Problem Set #7

Assigned: Friday, November 03, 2000
Due: Thursday, November 09, 2000 at lecture

Reading Assignments:	11/02/00	Sections 7.1-7.2 of Howe & Sodini
	11/07/00	Sections 7.3 – 7.5 of Howe & Sodini
	11/09/00	Sections 8.1 – 8.5 of Howe & Sodini

PLEASE WRITE YOUR RECITATION SESSION TIME ON YOUR PROBLEM SET SOLUTION

1. [25 points] An npn transistor with emitter area A_E = 2.5 μm X 2.5 μm is biased in the forward active region, with the collector current I_C = 25 μA. The emitter and base dimensions and doping are: $N_{dE} = 10^{19}$ cm–3, W_E = 0.3 μm, $N_{aB} = 10^{17}$ cm–3, and W_B = 0.25 μm.
   a. Sketch the minority carrier concentrations in the emitter and base.
   b. Find the base-emitter bias V_{BE}.
   c. Find the base current I_B.

2. [25 points] Given the npn transistor with the parameters and operating point above, with the additional information that V_{An} = 25 V.
   a. Find the transconductance g_m.
   b. Find the input resistance r_p.
   c. Find the output resistance r_o.

3. [25 points] Given the npn transistor with the parameters and operating point above, with the additional information that the emitter-base depletion width is x_{BE} = 0.05 μm.
   a. What is the minority electron charge storage $Q_{NB}(V_{BE})$ at this operating point?
   b. What is C_p at this operating point?
   c. At what frequency does $|1/jwC_p| = r_p$?

4. [25 points] An important development of the late 1980s was SiGe (silicon-Germanium) alloy emitter BJTs. We shall assume for this problem that the intrinsic concentration in the SiGe emitter is $n_{iE} = 5 \times 10^9$ cm^{-3}. Use the transistor doping levels and dimensions from Problem 1.
   a. Find α_F and forward active current gain β_F.
   b. Determine the base doping that will yield the same values of β_F as the transitor would have if its emitter were silicon instead of SiGe.

The idea of using different materials in the emitter and base of bipolar transistors was proposed by Professor Herbert Kroemer in the late 50's. He won the 2000 Nobel Prize for Physics for proposing the use of heterostructures in devices.