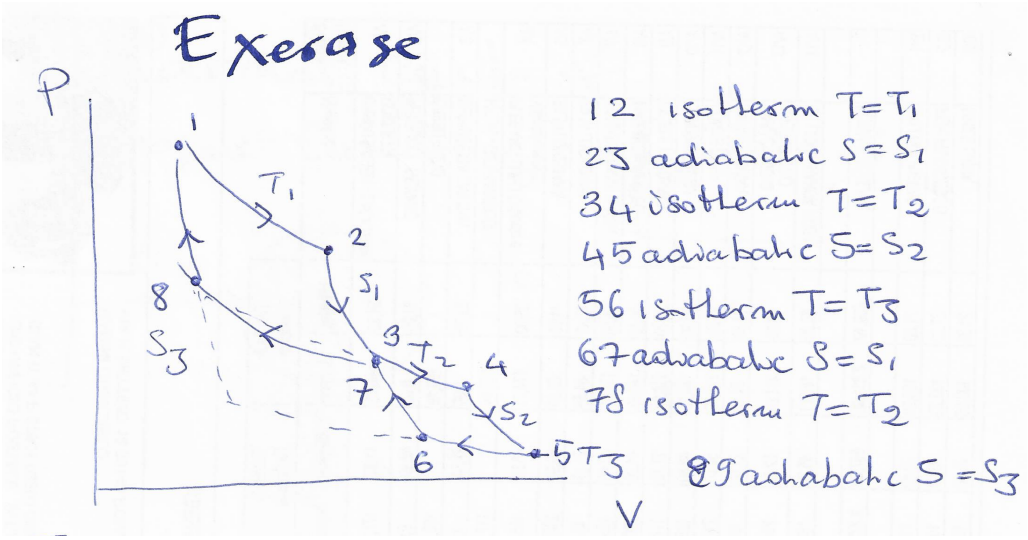
Exercise #1

due date: October 25 2021

a) Consider the following thermodynamic cycle:



- Draw the cycle in the T-S plane.
- Calculate the total work exerted by the system (W).
- Calculate the total heat exchanged by the system (Q).
- Calculate the efficiency $\eta={W}/{Q_{abs}}$ where Q_{abs} is the absorbed heat.

b) Include the fluctuation of number of particle in the description of stability and thermodynamic fluctuations. Perform the calculations in the variables T,V,N and S,P,N.

- Are fluctuations in these variables uncorrelated?

In the following you can alternatively choose c1) or c2).

c1) Read the notes about the Kac ring model:

- which set of variables describes a *microscopic* state?
- which set of variables describes the *macroscopic* state?
- write a code to calculate the number of black and white point (you can also do it considering a small size say N=4 and doing the evolution by hand...)

- compare the output of the code with the "molecular-chaos" solution given in the notes and discuss the results.

c2) Read the notes about the Logistic map:

- write a code to calculate the map evolution and the Lyapunov exponent.
- discuss the results in the parameters space described in the note discussing the local stability and the Lyapunov exponent.

d1) Consider only one one-dimensional classical harmonic oscillator

- write the Hamilton equation and *plot* a typical trajectory in the phase space
- is the system chaotic?

d2) now consider an ensemble made of replicas of the previous case i.e. one-dimensional classical harmonic oscillator with same ω and mass

- write the Liouville's evolution for and ensemble of such systems using momenta and position as variables
- consider an *isoenergetic* ensemble of oscillators (all osc. have energy=E). This ensemble starts with random phases between ϕ_0 and $\phi_0+\Delta$. In such conditions evaluate $<x(t)>$. Does it tends to a constant value? Is the system ergodic? Is the system mixing?

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