VSLI Homework 2 - Aidan Sharpe

Problem 1

A 90[nm] long transistor has a gate oxide thickness t_{ox} of 16[Å]. What is its gate capcaitance per micrion of width?

```
eps_0 = 8.85E-12
k_ox = 3.9

L = 90E-9       # 90nm expressed in meters
t_ox = 16E-10   # 16A expressed in meters

C_permeter = k_ox * eps_0 * L / t_ox
C_permicron = C_permeter * 1E-6

print(C_permicron)
```

$$\boxed{C_{\text{permicron}} = 1.94[\text{fF}/\mu\text{m}]}$$

Problem 2

Consider the nMOS transistor in a 0.6[μm] process with gate oxide thickness of 100[Å]. The doping level is $N_A = 2 \times 10^{17}[\text{cm}^{-3}]$ and the nominal threshold voltage is 0.7[V]. The body is tied to ground with a substrate contact. How much does the threshold change at room temperature if the source is at 4[V] instead of 0[V]?

```
from math import log, sqrt

V_t0 = 0.7              # The nominal threshold voltage
t_ox = 100E-8           # The gate threshold voltage in angstrom with CGS units
N_A = 2E17              # The doping level in cm^-3

k_ox = 3.9
k_si = 11.7
eps_0 = 8.85E-14        # Vacuum permittivity with CGS units
k = 1.380E-23           # Boltzmann's constant
q = 1.602E-19           # The charge of an electron

T = 300                 # Room temperature in Kelvin

v_T = k*T/q
n_i = 1.45E10           # The intrinsic carrier concentration of undoped Si

eps_ox = k_ox * eps_0
eps_si = k_si * eps_0
```

```
V_b = 0
V_s0 = 0
V_s1 = 4

gamma = (t_ox / eps_ox) * sqrt(2*q*eps_si*N_A)
phi_s = 2 * v_T * log(N_A / n_i)

def V_t(V_t0, V_s, V_b, gamma, phi_s):
    V_sb = V_s - V_b
    return V_t0 + gamma*(sqrt(phi_s + V_sb) - sqrt(phi_s))

Delta_V_t = V_t(V_t0, V_s1, V_b, gamma, phi_s) \
          - V_t(V_t0, V_s0, V_b, gamma, phi_s)

print(Delta_V_t)
```

$$\boxed{\Delta V_t = 0.955583[\mathrm{V}]}$$