

# SCHRED Exercises

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Consider a simple MOS capacitor structure with aluminum gate. The thickness of the oxide region equals 4 nm and the substrate is p-type with doping  $N_A$  that varies between  $10^{16}$  cm<sup>-3</sup> and  $10^{19}$  cm<sup>-3</sup>. Using SCHRED consider two cases for the charge description in the semiconductor: semiclassical with Fermi-Dirac statistics and quantum-mechanical model. Follow these steps to arrive at a plot that gives you the shift in the threshold voltage versus  $N_A$  due to quantum-mechanical charge description:

- (1) For a representative number of doping densities of your choice run SCHRED using first semiclassical and then quantum mechanical model for the charge in the depletion/inversion layer.
- (2) For both cases plot the electron sheet density vs. applied gate bias. Assume that the threshold voltage equals the gate voltage  $V_G$  for which the sheet electron density equals  $10^{12}$  cm<sup>-2</sup>. Register the  $V_G$  values for both quantum and classical model. Subtract  $V_G(\text{classical})$  from  $V_G(\text{quantum})$ .
- (3) Plot this difference versus doping density. Comment on the results and compare with experimental data.