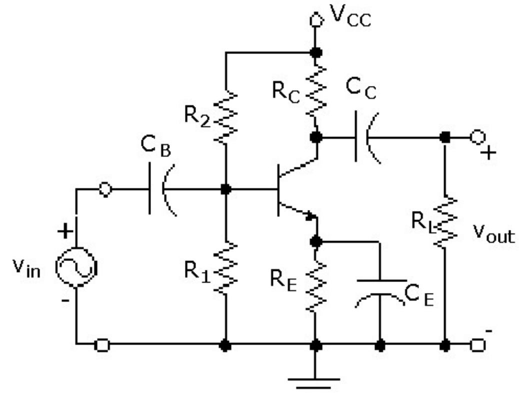
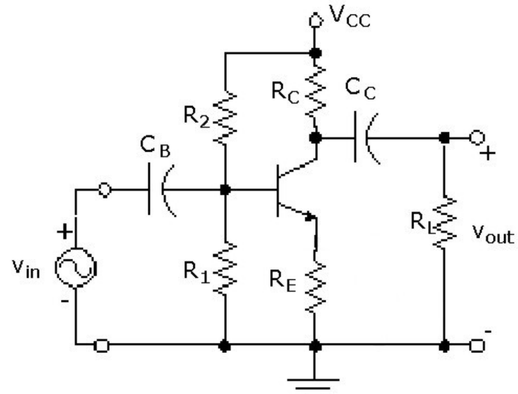
ETEE3211 Fall 2006 Test #2 Name:________________

Show all work. Clearly indicate final answer(s).
Cheatsheet must be turned in with test or a zero will be given for the *entire* test!

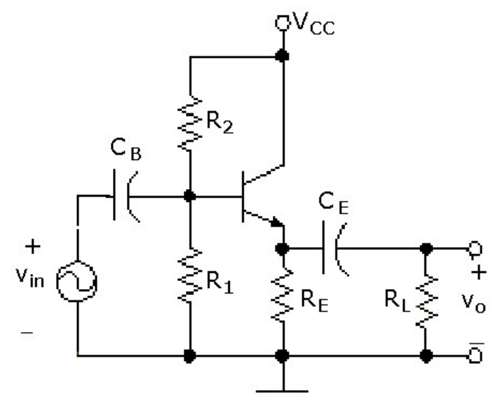
1. (40 pts) For the circuit to the right, if R_1=1.5kΩ, R_2=7kΩ, R_E=100Ω, R_C=R_L=1kΩ, β=180, V_{BE}=0.7V, V_{CC}=5V and all capacitors are infinite and ideal, determine:
   a. the Q-point;
   b. V_{opp};
   c. P_{out}(ac);
   d. dc power delivered by the source.



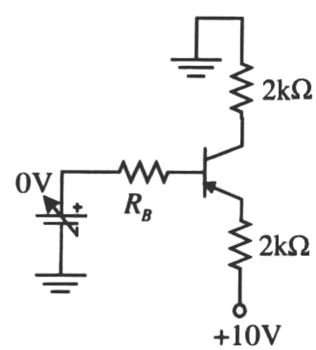
2. (25 pts) Given R_C=R_L=2kΩ, R_E=200Ω, β=200, V_{BE}=0.7V, V_{CC}=15V and all capacitors are infinite and ideal:
   a. select R_1 and R_2 for maximum possible symmetric current swing;
   b. determine the maximum symmetrical output voltage swing.



3. (35 pts) Given R_1=8kΩ, R_2=2kΩ, R_E=R_L=1kΩ, β=80, V_{BE}=07V and V_{CC}=15V:
   a. determine the maximum symmetrical output voltage swing ;
   b. sketch the ac & dc load lines;
   c. calculate the conversion efficiency of the amplifier.

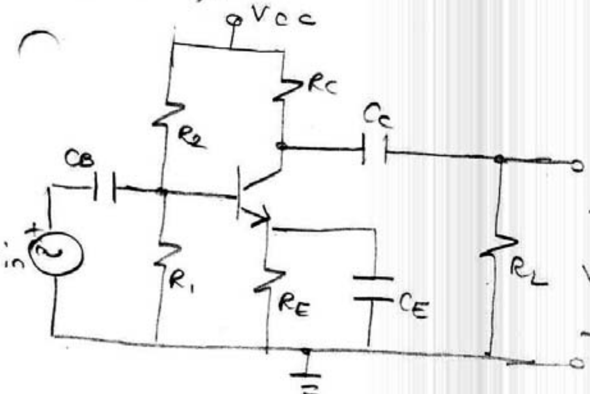


<u>Extra Credit:</u> (25 points max) For the circuit to the right, determine the β of the transistor at saturation when R_B=100kΩ, V_{BE} = -0.7V and $V_{CE(sat)}$ = -0.2V.



P1

Ex 4.2, p169



Given:
$R_1 = 1.5\,k\Omega$
$R_2 = 7\,k\Omega$
$R_E = 100\,\Omega$
$R_C = R_L = 1k\Omega$
$\beta = 180$
$V_{BE} = 0.7V$
$V_{CC} = 5V$
caps: ∞ + ideal
(i.e.: perfect open to dc, perfect short to ac)

a) $I_{CQ} = \dfrac{V_{BB} - V_{BE}}{R_B/\beta + R_E}$

2 $V_{BB} = \dfrac{R_1 V_{CC}}{R_1 + R_2} = \dfrac{(1.5k)(5)}{1.5k + 7k} = 0.882V$

2 $R_B = R_1 \| R_2 = (1.5k) \| (7k) = 1.24k\Omega$

3 $I_{CQ} = \dfrac{0.882 - 0.7}{1.24k/180 + 100} = \underline{\underline{1.70\,mA}}$

3 $V_{CEQ} = V_{CC} - I_{CQ} R_{dc} = V_{CC} - I_{CQ}(R_C + R_E)$
$= 5 - (1.7 \times 10^{-3})(1000 + 100) = \underline{\underline{3.13V}}$

b) 2 $V'_{CC} = V_{CEQ} + I_{CQ} R_{ac} = V_{CEQ} + I_{CQ}(R_C \| R_L)$
$= 3.13 + (1.7m)(0.5k) = 3.98V$

2 $I'_{CC} = \dfrac{V'_{CC}}{R_{ac}} = \dfrac{3.98}{500} = 7.96\,mA$

3 $I_{CQ} < \dfrac{I'_{CC}}{2}$ ∴ Q-pt in lower half of load line

3 $V_{opp} = 2(I_{CQ} - 0)(R_C \| R_L) = 2(1.7m)(0.5k) = \underline{1.7\,V_{pp}}$

c) $P_{out}(ac) = \frac{1}{2} i_L^2 R_L$

since $R_L = R_C$, $i_L = \frac{1}{2} I_{CQ}$ (current division)

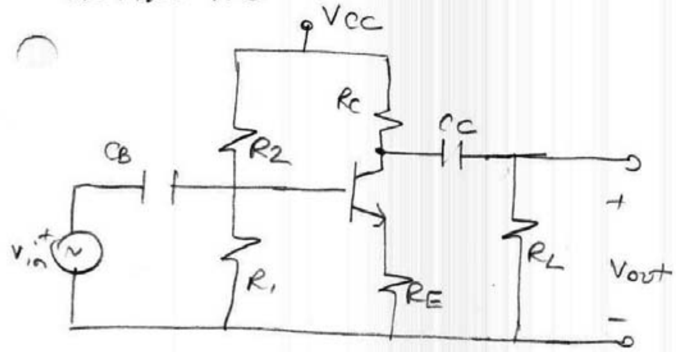
$P_{out}(ac) = \frac{1}{2}\left(\frac{1.7\times10^{-3}}{2}\right)^2(10^3) = 0.361\times10^{-3}\,W = \underline{361\,\mu W}$

d) $P_{Vcc}(dc) = I_{CQ}V_{CC} + \frac{V_{CC}^2}{R_1+R_2} = (1.7\times10^{-3})(5) + \frac{5^2}{(1.5+7)\times10^3}$

$= 8.5m + 2.94m = \underline{11.44\,mW}$

P2)

Ex 4.2 + 4.3



Given:

$V_{CC} = 15V$

$V_{BE} = 0.7V$

$R_C = R_L = 2k\Omega$

$R_E = 200\Omega$

$\beta = 200$

a) max swing ⇒ Qpt in center of load line

2 $R_{ac} = R_C \| R_L + R_E = 2k \| 2k + 200 = 1.2k\Omega$

2 $R_{dc} = R_C + R_E = 2k + 200 = 2.2k\Omega$

4 $I_{CQ} = \dfrac{V_{CC}}{R_{ac} + R_{dc}} = \dfrac{15}{1.2k + 2.2k} = 4.41mA$

3 Let: $R_B = 0.1\beta R_E = 0.1(200)(200) = 4k\Omega$

3 $V_{BB} = V_{BE} + I_{CQ}(R_B/\beta + R_E) = 0.7 + (4.41\times10^{-3})\left(\frac{4000}{200} + 200\right) = 1.67V$

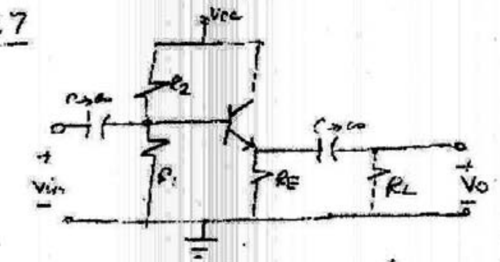
3 $R_1 = \dfrac{R_B}{1 - V_{BB}/V_{CC}} = \dfrac{4k}{1 - 1.67/15} = \underline{4.5k\Omega}$

3 $R_2 = \dfrac{V_{CC} R_B}{V_{BB}} = \dfrac{(15)(4k)}{1.67} = \underline{35.9k\Omega}$

b) Q-pt in center

5 $V_{opp} = 2I_{CQ}(R_L \| R_C) = 2(4.41m)(2k \| 2k) = \underline{8.82V_{pp}}$

E4.7



$V_{CC} = 15V$
$R_1 = 8k\Omega$
$R_2 = 2k\Omega$
$R_E = 1k\Omega$
$R_L = 1k\Omega$
$V_{BE} = 0.7V$
$\beta = 80$

max symmetric voltage swing ($V_{osym\,p\text{-}p}$) = ?

a) $V_{BB} = \dfrac{R_1 V_{CC}}{R_1 + R_2} = \dfrac{(8k)(15)}{8k + 2k} = 12V$

$R_B = R_1 \| R_2 = (8k)\|(2k) = 1.6k\Omega$

$I_{CQ} = \dfrac{V_{BB} - V_{BE}}{R_B/\beta + R_E} = \dfrac{12 - 0.7}{(1.6\times10^3)/80 + 10^3} = 1.108\times10^{-2} A = 11.08mA$

*cannot assume this is in the center of the load line, so must solve for I_{CQ} (use $I_E \approx I_C$)

$V_{CEQ} = V_{CC} - I_{CQ}R_E = 15 - (11.08\times10^{-3})(10^3) = 3.92V$

$V'_{CC} = V_{CEQ} + I_{CQ}(R_E \| R_L) = 3.92 + (11.08\times10^{-3})(1k\|1k) = 9.46V$

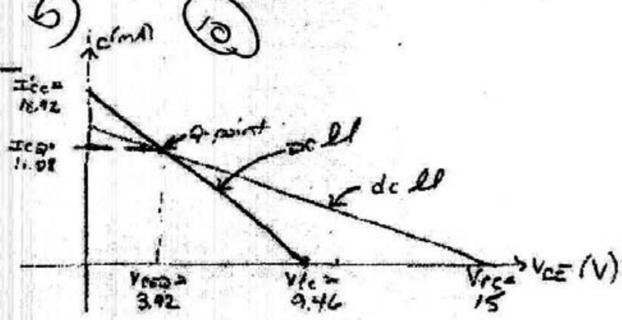
$I'_{CC} = \dfrac{V'_{CC}}{R_E \| R_L} = \dfrac{9.46}{500} = 18.92mA$

$V_{osym\,p\text{-}p} = 2(I'_{CC} - I_{CQ})(R_E \| R_L) = 2(18.92 - 11.08)(10^{-3})(500)$

$V_{osym\,pp} = 7.84V_{pp}$

b)

10



c) $\eta = \dfrac{P_{out(ac)}}{P_{in(dc)}} \times 100$

P3 (cont)

$R_L = R_E \quad \therefore \quad i_L = \frac{1}{2} I_{CQ} = \frac{11.08m}{2}$

$P_{out}(ac) = \frac{1}{2} i_L^2 R_L = \frac{1}{2}\left(\frac{I_{CQ}}{2}\right)^2 R_L = \frac{I_{CQ}^2 R_L}{8}$

2 $P_{out}(ac) = \frac{(11.08 \times 10^{-3})^2 (10^3)}{8} = 15.35\,mW$

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

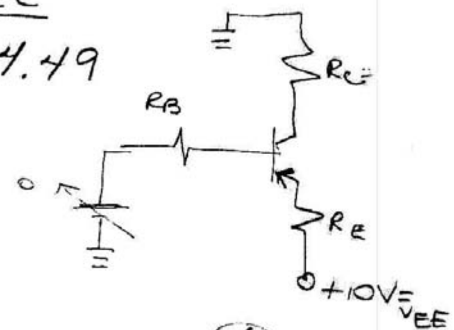
2 $= (3.92)(11.08m) + (11.08m)^2(1k) + \frac{15^2}{10k} =$

$P_{in}(dc) = 43.43m + 122.77m + 22.5m = 188.73\,mW$

3 $\eta = \frac{15.35m}{188.73m} * 100 = \underline{8.13\%}$

EC

P4.49



Given:
$R_B = 100k\Omega$ $R_C = R_E = 2k\Omega$
$V_{CE(sat)} = -0.2V$
$V_{BE} = -0.7V$
$\beta = 100$

want: β of transistor at saturation

(5)

w/value of β given: $I_C = \dfrac{-V_{EE} - V_{BE}}{\frac{R_B}{\beta} + R_E} = \dfrac{-10-(-0.7)}{\frac{100k}{100} + 2k} = -3.1mA$

(5) $I_{Csat} = \dfrac{-V_{EE} - V_{CE(sat)}}{R_C + R_E} = \dfrac{-10-(-0.2)}{4K} = -2.45mA$

$I_{Csat} = \dfrac{-V_{EE} - V_{BE}}{\frac{R_B}{\beta} + R_E}$, everything known but β

$I_{Csat}\left(\frac{R_B}{\beta} + R_E\right) = -V_{EE} - V_{BE}$

$\dfrac{R_B}{\beta} = \dfrac{-V_{EE} - V_{BE} - I_{Csat}R_E}{I_{Csat}}$

(5) $\beta = \dfrac{I_{Csat}R_B}{-V_{EE} - V_{BE} - I_{Csat}R_E}$

$\beta = \dfrac{(-2.45\times10^{-3})(100\times10^{3})}{-10-(-0.7)-(-2.45\times10^{-3})(2\times10^{3})} = \dfrac{-245}{-4.4} = \underline{55.7}$