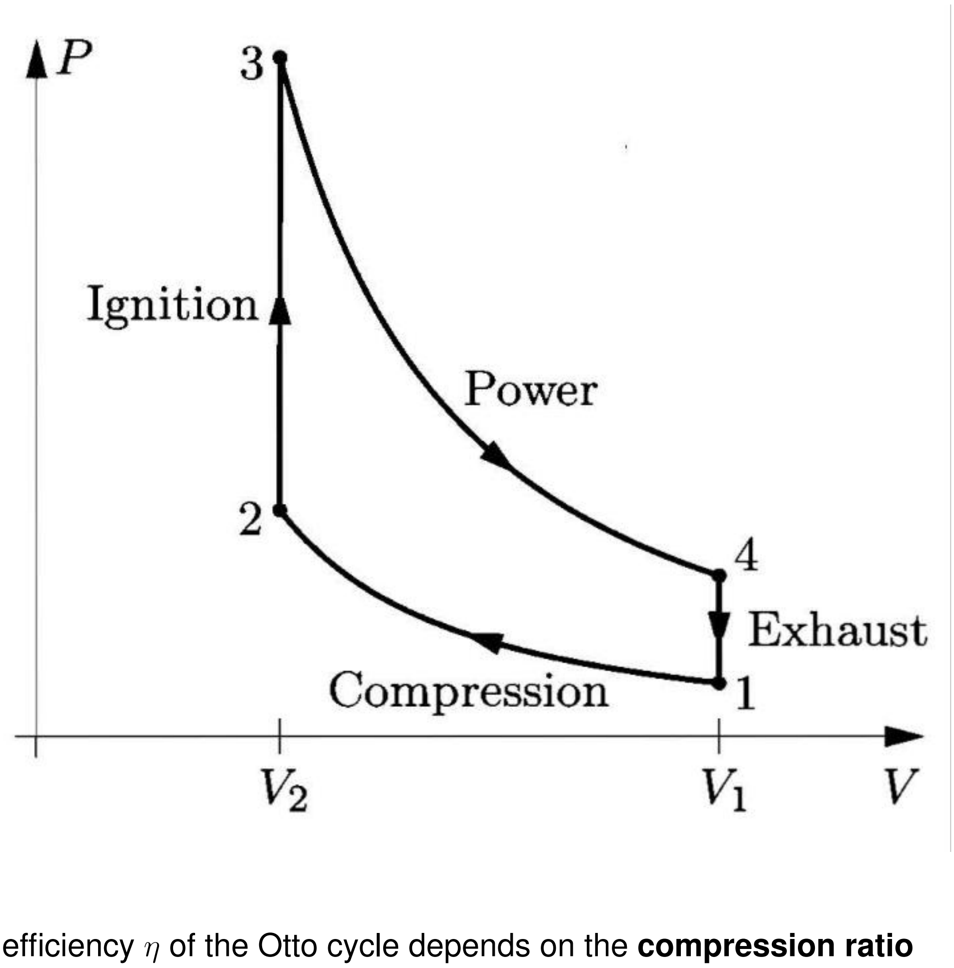
MATH327: Statistical Physics, Spring 2023
Tutorial activity — Otto cycle

The figure below shows the 'Otto cycle' that describes an idealized petrol engine.

- Fast (adiabatic) compression increases the pressure of the gas (a mixture of air and vaporized petrol), until a spark ignites it.
- This ignition introduces lots of heat almost instantaneously, while the volume is fixed at V_2. Even though the gas itself is burning, we can interpret this heat as coming from energy exchange with a hot thermal reservoir.
- The gas then does work by adiabatically expanding back to volume $V_1 > V_2$.
- Finally, heat is expelled at fixed volume V_1 by swapping the hot exhaust for an equal amount of cooler, fresh gas ready to be burned.



The efficiency η of the Otto cycle depends on the **compression ratio**

$$r \equiv \frac{V_1}{V_2} > 1.$$

What is this efficiency? How does it compare to the efficiency of the Carnot cycle? How should V_1 and V_2 be chosen to maximize the efficiency?

Hint: Given the labels in the PV diagram above, T_1 is the low temperature of the cold reservoir while T_3 is the high temperature of the hot reservoir. The corresponding Carnot cycle efficiency is therefore $\eta_C = 1 - \frac{T_1}{T_3}$, and the comparison is easiest if the Otto cycle efficiency is expressed in terms of temperatures rather than volumes.