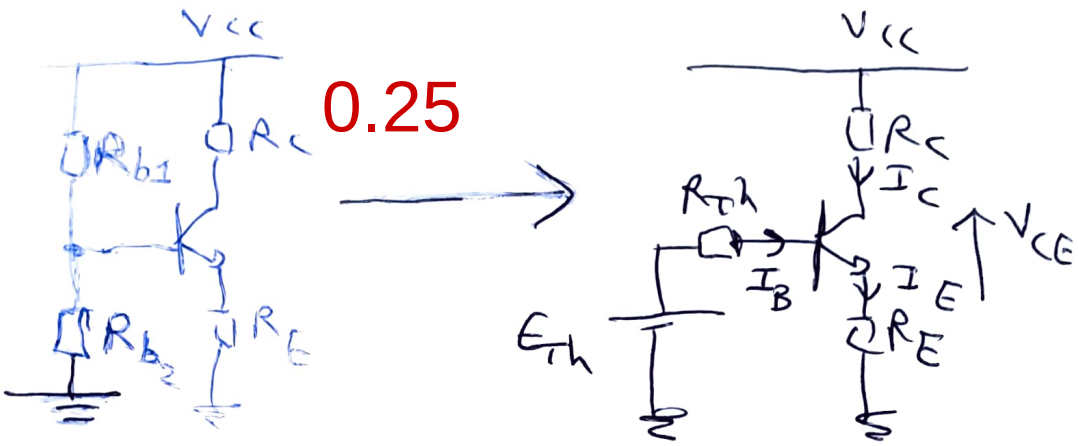
1) Droite de charge statique et $Q(V_{CEQ}, I_{CQ})$:



$V_{cc} - R_c I_c - R_E I_E - V_{CE} = 0$, $I_E = \left(1 + \frac{1}{\beta}\right) I_c$

$$\Rightarrow I_C = \frac{-V_{CE} + V_{cc}}{R_c + \left(1 + \frac{1}{\beta}\right) R_E}$$ avec: $I_{Cmax} = \frac{V_{cc}}{R_c + \left(1 + \frac{1}{\beta}\right) R_E}$; $V_{CEmax} = V_{cc}$

0.25

$E_{Th} - R_{Th} I_B - V_{BE} - R_E I_E = 0$

$$\Rightarrow I_{BQ} = \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1) R_E} \Rightarrow I_{CQ} = \beta \frac{E_{Th} - V_{BE}}{R_{Th} + (\beta + 1) R_E}$$

$$\Rightarrow V_{CEQ} = V_{cc} - \left(R_c + \left(1 + \frac{1}{\beta}\right) R_E\right) I_{CQ}$$

0.25

0.25

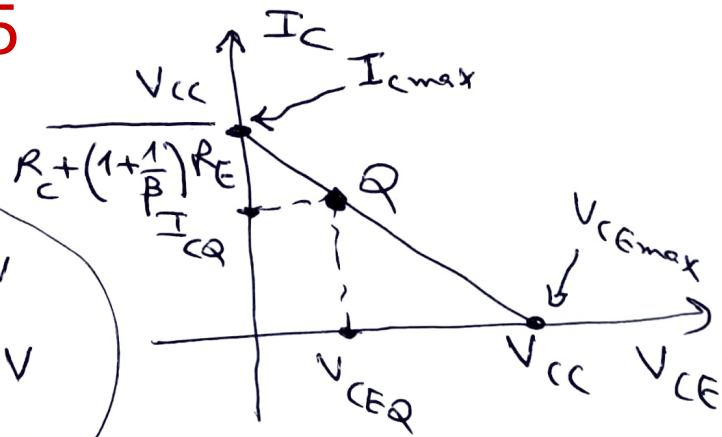
A.N :

$R_{Th} = 8{,}89\ k\Omega$

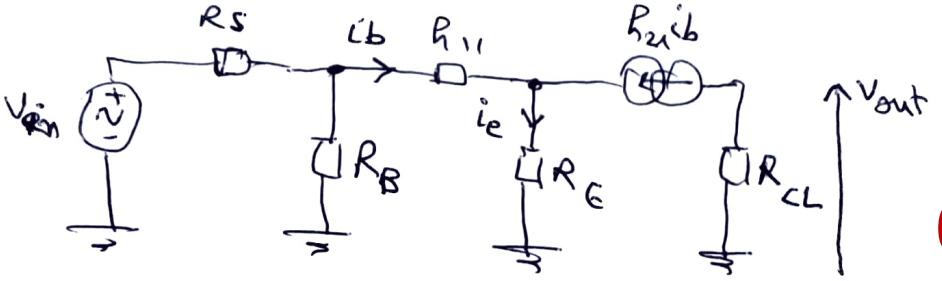
$E_{Th} = 1{,}11\ V$

$I_{Cmax} = 1{,}9\ mA$, $V_{CEmax} = 10\ V$

$I_{CQ} = 1{,}7\ mA$, $V_{CEQ} = 1{,}28\ V$



2) Schéma équivalent petits signaux (AC) :



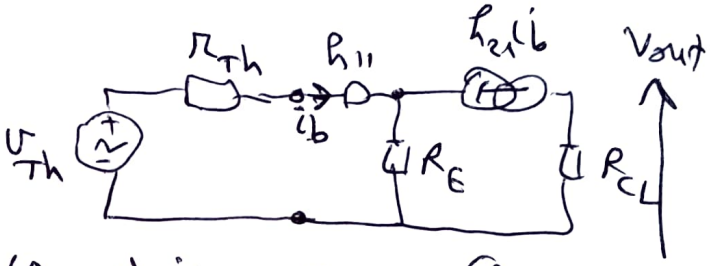
01.00

$R_B = R_{B1} // R_{B2}$, $R_{CL} = R_C // R_L$

3) Gain en tension :

$$V_{Th} = \frac{R_B}{R_B + R_S} \cdot V_{in}$$

$$R_{Th} = R_S // R_B$$



$$V_{Th} - (R_{Th} + h_{11}) i_b - R_E (h_{21} + 1) i_b = 0 \quad \text{——} (1)$$

0.25

$$V_{out} = -h_{21} i_b \cdot R_{CL} \quad \text{——} (2)$$

0.25

$$(1) \Rightarrow i_b = \frac{V_{Th}}{R_{Th} + h_{11} + (h_{21}+1) R_E} \quad \text{——} (3)$$

$$(3) \rightarrow (2) : V_{out} = -R_{CL} \cdot h_{21} \cdot \frac{V_{Th}}{R_{Th} + h_{11} + (h_{21}+1) R_E}$$

$$\Rightarrow V_{out} = -h_{21} R_{CL} \cdot \frac{\frac{R_B}{R_B + R_S} \cdot V_{in}}{R_{Th} + h_{11} + (h_{21}+1) R_E}$$

$$\Rightarrow G_V = \frac{V_{out}}{V_{in}} = -h_{21} \cdot \frac{\frac{R_B R_{CL}}{R_B + R_S}}{R_{Th} + h_{11} + (h_{21}+1) R_E}$$

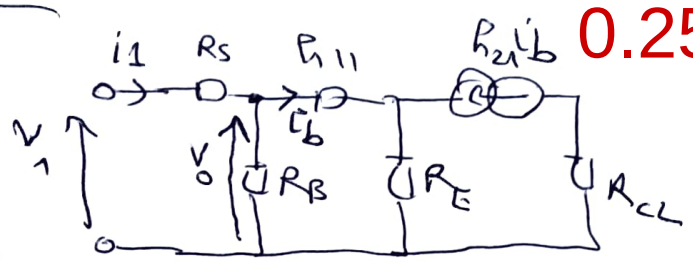
0.25

$$G_V \approx -h_{21} \cdot \frac{R_{CL}}{h_{11} + h_{21} R_E}$$

A.N. : $\boxed{G_V = -4{,}13}$

0.25

④ Résistance d'entrée :



0.25

$$V_o = h_{11} i_b + (h_{21}+1) R_E i_b$$

$$\Rightarrow V_o = \left[h_{11} + (h_{21}+1) R_E\right] i_b \quad \text{——— (1)}$$

$$V_1 = R_s i_1 + R_B (i_1 - i_b) \quad \text{——— (2)}$$

0.25

$$V_o = V_1 - R_s i_1 \quad \text{——— (3)}$$

$$(2) \Rightarrow i_b = \frac{(R_s + R_B) i_1 - V_1}{R_B} \quad \text{——— (4)}$$

(3) & (4) → (1) :

$$V_1 - R_s i_1 = \left[h_{11} + (h_{21}+1) R_E\right] \cdot \frac{(R_s + R_B) i_1 - V_1}{R_B}$$

$$\Rightarrow V_1 \left[1 + \frac{h_{11} + (h_{21}+1) R_E}{R_B}\right] = \left[R_s + (h_{21}+1) \frac{R_E}{R_B} (R_s + R_B)\right] i_1$$

$$\Rightarrow R_e = \frac{V_1}{i_1} = \frac{R_s + \left(h_{11} + (h_{21}+1) R_E\right)\left(1 + \frac{R_s}{R_B}\right)}{1 + \frac{h_{11} + (h_{21}+1) R_E}{R_B}}$$

$$= \frac{R_s \left[1 + \frac{h_{11} + (h_{21}+1) R_E}{R_B}\right] + h_{11} + (h_{21}+1) R_E}{1 + \frac{h_{11} + (h_{21}+1) R_E}{R_B}}$$

$$\Rightarrow \boxed{R_e = R_s + \frac{1}{\frac{1}{R_B} + \frac{1}{h_{11} + (h_{21}+1) R_E}}}$$

0.25

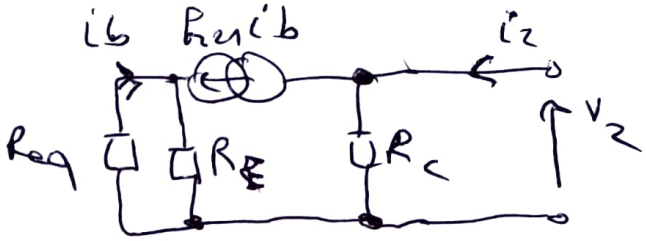
A.N. : $\boxed{R_e = 7{,}83\ k\Omega}$

0.25

⑤ Résistance de sortie :

0.25

$$R_{eq} = (R_s // R_B) + h_{11}$$



$$V_2 = R_C (i_2 - h_{21} i_b) \quad \text{(1)}$$

0.5

$$i_b = -\frac{R_E}{R_E + R_{eq}} \cdot h_{21} i_b \Rightarrow i_b = 0 \quad \text{(2)}$$

(2) → (1) : $V_2 = R_C i_C \Rightarrow$ $\boxed{R_{sortie} = \frac{V_2}{i_2} = R_C}$

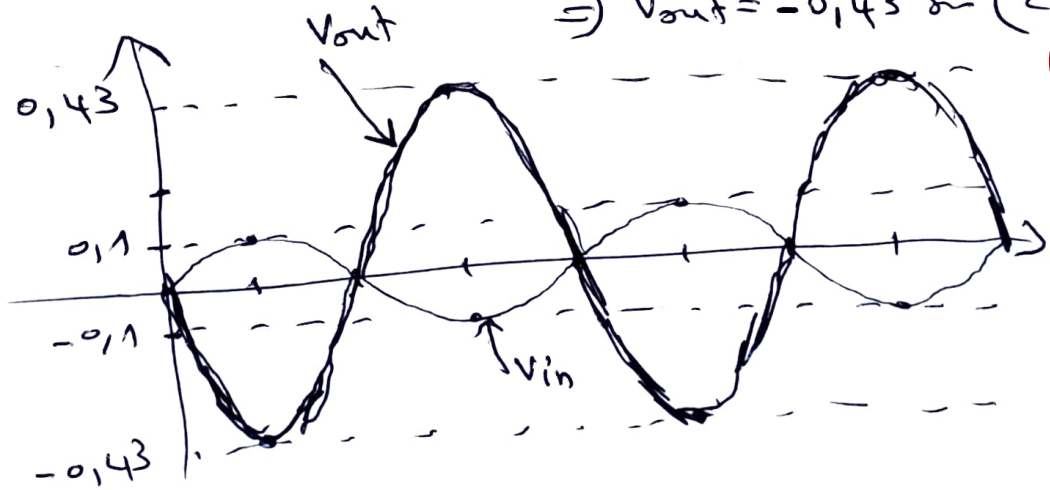
0.25

A.N : $\boxed{R_{sortie} = 5\ k\Omega}$

⑥ Tracés de V_{in} et V_{out} :

$V_{in} = 0,1 \sin(2\pi \cdot 10^4 t) \Rightarrow V_{out} = G_V \cdot V_{in}$

$\Rightarrow V_{out} = -0,43 \sin(2\pi 10^4 t)$



0.5

0.5