NAME: SOLUTION SET.

March 21st 2013

MAXIMUM POINTS: 100

EECE 322: Electronics-II (Spring 2013, University of New Mexico)
MID TERM EXAMINATION-I

RULES:

- Write your name on the top left corner
- Time Allotted = 75 Minutes
- Closed Book and Closed Notes
- You are allowed one single sided 8.5 x 11 page of formulae
- You may use a calculator
- Write your answers on the question paper. You may use additional sheets if needed.

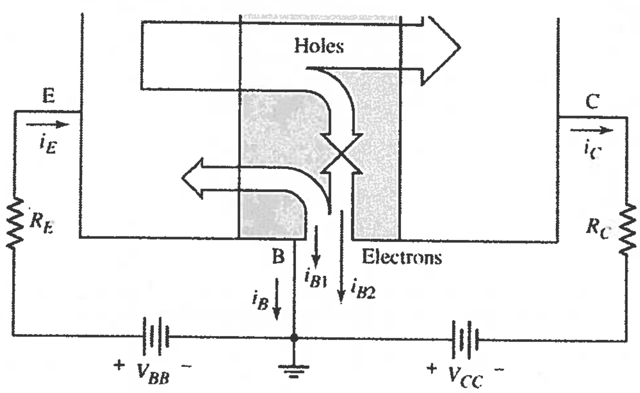
HINTS:

- Please read the questions carefully and only provide only the information that is requested. This will save you time.
- If you are stuck in a particular question, move on to the next and come back to the question later. Solving the easy problems will give you confidence to solve the more challenging questions.

Section A: Conceptual Questions (60 Points)

1. Consider the transistor shown below.

4 Points



Which of these statements about this transistor is true?

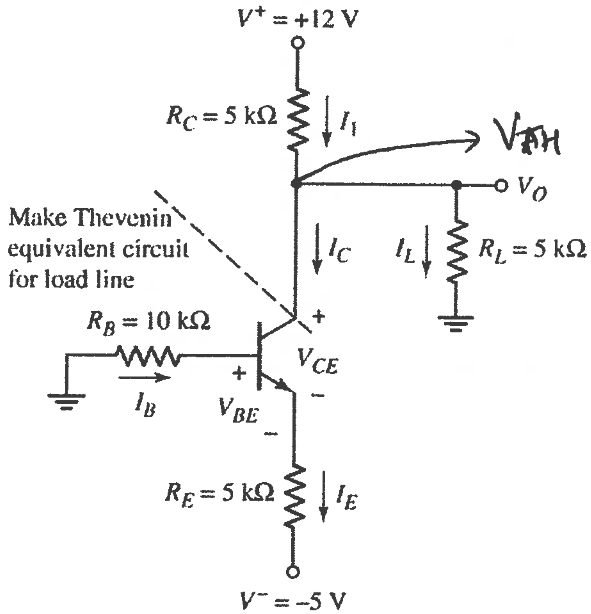
a. npn transistor in the forward active mode
b. pnp transistor in the inverse active mode
c. pnp transistor in the forward active mode
d. pnp transistor in the cut-off mode

2 The common emitter current gain is defined as ratio of 5 *Points*

a. Collector current to Emitter Current
b. Emitter current to Collector Current
c. Collector current to Base Current
d. Base current to Emitter Current

3 Thevenize the circuit shown below at the dotted line. Calculate the value for R_{TH} and V_{TH}?

8 Points



$R_{TH} = 5k\Omega \| 5k\Omega = 2.5k\Omega$

$V_{TH} = 12 \times \frac{5k}{5k+5k} = 6V$

4. If the h-parameter, h_{fe}, of the transistor is 100 and the diffusion resistance is 1KΩ, then the transconductance (g_m) is equal to

5 *Points*

(A) 10mA/V
(B) 100mA/V
(C) 1mA/V
(D) 0.1 mA/V

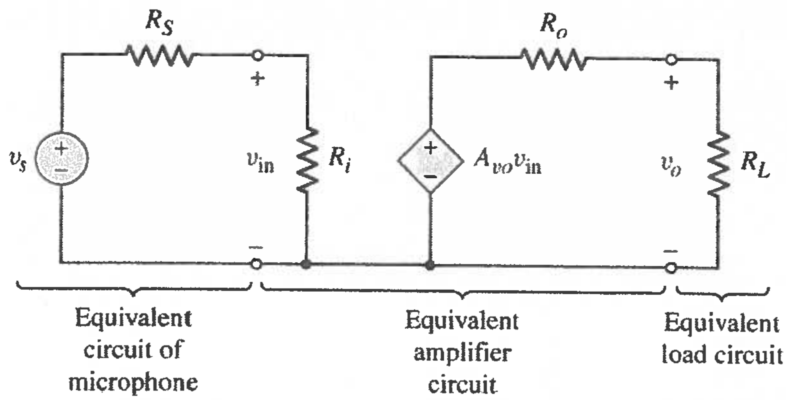
$h_{fe} = \beta = 100$

$g_m r_\pi = \beta$

$g_m = \frac{100}{1k\Omega} = 100mA/V$

5. Consider the figure below. Write an expression for the overall gain for the amplifier (v_O/v_S), including the loading effect.

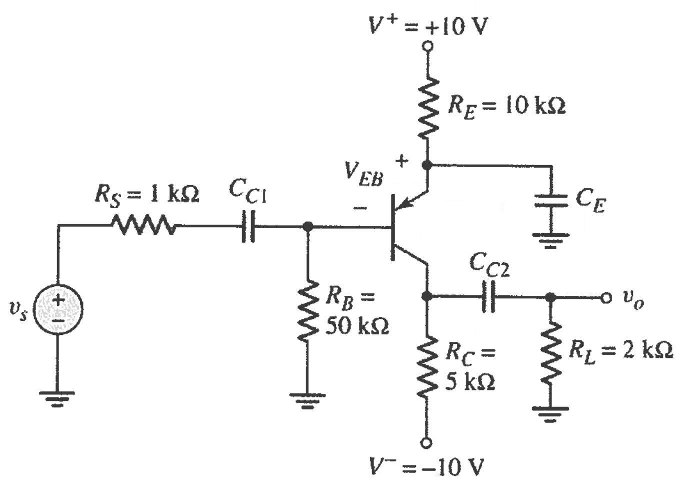
7 Points



$$\frac{V_o}{V_s} = \left(\frac{R_i}{R_i + R_S}\right) A_{V_o} \left(\frac{R_L}{R_o + R_L}\right)$$

6. In the circuit below, calculate the slope of the AC and the DC load line.

8 Points

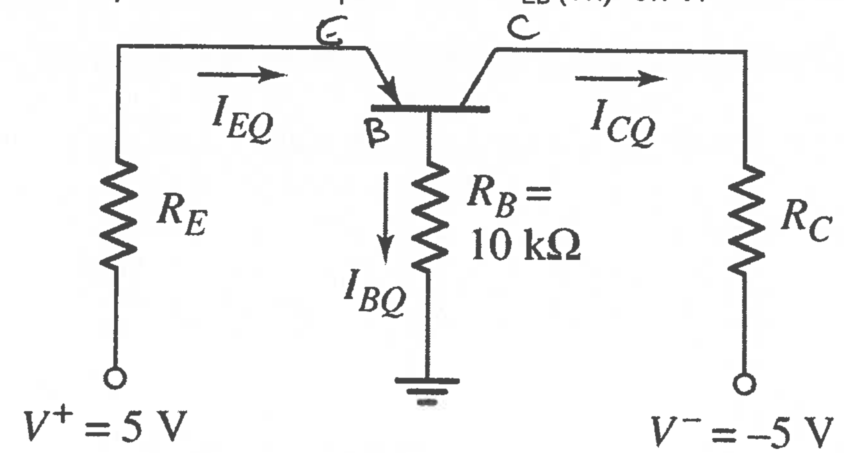


Slope of DC load line $= \dfrac{-1}{R_E + R_C} = \dfrac{-1}{15\,k\Omega}$

Slope of AC load line $= \dfrac{-1}{R_C \| R_L} = \dfrac{1}{1.43\,k\Omega}$.

7. Calculate the values for R_E and R_C, such that I_{EQ}=0.5mA and V_{ECQ}=4.0V. The transistor parameters are β=120 and V_{EB} (on)=0.7V.

8 Points



KVL on EB loop.

$$V^+ - I_{EQ}R_E - V_{EB(on)} - \frac{I_{EQ}}{(1+\beta)}R_B = 0$$

$$\underline{R_E = 8.52\,k\Omega}$$

$$I_{CQ} = \frac{I_{EQ}\,\beta}{(1+\beta)} = 0.496\ mA$$

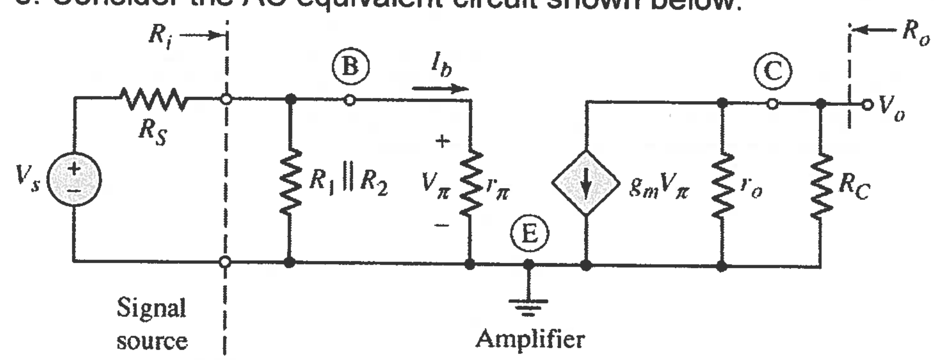
KVL on E-C loop

$$V^+ - I_{EQ}R_E - V_{ECQ} - I_{CQ}R_C - V^- = 0$$

$$\underline{R_C = 3.51\,k\Omega}$$

8. Consider the AC equivalent circuit shown below.

5 Points

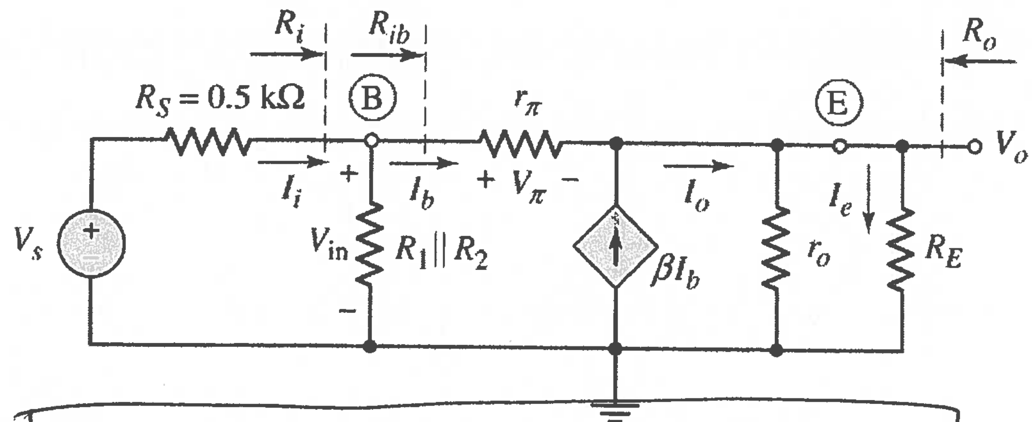


The output voltage is

a. $-g_mV_\pi(r_o//R_c)$
b. $-g_mV_\pi(R_c)$
c. $+g_mV_\pi(r_o//R_c)$
d. $-g_mV_\pi(r_o//R_c)\ (R_i/R_i+R_s)$

9. Write an expression for the input resistance, R_i, of the circuit shown below.

5 Points



$$R_{ib} = r_\pi + (1+\beta)\, r_o \,||\, R_E$$

$$R_i = R_1 \,||\, R_2 \,||\, R_{ib}$$

10. In circuit in problem 9, assume that R_S=0. Write an expression for the output resistance, R_o.

5 Points

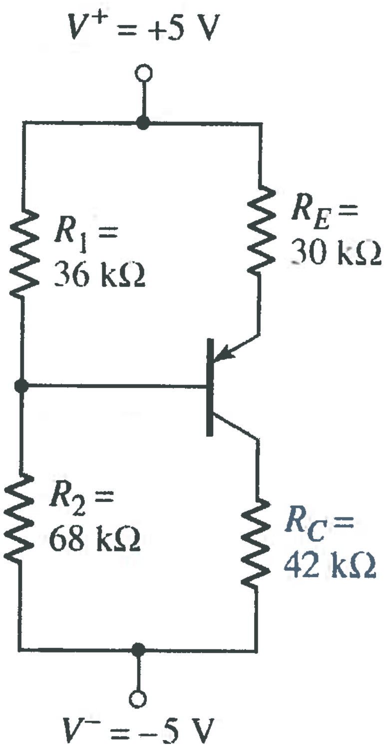
$$R_o = R_E \,||\, r_o \,||\, \frac{r_\pi}{1+\beta}$$

Section B: Problems (40 Points)

20 Points

B.1. Consider the circuit below. Assume $\beta = 50$.

(a) Calculate R_{TH} and V_{TH}.
(b) Calculate I_{CQ}
(c) Calculate V_{ECQ}
(d) Draw the DC load line and label I_{cmax}, V_{CEmax} and the Q-point. .



(a) $R_{TH} = 36k\Omega \,\|\, 68k\Omega = 23.5k\Omega$

$V_{TH} = \left(\frac{68}{36+68}\right)10 - 5 = 1.54V$

(b) KVL on ~~BE~~ EB loop

~~$V_{TH} - V_{BQ}$~~

$5V - I_{BQ}(1+\beta)R_E - V_{EB(on)} - I_{BQ}R_{TH} - V_{TH} = 0$

$I_{BQ} = 1.78\mu A$

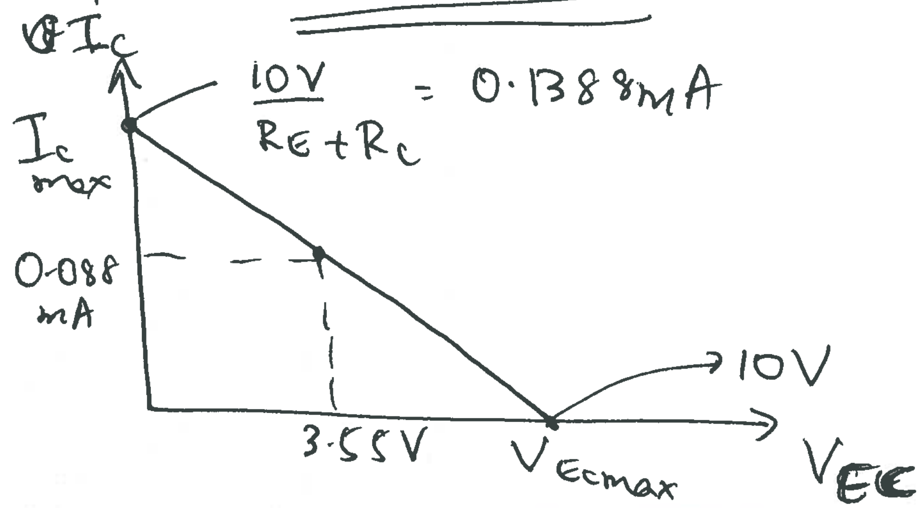
$I_{CQ} = 0.0888mA$ $I_{EQ} = 0.09$ mA

(c) KVL on EC loop

~~$10 - 2.7498$~~ $10 - (0.0906)(30) - V_{ECQ} - (0.0888)(12) = 0$

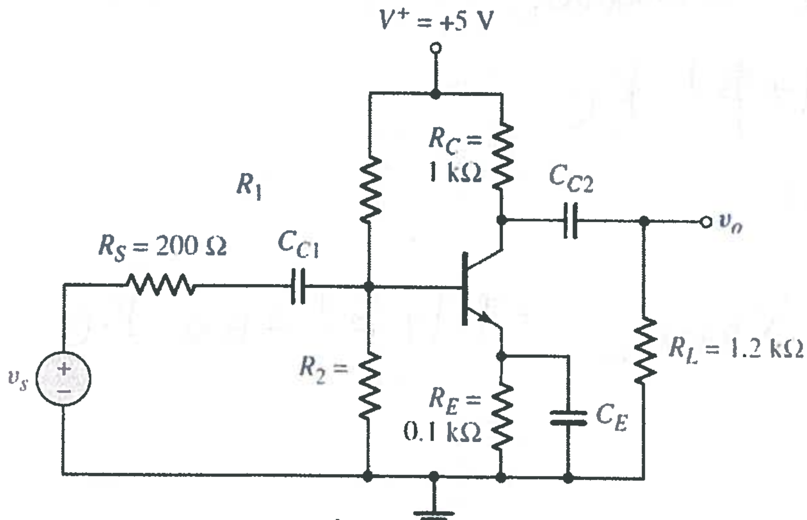
$V_{ECQ} = 3.55V$

(d)

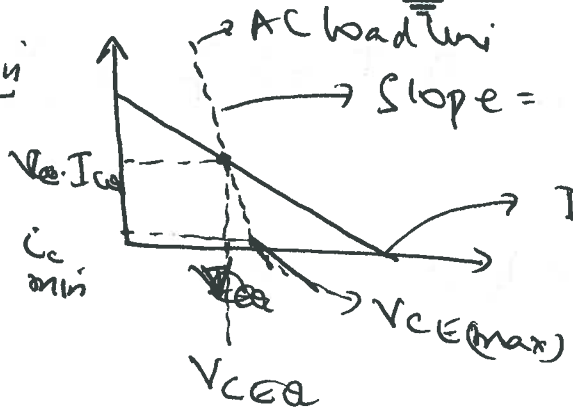


B.2 In the circuit below with transistor parameters $\beta = 180$ and $V_A = \infty$. Design the bias resistors (i.e. determine R_1 and R_2) to achieve maximum symmetrical swing in the output voltage and to maintain a bias-stable circuit. The total instantaneous C–E voltage is to remain in the range $0.5 \le v_{CE} \le 4.5$ V and the total instantaneous collector current is to be $i_C \ge 0.25$ mA.

20 Points



Solution



Slope $= \dfrac{-1}{1k\Omega \| 1.2k\Omega} = \dfrac{1}{0.545\,k\Omega}$

DC load line

For max symmetrical swing

$\Delta i_c = I_{CQ} - 0.25$

$\Delta v_{CE} = V_{CEQ} - 0.5V \qquad |\Delta i_c| = \dfrac{1}{0.545\,k\Omega} |v_{CE}|$

$$\boxed{I_{CQ} - 0.25 = \frac{V_{CEQ} - 0.5}{0.545}} \quad \text{A}$$

KVL on CE loop

$$5V - I_{CQ}(R_C + R_E) - V_{CEQ} = 0$$

$$V_{CEQ} = 5 - I_{CQ}(1.1) \Rightarrow \text{B}$$

combine (A) & (B) to get

$I_{CQ} = 2.82\,mA$ & $I_{BQ} = 0.0157\,mA$

For bias stable circuit,

$R_{TH} = (0.1)(1+\beta) R_E$

$= \underline{\underline{1.81\,k\Omega}}$

<u>KVL on BE loop</u>

$V_{TH} - I_{BQ} R_{TH} - V_{BE(on)} + (1+\beta) I_{BQ} R_E$

$V_{TH} = 1.013\,V$

R_2 But $V_{TH} = \frac{R_{TH}}{R_1} V^+ \Rightarrow R_1 = \underline{\underline{8.93\,k\Omega}}$

$\underline{\underline{R_2 = 2.27\,k\Omega}}$