1. **Parabolic 2D wave-guide**

Consider a 2D electronic wave-guide with a constant cross-section and the transverse parabolic potential

\[ U(x) = \frac{1}{2} m \omega^2 x^2. \]

Calculate the electron density in the wave-guide and the conductance as function of the Fermi energy. Compare with the case of a hard-wall potential.

2. **Adiabatic junction with a rectangular cross-section**

Consider an adiabatic junction with a rectangular hard-wall potential with the sizes \( L_x(z) \) and \( L_y(z) \). Assume

\[ L_x(z) = L_y(z) = W_0 - W_1/(1 + (z/L)^2), \quad W_1 < W_0. \]

At which energy does the first open channel appear? At which energy are there three open channels?

3. **Semi-open channels**

Consider the current through a perfect wire and the conductance at a finite voltage. What happens if the channel is semi-open \( \mu < E_n < \mu + eV \).

4. **Conductance quantization at finite temperature**

Consider the current through a perfect wire and the conductance at a finite temperature. In particular, the limit of small voltage.

5. **2D Sharvin conductance**

Calculate the semi-classical 2D Sharvin conductance (formula (25) in the Lecture). Hint: In the ballistic limit the incident electrons are fully transmitted through a point contact. To calculate the flux normally incident to a contact, the angular average (over \( \phi \)) should be done.