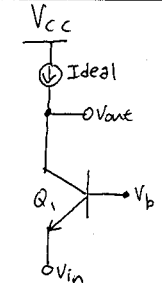
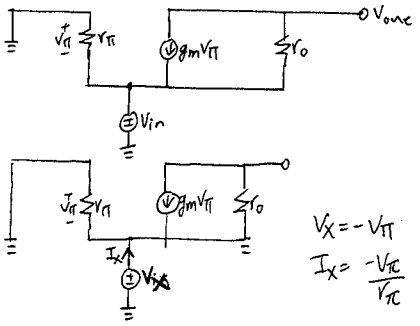
5.57





$V_{in} = -V_\pi$; $V_{out} = V_{in} - g_m V_\pi r_o$

$= V_{in} + g_m V_{in} r_o$

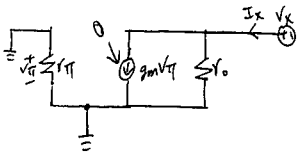
$= V_{in}(1 + g_m r_o)$

$$\frac{V_{out}}{V_{in}} = 1 + g_m r_o$$

$V_X = -V_\pi$

$I_X = \frac{-V_\pi}{r_\pi}$

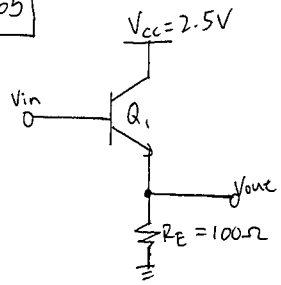
$\frac{V_X}{I_X} = r_\pi$ $\quad \boxed{R_{in} = r_\pi}$

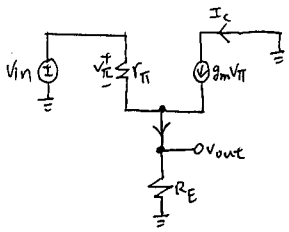


$V_X = I_X r_o$ $\quad \frac{V_X}{I_X} = r_o$

$$\boxed{R_{out} = r_o}$$

5.65





$V_{in} = V_\pi + V_{out}$ $\quad I_C = g_m V_\pi$

$V_{out} = I_E R_E$

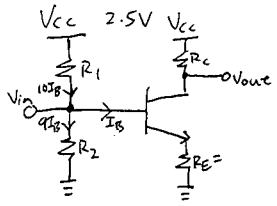
$$\frac{V_{out}}{V_{in}} = \frac{I_E R_E}{V_\pi + V_{out}} \cdot \frac{\frac{1}{I_E}}{\frac{1}{I_E}} = \frac{R_E}{\frac{V_\pi}{I_E} + R_E} \quad \text{(sub in } V_\pi\text{)}$$

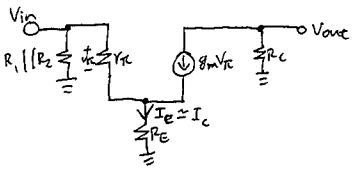
$$\frac{R_E}{\frac{I_C}{g_m I_E} + R_E} \left(I_C \simeq I_E\right) = \frac{R_E (I_C)}{\frac{1}{g_m} + R_E (I_C)} = \frac{R_E I_C}{V_T + I_C R_E}$$

$$\frac{100 I_C}{(0.026) + 100 I_C} = 0.8 \qquad \boxed{I_C = 0.00104A = 1.04mA}$$

5.80

$A_V = 5$ $\quad R_{out} = 500\Omega$ $\quad R_E I_E = 0.3V$ $\quad I_S = 6 \times 10^{-16} A$ $\quad \beta = 100$





$V_{out} = -g_m V_\pi R_C$; $V_{in} = I_C R_E + V_\pi$

$V_\pi = V_T$

$$\frac{V_{out}}{V_{in}} = \frac{-g_m V_\pi R_C}{I_E R_E + V_\pi} = \frac{I_C R_C}{I_E R_E + V_T}$$

$$\frac{I_C (500)}{0.3V + 0.026V} = 5 \qquad I_C = 0.00326A \qquad R_E I_C = R_E \frac{\beta}{1+\beta} I_E = 0.3\left(\frac{100}{101}\right) = 0.297$$

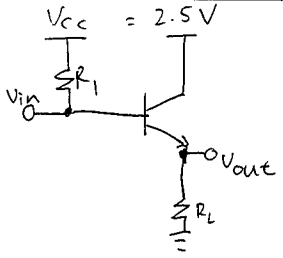
$$R_E = \frac{0.297}{I_C} = 91.1\Omega \qquad V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 0.762V \qquad I_B = \frac{I_C}{\beta} = 0.0000326A$$

$$R_1: \frac{2.5 - (V_{BE} + 0.3)}{R_1} = 10 I_B \qquad R_1 = \frac{2.5 - (0.762 + 0.3)}{0.000326} = 4410\Omega = 4.41k\Omega$$

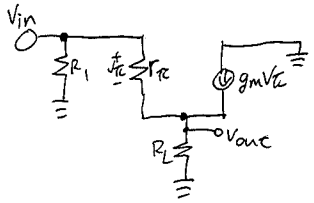
$$R_2: \frac{V_{BE} + 0.3}{9 I_B} = R_2 = \frac{0.762 + 0.3}{0.000293} = 3620\Omega = 3.62k\Omega$$

$R_C = R_{out} = 500\Omega$

5.88



$A_V = 0.85$ $R_{in} > 10k\Omega$ $R_L = 200\Omega$ $\beta = 100$ $I_s = 6\times10^{-16}A$



$V_{out} = I_E R_L \simeq I_C R_L$ $\quad V_{in} = I_B r_\pi + V_{out} = I_B r_\pi + I_E R_L \simeq I_B r_\pi + I_C R_L =$ $\quad \frac{V_{out}}{V_{in}} = \frac{I_C R_L}{I_B r_\pi + I_C R_L} = \frac{R_L}{\frac{r_\pi}{\beta} + R_L} = \frac{R_L}{\frac{1}{g_m} + R_L}$

$\frac{R_L}{\frac{1}{g_m} + R_L} = 0.85$ $\quad \frac{1}{g_m} = 35.2941$ $\quad g_m V_T = I_C = 0.000737\,A$ $\quad V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 0.724\,V$

$V_{out} = I_C R_L = 1.474$ $\quad V_{in} = I_B r_\pi + V_{out} \Rightarrow \frac{V_{in} - V_{out}}{I_B} = r_\pi = 3528\,\Omega$

$R_{in} = R_1 \,||\, \left(r_\pi + (1+\beta)(R_L)\right) = R_1 \,||\, 23.73k$ $\quad R_1 || 23.73k > 10k\Omega$

$R_1 > 17.28K$ $\quad R_1 = \frac{2.5 - (V_{BE} + I_E R_L)}{I_B} = \boxed{221k\Omega}$