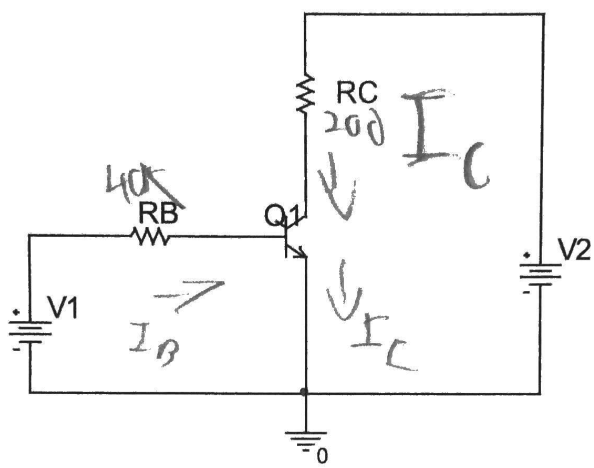
ECSE-2050 **Introduction to Electronics**
Summer 2020 **Name** ____________________

Homework 15

Reading: 6.1-4 (BJT discussion)

In all problems, you may assume that $V_{CEsat} \sim 0.2V$ ($V_{BE} \sim 0.7V$, $V_{BC} \sim 0.5V$) when the transistor is in the saturation region and that $V_{BE} \sim 0.7V$ when the transistor is on.

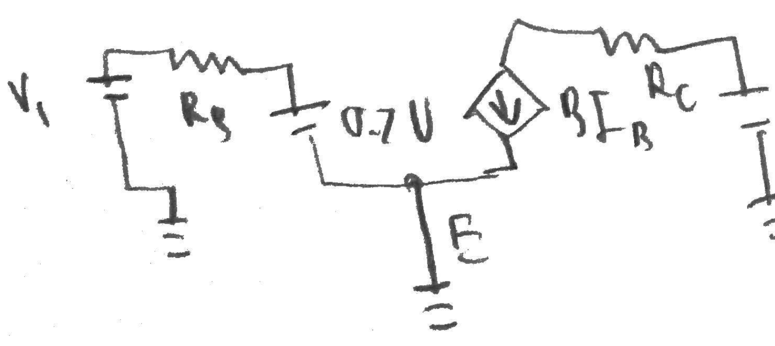
Problem 1) Simple DC biasing



In the above circuit, the forward active region has a common emitter current gain term, β = 150.

1) For RB = 40kΩ and RC = 200Ω, determine the three bias currents, IB, IC and IE for the following sources. For each case, draw the equivalent DC circuit (replacing the BJT with the equivalent circuit model for the region of operation).
   1. V1 = 10V, V2 = 10V
   2. V1 = 5V, V2 = 10V
   3. V1 = 10V, V2 = 5V

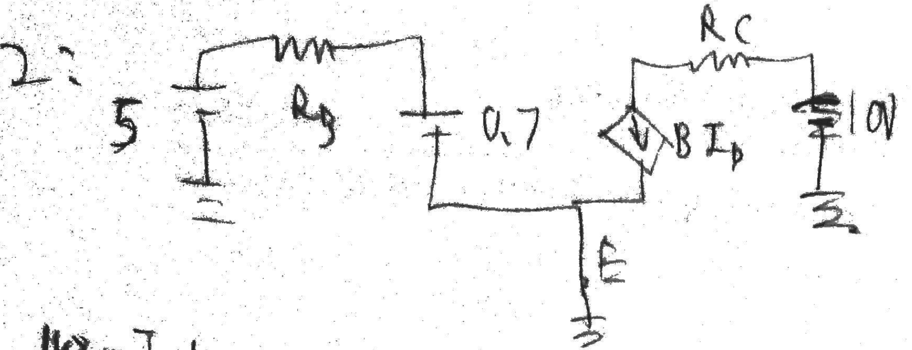
1: $V_1 = 10V = V_{BE} + I_B \cdot R_B = 40(10^3) I_B + 0.7 = 10$ $\quad I_B = 0.233mA$



$I_C = 150 \cdot I_B = 34.95mA = I_C$

$I_E = I_C + I_B = 35.183mA = I_E$

2:

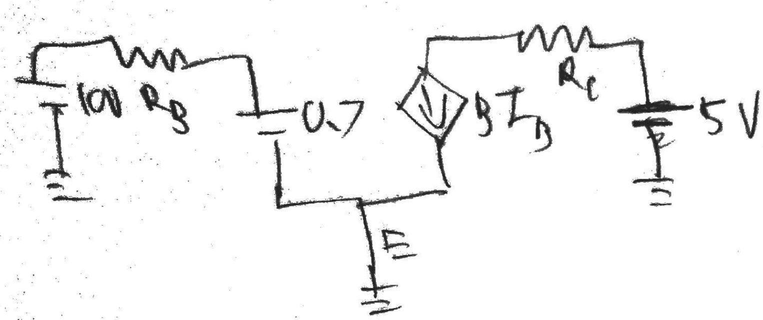


$4.3 = I_B R_B = 40k I_B$ $\quad$ $\underline{I_B = 0.1075 mA}$

$10V = I_C R_C + V_{CE} = 200 \cdot 150 \cdot I_B + V_{CE}$ ## $\quad$ $\underline{I_C = 16.125 mA}$

$\underline{I_E = I_C + I_B = 16.233 mA}$

3:

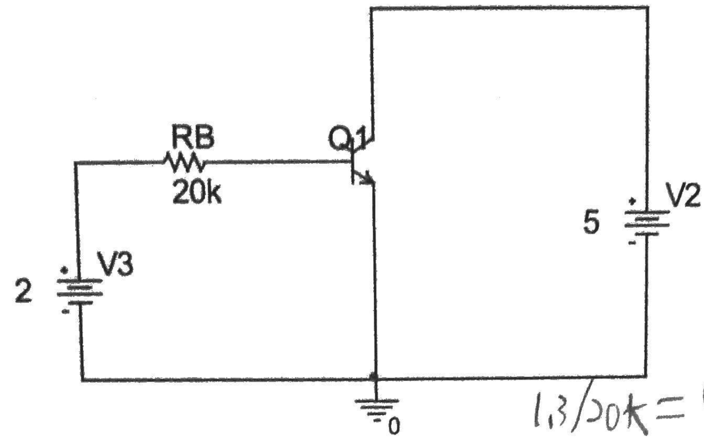


$9.3 = I_B R_B = 40k I_B$ $\quad$ $\underline{I_B = 0.233 mA}$

$5V = I_C R_C + V_{CE} = 200 \cdot 150\, I_B + V_{CE}$ ## $\quad$ $\underline{I_C = 34.95 mA}$

$\underline{I_E = 35.18 mA}$

Problem 2) Emitter resistor effects



$1.3/20k = 6.5\times10^{-5} = I_B$

$I_C = 6.5\,mA$

1) Determine the collector current when β = 100.
2) Determine the collector current when β = 200. → $I_C = 13\,mA$

$2 = 20k\, I_B + 0.7 + (\beta+1) I_B R_E$

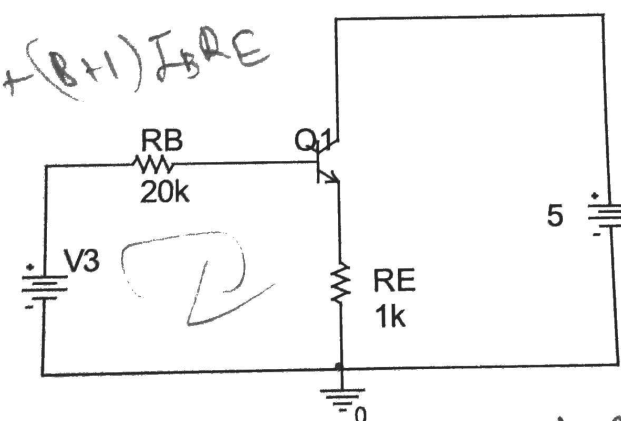
$I_B = 0.0107\,mA$

$I_C = 1.07\,mA$

$2 = 20k\, I_B + 0.7 + 1k \cdot I_E$

$I_B = 0.058\,mA$

$I_C = 11.76\,mA$



3) Determine the collector current when β = 100. $I_C = 1.07\,mA$
4) Determine the collector current when β = 200. $I_C = 11.76\,mA$
5) In terms of the DC biasing of the collector current, what is one advantage of adding an emitter resistor to the circuit when our transistor characteristics (forward active current gain for example) have a large variation in values?

Series resistance limit currents to the rest of the circuit.

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Problem 3) Saturation – Forward Active transitions
In the following circuits, the forward active region has a common emitter current gain term, β=100.

$I_C = 7.041\ mA$

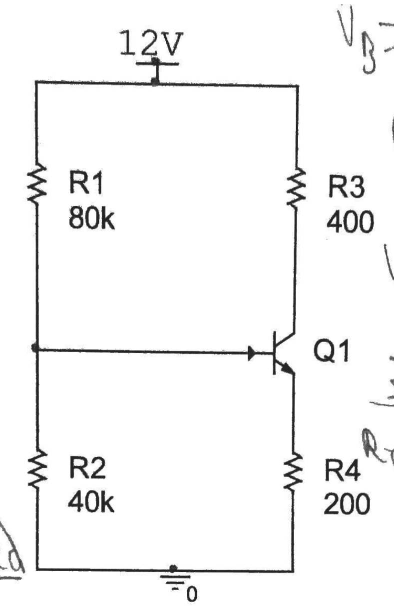
$V_{CE} = V_{CC} - I_C R_3 - I_E R_4$

$12 - (7mA)(400) -$

$(7mA + 70\mu A)200$

$= 7.76V > 0.2V$

Forward active satisfied



$V_B = \frac{12(40)}{120} = 4V$

$R_{TH} = R_1 \| R_2 = 26.67k$

$V_B = V_{RTH} + 0.7 + (\beta+1) I_B R_4$

$\frac{3.3}{R_{TH} + (101 \cdot 200)} = 7.041\times10^{-5} A$

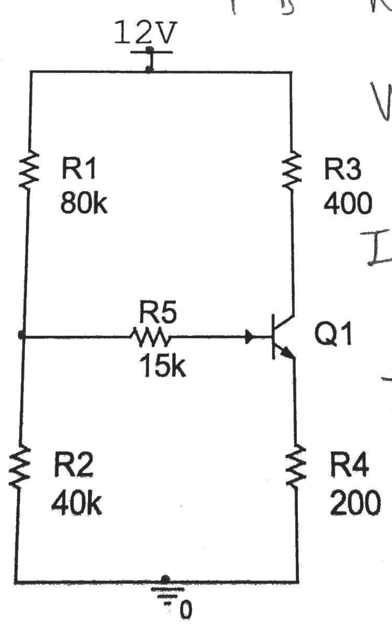
a) Verify that the transistor is in the Forward Active region of operation for the above circuit.

as seen by V_B $R_{TH} = R_1 \| R_2 + R_5 = 41666.67$

$V_{ce} = V_{cc} - I_C R_3 - I_E R_4$

$= 12 - 1.94 - .980$

$= 9.08V > 0.2V$



$V_B = \frac{12(40)}{120} = 4V$

$I_B = \frac{3.3}{R_{TH} + (\beta+1)R_4} = 4.85\times10^{-5}$

$I_C = \beta I_B = 4.85\ mA$

$I_E = (\beta+1) I_B = 4.9\ mA$

Forward active satisfied

a) Verify that the transistor is in the Forward Active region of operation for the above circuit. (Hint: Think of how you would apply Thevenin in this circuit.)