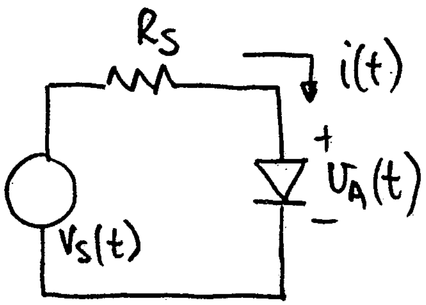
Course:	**Semiconductor Device Fundamentals**
Level:	**Undergraduate**
Module:	**B**
Test:	**B9**
Type:	***Open* Book, *Open* Notes**

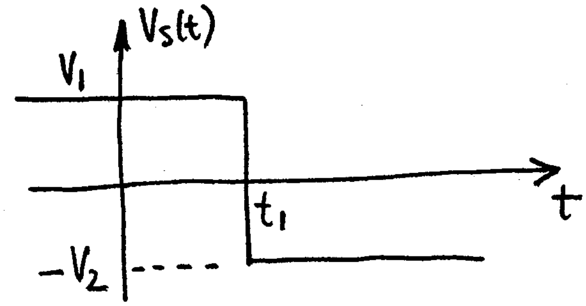
Problem Weighting---
1...5
2...15 (5 each part)
3...5
4...10
5...10
6...15 (a-10, b-5)
7...40 (8 each part)

1. In a Si pn-junction diode, the reverse-bias small signal capacitance is larger than that for forward bias.

T F

2. Consider the Thevenin equivalent of a diode switching circuit:





$$|v_A(t)| << |V_S(t)|$$

a. A larger V_2 (more negative) will decrease the switching time since more charge per unit time will be extracted from the bulk regions.

T F

b. For $t > t_1$, the resistor R_S restricts the storage time.

T F

c. Additional impurity recombination centers in the bulk p and n regions would further slow the switching, since the average carrier diffusion velocity would be reduced due to scattering.

T F

3. If non-degenerate doping is assumed, is it possible for the contact potential in a pn junction, qV_{bi}, to exceed the bandgap, E_G?

Y N

4. Consider a GaAs pn step junction with $N_A = N_D$, $\tau_p \simeq \tau_n = 10^{-8}$sec and mobilities $\mu_n = 8500$ cm^2/V–s, $\mu_p = 400$ cm^2/V–s. For forward bias, does electron or hole injection dominate?

electron hole

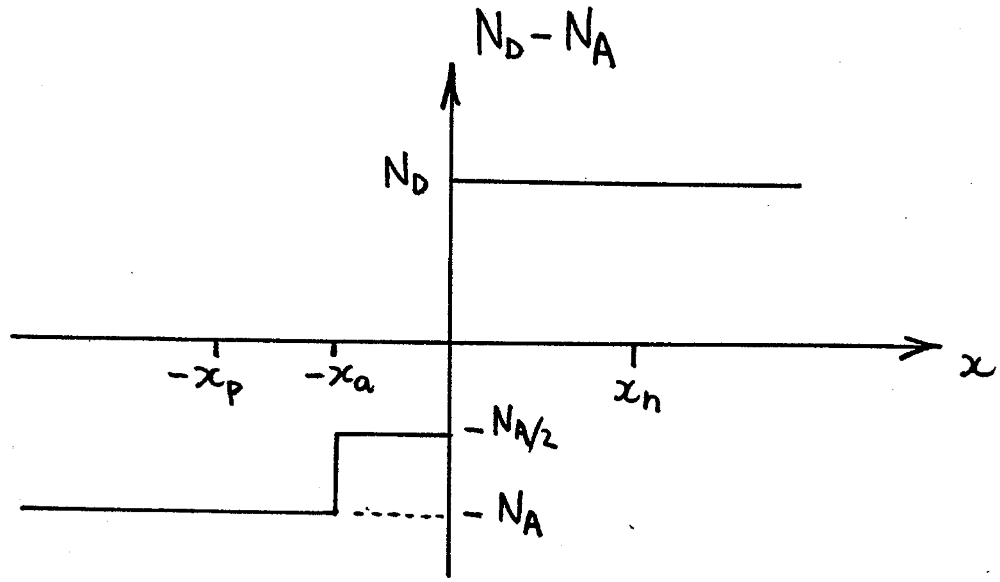
5. Why is the diffusion capacitance negligible for a reverse-biased pn junction?

6. Consider a p^+n Si step-junction diode with $N_A = 10^{17}\,cm^{-3}$, $N_D = 10^{15}\,cm^{-3}$, $T = 300\,^\circ K$, $K_s = 12$ and $\epsilon_0 = (36\pi \times 10^9)^{-1} F/m$.

   a. What is the maximum electric field at the onset of breakdown?

   b. What physical mechanism would you associate with reverse-biased breakdown in this device?

7. Consider a Si pn junction diode with $N_A = N_D = 10^{15}\,cm^{-3}$ operating at $T = 300\,^\circ K$ and having a permittivity of $\epsilon = K_s \epsilon_0$ with $K_s = 12$. The doping profile is sketched below.



a. If $x_p > x_a$ under equilibrium conditions and invoking the depletion approximation, sketch the charge density as a function of position inside the diode.

Consider equilibrium conditions for (a)-(e).

b. Find $\mathscr{E}(x)$ for $-x_p \leq x \leq 0$ and sketch the electric field for all x. Assume $\mathscr{E}(-x_p) = 0$.

c. Find $V(x)$ for $-x_p \leq x \leq 0$. Assume $V(-x_p) = 0$.

d. Write down an expression for V_{bi} and then evaluate.

e. Establish an expression for the equilibrium depletion width W in terms of V_{bi} for the case $x_p = 2x_a$.