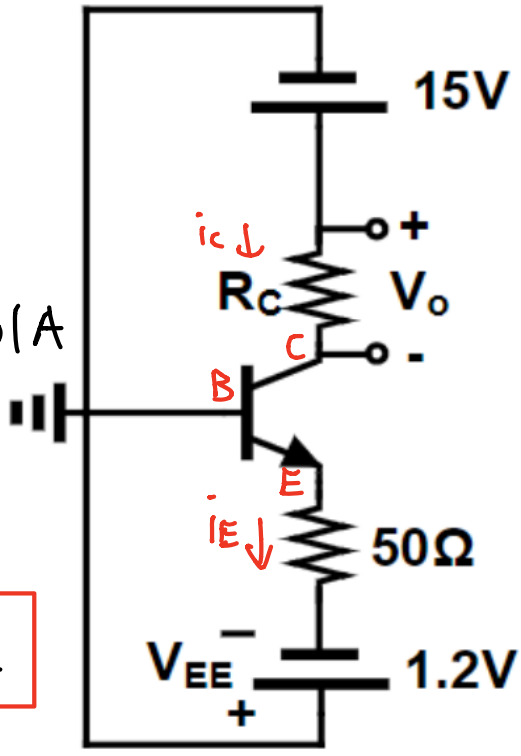
Question 1 :



(a) $V_{BE} = 0.7\,V$, $V_B = 0\,V$

$\Rightarrow V_E = -0.7\,V$

$\Rightarrow i_E = \dfrac{-0.7-(-1.2)}{50} = 0.01\,A$

$\Rightarrow i_C = \alpha \cdot i_E = 0.009\,A$

$R_C = \dfrac{V_o}{i_C} = \dfrac{4.5}{0.009} = 500\,\Omega$

(Check Forward-Active $V_{CE} \geq V_{BE}$)

(b) $V_{CB} = 7.5\,V$, $V_B = 0\,V$

$\Rightarrow V_C = 7.5\,V$,

$i_C = \dfrac{V_o}{R_C} = \dfrac{15-7.5}{500} = 0.015\,A$

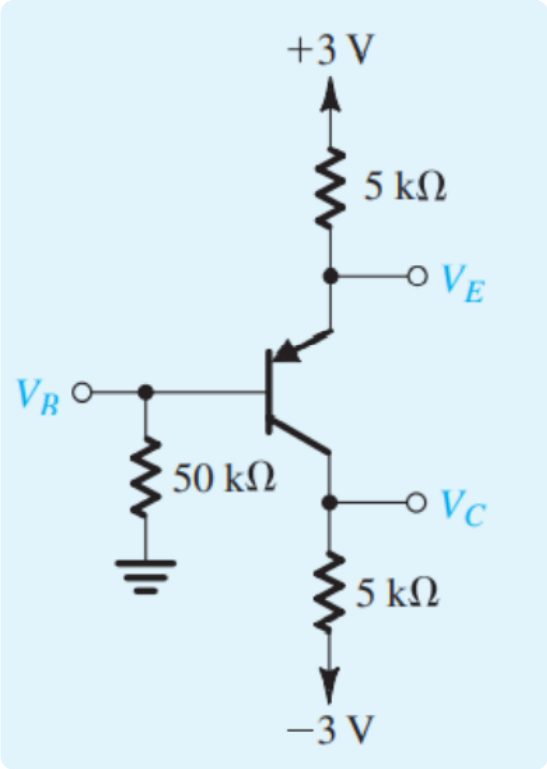
$\Rightarrow i_E = \dfrac{i_C}{\alpha} = \dfrac{V_E-(-V_{EE}')}{50\,\Omega}$

$\dfrac{0.015}{0.9} = \dfrac{-0.7+V_{EE}'}{50}$

$V_{EE}' = 1.5333\,V$

$|\Delta V_{EE}| = 1.5333-1.2 = 0.33\,V$

Question 2 :



$V_E = 1.0\,V$, $V_{BE} = 0.7\,V$

$\Rightarrow$ $V_B = 0.3V$

$I_B = \frac{V_B}{50k\Omega} =$ $6\,\mu A$

Apply Kirchhoff's voltage law :

$3 - I_E \cdot 5k\Omega - V_E = 0$

$I_E = \frac{3-1}{5000} =$ $0.4\,mA$

$I_C = I_E - I_B =$ $0.394\,mA$

Apply Kirchhoff's voltage law :

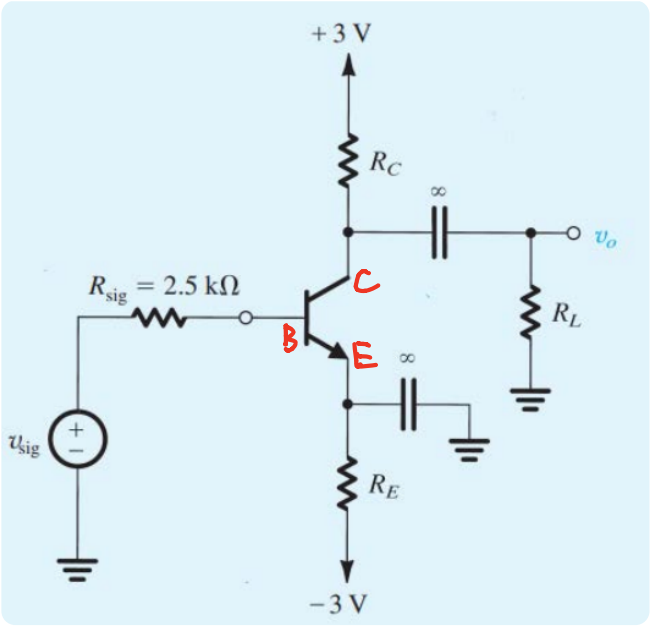
$-V_C + I_C \cdot 5k\Omega - 3V = 0$

$V_C = 0.394 \times 5 - 3 =$ $-1.03V$

$\beta = \frac{I_C}{I_B} = \frac{0.394 \times 10^{-3}}{6 \times 10^{-6}} =$ 65.667

$\alpha = \frac{\beta}{\beta+1} =$ 0.985

Question 3 :



(a) Apply Kirchhoff's voltage law to the input side:

$$I_B R_{sig} + V_{BE} + I_E R_E - 3 = 0$$

Since $I_B = \frac{I_E}{\beta+1}$

$$R_E = \frac{3 - V_{BE}}{I_E} - \frac{R_{sig}}{\beta+1}$$

$$= \frac{3 - 0.7}{0.5\times10^{-3}} - \frac{2.5\times10^{3}}{100+1}$$

$$\approx 4575.25\ \Omega$$

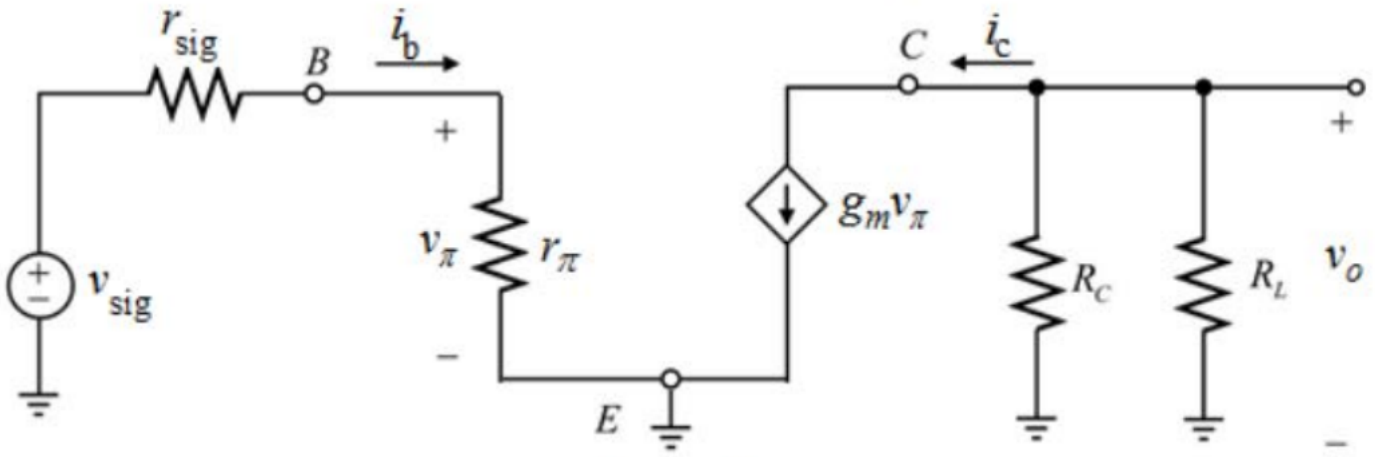
(b) $$I_C = \alpha I_E = \frac{\beta}{\beta+1} I_E$$

$$= \frac{100}{100+1} \times 0.5 = 0.495\ mA$$

$$R_C = \frac{3V - V_C}{I_C}$$

$$= \frac{3 - 0.5}{0.495\times10^{-3}} = 5050\ \Omega$$

(c)



$$V_\pi = V_{sig} \cdot \frac{r_\pi}{r_\pi + r_{sig}}$$

$$r_\pi = \frac{\beta}{gm}$$

$$gm = \frac{I_C}{V_T} = \frac{100}{100+1} \cdot 0.5 / 0.025 = 19.8\ mA/V$$

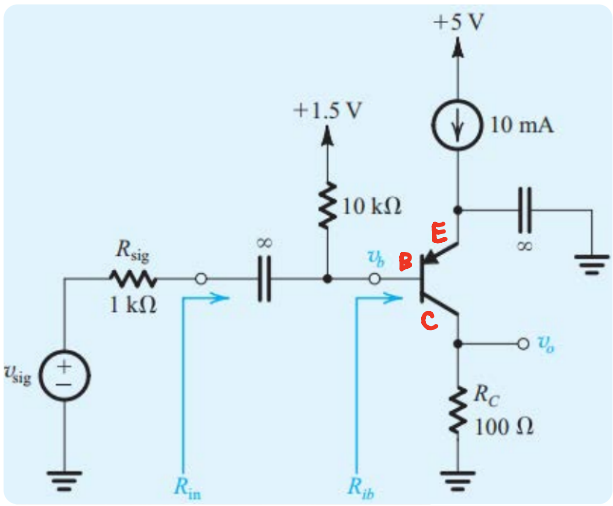
$$A_0 = \frac{V_o}{V_{sig}} = \frac{-gm\,(R_C \| R_L)\, V_\pi}{V_{sig}}$$

$$= -gm \cdot (R_C \| R_L) \cdot \frac{r_\pi}{r_\pi + r_{sig}}$$

$$= -19.8\times10^{-3} \cdot \frac{5050 \times 10\times10^3}{5050 + 10\times10^3} \cdot \frac{100 / 19.8\times10^{-3}}{100/19.8\times10^{-3} + 2500}$$

$$\approx -44.44$$

Question 4 :



(a) $\beta = 200$, $i_E = 10\,mA$

$$i_C = \frac{\beta}{\beta+1} \cdot i_E = 9.95\,mA$$

$$i_B = \frac{i_C}{\beta} = 0.05\,mA$$

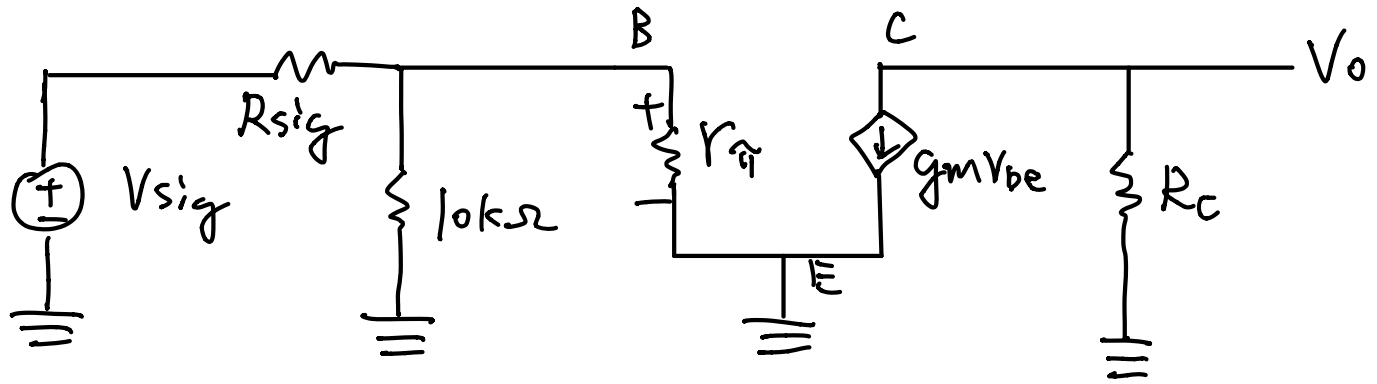
$$V_B = 1.5 + 10\times10^3 \times i_B = 1.9975\ V$$

$$V_E = V_B + V_{EB} = 2.6975\ V$$

$$V_C = 100\,\Omega \cdot i_c = 0.995\ V$$

(Check forward active)

(b)



(c) $$R_{ib} = r_\pi = \frac{\beta}{g_m} = \frac{\beta V_T}{I_C} = \frac{200\times0.025}{9.95\times10^{-3}}$$

$$= 502.5\,\Omega$$

$$R_{in} = r_\pi \,||\, 10k\Omega = 478.5\,\Omega$$

$$A_v = -g_m R_C \frac{R_{in}}{R_{in}+R_{sig}} = \boxed{-12.88}$$