NOTES:

Design problems and some Digital Logic implementation problems can have ∞ solutions. One solution is shown below.

SOLUTIONS:

Problem 1:
Cascode amplifier with active load so the gain

$$A_v = -\left(\frac{g_m}{g_0}\right) = -\frac{0.039}{10\,\mu} = -3900\ V/V$$

$$g_m = \frac{I_{CQ}}{V_t} = \frac{1\ mA}{25.8\ mV} = 0.039\ \&\ g_0 = \frac{1\ mA}{100\ V} = 10\ \mu$$

Problem 2:

$$A_V = -\frac{{g_m}^2}{g_0 g_\pi}\frac{1}{2} \cong -196000\ V/V$$

$$g_m = \frac{I_{CQ}}{V_t} = \frac{1\ mA}{25.8\ mV} = 0.039\ \&\ g_0 = \frac{1\ mA}{100\ V} = 10\ \mu\ \&\ g_\pi = \frac{1\ mA}{100 * 25.8mV} = 0.388\ m$$

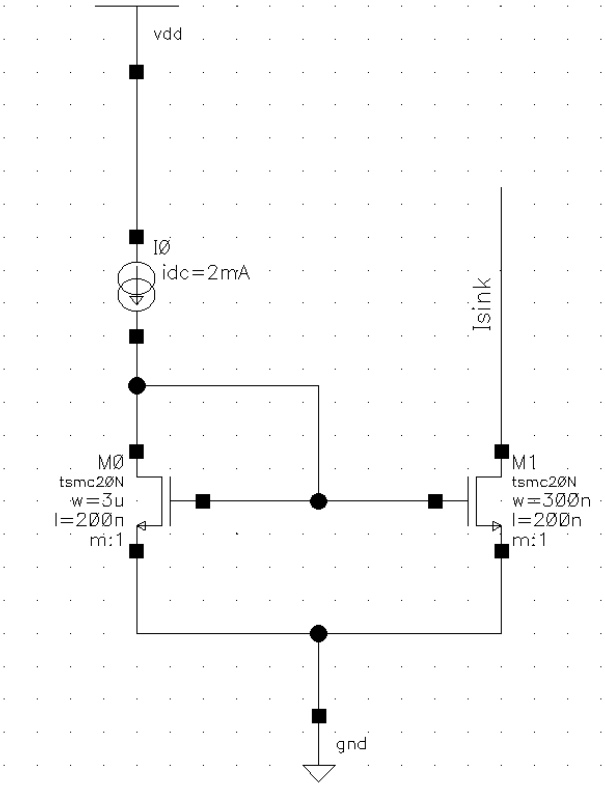
Problem 3:

$2 + A_v V_{in} = 2 + (1 * 10^{-6})(-1.96 * 10^5) = -2.196\ V$

This means it would be very difficult to get the system to be biased correctly.

Problem 4:

a) Design is shown below, the ratio of W/L of M1 to W/L of M0 is 1:10



b) We need M1 to be in saturation and we know I_{DSQ} = 200 µA

$$V_{GS} - V_T = \sqrt{\frac{2 * I_{DSQ}}{\mu C_{ox} * \frac{W}{L}}} = \sqrt{\frac{2 * 200\,\mu}{350\,\mu * \frac{3}{2}}} = 0.873\,V$$

$V_{DS} > V_{GS} - V_T$ therefore $V_{Drainmin} = 0.873$ V

Problem 5:

$$V_{OUT} = 8 - I_{out} * R \rightarrow I_{out} = 50\,\mu * \frac{15}{1} * \frac{1}{5} = 150\,\mu A$$

$$V_{OUT} = 8 - 150\,\mu * 25\,k = 4.25\,V$$

$$V_{GS} - V_T = \sqrt{\frac{2 * I_{DSQ}}{\mu C_{ox} * \frac{W}{L}}} = \sqrt{\frac{2 * 150\,\mu}{350\,\mu * \frac{15}{1}}} = 0.239\,V \rightarrow Saturation\ assumption\ validated$$

Problem 6:

High

A	B	Out
1	1	1
1	0	1
0	1	1
0	0	1

OR

A	B	Out
1	1	1
1	0	1
0	1	1
0	0	0

A|~B

A	B	Out
1	1	1
1	0	1
0	1	0
0	0	1

A

A	B	Out
1	1	1
1	0	1
0	1	0
0	0	0

~A|B

A	B	Out
1	1	1
1	0	0
0	1	1
0	0	1

B

A	B	Out
1	1	1
1	0	0
0	1	1
0	0	0

(AB)|(~A~B)

A	B	Out
1	1	1
1	0	0
0	1	0
0	0	1

AND

A	B	Out
1	1	1
1	0	0
0	1	0
0	0	0

NAND

A	B	Out
1	1	0
1	0	1
0	1	1
0	0	1

XOR

A	B	Out
1	1	0
1	0	1
0	1	1
0	0	0

~B

A	B	Out
1	1	0
1	0	1
0	1	0
0	0	1

A~B

A	B	Out
1	1	0
1	0	1
0	1	0
0	0	0

~A

A	B	Out
1	1	0
1	0	0
0	1	1
0	0	1

~AB

A	B	Out
1	1	0
1	0	0
0	1	1
0	0	0

NOR

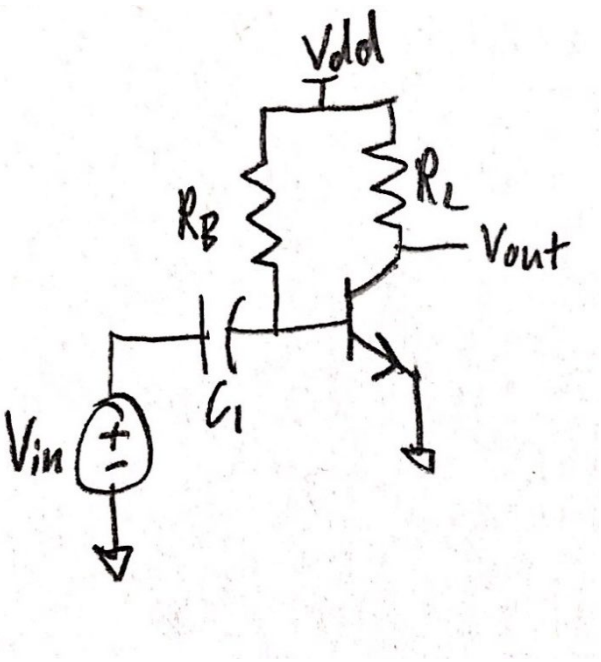
A	B	Out
1	1	0
1	0	0
0	1	0
0	0	1

Low

A	B	Out
1	1	0
1	0	0
0	1	0
0	0	0

The named ones are the most commonly used

Problem 7:



Assume C_1 is large, and set $VDD = 10V$

$$I_C = \frac{V_{DD} - V_{outQ}}{R_L} = \beta_n I_B = 100 * \frac{V_{DD} - 0.6V}{R_B}$$

$$\frac{10V - 5V}{10k\Omega} = 100 * \frac{10V - 0.6V}{R_B}$$

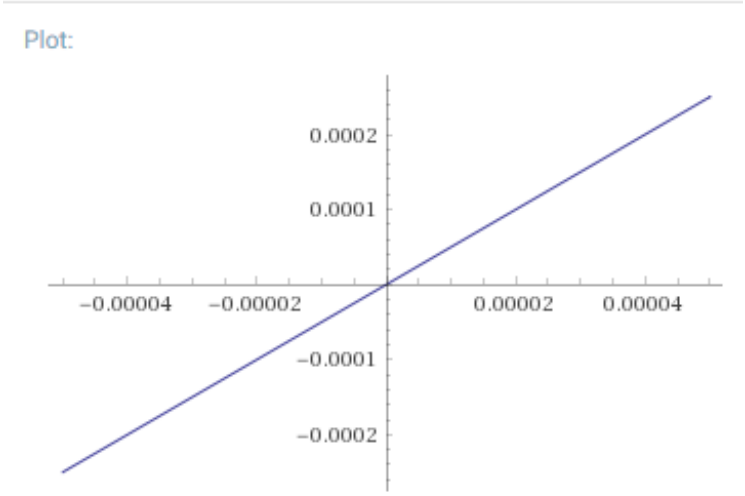
$R_B = 1.88\,M\Omega$

Image of design is on the right.

Problem 8:

a) $I_{out} = \frac{A_{E1}}{A_{E0}}(I_{in} + I_{BS}) - I_{BO} = 5I_{BS} + 250\mu - 250\mu = 5I_{in}$

b) I used WolframAlpha

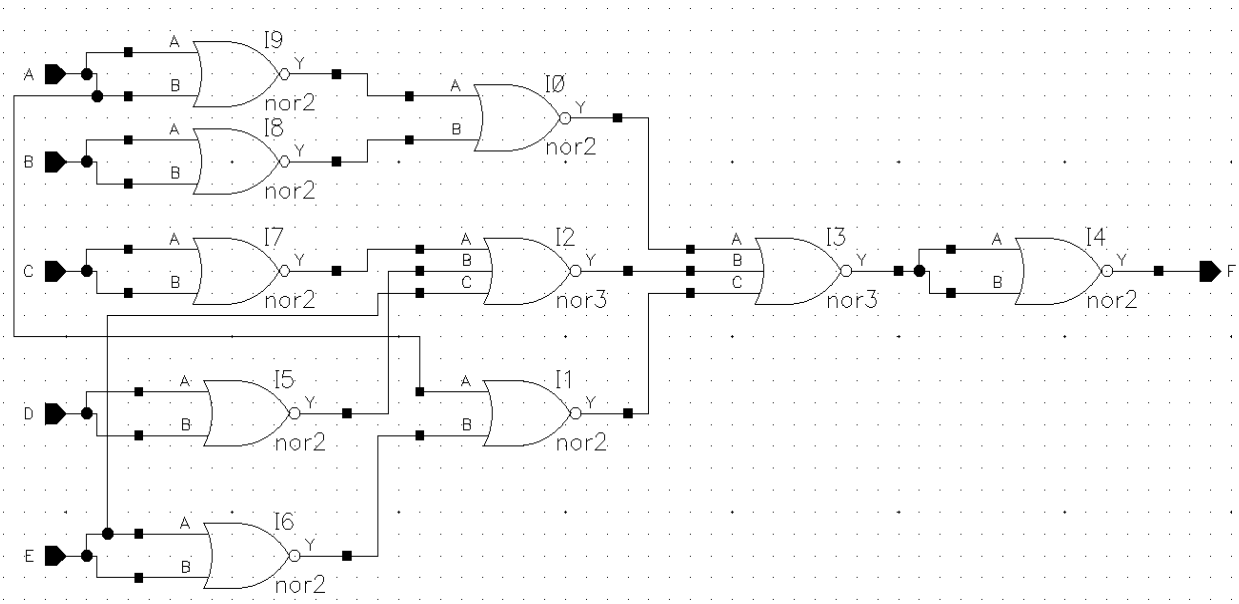


Problem 9:

a.) $F = AB + CD\bar{E} + \bar{A}E$

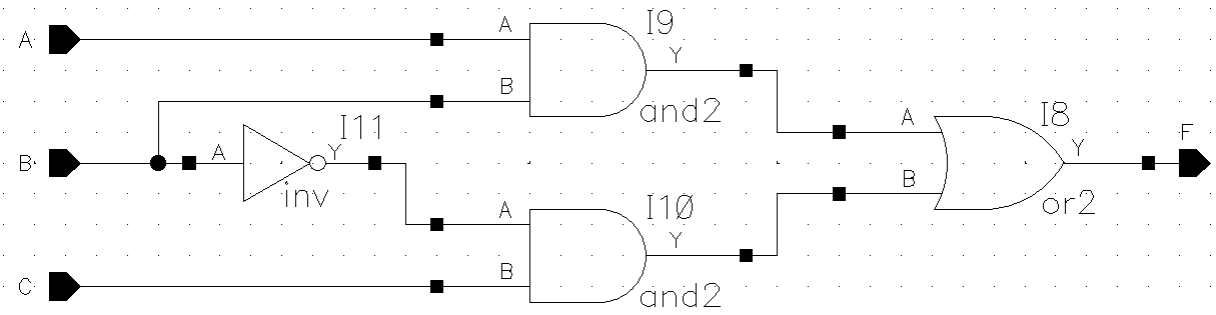
b.) Assign F = (A & B) | (C & D & ~E) | (~A & E)

c.) $F = \overline{\overline{\bar{A} + \bar{B} + \bar{C} + \bar{D} + E + \bar{A} + \bar{E}}}$



Problem 10:

a) $F = AB + \bar{B}C$



b) $F = \overline{\overline{AB} * (B + \overline{C})}$