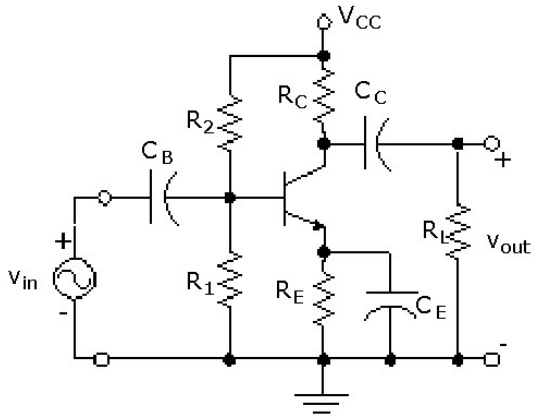
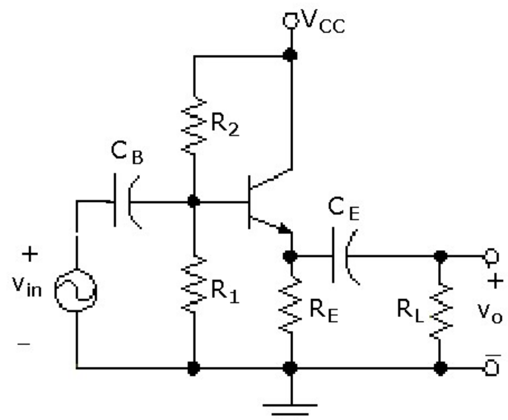
ETEE3211 **Fall 2007** **Test #2** **Name:__________________**

Show all work. Clearly indicate final answer(s).

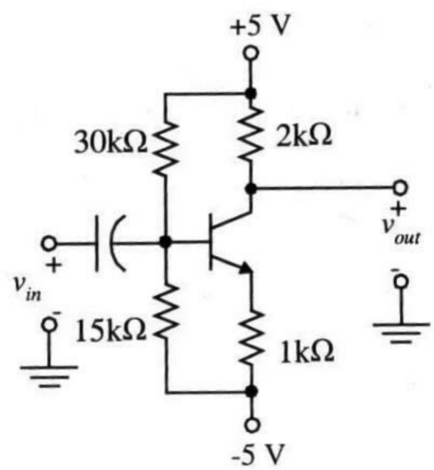
1. (20 pts) For the amplifier to the right, use the following values: V_{CC}=20V, V_{BE}=0.7V, β=100, R_C=R_L=2kΩ, R_E=200Ω, and all capacitors infinite and ideal. Find:
    a. R_1 and R_2 for I_{CQ}=8mA
    b. The symmetrical output voltage swing for the values of part (a)



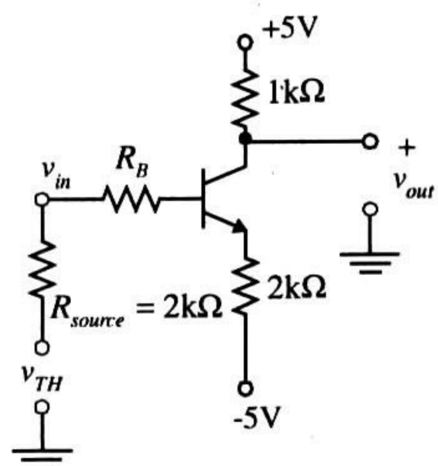
2. (30 points) For the amplifier to the right, use the following values: V_{CC}=12V, V_{BE}=0.7V, β=100, R_1=10kΩ, R_2=20kΩ, R_E=R_L=600Ω, and all capacitors infinite and ideal.
    a. Determine the symmetrical output voltage swing.
    b. Sketch the ac and dc load lines



3. (20 points) For the circuit shown to the right, determine the output voltage, v_{out}, when V_{BE}=0.7V, β = 200 and v_{in}=0.



4. (30 points) For the circuit of problem 1, use V_{CC}=5V, V_{BE}=0.7V, β=180, R_C=R_L=1kΩ, R_E=100Ω, and all capacitors infinite and ideal.
    a. Select R_1 and R_2 for maximum output voltage swing
    b. Determine V_{opp}
    c. Calculate the maximum conversion efficiency η

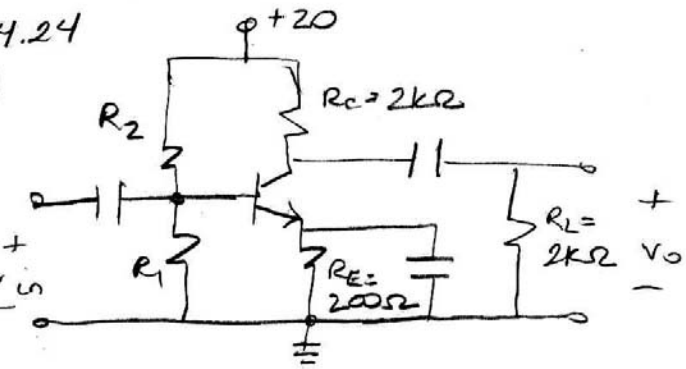


Extra Credit: (25 points max) An ac voltage source v_{TH} is applied directly to the base of an npn transistor as shown in the figure to the right. The internal resistance of the ac source is shown as R_{source}.

a. Determine I_{CQ}, V_{CEQ}, and V_{out} when the ac input is zero, assuming β=100, V_{BE}=0.7V and R_B=0.
b. What value of resistor needs to be added in the base circuit to make the output go to 3V when v_{in}=0?

P4.24

1



$V_{BE} = 0.7V$
$\beta = 100$

a) Given $I_{CQ} = 8mA$, find R_1 + R_2

$R_1 = \frac{R_B}{1 - V_{BB}/V_{CC}}$ $\quad R_2 = \frac{R_B V_{CC}}{V_{BB}}$, need R_B, V_{BB}

$V_{BB} = V_{BE} + I_{CQ}\left(\frac{R_B}{\beta} + R_E\right)$, need R_B

use $R_B = 0.1\beta R_E = (0.1)(100)(200) = 2K\Omega$

$V_{BB} = 0.7 + (0.008)\left(\frac{2000}{100} + 200\right) = 2.46V$

$R_1 = \frac{2K}{1 - 2.46/20} = \underline{2.28K\Omega}$ $\quad R_2 = \frac{(2K)(20)}{2.46} = \underline{16.26K\Omega}$

b) $V_{opp} = ?$

$V_{CEQ} = V_{CC} - I_{CQ}R_{dc} = 20 - (8m)(2.2K) = 2.4V$

$V_{CC}' = V_{CEQ} + I_{CQ}R_{ac} = 2.4 + (8m)(1K) = 10.4V$

$I_{CC}' = \frac{V_{CC}'}{R_{ac}} = \frac{10.4}{1K} = 10.4mA$; $I_{CQ} > \frac{I_{CC}'}{2}$ ∴ Qpt in upper half

$V_{opp} = 2(I_{CC}' - I_{CQ})R_{ac} = 2(10.4m - 8m)(1K) = \underline{4.8V}$

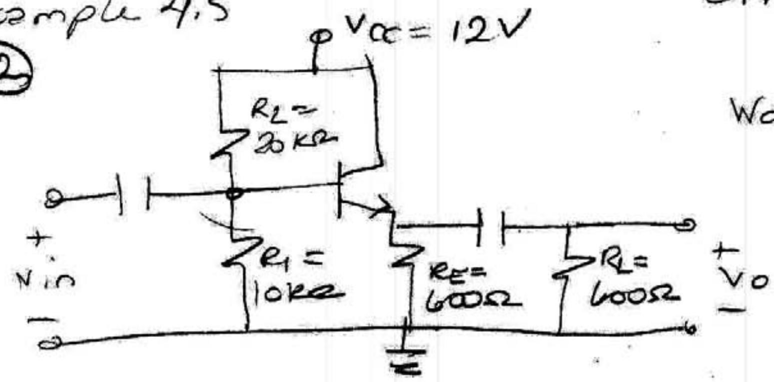
Example 4.5

②

Given: $V_{BE} = 0.7V$

$\beta = 100$

Want V_{opp}



$$R_B = R_1 \| R_2 = 10K \| 20K = 6.67 K\Omega$$

$$V_{BB} = \frac{R_1 V_{CC}}{R_1 + R_2} = \frac{(10K)(12)}{10K + 20K} = 4V$$

$$I_{CQ} = \frac{V_{BB} - V_{BE}}{R_B/\beta + R_E} = \frac{4 - 0.7}{\frac{6.67K}{100} + 0.6K} = 4.95mA$$

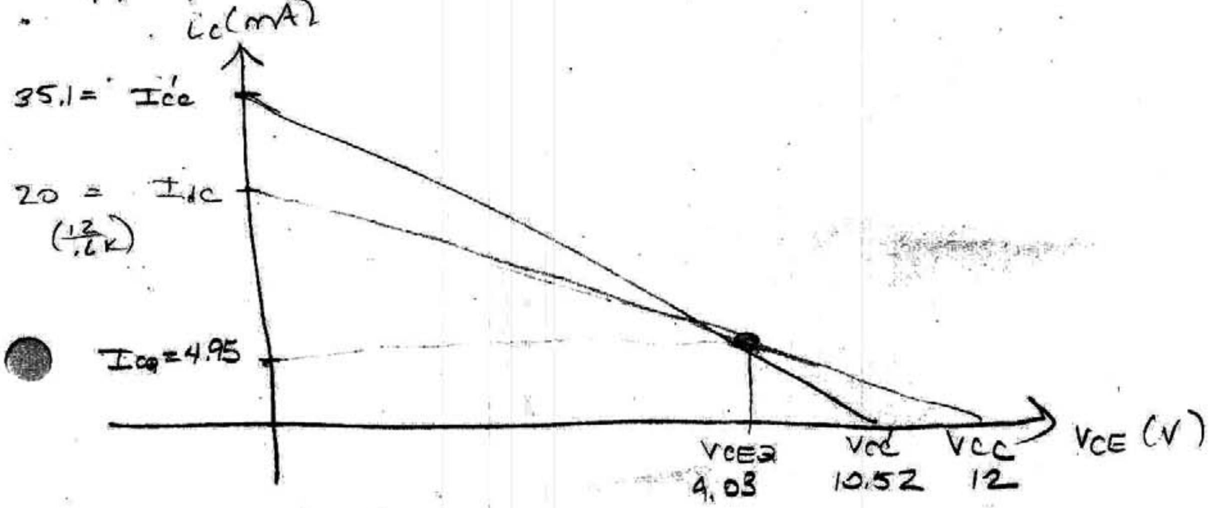
$$V_{CEQ} = V_{CC} - I_{CQ} R_{dc} = 12 - (4.95m)(0.6K) = 9.03V$$

$$V_{CC}' = V_{CEQ} + I_{CQ} \underset{R_E \| R_L}{R_{ac}} = 9.03 + (4.95m)(0.3K) \simeq 10.52V$$

$$I_{CC}' = \frac{V_{CC}'}{R_{ac}} = \frac{10.52}{0.3K} = 35.1mA$$

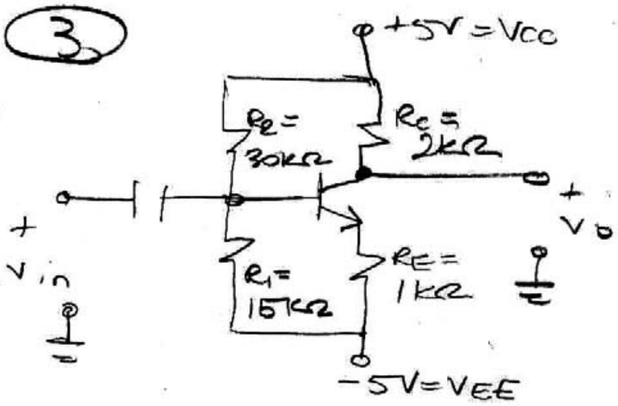
$I_{CQ} < \frac{I_{CC}'}{2}$ ∴ Q pt in lower half

$$V_{opp} = 2(I_{CQ} - 0)R_{ac} = 2(4.95m)(0.3K) = \underline{\underline{2.97V}}$$



P4.8

3



Given: $V_{BE} = 0.7V$

$\beta = 200$

$v_{in} = 0$

Want: v_{out}

$$R_B = R_1 \parallel R_2 = (15k) \parallel (30k) = 10k\Omega$$

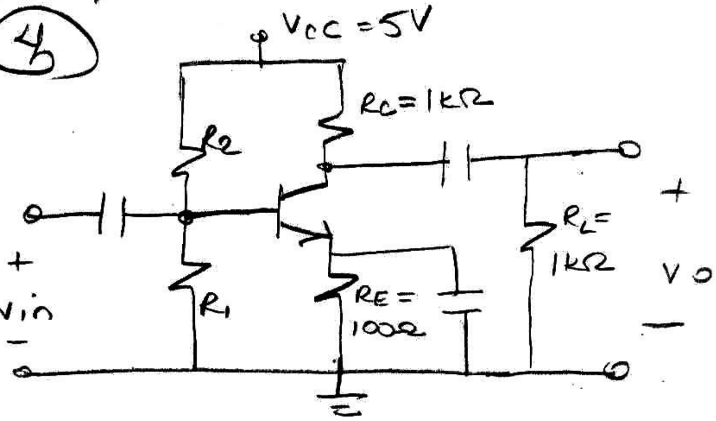
$$V_{BB} = \frac{R_1 (V_{CC} - V_{EE})}{R_1 + R_2} = \frac{(15k)(5 - {}^-5)}{30k + 15k} = 3.33V$$

$$I_{CQ} = \frac{V_{BB} - V_{BE}}{R_B/\beta + R_E} = \frac{3.33 - 0.7}{10k/200 + 1k} \cong 2.50\,mA$$

$$V_o = V_C = V_{CC} - I_{CQ} R_C = 5 - (2.5m)(2k) = \underline{0V}$$

Example 4.3

4



Given: $V_{BE}=0.7V$

$\beta=180$

Want: max swing

R_1, R_2, V_{opp}, η

Let $R_B = 0.1\beta R_E = (0.1)(180)(100) = 1.8k\Omega$

$R_{ac} = R_c \parallel R_L = 1k \parallel 1k = 500\Omega$

$R_{dc} = R_c + R_E = 1k + 100 = 1.1k\Omega$

$$I_{CQ} = \frac{V_{cc}}{R_{ac}+R_{dc}} = \frac{5}{1.6k} \cong 3.13mA$$

$$V_{BB} = V_{BE} + I_{CQ}\left(\frac{R_B}{\beta} + R_E\right) = 0.7 + (3.13m)\left(\frac{1.8k}{180} + 0.1k\right) = 1.04V$$

$$R_1 = \frac{R_B}{1 - V_{BB}/V_{cc}} = \frac{1.8k}{1 - 1.04/5} = \underline{2.27k\Omega} \quad R_2 = \frac{R_B V_{cc}}{V_{BB}} = \frac{(1.8k)(5)}{1.04} = \underline{8.65k\Omega}$$

$$V_{opp} = 2 I_{CQ} R_{ac} = 2(3.13m)(0.5k) = \underline{3.13V}$$

$$\eta = \frac{P_{out}(ac)}{P_{vcc}(dc)} * 100 =$$

$$P_{vcc}(dc) = \frac{V_{cc}^2}{R_1+R_2} + I_{CQ}^2(R_C+R_E) + V_{CEQ} I_{CQ}$$

$$V_{CEQ} = V_{cc} - I_{CQ}R_{dc} = 5 - (3.13m)(1.1k) = 1.56V$$

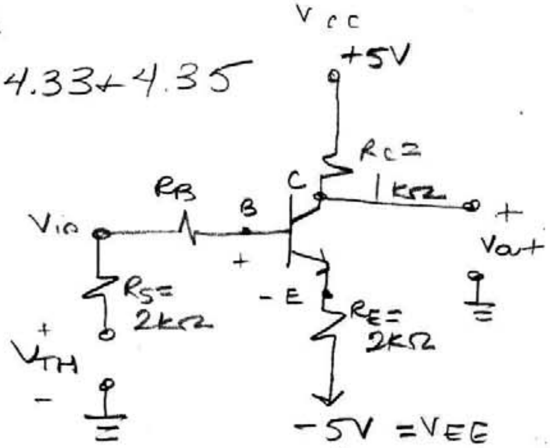
$$P_{vcc}(dc) = \frac{5^2}{10.92K} + (3.13m)^2(1.1K) + (1.56)(3.13m) = 17.95mW$$

$$P_{out}(ac) = \left(\frac{I_{CQ}}{2}\right)^2 R_{ac} = \left(\frac{3.13m}{2}\right)^2(0.5K) = 1.22mW$$

$$\eta = \frac{1.22}{17.95} * 100 \cong \underline{\underline{6.8\%}}$$

EC

P4.33+4.35



a) Given: $\beta = 100$
$V_{BE} = 0.7V$
$R_B = 0$
$V_{TH} = 0$

Want I_{CQ}, V_{CEQ}, V_{out}

b) want R_B to make $V_{out} = 3V$

Not std bias ckt, so can't use std eqns

a) KVL @ BE loop @ Q pt

$$-\underbrace{V_{TH}}_{0} + R_S \underbrace{I_{BQ}}_{\frac{I_{CQ}}{\beta}} + \underbrace{R_B I_{BQ}}_{0} + V_{BEQ} + \underbrace{I_{EQ}}_{I_{CQ}} R_E + V_{EE} = 0$$

$$2k\left(\frac{I_{CQ}}{100}\right) + 0.7 + (2k) I_{CQ} + (-5) = 0$$

$$I_{CQ}(2020) = 4.3 \;;\; I_{CQ} = \frac{4.3}{2020} \simeq \underline{2.13\,mA}$$

$$V_{CEQ} = (V_{CC} - V_{EE}) - I_{CQ} R_{dc} = 10 - (2.13m)(3k) = \underline{3.61V}$$

$$V_O = V_C = V_{CC} - I_{CQ} R_C = 5 - (2.13m)(1k) = \underline{2.87V}$$

b) work backwards (more or less)

$$V_o = V_{CC} - I_{CQ} R_C \;;\; 3 = 5 - I_{CQ}(1k) \;;\; I_{CQ} = \frac{5-3}{1k} = 2mA$$

from derived eqn w/ $R_B \neq 0$

$$\frac{R_S I_{CQ}}{\beta} + R_B \frac{I_{CQ}}{\beta} + V_{BEQ} + R_E I_{CQ} + V_{EE} = 0$$

$$\frac{(2k)(2m)}{100} + R_B\left(\frac{2m}{100}\right) + 0.7 + (2k)(2m) + (-5) = 0$$

$$R_B\left(\frac{0.002}{100}\right) - 0.26 = 0$$

$$R_B = 0.26\left(\frac{100}{0.002}\right) = \underline{13k\Omega}$$