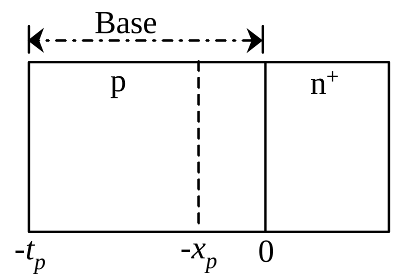
For 1-4 below, your explanation of why should include an appropriate mathematical equation substantiating your answer.

1. If you want to build a diode that has an ideality factor of 1 at room temperature, would you choose Si, Ge, or GaAs? Why?
2. For a diode with n=1 biased under forward bias at a fixed voltage, $V_A > 3kT$, will the current increase or decrease as the temperature is increased? Write down an equation that gives the dominant temperature dependence.
3. Under low forward bias the ideality factor of a Si diode is n=2. Explain why.
4. Under very high forward bias the ideality factor of a Si diode is also n=2. Explain why.

5. For an $n^+$-p short base diode shown at right, assume that $\Delta n_p(-t_p) = 0$ (see Sec. 2.2.4 of Taur).




(a) Derive $\Delta n_p(x)$.
(b) Assume that $t_p - x_p \ll L_n$. Derive a linear expression for $\Delta n_p(x)$.
(c) Define a velocity v(x) by the following expression, $J_n(x) = -q\, v(x)\, \Delta n_p(x)$. Derive an expression for v(x).
(d) The average time to traverse the base is called the base transit time given by

$$\tau_B = \int_{-t_p}^{-x_p} \frac{dx}{v(x)}$$

Derive $\tau_B$.

(e) Show that the current is given by $J_n = q\Delta N_p/\tau_B$ where $\Delta N_p$ is given by

$$\Delta N_p = \int_{-t_p}^{-x_p} dx\, \Delta n_p(x)$$

(f) For $V_A = 0.7$V, $N_D = 10^{18}/\text{cm}^3$, $N_A = 10^{16}/\text{cm}^3$, $t_p - x_p = 0.1\ \mu$m, T=300K, and $\mu_n = 1500\ \text{cm}^2/\text{Vs}$, calculate $J_n$.
(g) Compare this value to the current for the above diode with $t_p - x_p \gg L_n$ and $\tau_n = 1$ns.
(h) Considering the linear expression for $\Delta n_p(x)$ from part (b), derive, as we did in class, an expression for the ac conductance and diffusion capacitance under forward bias. What is the frequency dependence?