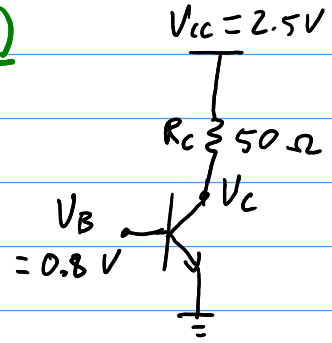
4.21 (a)



If in active region:

$$I_C = I_S e^{V_B/V_T}$$
$$= 8 \times 10^{-16} e^{0.8/0.026}$$
$$= 18.45\ mA.$$

Check if V_C is high enough.

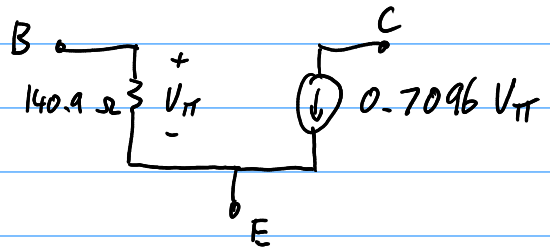
$$V_C = 2.5 - I_C R_C = 2.5 - 0.01845 \times 50 = 1.578\ V.$$

We have $V_C > V_B > V_E$ ∴ in forward active region.

Calc. parameters for small signal model.

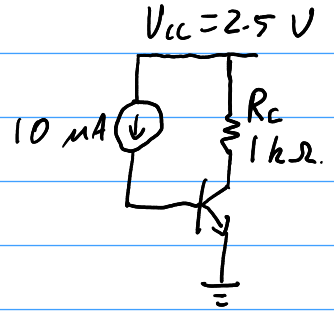
$$g_m = \frac{I_C}{V_T} = \frac{18.45\ mA}{26\ mV} = 0.7096\ S.$$
$$r_\pi = \frac{\beta}{g_m} = \frac{100}{0.7096} = 140.9\ \Omega.$$

∴ Small signal model is:



No r_o since $V_A = \infty$

4.21 (b)

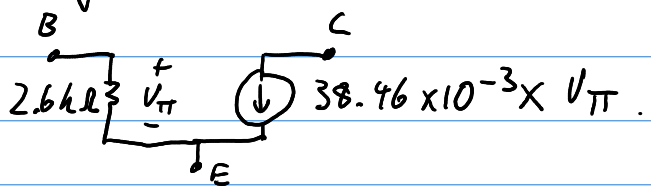


Given $\beta = 100$
$I_S = 8 \times 10^{-16}\ A$
$V_A = \infty$

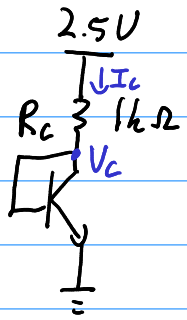
$I_C = \beta I_C = 100 \times 10 \times 10^{-6}$
$= 1\ mA.$

Calc. parameters. $g_m = \frac{I_C}{V_T} = \frac{1 \times 10^{-3}}{0.026} = 38.46\ mS.$
$r_\pi = \frac{\beta}{g_m} = \frac{100}{38.46 \times 10^{-3}} = 2.6\ k\Omega.$

$\therefore$ Small signal model is:



4.21 (c)



$V_{BE} = V_B = V_C$
$V_C = 2.5 - 1000 I_C$
$I_C = I_S e^{V_{BE}/V_T}$
$= I_S e^{(2.5 - 1000 I_C)/V_T}$

Solving numerically (or trial and error)
Starting from an initial guess $V_{BE} \approx 0.7\ V.$
$\Rightarrow I_C = 1.76\ mA.$

$\therefore g_m = \frac{I_C}{V_T} = 67.7\ mS.$
$r_\pi = \frac{\beta}{g_m} = 1.48\ k\Omega.$