Prob 1) Thévenin and Norton Equivalents

(a) Refer to Figure 4.41, page 172 in the Textbook. This is a voltage amplifier (its actually a model of a bipolar transistor amplifier, but you do not need to know that). Suppose $R_L = r_\pi = 5K$, and $\beta = 100$. What is the voltage gain $V_{AB} / V_1$. (Note the sign of voltage gain can be positive or negative).

(b) Imagine the circuit placed in a box with only the input terminals (where $V_1$ is attached) sticking out. Nothing is connected to A-B. You are to find the Thévenin equivalent of the input (with $V_1$ removed of course). Note that the Thévenin resistance is not simply $r_\pi$.

(c) Now do the reverse; find the Thévenin equivalent circuit of the circuit as seen from the terminals AB. Assume $V_1$ is 1V.

Prob 2) Load –line method

Box A below has the non-linear I-V characteristics shown in Figure 1. The box is connected to circuit B below. Find the voltage $V_{AB}$ as well as the current, $I$, when the two circuits are connected with terminals a and b of box A connected to the corresponding terminals a and b of circuit B.

![Figure 1: Non-linear circuit](image-url)
**Prob 4) Nonlinear problems**

Consider the following circuit. You are find the “bias point” of the nonlinear device X. In other words find the current $I_x$ and the Voltage $V_x$.

You may use graphical analysis and the answer need only be accurate within 20% or 1mA or 1mV, whichever is greater. Solve for the following two cases:

a) Device X has a nonlinear I-V characteristic of $I_x = 10^{-15} \exp(V_x/0.026)$

b) Device X has a nonlinear I-V characteristic with $I_x = 10^{-4} V^2$

**Prob 5) Operational Amplifier** (use the ideal op-amp model)

Solve for $V_{out}$ in terms of $I_{in}$ for the following circuit: