https://www2.physik.uni-muenchen.de/lehre/vorlesungen/sose_24/thermodynamik/index.html

Sheet 06

Discussion: Thursday 20.06.2024

Exercise 1 Navier-Stokes equation

Determine the velocity field $u_z(x)$ of a laminar flow in the z-direction between two parallel (infinitely long) walls, i.e. the velocity components in the x and y directions vanish, in the steady state. The walls are located at $x = -d$ and $x = d$. Assume that the pressure p is constant within a plane perpendicular to the z-axis. Derive the equation of motion starting from the Navier-Stokes equation,

$$\rho \left(\frac{\partial}{\partial t} + \mathbf{u} \cdot \nabla \right) \mathbf{u} = -\nabla p + \eta \Delta \mathbf{u}, \tag{1}$$

with constant density ρ, viscosity of the fluid η, and velocity $\mathbf{u}$. Solve the equation of motion for the boundary conditions $u_z(x = d) = 0$ and $u_z(x = -d) = 0$. Assume that the pressure gradient is constant.

Exercise 2 Decomposition of thermodynamic potentials

1. When can we decompose thermodynamic potentials? As an example, consider the energy
$$E = E_{\text{kin}} + E_{\text{pot}} \tag{2}$$
of a harmonic oscillator. Why can we decompose E into E_{kin} and E_{pot}?
Hint: On which variables do the various energies depend? How can we interpret that?

2. Generalize the condition from 1. to the thermodynamic potentials F, H and G.

3. Argue that the thermodynamic potentials F, H, and G for an ideal gas are not decomposable.

4. Now consider a solid. Starting from
$$\mathrm{d}E = T\mathrm{d}S - P\mathrm{d}V, \tag{3}$$
argue that we cannot decompose the energy into $E(S, V) \approx E_1(S) + E_2(V)$. Why is this different when we consider enthalpy H or Gibbs energy G?
Hint: Is the volume of a solid sensitive to temperature or pressure?

5. Is a decomposition of H and G meaningful for liquids?