1. (10%) Explain how the following two biasing scheme are good biasing scheme.

![Biasing Scheme 1](image1.png)

![Biasing Scheme 2](image2.png)

Ans: (a) if \( I_C \uparrow \rightarrow I_E \uparrow \rightarrow V_E \uparrow \quad \therefore V_{BE, fixed} \downarrow \rightarrow \therefore I_C \uparrow \quad \therefore I_C \downarrow \)

Figure (a) is a good biasing scheme.

(b) if \( I_D \uparrow \rightarrow I_{D}R_{D} \uparrow \rightarrow V_{DS} \downarrow \rightarrow V_{GS} \downarrow \quad \therefore I_D = \frac{\mu_n C_m W}{2L}(V_{GS} - V_T)^2 \rightarrow \therefore I_D \downarrow \)

Figure (b) is also a good biasing scheme.

2. (20%) Consider the following CE Amplifier,

(a) Find \( g_m, r_e, r_o, \) in the case of \( \beta = 100, V_A = 100 \)

(b) Find \( A_w, A_v, R_o, R_i. \)

![CE Amplifier](image3.png)
(a) DC analysis

\[ I_1 = \frac{5 - V_{BE} - (-5)}{9.3k} = \frac{10 - 0.7}{9.3} = 1mA \]

\[ I_1 = I_C + 2I_B = (\beta + 2)I_B \]

\[ I_Q = I_C = \beta \frac{I_1}{\beta + 2} = \frac{100 \times 1mA}{102} = 0.99mA \]

\[ g_m = \frac{I_Q}{V_T} = \frac{0.99}{25} \approx 0.04 \]

\[ r_e = \frac{V_T}{I_E} \approx \frac{25}{1} = 25 \]

\[ r_\pi = \frac{V_T}{I_B} \approx \frac{25}{0.01} = 2.5k \]

\[ r_o = \frac{V_A}{I_C} = \frac{100}{0.99} \approx 100k \]

\[ A_{vo} = \frac{v_o}{v_i} \bigg|_{R_L \to \infty} = \frac{g_m v_{be} (r_o // R_C // R_L)}{v_{be}} = g_m (r_o // R_C) \]

\[ A_{is} = \frac{i_o}{i_i} \bigg|_{R_e \to 0} = \frac{-g_m v_{be}}{v_{be} + v_{be}} = -g_m (r_\pi // R_B) \]

\[ R_0 = \frac{V}{I} \bigg|_{v_i=0} = r_o // R_C \]

\[ R_i = \frac{V}{I} = \frac{V}{R_B + \frac{1}{r_\pi} + \frac{1}{R_B // r_\pi}} = \frac{1}{R_B + \frac{1}{r_\pi}} \]

3. (20%) Consider the following CC configuration BJT's circuit,

(a) Find \( g_m, r_\pi, r_e \), in the case of \( \beta = 100 \)

(b) Find \( A_{vo}, A_{is}, R_o, R_i \).
12 = 600k \times I_B + 0.7 + 5k(1 + \beta)I_B

I_B = 1.113 \times 10^{-5} \, A

I_C = 1.113mA

I_E = 1.124mA

\[ g_m = \frac{I_C}{V_T} = \frac{1.158mA}{25mV} = 0.045 \]

\[ r_x = \frac{V_T}{I_B} = \frac{25mV}{1.158 \times 10^{-5} \, A} = 2.246k\Omega \]

\[ r_e = \frac{V_T}{I_E} = \frac{25mV}{1.17mA} = 22.234\Omega \]

\[ A_{vo} = \frac{v_o}{v_i} \mid_{s_i \rightarrow s} = \frac{i_v \times 5k}{i_b \times 100k + i_v (r_v + 5k)} = \frac{5k}{1 + \beta + (r_v + 5k)} \]

\[ A_{os} = \frac{i_o}{i_j} \mid_{s_i \rightarrow o} = \frac{i_v}{v_i + i_b \times 500k} = \frac{i_v}{100k + i_v (r_e + 5k) + i_v \times 500k} = \frac{1}{1 + \beta} + \frac{1}{500k} + \frac{1}{1 + \beta} \]

\[ R_a = \frac{V}{I} \mid_{s_i \rightarrow o} = \frac{-i_v - 100k}{V \times 5k - i_v} = \frac{r_e + 5k}{1 + \beta} = \frac{(r_e + 100k)(5k)}{1 + \beta} \]

\[ R_i = \frac{V}{I} \mid_{s_i \rightarrow o} = \frac{100k \times i_v + i_v (r_e + 5k)}{V \times 500k + i_b} = \frac{100k}{1 + \beta} \times i_v + i_v (r_e + 5k) + \frac{5k}{500k} + \frac{1}{1 + \beta} \]

\[ \frac{100k}{1 + \beta} + (r_e + 5k)500k \]

\[ \frac{100k}{1 + \beta} + (r_e + 5k) \]
4. (20%) Consider the following CB configuration BJT’s circuit,

(a) Find \( g_m, r_e, r_c \), in the case of \( \beta = 100 \)

(b) Find \( A_v, A_i, R_o, R_i \).

\[
8V = 5k \times I_E + 0.7 \Rightarrow I_E = \frac{7.3}{5k} = 1.46mA
\]

\[
I_C = 1.45mA, I_B = 0.0145mA
\]

\[
V_E = 0.7
\]

\[
V_C = -2V + 0.68k \times I_C = -1.014V
\]

\[
\Rightarrow BC \text{ reverse } \Rightarrow Bias sin g
\]

\[
g_m = \frac{I_C}{V_T} = \frac{1.45}{25} = 0.058
\]

\[
r_e = \frac{V_T}{I_B} = \frac{25}{0.0145} = 1.724k
\]

\[
r_e = \frac{V_T}{I_E} = \frac{25}{1.46} = 17.12
\]

\[
A_v = \left. \frac{v_o}{v_i} \right|_{R_L \to \infty} = \frac{g_m v_\pi \times 0.68k}{v_\pi} = g_m \times 0.68k
\]

\[
A_i = \left. \frac{i_o}{i_i} \right|_{R_L \to 0} = \frac{g_m v_\pi}{v_\pi + v_\pi} = \frac{g_m}{\frac{5k}{r_\pi} + \frac{1}{r_\pi}} = g_m \left( \frac{5k}{r_\pi} \right)
\]

\[
R_o = \left. \frac{V}{I} \right|_{v_i \to 0} = 0.68
\]

\[
R_i = \left. \frac{V}{I} \right|_{v_i} = \frac{V}{\frac{5k}{r_\pi}} = (5k // r_\pi)
\]
5. (10%) Cascade the above three amplifiers, find the best overall voltage gain 
\[ \frac{v_o}{v_s} \].

Problem 2: CE

\[ R_0 = \frac{V}{I} \bigg|_{v_i=0} = r_o // R_C \approx R_C , \text{ let } R_C = 0.68k \Rightarrow R_0 = 0.68k \]

\[ R_i = \frac{V}{I} = \frac{V}{V + V} = \frac{1}{R_B + \frac{1}{r_\pi}} = (R_B // r_\pi), \text{ let } R_B = 100k \Rightarrow R_i \approx r_\pi = 2.5k \]

Problem 3: CC

\[ R_0 = \frac{V}{I} \bigg|_{v_i=0} = 5k /(r_e + \frac{100k}{1+\beta}) \approx 5k / 1k = \frac{5}{6}k = 0.833k \]

\[ R_i = \frac{V}{I} = 500k / [100k + (1 + \beta)(r_e + 5k)] \approx 500k / 600k = \frac{3000}{11}k = 273k \]

Problem 4: CB

\[ R_0 = \frac{V}{I} \bigg|_{v_i=0} = 0.68k \]

\[ R_i = \frac{V}{I} = \frac{V}{V} = (5k // r_\pi) = 1.27k \]

The overall voltage gain is:
\[ \frac{v_o}{v_s} = \frac{R_{i1}}{R_s + R_{i1}} \frac{R_{i2}}{R_{o1} + R_{i2}} \frac{R_{i3}}{R_{o2} + R_{i3}} \frac{R_L}{R_{o3} + R_L} A_{vo1}A_{vo2}A_{vo3} \]

The best overall voltage gain is:
\[ \frac{v_o}{v_s} = \frac{2.5}{R_s + 2.5} \frac{1.27}{0.68 + 1.27} \frac{273}{0.68 + 273} \frac{R_L}{0.833k + R_L} A_{vo1}A_{vo2}A_{vo3} \]
6. (5%) (a) Sketch the Voltage-Current characteristic curve of a BJT and MOSFET.
(5%) (b) Sketch the equivalent model of the current amplifier and the voltage amplifier.
7. (20%) false and true
   a. A NMOSFET is said to have entered the triode region of operation if \( v_{DS} \geq V_t - v_{GS} \). The transistor current
      \[ I_D = \frac{\mu_n C_{ox} W}{2L} [2(V_{GS} - V_t) V_{DS} - V_{DS}^2] \].
      Ans: False  A NMOSFET is said to have entered the triode region of operation if \( v_{DS} \leq V_t - v_{GS} \). The transistor current
      \[ I_D = \frac{\mu_n C_{ox} W}{2L} [2(V_{GS} - V_t) V_{DS} - V_{DS}^2] \].
   
   b. When we do small-signal analysis, we eliminate the DC sources by replacing each DC voltage source and DC current source with a short circuit.
      Ans:  False,  When we do small-signal analysis, we eliminate the DC sources by replacing each DC voltage source with a short circuit, and DC current source with an open circuit.
   
   c. The enhancement NMOSFET, to induce a channel we have to apply a gate voltage \( V_{GS} \) that is more negative than the threshold voltage \( V_t \).
      Ans: False. The enhancement NMOSFET, to induce a channel we have to apply a gate voltage \( V_{GS} \) that is more positive than the threshold voltage \( V_t \).
   
   d. The Early effect drive the \( v_{CE} - i_C \) characteristic of a BJT in the saturation region be not a horizontal line.
      Ans: False The Early effect drive the \( v_{CE} - i_C \) characteristic of a BJT in the forward active region be not a horizontal line.
   
   e. A resistance \( r_o = \frac{V_A}{I_G} \) between the Drain and the Gate can model the channel-length modulation effect of the MOSFET.
      Ans: False A resistance \( r_o = \frac{V_A}{I_D} \) between the Drain and the Gate can
model the channel-length modulation effect of the MOSFET.

f. When the MOSFET is employed in the logic circuit, the transistor has to operate at the saturation region.
Ans: False When the MOSFET is employed in the logic circuit, the transistor has to operate at the triode region.

g. The input resistance of an ideal current amplifier should be infinite. Contrarily, the output resistance should be as small as possible.
Ans: False The input resistance of an ideal current amplifier should be as small as possible. Contrarily, the output resistance should be infinite.

h. When the BJT is used as an amplifier, the transistor has to operate at the saturation region.
Ans: False When the BJT is used as an amplifier; the transistor has to operate at the forward active region.

i. In the problem 4 the coupling capacitors block DC and thus allow us to couple the small signal. The capacitors should be selected sufficiently large so that it approximates an open circuit at small signal analysis.
Ans: False In the problem 4 the coupling capacitors block DC and thus allow us to couple the small signal. The capacitors should be selected sufficiently large so that it approximates a short circuit at small signal analysis.

j. The Early effect drive the characteristic of a MOSFET in the saturation region be not a horizontal line.
Ans: False The channel-length modulation effect drive the characteristic of a MOSFET in the saturation region be not a horizontal line.