Steps for converting <u>complete</u> circuits to <u>small-signal</u> circuits

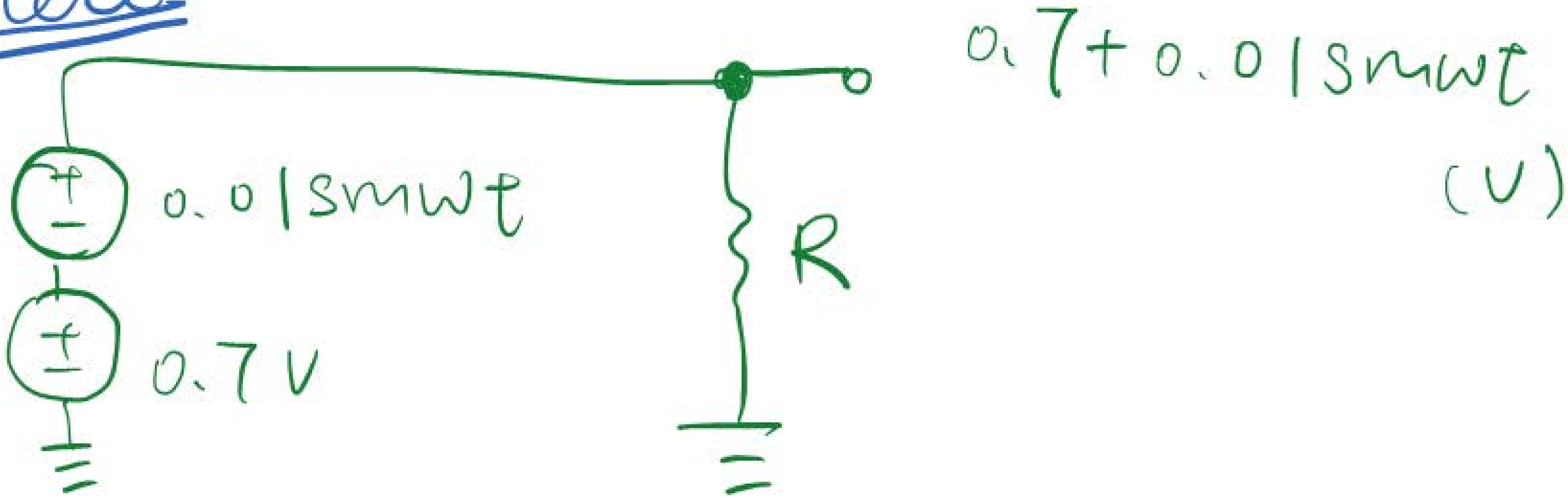
1° Draw the complete small-signal model of the transistors.

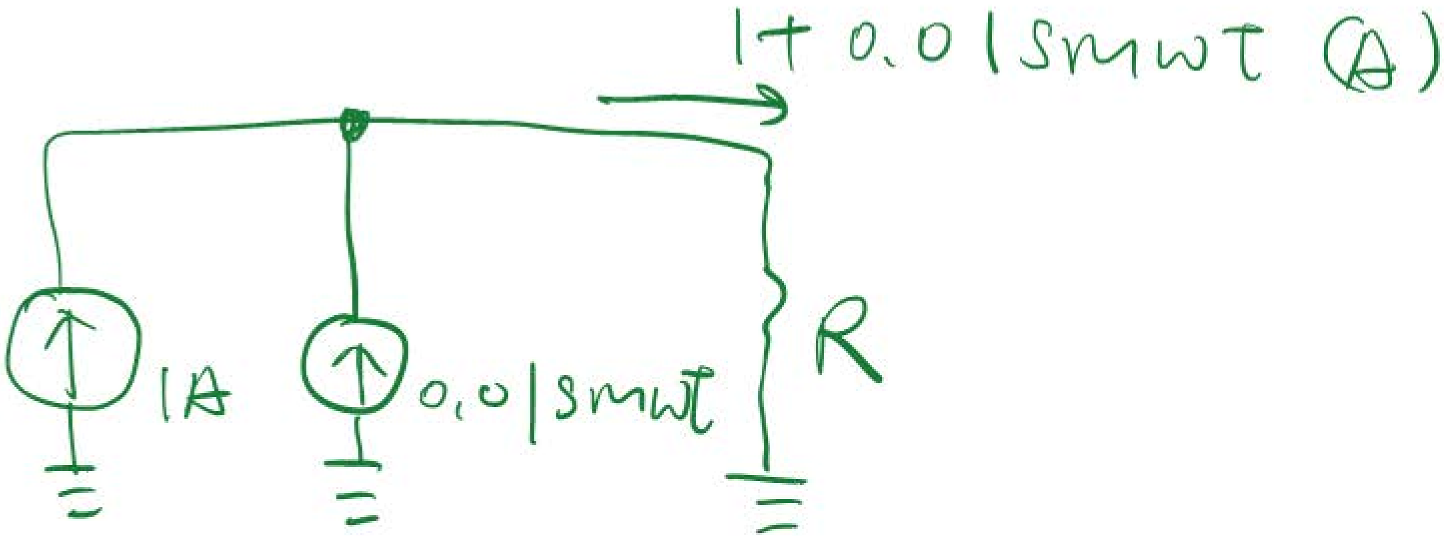
2° Finish the external wiring.

DC voltage → short

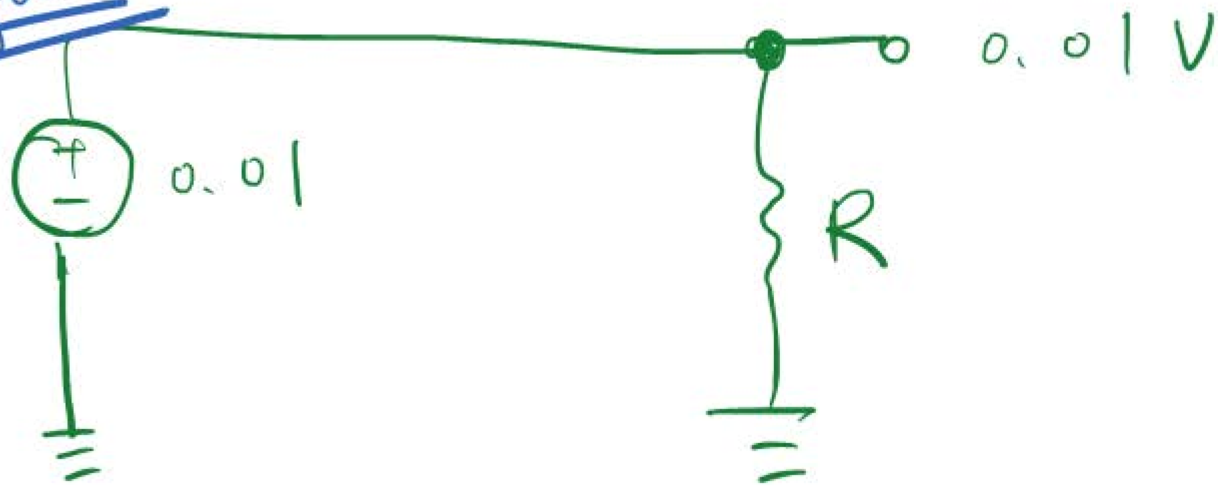
DC current → open

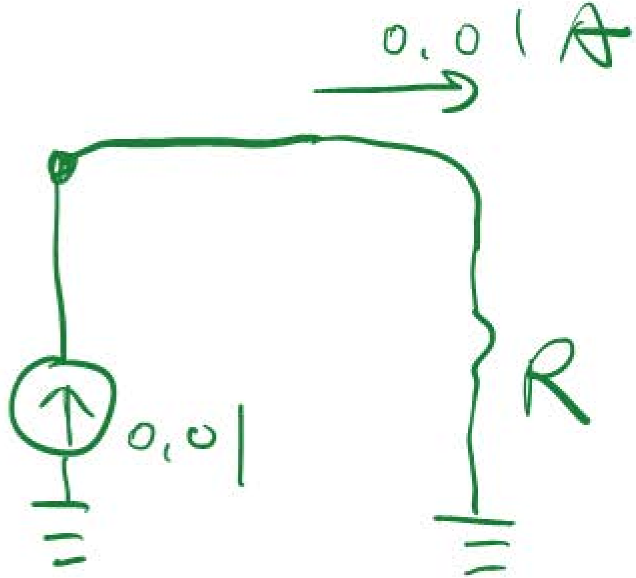
complete





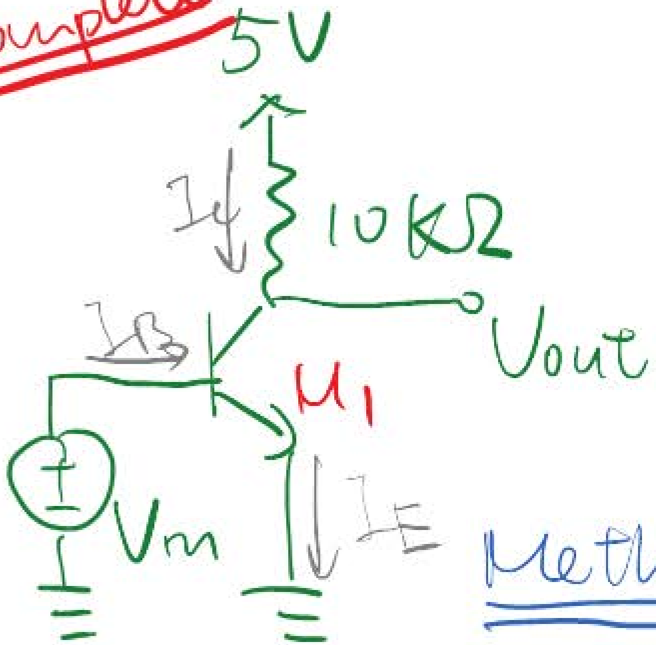
Small-signal





.model Qbreakn NPN IS=1e-18 BF=100 VAF=100

complete



Method 1

$$V_{in} = V_{IN} + v_m$$
$$= 0.7 + 0.01\sin(2\pi 60 t)$$

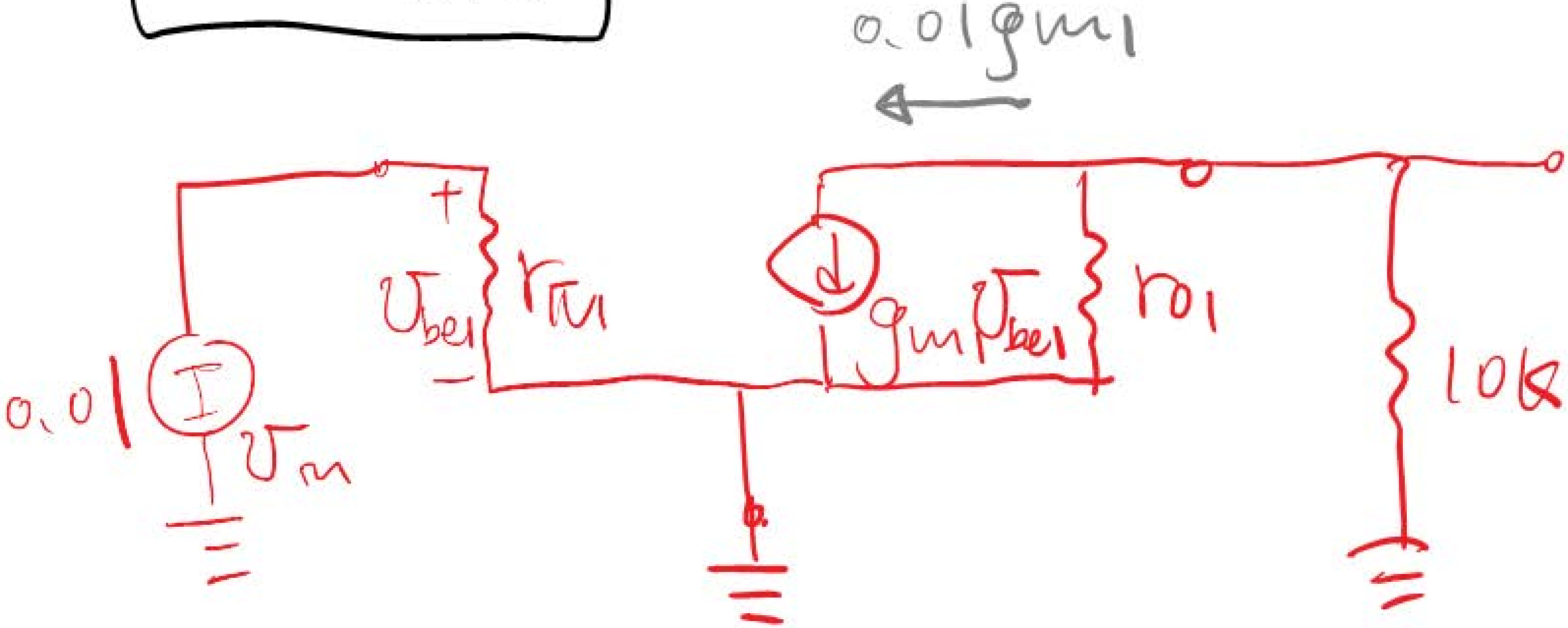
$$V_{out} = V_{OUT} + v_{out} = ?$$

Make sure $V_{OUT} \geq 0.7$

$$\begin{cases} 5 - (10k) I_C = V_{OUT} \\ I_C = (1 \times 10^{-18})\left(e^{\frac{0.7}{0.026}} - 1\right)\left(1 + \frac{V_{OUT}}{100}\right) \end{cases}$$

For getting the DC biasing condition

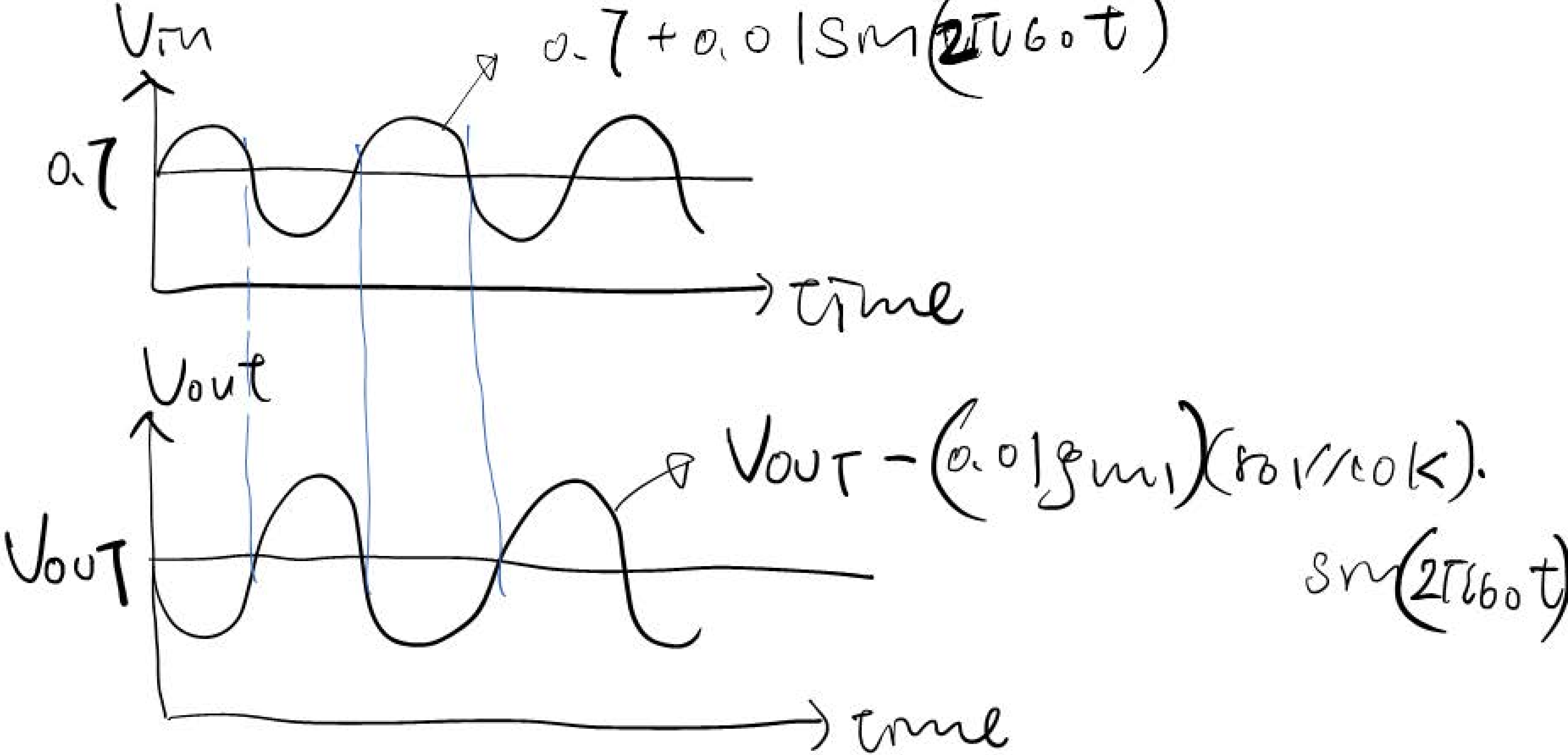
$$\boxed{A_v = \frac{v_{out}}{v_{in}}} = -g_{m1}(r_{o1} /\!/ 10k)$$



$$v_{out} = -(0.01 g_{m1})(r_{o1} /\!/ 10k).$$

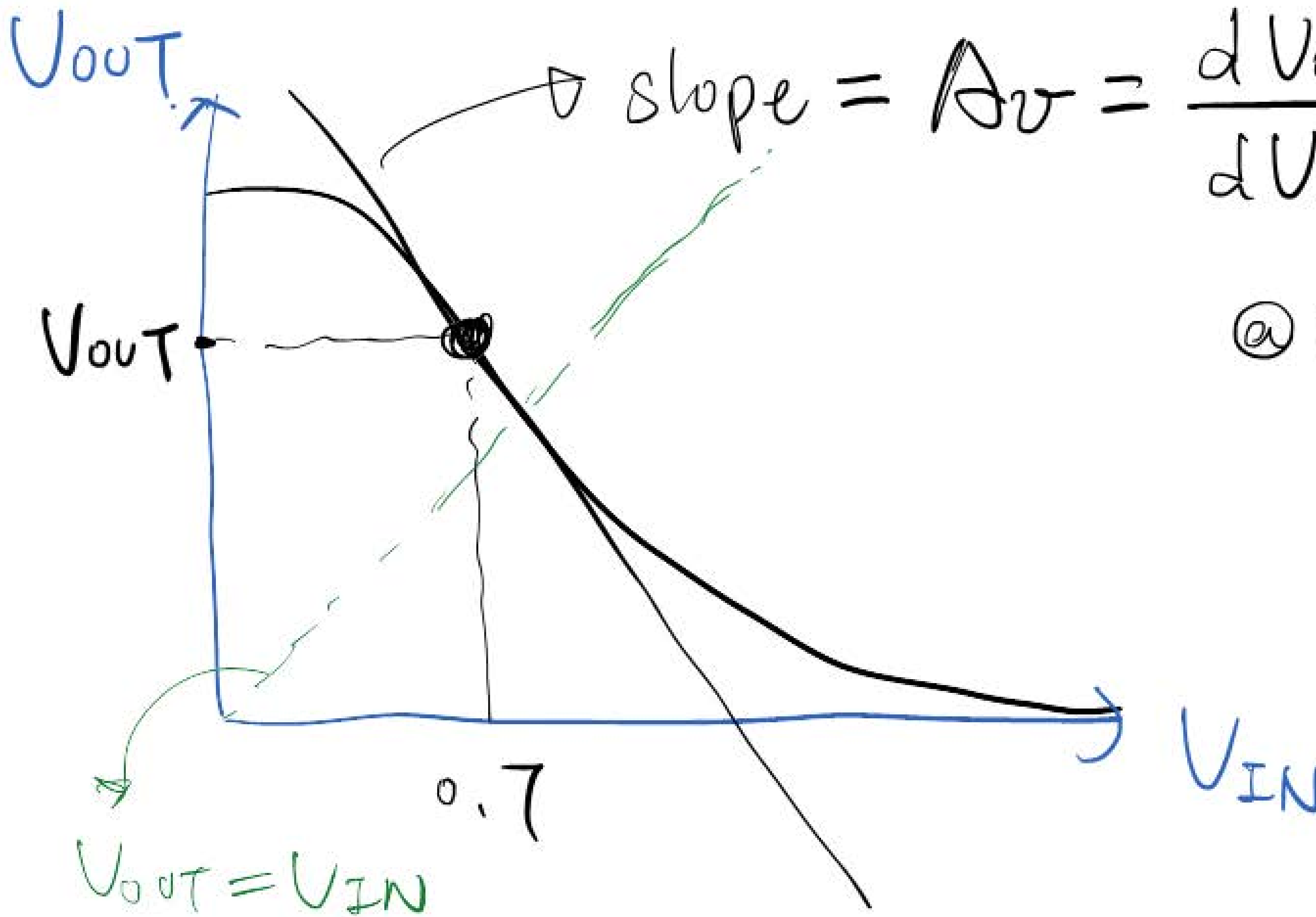
Amplitude of v_{out} in complete circuit.

$$\begin{cases} g_{m1} = \dfrac{I_c}{0.026} & (A/V) \\ r_{o1} = \dfrac{100}{I_c} & (\Omega) \end{cases}$$



V_{in}
$0.7 + 0.01\sin(2\pi 60 t)$
0.7
time
V_{out}
$V_{OUT} - (0.01 g_{m1})(r_{o1} // 60k) \sin(2\pi 60 t)$
V_{OUT}
time

Method 2



slope $= A_v = \left.\dfrac{dV_{OUT}}{dV_{IN}}\right|_{@\, V_{IN}=0.7}$

$$\boxed{A_v = \frac{v_{out}}{v_{in}} = \frac{dV_{OUT}}{dV_{IN}}}$$

npn BJT Cross Section