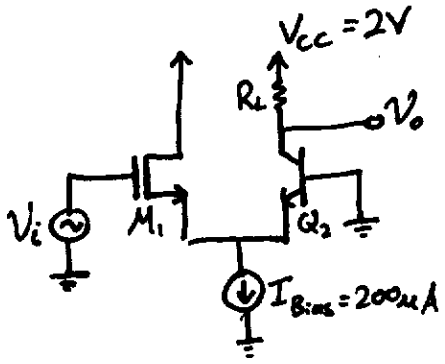
1)



M_1: $V_T = 0.6V$
$\mu_n C_{ox}\frac{W}{L} = 1mA/V^2$

Q_2: $I_S = 10^{-16}A$, $V_A = \infty$, $V_{CE,sat} = 0.2V$
$\beta_F = \beta_R = 200$ $V_{TH} = 25mV$

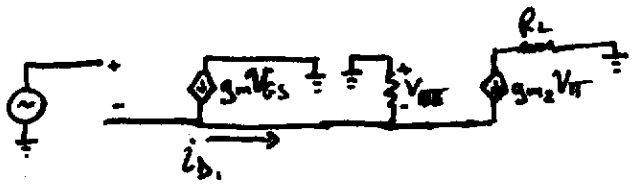
a) $I_{C_2} = 100\mu A$, $V_o = 1V = 2V - R_L \cdot 100\mu A \rightarrow R_L = 10k\Omega$

$\hookrightarrow I_{D_1} \approx I_{C_2} = 100\mu A \rightarrow I_{C_2} = I_S e^{\frac{V_{BE}}{V_{TH}}} \rightarrow V_{BE} = V_{TH}\ln\left(\frac{I_{C_2}}{I_S}\right) = 0.691V$

$I_{D_1} = \frac{\mu_n C_{ox}}{2}\frac{W}{L}(V_{GS_1}-V_T)^2 \rightarrow V_{GS_1} = \sqrt{\frac{2I_{D_1}L}{\mu_n C_{ox} W}} + V_T = 1.047V$

$$\boxed{V_I = 0 - V_{BG_2} + V_{GS_1} = 0.356V}$$

b)



$i_{D_1} = -(i_{B_2} + i_{C_2}) = -\left(1+\frac{1}{\beta}\right) i_{C_2}$

$V_o = -R_L i_{C_2} = \frac{i_{D_1} R_L}{1+\frac{1}{\beta}} = \frac{V_{in}\, g_{m_1} R_L}{\left(1+\frac{1}{r_{\pi_2} g_{m_2}}\right)\left(1+\frac{g_{m_1}}{g_{m_2}}\right)}$

$i_{D_1} = V_{GS} \cdot g_{m_1}$; $V_S = i_{D_1} \cdot \frac{1}{g_{m_2}}$ ← Z reflection

$V_{GS} = V_{in} - V_S = V_{in} - i_{D_1}\frac{1}{g_{m_2}}$

$i_{D_1} = V_{in} g_{m_1} - i_{D_1}\frac{g_{m_1}}{g_{m_2}}$

$i_{D_1} = \frac{V_{in} g_{m_1}}{1+\frac{g_{m_1}}{g_{m_2}}}$

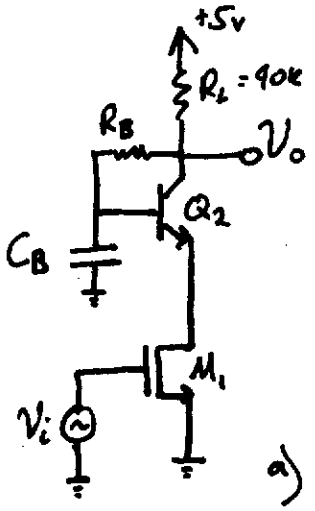
$$\boxed{a_v = \frac{V_o}{V_i} = \frac{g_{m_1} R_L}{\underbrace{\left(1+\frac{1}{r_{\pi_2} g_{m_2}}\right)}_{\text{negligible}}\left(1+\frac{g_{m_1}}{g_{m_2}}\right)}}$$

c) $g_{m_1} = \sqrt{2 I_{D_1} \mu_n C_{ox}\frac{W}{L}} = 4.47\times10^{-4}\frac{A}{V}$

$g_{m_2} = \frac{I_{C_2}}{V_{TH}} = 4.0\times10^{-3}\frac{A}{V}$

$$\boxed{a_v = \frac{10k \cdot g_{m_1}}{1+\frac{g_{m_1}}{g_{m_2}}} = 4.02}$$

2)

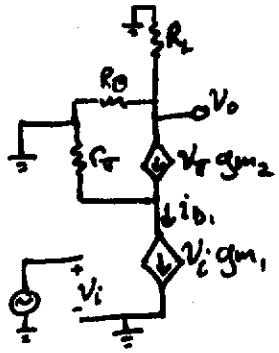


$M_1: V_T = 0.6V \quad \mu_n C_{ox} \frac{W}{L} = 200\mu A/V^2 \quad \lambda = 0$

$Q_2: I_S = 10^{-15} A, \; V_A = \infty, \; V_{ce,sat} = 0.2V$

$\beta_F = \beta_0 = 200$

$I_{C_2} = 50\mu A \;, \; V_o = 3V$



a) $i_{D_1} = v_i g_{m1}$

$i_{D_1} = i_{B_2} + i_{C_2} = \frac{v_{\pi_2}}{r_{\pi_2}} + v_{\pi_2} g_{m2}$

$v_i g_{m1} = v_{\pi_2}\left(\frac{1}{r_{\pi_2}} + g_{m2}\right)$

$v_o = -\underbrace{R_L \| R_B}_{R_L} \cdot \underbrace{i_{C_2}}_{i_{D_1} - i_{B_2}}$

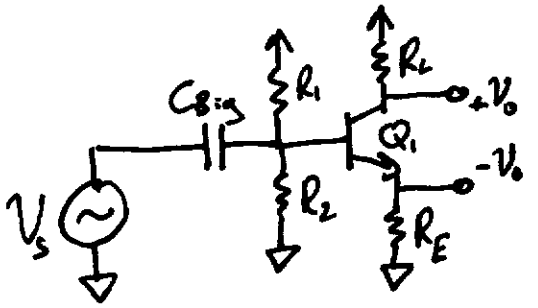
$v_o = \left(v_i g_{m1} - \underbrace{\frac{v_{\pi_2}}{r_{\pi 2}}}_{\text{negligible}}\right) R_L \Rightarrow$

$$\boxed{\frac{v_o}{v_i} = -g_{m1} R_L \quad | \quad r_{in} = \infty \quad | \quad r_{out} = R_L \| R_B \approx R_L}$$

b) $$\boxed{a_v = -g_{m1} R_L = \sqrt{2 I_{D_M} C_{ox} \frac{W}{L}} \cdot R_L = -5.66}$$

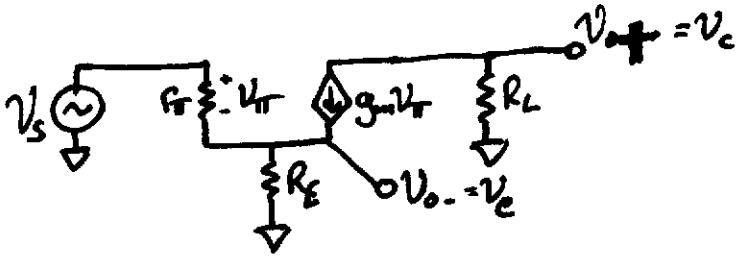
$$\boxed{\begin{array}{l} R_{in} = \infty \\ R_{out} = 90k\Omega \end{array}}$$

3)



$\beta_F = \beta_o = 100$, Ignore DC Base Currents

b)



$V_\pi = V_s - V_e$

$V_e = \left(\frac{V_\pi}{r_\pi} + g_m V_\pi\right) R_E \approx g_m R_E V_\pi$

$V_\pi = \frac{V_s}{1+g_m R_E} \rightarrow V_{o+} = -g_m V_\pi R_L = -\frac{g_m R_L V_s}{1+g_m R_E}$

$V_{o-} = V_e \approx g_m R_E V_\pi = \frac{g_m R_E V_s}{1+g_m R_E}$

$V_{o+} - V_{o-} = -\frac{2 g_m R_E V_s}{1+g_m R_E} \rightarrow \boxed{\frac{V_o}{V_s} = -\frac{2 g_m R_E}{1+g_m R_E}}$

c)

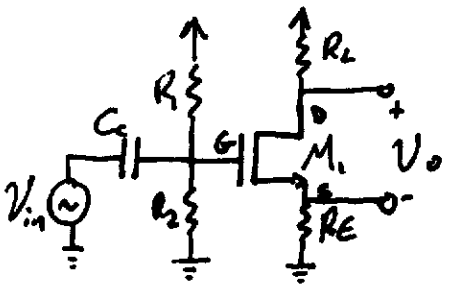
$V_B = V_{cc} \frac{R_2}{R_1+R_2}$ $V_E \approx R_E I_C$

$I_C = I_S e^{\left(\frac{V_B - V_E}{V_{TH}}\right)} \rightarrow I_C = .955\,mA$

$g_m = \frac{I_C}{V_{TH}} = .0382$ mho's

$$\boxed{\frac{V_o}{V_s} = \frac{-2 g_m R_E}{1+g_m R_E} = -1.975}$$

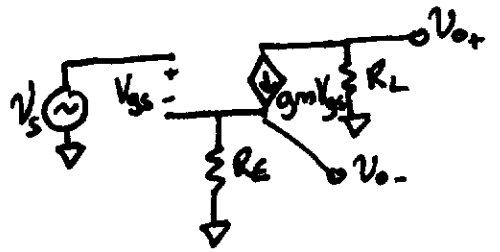
1)



$V_T = 0.6 \quad \mu_n C_{ox} \frac{W}{L} = 100\,mA/V^2 \quad \lambda = 0$

a) ~~$V_G = \frac{R_2}{R_1+R_2} V_{CC}$ \ I_D~~

b)



$$V_o = V_D - V_S = -g_m V_{GS} R_L - g_m V_{GS} R_E$$

$$V_{gs} = V_s - V_S = V_s - i_D R_E$$

$$i_D = V_{gs} g_m = g_m (V_s - i_D R_E)$$

$$i_D = \frac{V_s g_m}{1 + R_E g_m}$$

$$V_o = \frac{-V_s g_m R_L}{1 + R_E g_m} - \frac{V_s g_m R_E}{1 + R_E g_m} = \frac{-2 V_s g_m R_E}{1 + R_E g_m} \rightarrow \boxed{\frac{V_o}{V_s} = \frac{-2 g_m R_E}{1 + R_E g_m}}$$

c) $$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_G - V_S - V_T)^2 = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_G - I_D R_E - V_T)^2$$

$$V_G = V_{CC} \frac{R_2}{R_1 + R_2} = 2.6V$$

$$I_D = 0.146\,mA$$

$$g_m = \sqrt{2 I_D \mu_n C_{ox} \frac{W}{L}} = 1.71 \times 10^{-6} \text{ mhos}$$

$$\frac{V_o}{V_s} = \frac{-2 g_m R_E}{1 + g_m R_E} = -0.509$$