Exercises

1. Calculate g_m, r_e and r_{be} when I_C = 10 μA and when I_C = 0.25mA. Comment on the values (β_o = 200)

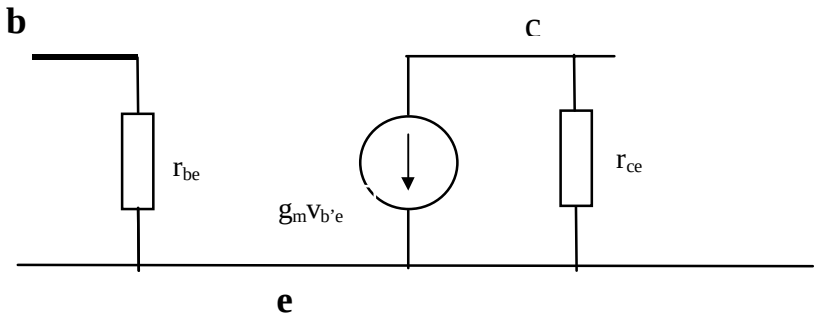
$g_m = 40 I_C$ $\quad$ $r_e = 1/g_m$ $\quad$ $r_{be} = \beta_o / g_m$

I_C	g_m	r_e	r_{be}
10μA	**0.4 mA/V**	**2.5kΩ**	**500kΩ**
0.25mA	**10mA/V**	**0.1kΩ**	**20kΩ**
1mA	**40mA/V**	**0.025kΩ**	**5kΩ**

2. Why is the small-signal equivalent circuit of a battery (d.c. voltage source) taken to be a short circuit?

3. What would be the small signal equivalent circuit of an ideal current source?

4. What are the equivalent circuit parameters for a transistor whose β_o = 200 and whose Early voltage is 150V when it is operating at I_C = 0.1mA and V_{CE} = 5V?



$g_m = 40 I_C$ $\quad$ $r_{ce} = \dfrac{V_A + V_{CE}}{I_C}$ $\quad$ $r_{be} = \beta_o / g_m$

4 mA/V $\quad$ **1.55MΩ** $\quad$ **50kΩ**

5. Calculate the values of I_C, I_E and I_B of a transistor in the common emitter configuration, when V_{CE} = 8V and V_{BE} =0.63V; given that $I_S = 10^{-13}$ A at V_{CE} = 5V, β = 200 and VA = 150V.

$I_C = I_{CO}\left[1 + \dfrac{V_{CE}}{V_A}\right]$ $\quad$ Where $\quad$ $I_{CO} = I_S \exp\left(\dfrac{V_{BE}}{V_T}\right)$

so when V_{BE} = 0.63V, $I_S = 10^{-13}$ A; $\quad$ **I_{CO} ~ 9mA**

(note that I_C at V_{CE} = 5V is given by $I_C = 9mA\left[1 + \dfrac{5}{150}\right]$ = 9.1 mA

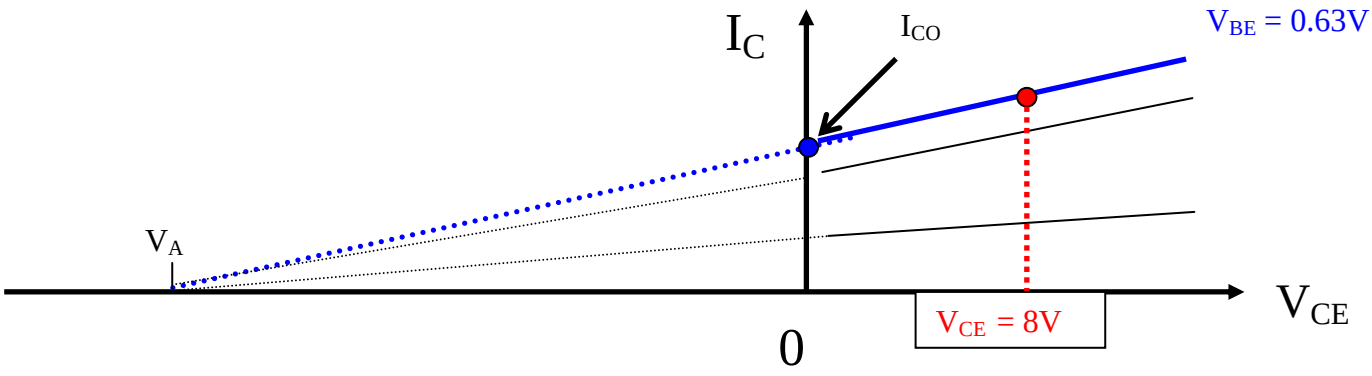
We need to find I_C, I_B and I_E at V_{CE} = 8V

- we're on the same V_{BE} characteristic so I_{CO} is the same.

Therefore $I_C = 9mA\left[1 + \dfrac{8}{150}\right]$ **~ 9.3 mA**

$\beta = \frac{I_C}{I_B} = 200$ so **$I_B \sim 50\ \mu A$**

$I_E = I_C + I_B$ so **$I_E \sim 9.35\ mA$**



6. What is the output resistance of the transistor at the operating point in 5 above?

Operating point is V_{CE} = 8V, I_C = 9.3mA

So
$$r_{ce} = \frac{V_A + V_{CE}}{I_C}$$
$$r_{ce} = \frac{150 + 8}{9.3 \cdot 10^{-3}} \quad \textbf{=17 k}\Omega$$

or
$$r_{ce} = \frac{V_A}{I_{CO}}$$
$$r_{ce} = \frac{150}{9 \cdot 10^{-3}} \quad \textbf{=17 k}\Omega$$