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Exercises Condensed Matter Physics (Experimentalphysik 5c), WS16/17

1) **Derivative of the Fermi-Dirac distribution** (2 credits)

Show for a free electron gas, that

$$\frac{\partial f_0}{\partial k_x} = \frac{\partial f_0}{\partial E} \hbar v_x$$

2) **Conductivity of a metal within Boltzmann transport theory** (2 credits)

Show the missing steps in the derivation of the conductivity as discussed in the lecture

$$\sigma = \frac{e^2 \tau(E_F)}{m^*} n$$

3) **Thermocouple** (1 credits)

In experimental or technical set-ups the temperature is often measured using a thermocouple, i.e. two wires of different metals (with different Seebeck coefficients S), which are electrically connected at the position, where the temperature T should be measured. The resulting voltage V_{th} at the open ends of the wires is measured at room temperature (300K), from which T can be determined.
Using an Fe/ Ni thermocouple a thermoelectric voltage of V_{th}= 25mV is obtained. Calculate the corresponding temperature T.
(Seebeck coefficients are typically given relative to Cu or Pt. $S_{Ni\text{-}Cu}$ = -22 μV/K, $S_{Fe\text{-}Cu}$ = 10 μV/K.)

4) **4-probe resistivity measurement** (3 credits)

To avoid contributions of wire and contact resistivity in precession resistivity measurements the so called 4-probe technique is used: On each end of the sample wires are attached through which a current of 10mA is sent through the sample. With a second pair of wires a voltage V is measured using a high ohmic voltmeter (1MΩ). Which voltage U is obtained and which specific resistivity of the sample results from this measurement?
(probe wires: resistivity ρ_{Cu} = 1.7μΩcm, diameter 0.5mm^2, lengths l = 3m; specific sample resistivity ρ_{sample} = 100μΩcm, sample dimensions 3.0 × 0.5 × 0.1 mm^3)