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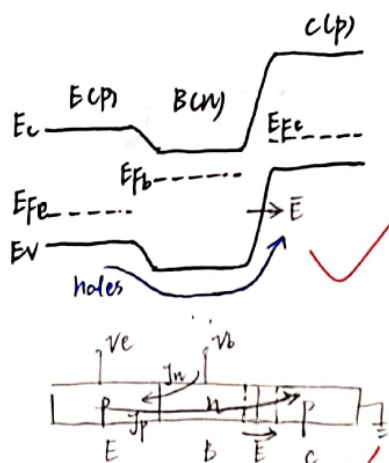
Student ID:

1. What is Early effect? How to minimize it?

Early Effect: As V_c becomes larger, the base-collector is more reverse-biased, then the depletion region becomes larger and extends more into the base region. Hence, electrons are more likely to be swept into the collector, resulting in a higher gain.

To minimize it, we can make doping concentration in the base larger than that in the collector, so that the depletion region in the base is small.

2. Please draw the energy band diagram of a pnp BJT in forward active mode, and explain how it works.



Due to diffusion of holes from E \rightarrow B and electrons from B \rightarrow E, we can manipulate the parameters in the following equation to achieve a high current from E \rightarrow B:

$$\frac{J_p}{J_n} = \frac{D_p N_A / L_p}{D_n N_b / L_n}$$

Then the built-in electric field in the depletion region of B and C (pointing from B \rightarrow C) will sweep the holes from B \rightarrow C, resulting in $I_c \approx I_p$.

3. What are the two ways to measure the contact resistance correctly?

- ① Transfer length method (TLM) measurements
- ② 4 point probe measurements

