1-p)\ln(1-p)$ is the binary Shannon entropy. (Hint: couple the pistons from all the Szilárd engines so that they can only move together.) Show that you cannot reset the array at a (significantly) better cost.