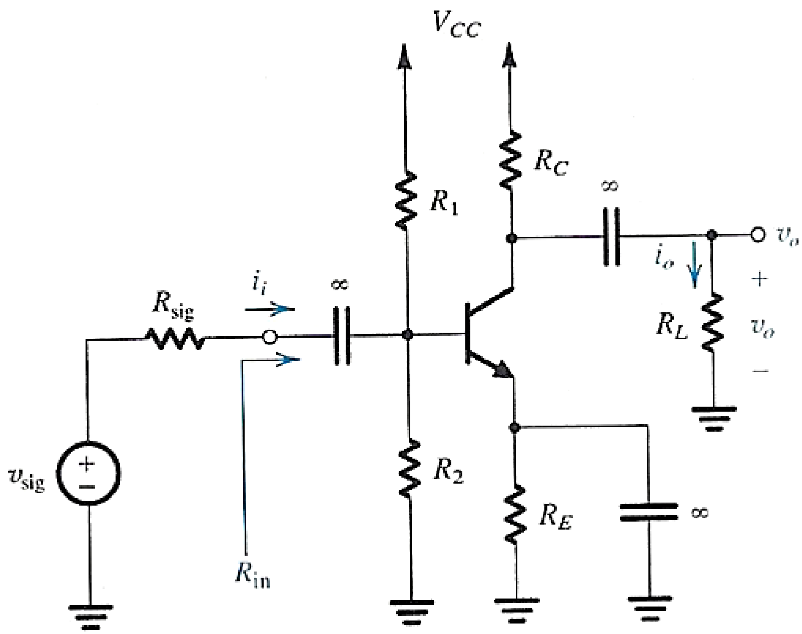
Example:

For the common-emitter amplifier shown below, let
V_{CC} = 9 V, R_1 = 27 kΩ, R_2 = 15 kΩ, R_E = 1.2 kΩ and R_C = 2.2 kΩ.
The transistor β = 100 and V_A = 100 V.
Calculate the dc bias current I_E. If the amplifier operates between a source for which R_{sig} = 10 kΩ and a load of 2 kΩ, replace the transistor with its hybrid-π model, and find the values of R_{in}, the voltage gain v_o/v_{sig}, and the current gain i_o/i_i.



We first draw the DC equivalent circuit (all caps are open-circuited), then we find Thevenin's equivalent looking out of the base.

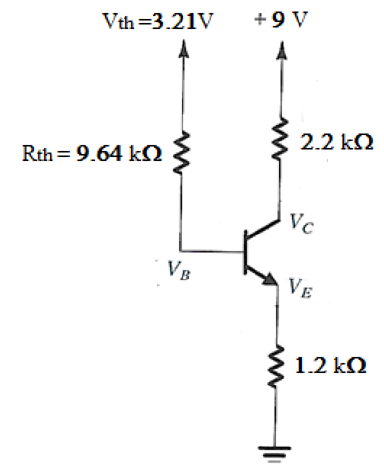
$$R_{th} = R_1 \,||\, R_2 = 27\text{ k}\Omega \,||\, 15\text{ k}\Omega = \frac{27\times15}{27+15} = 9.64\text{ k}\Omega$$

$$V_{th} = \frac{R_2}{R_1+R_2}\times V_{CC} = \frac{15}{27+15}\times 9 = 3.21\text{ V}$$

Assuming the transistor is in active mode:

$$(\beta+1)I_B = I_E$$

$$101\times\frac{3.21-(0.7+V_E)}{9.64} = \frac{V_E}{1.2} \;\rightarrow\; 2.51 - V_E = 0.0796V_E$$



$$\rightarrow V_E = 2.325 \text{ V} \rightarrow I_E = \frac{2.325}{1.2} = 1.9375 \text{ mA;}$$

$$I_C = (\frac{100}{101}) \times I_E = 1.918 \text{ mA}$$

$$V_B = V_E + 0.7 = 2.325 + 0.7 = 3.025 \text{ V}$$

$$V_C = 9 - 2.2 \times I_C; = 9 - 2.2 \times 1.918 = 4.78 \text{ V}$$

$$V_{BC} = V_B - V_C = 3.025 - 4.78 = \text{ -1.755 V} \leq \text{ 0.4 V}$$

$\rightarrow$ the BJT is in active mode as assumed.

$$g_m = \frac{I_C}{V_T} = \frac{1.918}{26} = 73.8 \text{ mS;}$$

$$r_\pi = \frac{V_T}{I_B} = \beta \frac{V_T}{I_C} = \frac{\beta}{g_m} = \frac{100}{73.8} \times 10^3 = 1.355 \text{ k}\Omega$$

$$R_{in} = R_1 \,||\, R_2 \,||\, r_\pi = R_{th} \,||\, r_\pi = 9.64 \,||\, 1.355 = 1.18 \text{ k}\Omega$$

$$\frac{v_{be}}{v_{sig}} = \frac{R_{in}}{R_{in} + R_{sig}} = \frac{1.19}{1.19 + 10} = 0.106$$

$$v_o = -g_m v_{be} \times (R_C \,||\, R_L) = -77.3 v_{be} \rightarrow \frac{v_o}{v_{be}} = -77.3$$

$$A_V = \frac{v_o}{v_{sig}} = \frac{v_o}{v_{be}} \times \frac{v_{be}}{v_{sig}} = 0.106 \times (-77.3) = -8.2 \text{ V/V}$$

$$\frac{v_o}{v_{be}} = \frac{i_o \times R_L}{i_i \times R_{in}} = -77.3 \rightarrow \frac{i_o}{i_i} = \frac{R_{in}}{R_L} \times \frac{v_o}{v_{be}} = -45.6 \text{ A/A}$$