EECE 480 Assignment 5

Due date: December 1, at the beginning of the class.

Objective: To become familiar with some of the factors affecting the performance of a modern MOSFET, *i.e.*, a CMOS45 N-FET with the parameters listed below. This FET has a metal gate.

1. The target value for the "long-channel" threshold voltage of the device is 0.47 V.
   What workfunction must the metal gate have in order to achieve this V_T ?

2. Tensile strain can improve the electron mobility in Si N-FETs by lowering the energy of the Δ_2 valleys with respect to the Δ_4 valleys, as discussed in class and in Section 13.1.3 of the textbook.
   A stress has been applied to "our" FET such as to cause 80% of the electrons to reside in the Δ_2 valleys.
   Estimate the effective electron mobility if its value in the unstrained case is as given below.

3. The value for the OFF current density at $V_{DS} = 1\,\text{V}$ is $14\,\text{nA}/\mu\text{m}$.
   What is the change in threshold voltage due to short-channel effects that must be operative in order for this OFF current to be realized?

4. Evaluate the ON current density at $V_{GS} = V_{DS} = V_{DD}$, and determine the ON/OFF-current ratio.

Information on CMOS45 technology:
$V_{DD} = 1.0\,\text{V}$;
$L = 45\,\text{nm}$;
$t_{ox} = 1.75\,\text{nm}$; (This is the effective value based on $\epsilon_{ox} = 3.9\epsilon_0$.)
$N_A = 3.24 \times 10^{18}\,\text{cm}^{-3}$;
$\mu_{\text{eff}} = 391.4\,\text{cm}^2(\text{Vs})^{-1}$; (This is the unstrained value.)
$v_{sat} = 1.3 \times 10^7\,\text{cm/s}$.