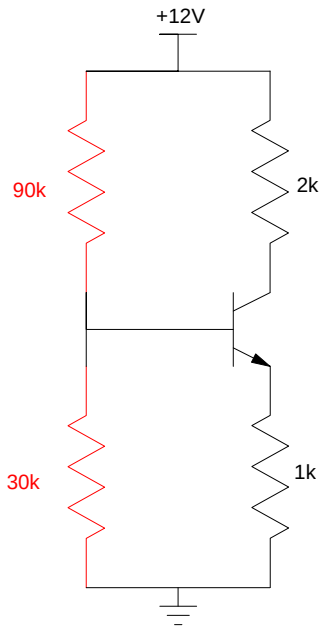
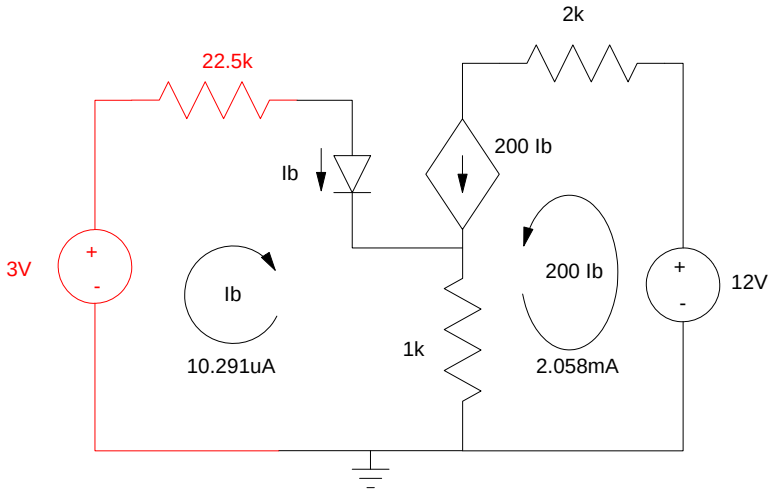
ECE 321 - Solution to Homework #5

1) Find the Q-point for the following circuit





First, redraw the circuit using the Thevenin equivalent for R1 and R2

- Vth = 3.00V
- Rth = 22.5k

Next, analyze the circuit

$$-3V + 22500I_b + 0.7 + 1000(1+\beta)I_b = 0$$

$$I_b = 10.291\mu A$$

$$I_c = \beta I_b = 2.058mA$$

$$V_c = 12 - 2000I_c = 7.884V$$

$$V_e = (I_b + I_c)1000 = 2.068V$$

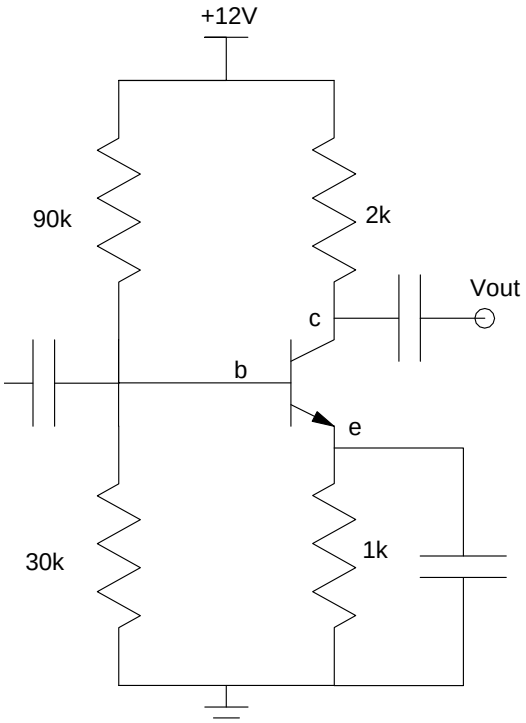
$$V_{ce} = 5.815V$$

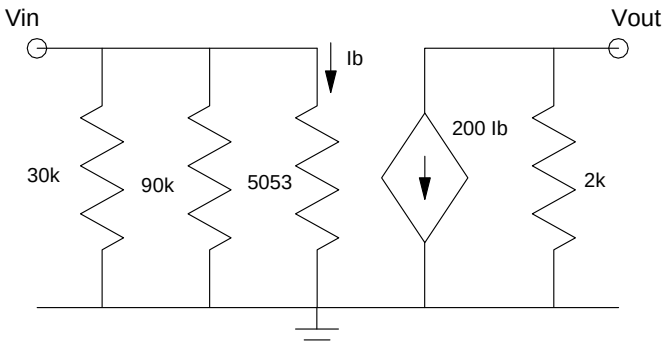
Q-Point:

Ic = 1.058mA

Vce = 5.815V

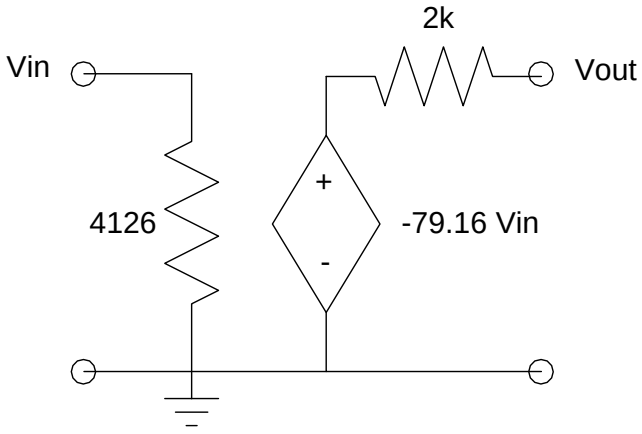
2) Find the 2-port model when connected as a common-emitter amplifier





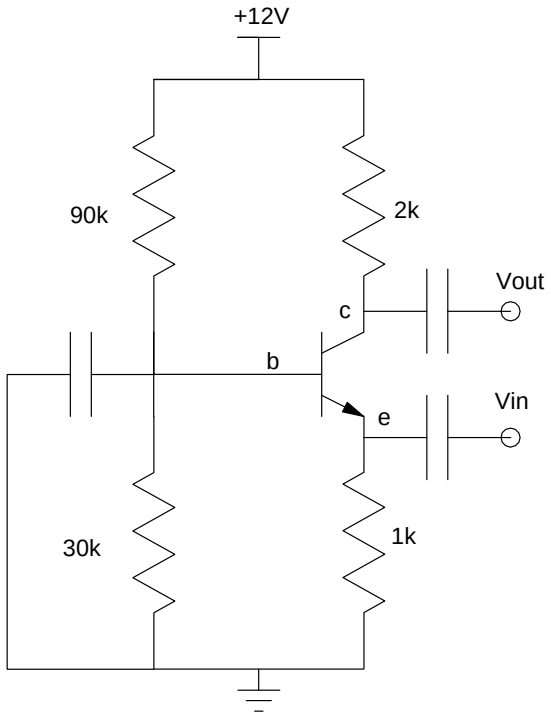
2-Port Model:

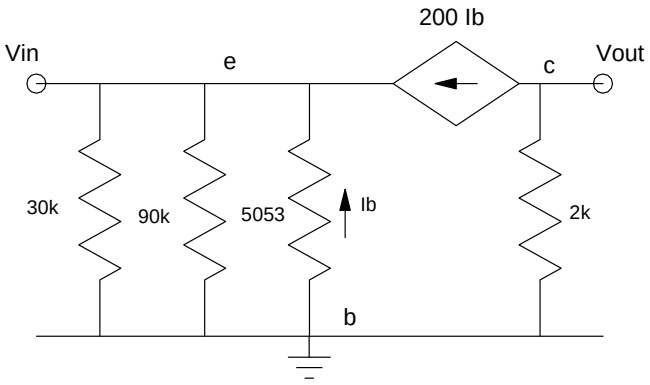
- Rin = 30k || 90k || 5053 = 4126
- Ai = 0
- Rout = 2k
- Ao = $-\left(\frac{\beta R_c}{r_f}\right) = -79.16$



3) Find the 2-port model as a common-base configuration

3a) Draw the small-signal model





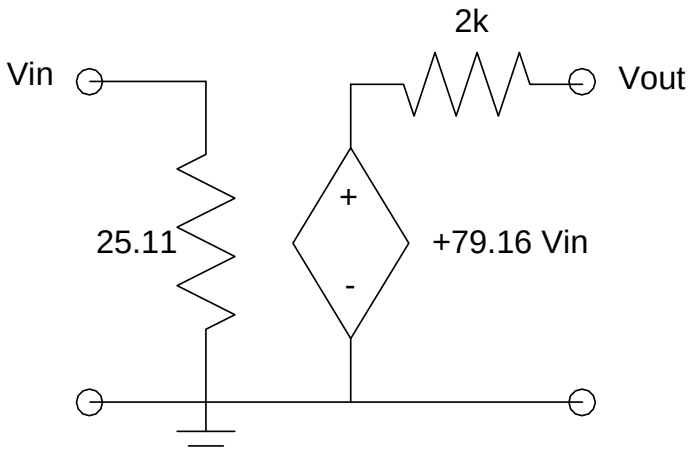
3b) Find the 2-port model

$$R_{in} = 30k||90k||5053||\frac{5053}{200} = 25.11\Omega$$

$$A_{in} = 0$$

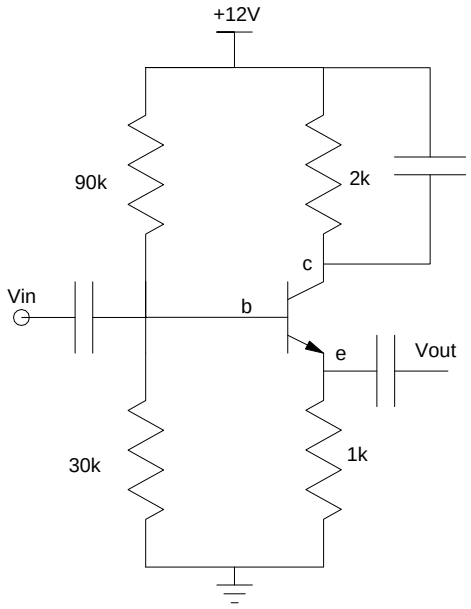
$$R_{out} = 2k$$

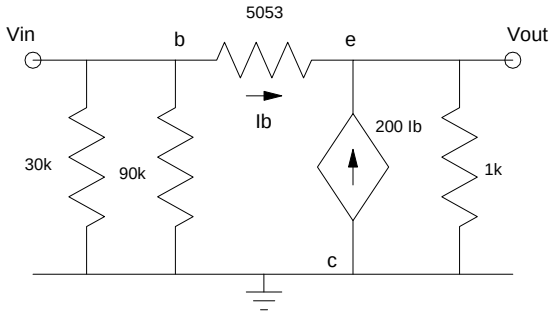
$$A_{out} = +\frac{\beta R_c}{r_f} = +79.61$$



4) Find the 2-port model as a common-collector configuration

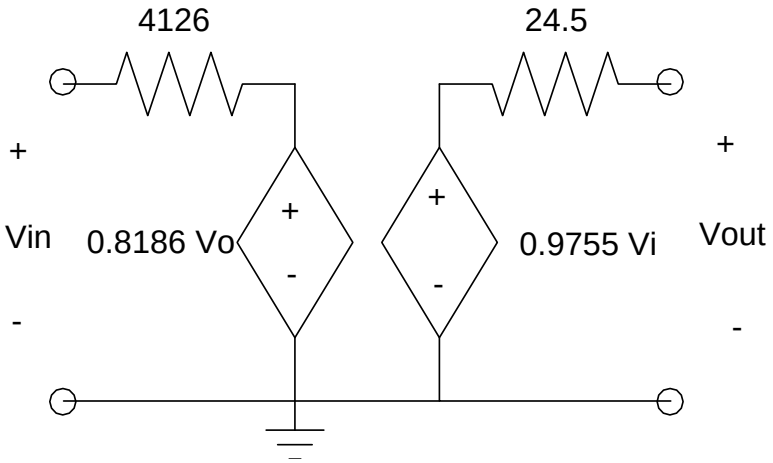
4a) Draw the small-signal model





4b) Find the 2-port model

- Rin = 30k || 90k || 5053 = 4126
- $A_{in} = \left(\frac{30k||90k}{30k||90k+5053}\right) = 0.8166$
- $R_{out} = 1k||5053||\frac{5053}{200} = 24.5\Omega$
- $A_{out} = \left(\frac{1k}{1k+\frac{5053}{\beta+1}}\right) = 0.9755$



5) Design a multi-stage amplifier for

- Input: Vin = 1uV, Rth = 1k
- Output: 8 Ohm speaker
- Relationship: Vo = 1e6 Vin

First stage = CE (high input impedance)

Last stage = push-pull amp

Each stage adds a gain of 53.33

$$79.16 \cdot \left(\frac{4126}{4126+2000}\right) = 53$$

To get a gain of 1,000,000

$$\left(\frac{4126}{4126+1000}\right) \cdot 53 \cdot 53 \cdot 53 \cdot 53 \cdot k = 1,000,000$$

So, 4 CE stages is enough. To trim the gain, add a resistor to reduce the gain by 5.2