Drude and Tompson proposed the classical free-electron model of metals to calculate the electrical and thermal conductivities.

According to their model, the electrical conductivity σ is given by

$$\sigma = \frac{n e^2 L}{(3 k_B T m_e)^{1/2}}$$

(n: # of free electrons/cm^3; L: mean free path; T: temperature (K))

and the resistivity ρ is given by

$$\rho = \frac{1}{\sigma} = \frac{\sqrt{3 k_B m_e}}{n e^2 L} \sqrt{T} \propto \sqrt{T}$$

However experimental measurements show that

$\rho \propto T$!

Furthermore σ calculated is different from σ measured by one order of magnitude!

If L is replaced by the quantum mean free path and v_{rms} is replaced by the Fermi velocity $\Rightarrow$ $\sigma_{measured} = \sigma_{calculated}$!