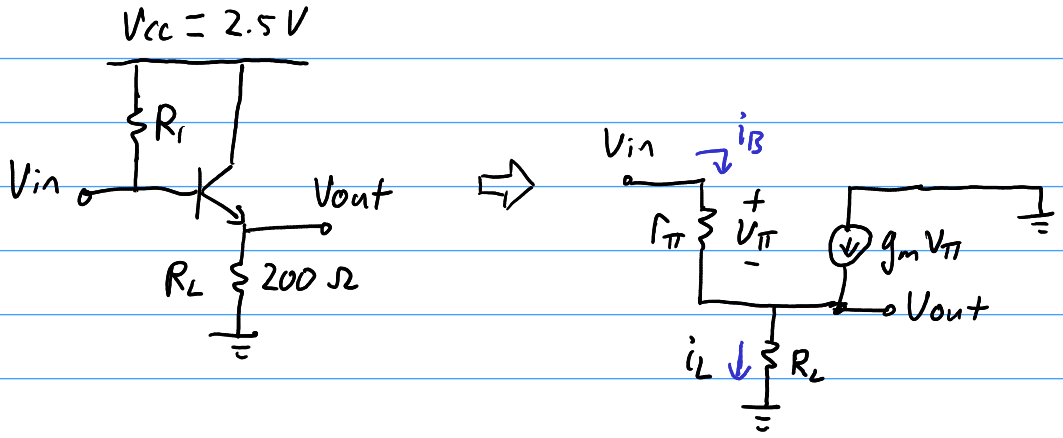
5.88 Design emitter follower for $A_v = 0.85$, $R_{in} > 10\ k\Omega$, $R_L = 200\ \Omega$.



By KCL at Vout: $i_L = i_B + g_m v_\pi$

$$\frac{V_{out}}{R_L} = \frac{V_\pi}{r_\pi} + g_m V_\pi = \left(\frac{1}{r_\pi} + g_m\right) V_\pi$$

$$\therefore V_\pi = \frac{1}{\frac{1}{r_\pi} + g_m} \times \frac{V_{out}}{R_L}.$$

Since $r_\pi = \frac{\beta}{g_m}$, $\frac{1}{r_\pi} = \frac{g_m}{\beta}$ $\therefore g_m \gg \frac{1}{r_\pi}$

$$\therefore V_\pi \approx \frac{V_{out}}{g_m R_L}.$$

By KVL from Vin to ground: $V_{in} = V_\pi + V_{out}$.

$$\therefore V_{in} = \frac{V_{out}}{g_m R_L} + V_{out} = \left(\frac{1 + g_m R_L}{g_m R_L}\right) V_{out}.$$

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

Given $A_v = 0.85$ and $R_L = 200\ \Omega$,

$$0.85(1 + 200 g_m) = 200 g_m.$$

$$0.85 = (200 - 0.85 \times 200) g_m$$

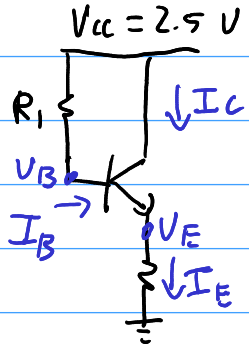
$$g_m = 28.33\ mS.$$

$$\therefore I_C = V_T g_m = 736.7\ \mu A.$$

Design bias (R_1). $V_{BE} = V_T \ln\left(\frac{I_C}{I_S}\right) = 0.7237$ V.

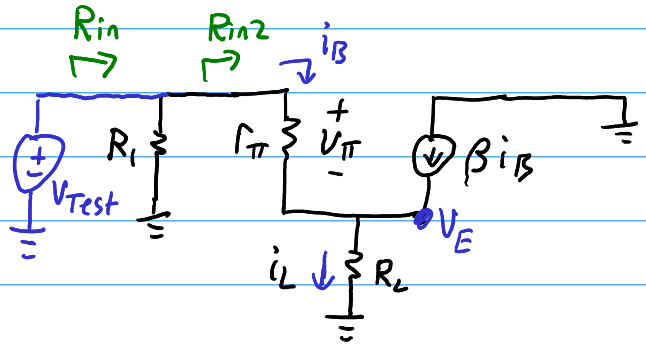
$V_E = I_E R_L \approx I_C R_L = 0.1413$ V.

$V_B = V_{BE} + V_E = 0.8711$ V.



$$R_1 = \frac{V_{CC} - V_B}{I_B} = \frac{V_{CC} - V_B}{I_C/\beta} = 221.1\ k\Omega$$

Check input resistance $R_{in} > 10\ k\Omega$.



$R_{in} = R_1 \parallel R_{in2}$.

To calc. R_{in2}, notice that the impact of R_L is amplified by the current source.

$$V_{test} = i_B r_\pi + (i_B + \beta i_B) R_L.$$

$$\therefore \frac{V_{test}}{i_B} = R_{in2} = r_\pi + (1+\beta) R_L.$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{28.33 \times 10^{-3}} = 3.53\ k\Omega.$$

$$R_{in2} = 3.53 \times 10^3 + (1 + 100) \times 200 = 23.73\ k\Omega.$$

$$\therefore R_{in} = R_1 \parallel R_{in2} = 221.1\ k\Omega \parallel 23.73\ k\Omega = 21.4\ k\Omega.$$

$\therefore$ Exceeds the requirement. ✓