Lecture 25

Phys 404

We discussed the Otto cycle, which is an idealization of the cyclic process utilized in an internal combustion engine. The working substance is an air-fuel mixture, which can be treated approximately as an ideal gas. The system is in contact with the hot reservoir when combustion takes place, and is in contact with the cold reservoir when the burnt fuel-air mixture is exhausted to the atmosphere.

We also examined an idealized cyclic process involving an ideal gas as a working substance. The ideal gas has known equation of state ($PV = N\tau$), known energy ($U = \frac{3}{2}N\tau$), and known entropy ($\sigma = N\left(log\left(\frac{n_Q}{n}\right) + \frac{5}{2}\right)$), with $n_Q = \left(\frac{m\tau}{2\pi\hbar^2}\right)^{3/2}$. We fix the number of particles in the gas, N. There are four steps in the cyclic process that converts heat into work. The first is an isothermal expansion at the temperature of the hot reservoir (τ_H). This brings heat Q_H into the gas. The second step involves separating the gas from the hot reservoir and performing an isentropic (constant entropy) expansion to a lower temperature τ_C. In the third step, the gas is brought into contact with a cold reservoir at temperature τ_C and an isothermal compression is done, ejecting heat Q_C from the gas to the reservoir. In the fourth step, the gas is separated from the cold reservoir and compressed isentropically to the same volume it started with in step 1. The net work done on the outside world in the process is positive. The efficiency of this cyclic process is equal to the Carnot efficiency.