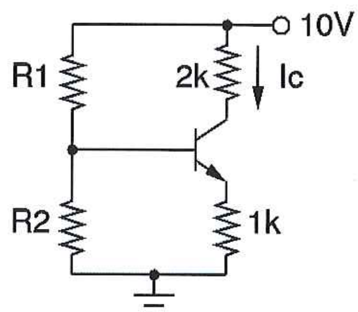
Name .... Score ....

1) BJT Biasing



BJT Parameters:
$V_T = 30$ mV
$V_{BEQ} = 0.7$ V
$V_A = \infty$
$\beta = 100$

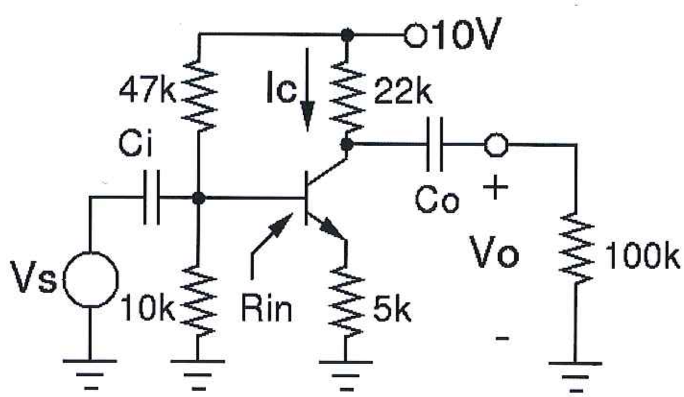
a) If R_2**=2.7 kΩ,** find a **value** for R_1 such that I_{CQ}**=2 mA**.

b) If the equivalent base resistor R_B is **4 kΩ** (not the solution of the above question), how much would I_{CQ} **change** (in **%**) if you were to **double** the values of R_1 and R_2?

c) If R_B is **4 kΩ**, how much would I_{CQ} **change** (in **%**) if you were to double the **value** of R_E?

d) If $R_2=\infty$ while R_E is kept at **1 kΩ,** find a **value** for R_1 such that I_{CQ} remains at **2 mA.**

2) Common Emitter Amplifier



BJT Parameters:
$V_T = 30$ mV
$V_{BEQ} = 0.7$ V
$V_A = \infty$
$\beta = 100$

Assume that the 2 **caps** act as **AC shorts** for the frequency range of interest.

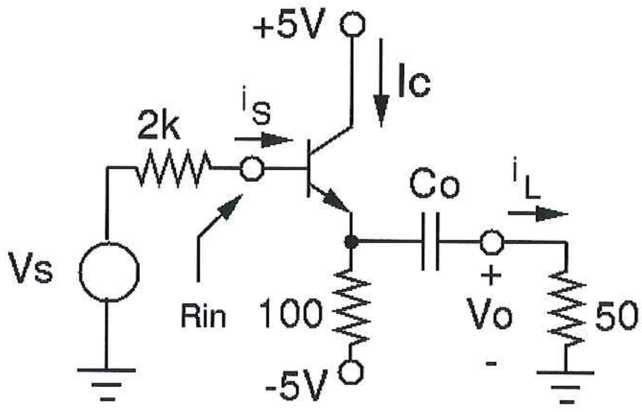
a) Derive values for I_{CQ} and V_{CEQ}.

b) Sketch the **small signal equivalent circuit** and find a **value** for the transistor **input resistor** r_{ie} or $r_{\pi e}$ (Describe the transistor collector current as βi_b and clearly mark i_b).

c) Derive a **value** for the **input resistance** R_{in} seen at the base of the transistor.

d) Derive a **value** for the **voltage gain** $A_V=v_o/v_s$.

3) Common Collector Amplifier



BJT Parameters:
$V_T = 30$ mV
$V_{BEQ} = 0.7$ V
$V_A = \infty$
$\beta = 100$

Vs is an **ideal AC voltage source.**

a) Find **values** for the transistor Q-point parameters I_{CQ} and V_{CEQ}.

b) Assuming linear operation, what is the **maximum amplitude of v_o** this amplifier can support?

c) Derive an **expression** and a **value** for the **input resistance R_{in}** seen at the base of the transistor (Assume that Co acts as a short for the frequency range of interest).

d) Find a **value** for the **AC current gain $A_I=i_L/i_s$** of the depicted amplifier. (Assume that Co acts as a short for the frequency range of interest).

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1) a) $\left| I_{CQ} \cong \dfrac{V_{CC}\dfrac{R_2}{R_1+R_2} - V_{BEQ}}{\dfrac{R_1R_2}{\beta(R_1+R_2)} + R_E} = \dfrac{\dfrac{27}{R_1+2.7} - 0.7}{\dfrac{2.7R_1}{100(R_1+2.7)} + 1} \text{ [mA]} \right|$

$\therefore \quad 27 + .7(R_1+2.7) = 0.054R_1 + 2R_1 + 5.4$

$\| R_1 = \dfrac{19.71}{2.754} \text{ [k}\Omega\text{]} = 7.16\text{ k}\Omega \|$ 3

b) $R_{B1} = 4\text{ k}\Omega \quad R_{B2} = 8\text{ k}\Omega$

$\therefore \left| \dfrac{I_{CQ2}}{I_{CQ1}} = \dfrac{\dfrac{R_{B1}}{\beta} + R_E}{\dfrac{R_{B2}}{\beta} + R_E} = \dfrac{40 + 1{,}000}{80 + 1{,}000} \cong 0.96 \right|$

$\therefore$ ‖ I_{CQ} would decrease by 4% ‖ 3

c) $R_{E1} = 1\text{ K}\Omega \quad R_{E2} = 2\text{ k}\Omega$

$\left| \dfrac{I_{CQ2}}{I_{CQ1}} = \dfrac{\dfrac{R_B}{\beta} + R_{E1}}{\dfrac{R_B}{\beta} + R_{E2}} = \dfrac{40 + 1{,}000}{40 + 2{,}000} \cong 0.51 \right|$

$\therefore$ ‖ I_{CQ} would decrease by 49% ‖ 3

d) $\left| I_{CQ} = \dfrac{V_{CC} - V_{BEQ}}{\dfrac{R_1}{\beta} + R_E} = \dfrac{10 - 0.7}{\dfrac{R_1}{100} + 1} \text{ [mA]} \right|$

$\therefore \| R_1 = 100\left[\dfrac{9.3}{2} - 1\right] \text{[k}\Omega\text{]} = 365\text{ k}\Omega \|$ 3

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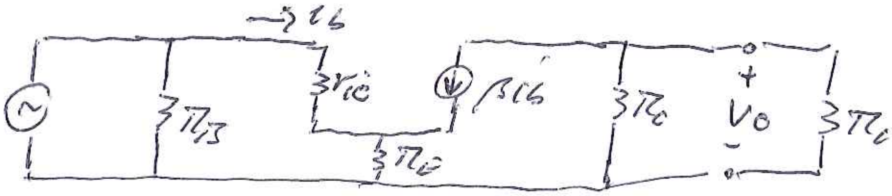
2) a)

$$I_{CQ} \cong \frac{V_{CC}\frac{R_2}{R_1+R_2} - V_{BEQ}}{\frac{R_1 \cdot R_2}{\beta(R_1+R_2)} + R_E} \cong 0.21\,mA$$ 2

$$V_{CEQ} \cong V_{CC} - I_{CQ}(R_C + R_E) \cong 4.3\,V$$ 1

b)



2

$$r_{ie} = \frac{\beta}{g_m} = \beta\frac{V_T}{I_{CQ}} \cong 14.3\,k\Omega$$ 1

$$R_B = R_1 \| R_2 \cong 8.25\,k\Omega$$

c)

$$R_{in} = r_{ie} + (1+\beta)R_E$$

$$\therefore R_{in} = 14.3\,k\Omega + 505\,k\Omega \cong 519\,k\Omega$$ 3

d)

$$V_s = i_b\,(r_{ie} + [1+\beta]R_E)$$

$$V_o = -\beta\, i_b\, R_C \| R_L$$

$$\therefore A_v = \frac{V_o}{V_s} = -\frac{\beta\, R_C \| R_L}{r_{ie} + [1+\beta]R_E}$$

$$\therefore A_v \cong -\frac{g_m\, R_C \| R_L}{1 + g_m R_E} \cong -3.5$$ 3

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3) a)

$$I_{CQ} \cong \frac{V_{BB}-V_{BE(on)}}{\frac{R_B}{\beta}+R_E} = \frac{5-0.7}{20+100}\,[\text{mA}] = 35.8\,\text{mA}$$ 2

$$V_{CEQ} = V_{CC}+V_{EE}-I_{CQ}R_E \cong 6.44\,\text{V}$$ 1

b)

$$V_{o\,max} = I_{CQ}\cdot R_E \| R_L \cong 1.19\,\text{V}$$ 3

c)

$$R_{in} = r_\pi + (1+\beta) R_E \| R_L$$

$$\therefore R_{in} = \frac{\beta}{g_m} + (1+\beta) R_E \| R_L \cong 3.45\,k\Omega$$ 3

d)

KCL: $i_e + i_L = (1+\beta)\, i_s$

KVL: $i_e R_E = i_L R_L$

$$\therefore i_L\left(\frac{R_L}{R_E}+1\right) = (1+\beta)\, i_s$$

$$\therefore A_I = \frac{i_L}{i_s} = \frac{1+\beta}{R_L/R_E+1} \cong 67.3$$ 3

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