

1. Use: ignore r_o , $|V_{BE}|=0.7$, $\beta=100$

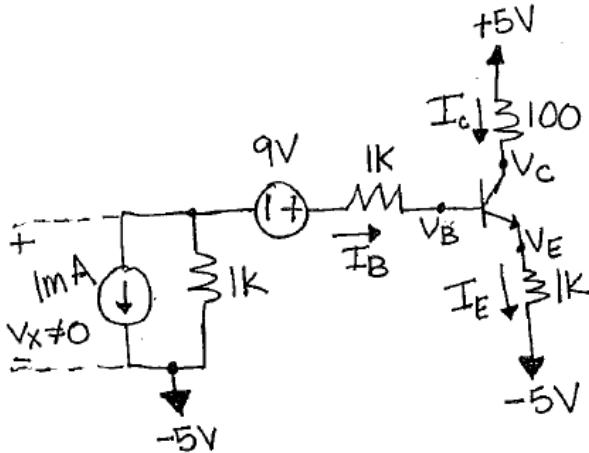
$V_I = 3 + 0.05\sin(20t)$

The current source is not ideal and has a voltage drop across it.

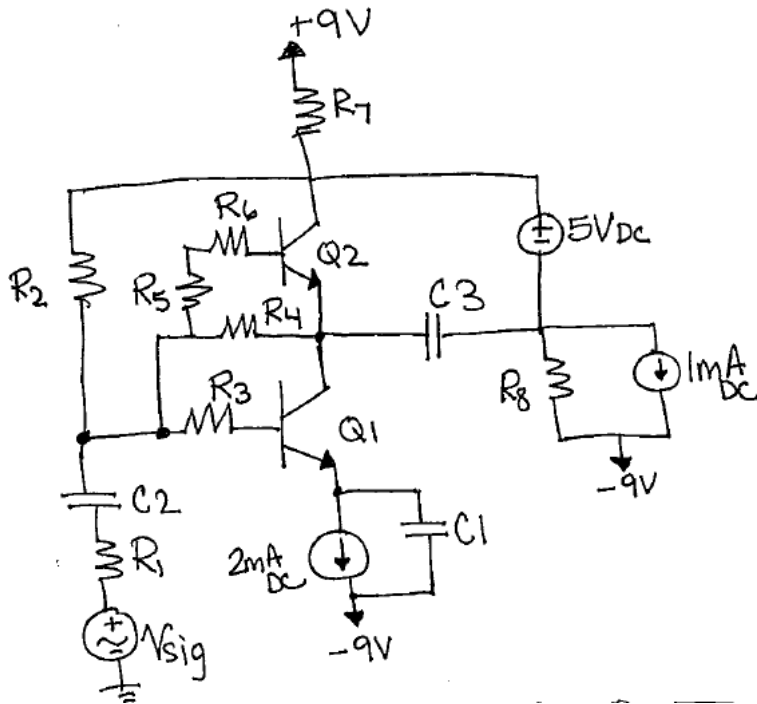
Assume that analysis reveals that

$I_B = 70.9\mu, I_C = 7.09m, I_E = 7.16m, V_B = 2.86V, V_E = 2.16V, V_C = 4.29V$

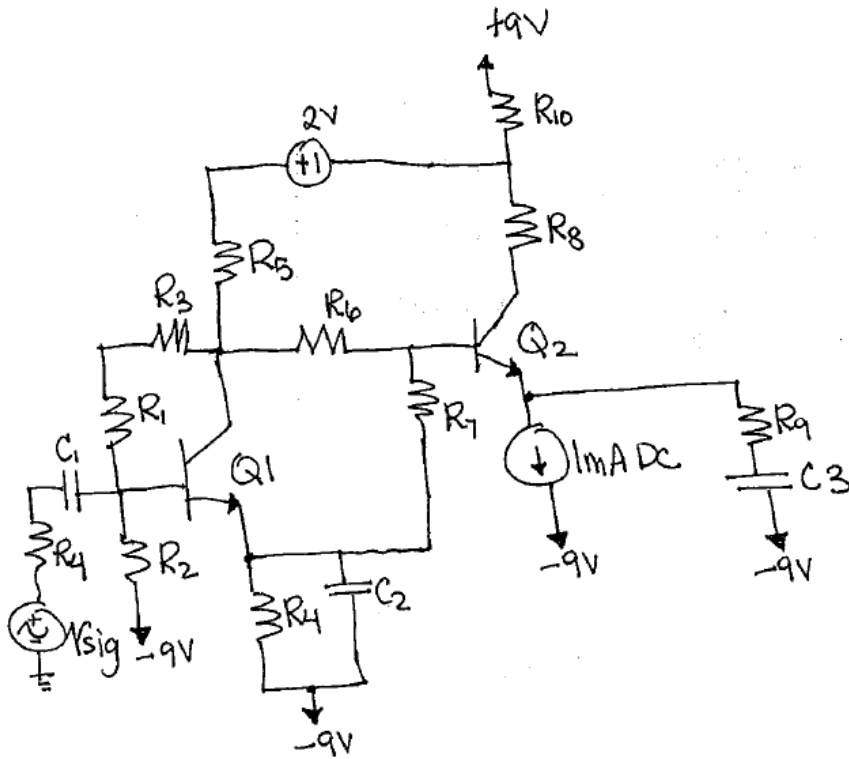
• What is the maximum value that the $R_C = 100\Omega$ can be to keep the transistor in the active region?



2. For the circuit shown below, draw the AC small-signal equivalent circuit (use hybrid- π). Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1} , $v_{\pi2}$, etc.). Include r_o for all transistors. $v_{sig}=0.001\sin(10t)$ AC. Assume that the capacitors act as a short.

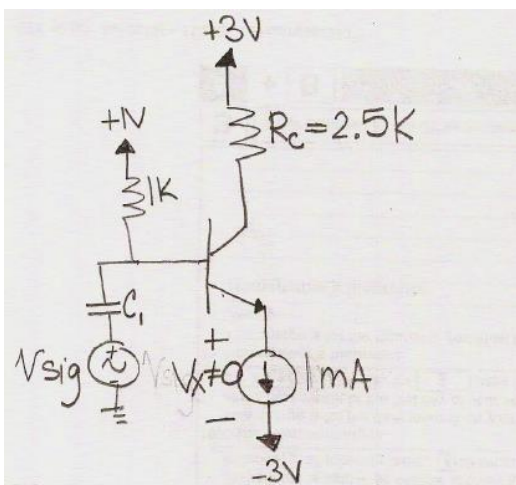


3. For the circuit shown below, **draw** the AC small-signal equivalent circuit (use hybrid- π or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1} , $v_{\pi 2}$, etc.). **Include r_o** for all transistors. $v_{sig} = 0.001 \sin(10t)$ AC. Assume that the capacitors act as a short.



4. $|V_{BE}| = 0.7$, $\beta = 100$, $V_T = 25 \text{ mV}$, $|V_{CE_{SAT}}| = 0.2 \text{ V}$, ignore r_o , $v_{sig} = \{2 + 0.1 \sin(\omega t)\}$ Volts. Assume that the capacitor acts as an open for DC operation and short for AC operation. There is an unknown voltage drop across the 1mA current source.

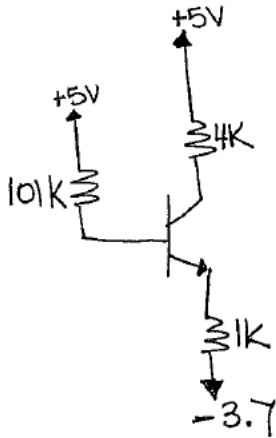
- (a) Assume transistor is acting in saturation, write **three independent equations** that would be used to solve for I_B and I_C . (You do not need to solve these equations.)
- (b) Assume that your solution from (a) yields $I_B = 900 \mu$ and $I_C = 9 \text{ m}$ (not actual values). Determine β_{forced} .
- (c) Express the condition for R_C in order to keep the transistor in the **active region**.



5. Use $|V_{BE}|=0.7$, $\beta=100$, $V_T=25\text{mV}$, $|V_{CE\text{SAT}}|=0.2\text{V}$.

Assume transistor is acting in saturation, write **three independent equations** that would be used to solve for I_B , I_C , and I_E . (You do not need to solve these equations.)

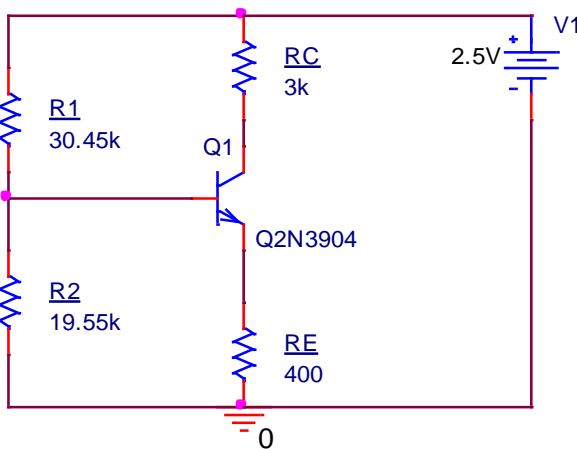
- Determine β_{forced} if your solution from (a) yields $I_B = 1\mu$, $I_C = 9\mu$, $I_E = 10\mu$. (not actual values)



6. Solve Problem 5 for the actual values of I_B , I_E , and I_C . What is the actual β_{forced} ?

7. Draw the following circuit in PSpice.

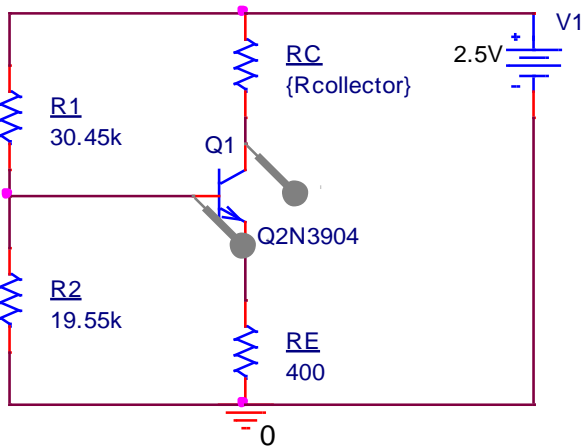
- Run a transient simulation and find the following values: $I_E, I_B, I_C, V_C, V_B, V_E$.
- Compare these to the designed values for $I_C = 0.5\text{mA}$, $I_1 = 10I_B$, and $V_{BE} = 778\text{m}$ derived in class. What causes the differences in values from the designed values.
- What region of operation is this circuit operating in?



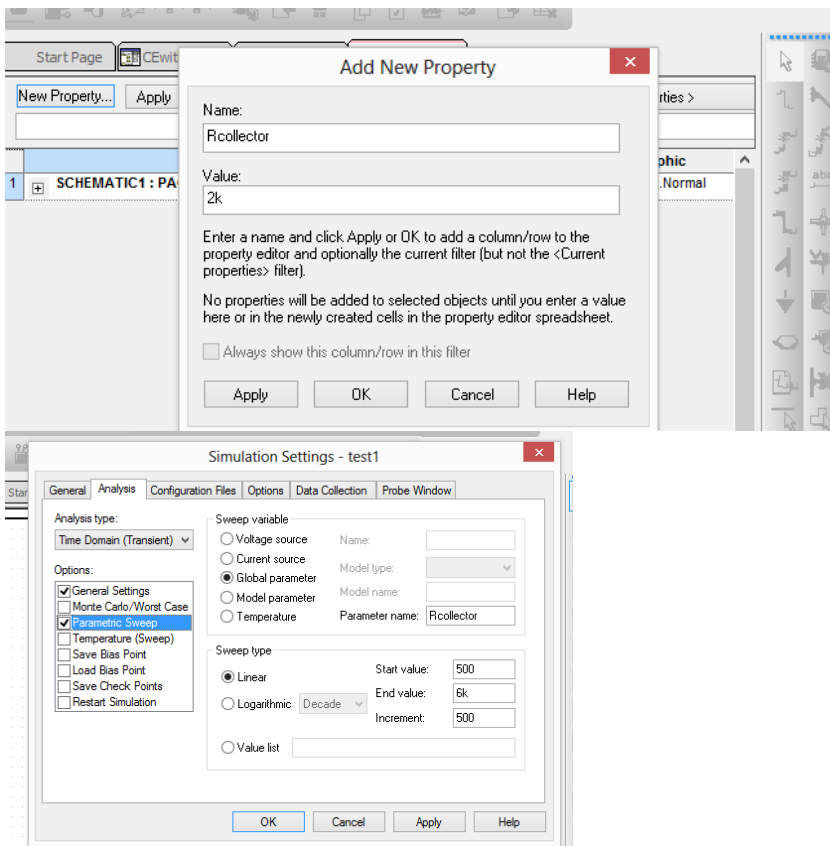
Problems 8-10:

Using the drawn circuit of problem 7, this problem will walk you through “Parameterizing” a resistor. This technique can be used for any component. Double click on the 3k value and change the value to a word surrounded by the squiggly brackets that look like $\{ \}$. In this case, I used $\{\text{Rcollector}\}$. Place a part called PARAM (located in the special library) anywhere on the schematic. Double click on the word “PARAMETERS” and a spreadsheet pops up in a new window. Select the

box that says “New Property”. A window may pop up that says UNDO Warning. Click Yes. Put the name you placed inside the { } without the squiggly brackets. In this examples the name is Rcollector. Put a value in the value box. This value will only be used for simulations that are not parametric analysis. Click Apply and then YES if the warning box comes up again. Close this window and in the schematic page create a new simulation profile. Go to edit simulation profile and choose the type of simulation you want. In this case, select transient analysis. Click on the Parametric Analysis box. Change the sweep variable to Global Parameter and type in the word you typed between the squiggly brackets (without the actual squiggly brackets) in the Parameter name box. Put the sweep type as LINEAR, start value -> 500 to end value -> 6k and increment ->500. Screen shots of these steps are below:

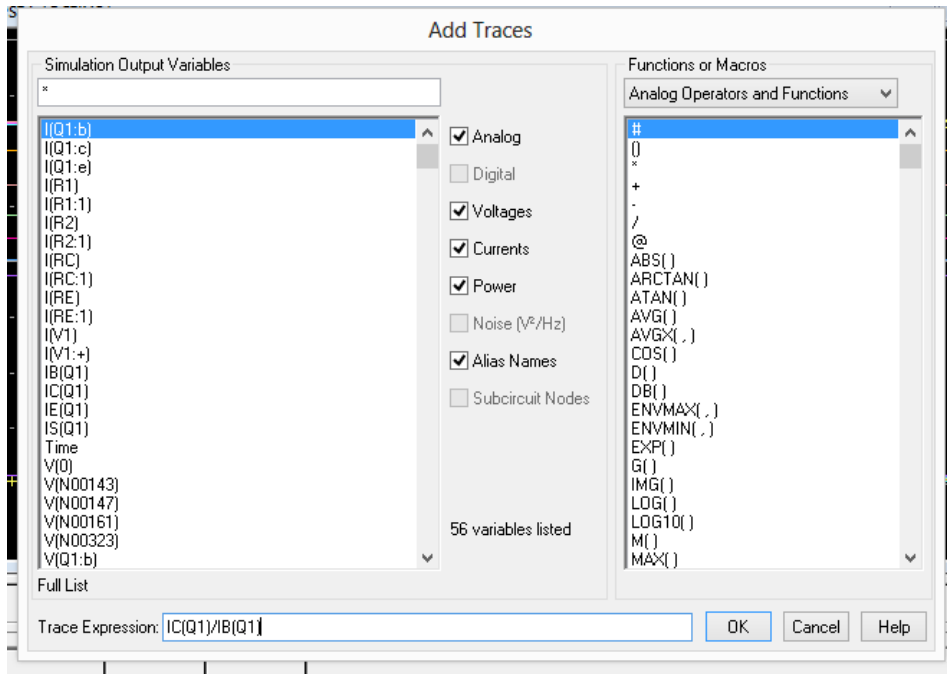


PARAMETERS:

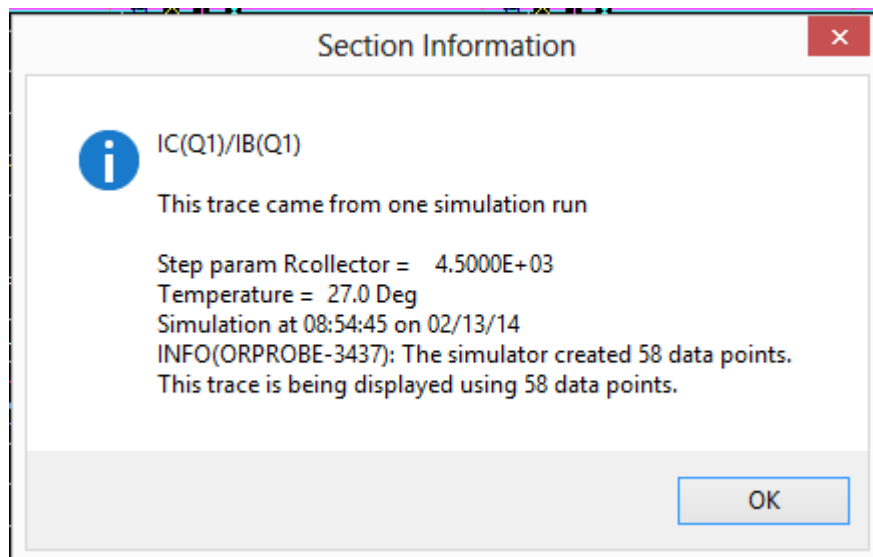


- This problem investigates when Rc is too large and moves the transistor into saturation by changing its value from 500 to 6k and then measuring $\beta = I_C / I_B$. Place a current probe at

the collector of Q1 and the base of Q1. Run the transient simulation once it is setup as described above. Once the plot comes up, click on the Trace menu and -> Add trace. In the add traces window, type in IC(Q1)/IB(Q1) in the trace expression box at the bottom and click ok. Delete the other traces from the plot by selecting them and hitting the delete button. This is now a plot of β for various values of R_c.

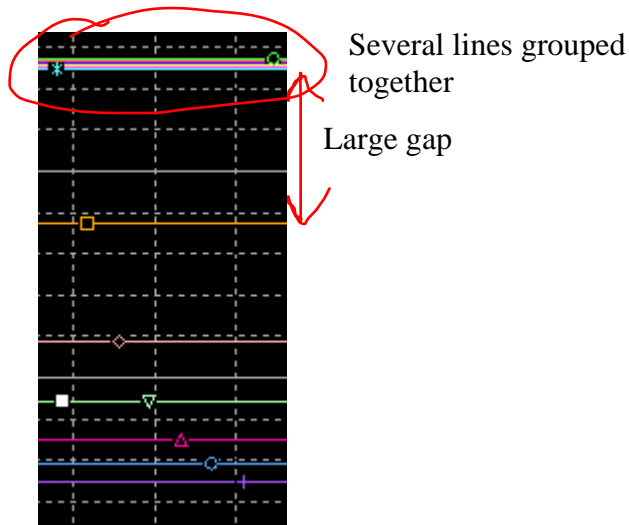


You can select a line, right click on it, select TRACE INFORMATION and a window such as the following pops up:



From this, you can see the value for R_{collector} that resulted in the line you selected.

The groupings of the graphs should look like the following:



8. a. What value of β is the nominal value? (this is the value for those lines grouped together keeping β approximately constant)
b. What value of $R_{\text{collector}}$ results in the transistor moving out of the active region. (This is the first line separated by the large gap.)
9. Explain in your own words what is happening as R_c is increased.
10. Pick a value for R_c that keeps the circuit in the active region. Replace $\{R_{\text{collector}}\}$ with this value and rerun the simulation without a parametric analysis. What is the DC bias (I_C value) for this R_c ?

Note: Save this schematic because you will also be using it in Homework 5.