General Considerations

• *Systems:* We will consider a stationary system, i.e., one in which all quantities are time-independent but there are non-vanishing flows (the situation is not static); these describe transport phenomena, such as heat and electricity conduction, and viscosity.

Viscosity

• *Idea:* Viscosity is the internal friction that arises in a fluid when different layers of it are moving at different velocities and forces arise between those layers. Phenomenologically, the behavior of a fluid is quantified by a coefficient of viscosity η, which relates the variation in a velocity component to the corresponding component of the stress tensor, for example

$$P_{zx} = -\eta\,\frac{\partial u_x}{\partial z}\;, \qquad \text{with} \qquad P_{zx} = \frac{\Delta p_x}{\Delta t\,\Delta A}\;.$$

• *Rough calculation:* Physically, viscosity arises from particles crossing between z-layers moving at different $u_x(z)$'s and carrying momentum with them (this process is dominant in thin gases), and collisions between particles (important at higher densities).

• *More detailed calculation:* One needs to take into account the Maxwell distribution for particle velocities, and the collision cross-section.

Self-Diffusion

• *Remark:* (Do this one because it will be a good example of the fluctuation-dissipation theorem too.)
• *Idea:* Consider a solute present in very low concentrations in a fluid solvent. Starting from the equation of continuity for the solute particle number density and flux, $\partial n/\partial t = -\nabla\cdot\mathbf{j}$, and introducing a phenomenological self-diffusion constant D by $\mathbf{j} = -D\,\nabla n$, we get $\partial n/\partial t = D\,\nabla^2 n$ (both of these equations go under the name of Fick's law).

Thermal Conductivity

• *Topic:* ...

Electric Conductivity

• *Topic:* ...

Relevant Sections: [PHY 731]; Chandler; Halley; Mattis; Reif, Ch 12; Schwabl.