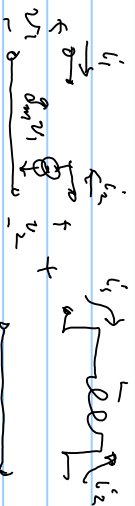
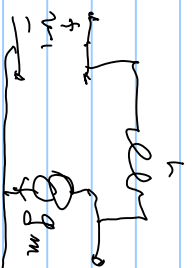
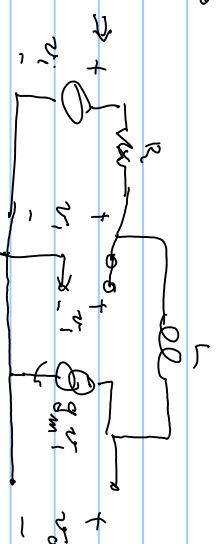


derive $\frac{v_o}{v_i}(s)$



$$i_1 = \frac{1}{R} v_1 - \frac{1}{R} v_2$$

$$y = y_1 + y_2$$

$$y = \begin{bmatrix} \frac{1}{R} & -\frac{1}{R} \\ g_m - \frac{1}{R} & \frac{1}{R} \end{bmatrix}$$

$$y_1 = \begin{bmatrix} 0 & 0 \\ g & 0 \end{bmatrix}$$

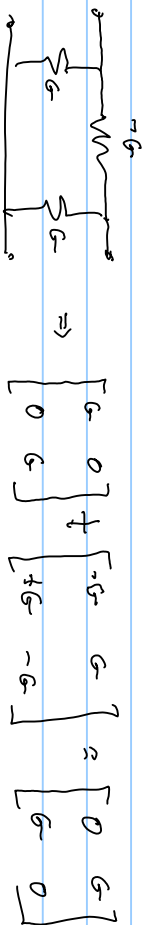
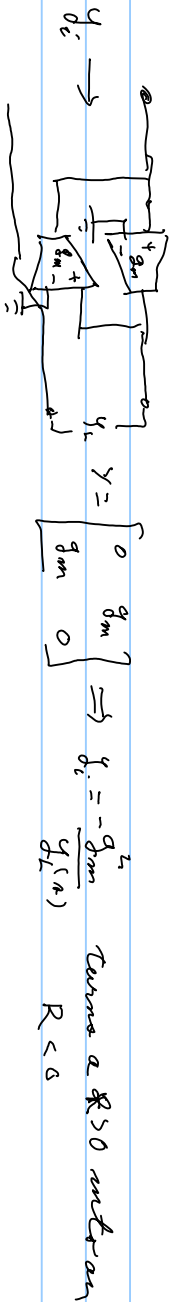
$$y_2 = \begin{bmatrix} \frac{1}{R} & \frac{1}{R} \\ -\frac{1}{R} & \frac{1}{R} \end{bmatrix}$$

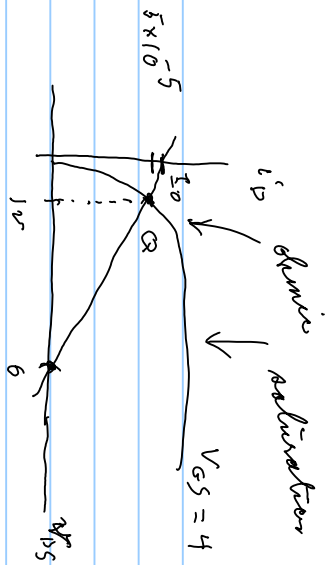
$$(2 = g_{21}v_1 + g_{22}v_2 = 0 \Rightarrow v_1 = -\frac{g_{22}}{g_{21}}v_2 = \frac{-1/a_L}{g_m - 1/a_L} v_2 = \frac{1}{1 - g_m a_L} v_2$$

$$v_1 = R i_1 + v_1 = R [g_{11}v_1 + g_{12}v_2] + \left(\frac{-1/a_L}{g_m - 1/a_L} \right) v_2 = R \left[\frac{1/a_L}{g_m - 1/a_L} + (-1/a_L) \right] \frac{1}{v_2} v_2$$

$$\frac{v_2}{v_i} (A) = \frac{1}{g_m - 1/a_L} \left[R \left(-1/a_L^2 + (-1/a_L)(g_m - 1/a_L) \right) - 1/a_L \right] = \frac{N(s)}{D(s)} = \frac{1 - g_m a_L}{1 + g_m R}$$

zero in RHP at $\omega = 1/a_L$
pole @ ∞

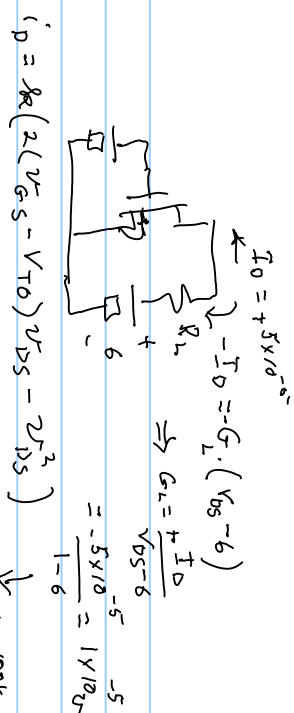




$$I_D = 10^{-5} (2(4-1)(1-1)^2) = 10^{-5} (6-1) = 5 \times 10^{-5} \text{ A}$$

$$= 0.05 \text{ mA}$$

draw R_L to get three bias Q



$$K = 10^{-5} \text{ A/V}^2, \quad V_{T0} = 1$$

$$\text{Here } V_{DS} = 1, \quad V_{GS} - V_{T0} = 4 - 1 = 3$$

$$\text{at Q } V_{DS} < V_{GS} - V_{T0} \Rightarrow \text{ohmic}$$

$$V_D = m \cdot V_{DS} + I_0 = -10^{-5} + I_0$$

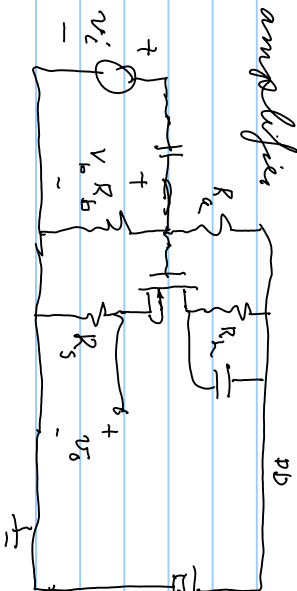
$$m = \text{slope} \quad (I_D - 0) / (1 - 6) = \frac{5 \times 10^{-5}}{-5}$$

corresponding ratio on x axis = V_{DS}

$$\text{② } V_{DS} = 6, \quad i_D = 0 \Rightarrow 0 = -10^{-5} V_{DS} + I_0$$

$$\Rightarrow I_0 = 6 \times 10^{-5} \text{ A} \quad V_{DS} = 6$$

Design an amplifier



assume in saturation
 $i_D = k(v_{GS} - V_{T0})^2$

$$k = 10^{-5}, V_{T0} = 1$$

$$\text{Let } I_D = 90 \mu A = 90 \times 10^{-6} A$$

$$9 \times 10^{-5} = 10^{-5} \times (V_{GS} - 1)^2 \Rightarrow V_{GS} = 4$$

$$9 = (V_{GS} - 1)^2 \Rightarrow V_{GS} - 1 = \sqrt{9} = 3$$

assume given

$$R_L = 1 k\Omega, R_S = 10 k\Omega \Rightarrow \text{give voltage across } R_B, V_b = V_{GS} + V_o$$

$$V_o = R_S \times I_D$$

$$V_o = R_S \times I_D = 10 \times 10^3 \times 90 \times 10^{-6} = 900 \times 10^{-3} V = 0.9 V$$

Q

$$V_{R_b} = V_{GS} + I_D R_S = 4 + 0.9 = 4.9 V$$

$$\text{choose } V_{DD} = 15 V, \frac{R_o \times V_{DD}}{R_o + R_L} = \text{Voltage divided down from } V_{DD} \text{ by voltage divider}$$

$$\frac{R_o + R_L}{R_b + R_L} = \frac{4.9}{15}$$

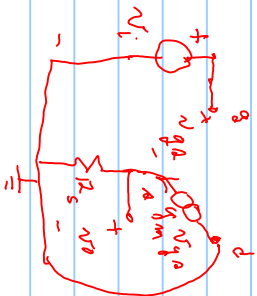
given R_{eff}

$$\text{know } R_b \Rightarrow \text{choose } R_b = 10 M\Omega = 10 \times 10^6 \Omega \Rightarrow \text{allows choice of } R_L$$

$$\frac{10}{10+R_a} = \frac{4.9}{15} \Rightarrow \text{active for } R_a \text{ (in Meg } \Omega)$$

next find $\frac{v_o}{v_i} < 1$ max $g_m \approx \frac{\partial i_D}{\partial v_{GS}} = \frac{2I_D}{(V_{GS}-V_{TO})} = \frac{2 \times 90 \times 10^{-6}}{(4-1)} = 60 \times 10^{-6} \text{ S}$

result



$$v_o = v_i - v_{gs} = R_s g_m v_{gs} \Rightarrow v_{gs} = \frac{v_i}{1+R_s g_m}$$

$$\Rightarrow v_o = \left(1 - \frac{1}{1+R_s g_m}\right) v_i \Rightarrow \frac{R_s g_m}{1+R_s g_m} = \frac{v_o}{v_i} < 1$$
