ESC201T : Introduction to Electronics

HW8: Solution

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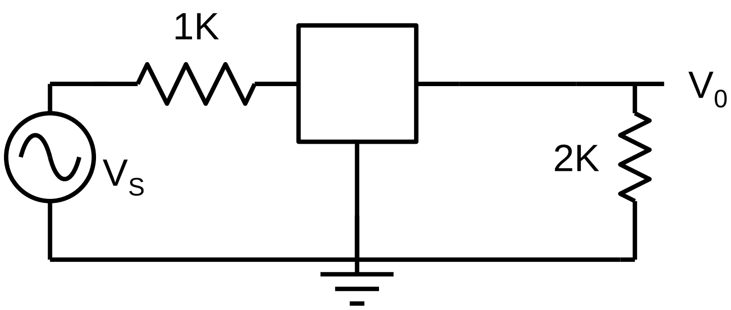
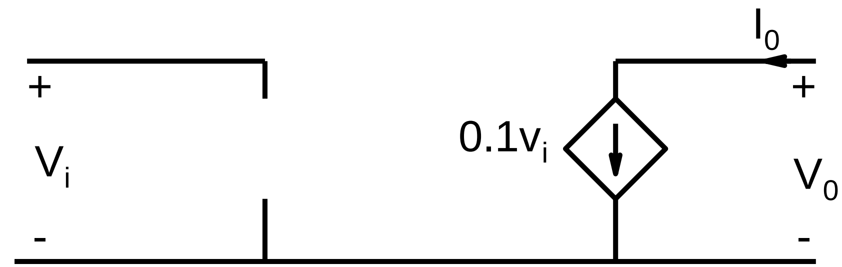
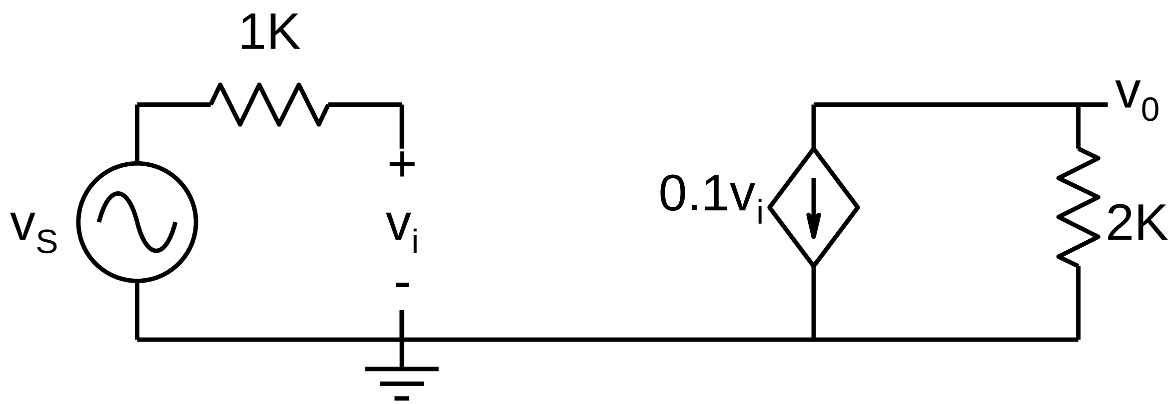
Q.1 Determine the voltage gain of the amplifier for the ideal transistor model shown below





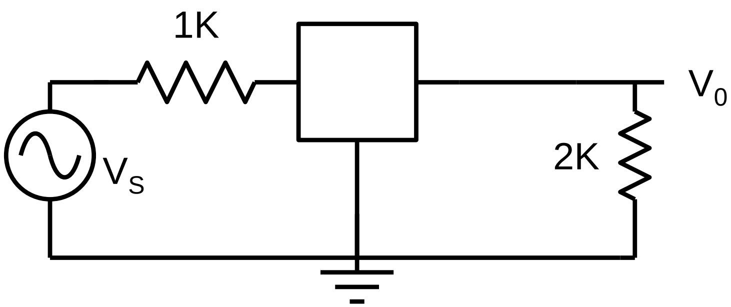


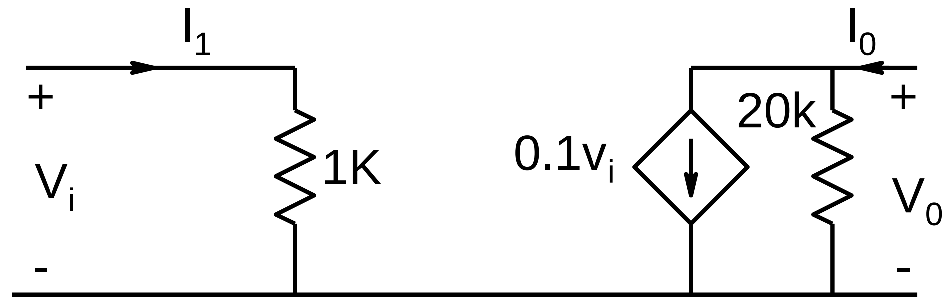
$$v_S = v_I$$

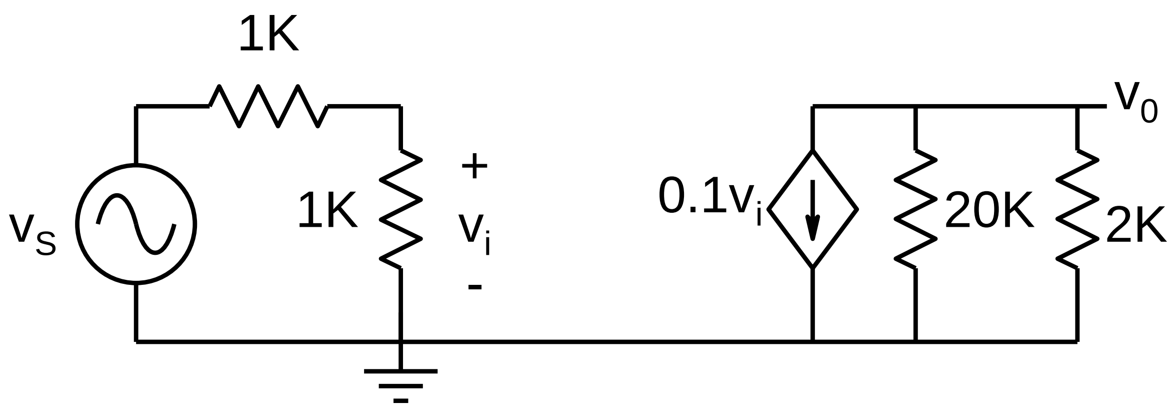
$$v_O = -0.1 v_I \times 2 \times 10^3$$

$$\frac{v_O}{v_S} = -200$$

Q.2 Determine the voltage and power gain of the amplifier shown below on the left for the transistor model shown below on the right







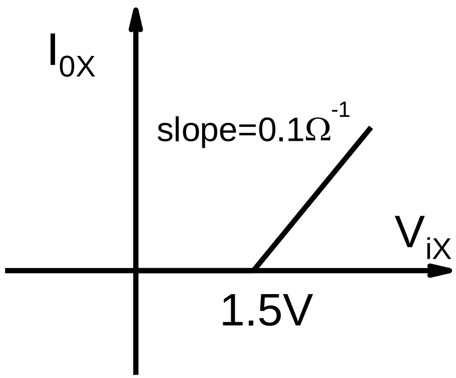
$$v_S = 0.5 v_I$$

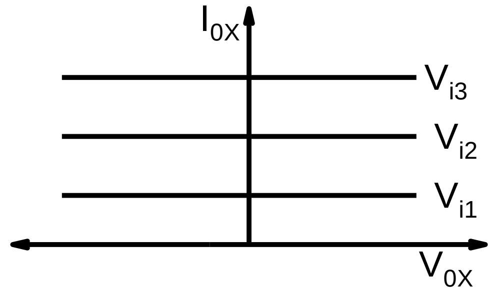
$$v_O = -0.1 v_I \times 2K \| 20K$$

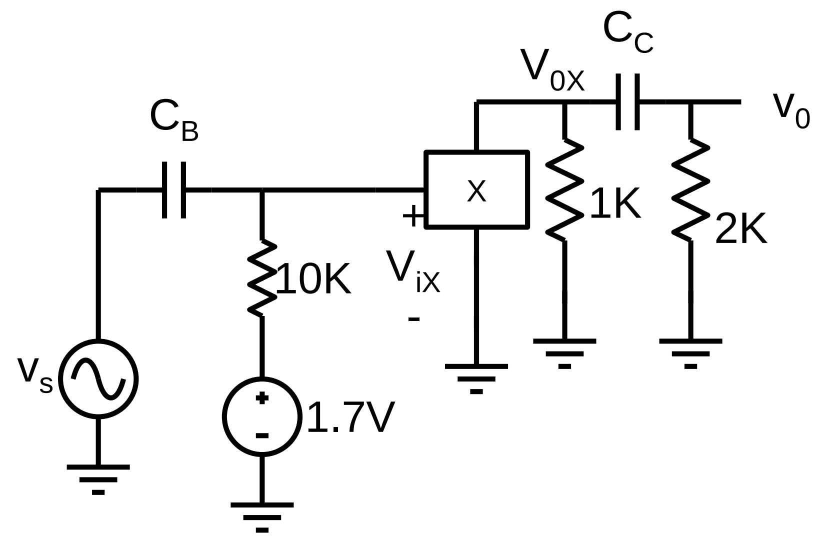
$$\frac{v_O}{v_S} = -90.9$$

Note that the consequence of finite input and output resistance is to reduce gain.

Q.3 Carry out dc and ac analysis of the amplifier circuit shown below on the right for the device X characteristics shown below on the left. Sketch V_{ix} V_{ox} and v_o for $v_s = 0.2\mathrm{Sin}(\omega t)$.







When there is both dc and ac source in the circuit, voltages and currents in general will have a dc component and an ac component. As a result two analysis, one dc and another ac have to be carried out.

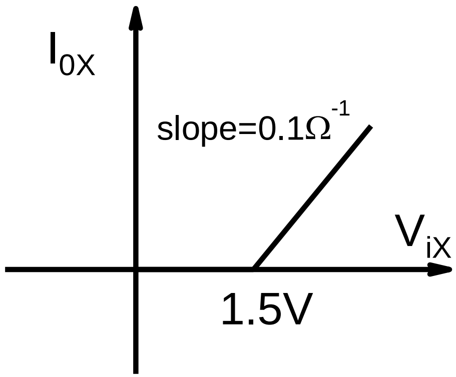
Note the convention in naming voltage (or current) at node X

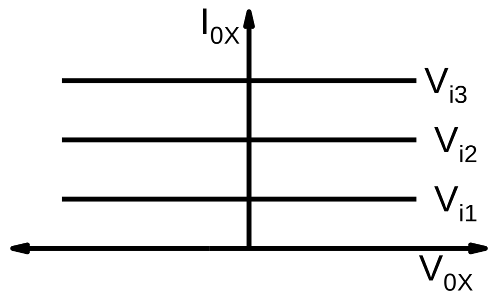
dc Voltage : V_X ; ac voltage : v_x ; Net Voltage: $V_x = V_X + v_x$

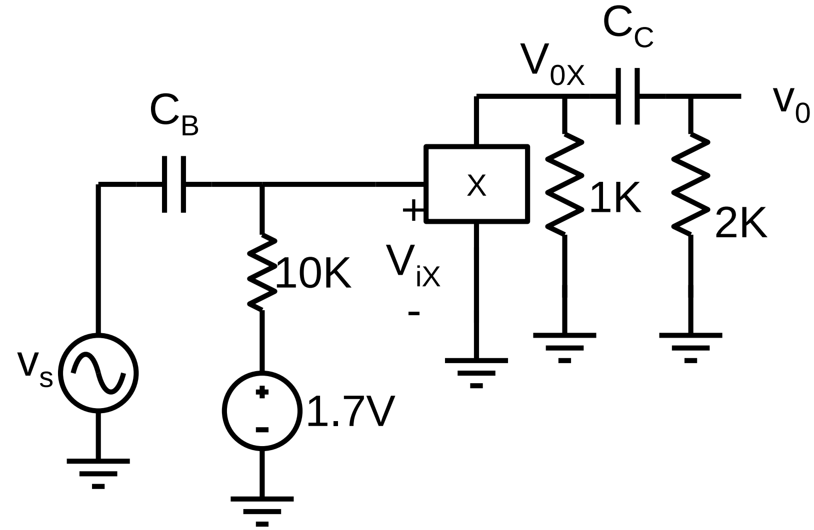
All capital letters

All small letters

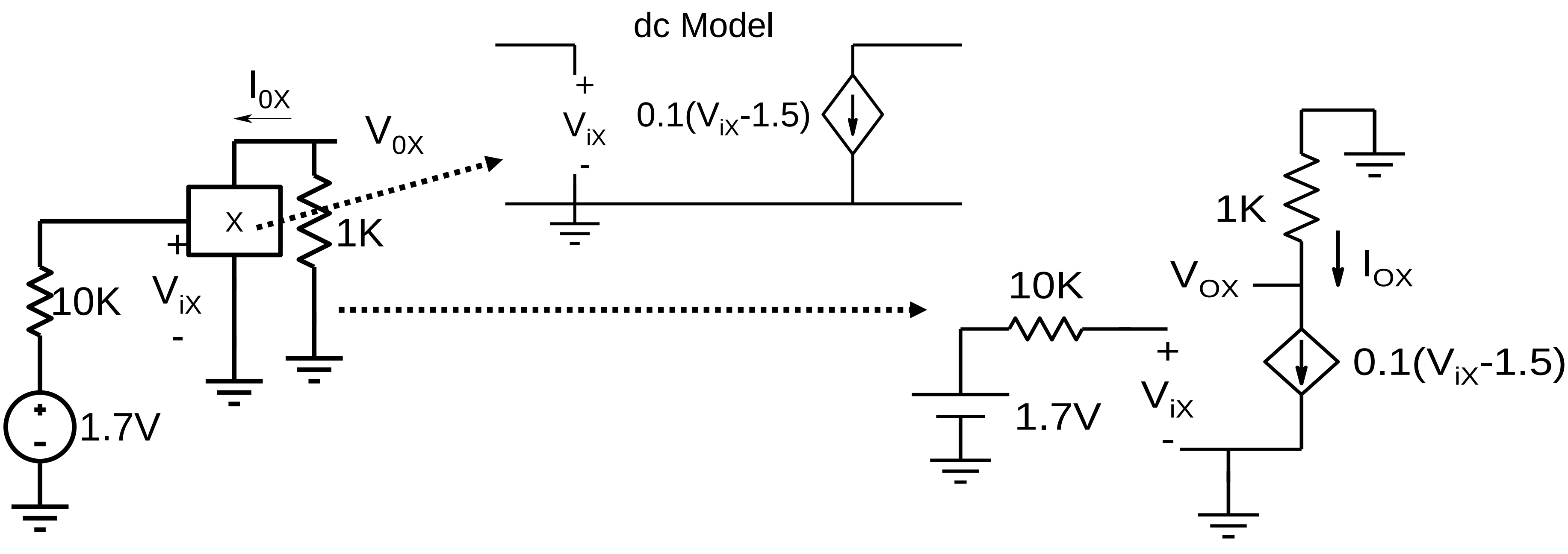
Subscript is small letters

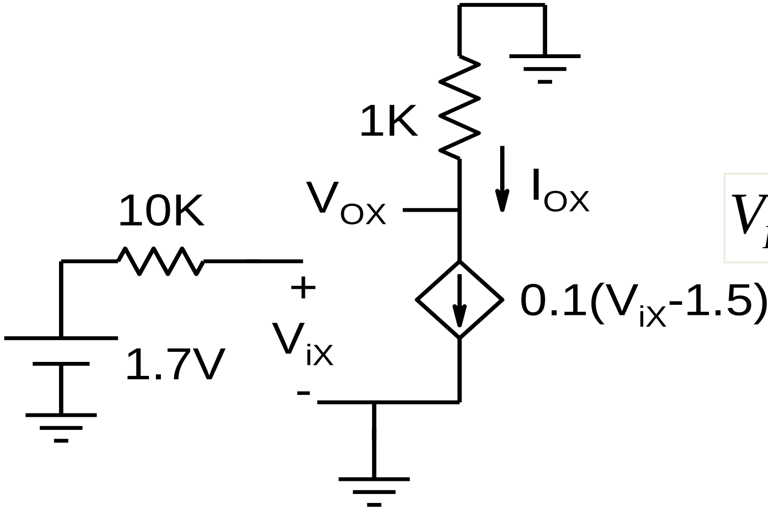






Dc analysis: draw the dc circuit obtained by open circuiting the capacitors



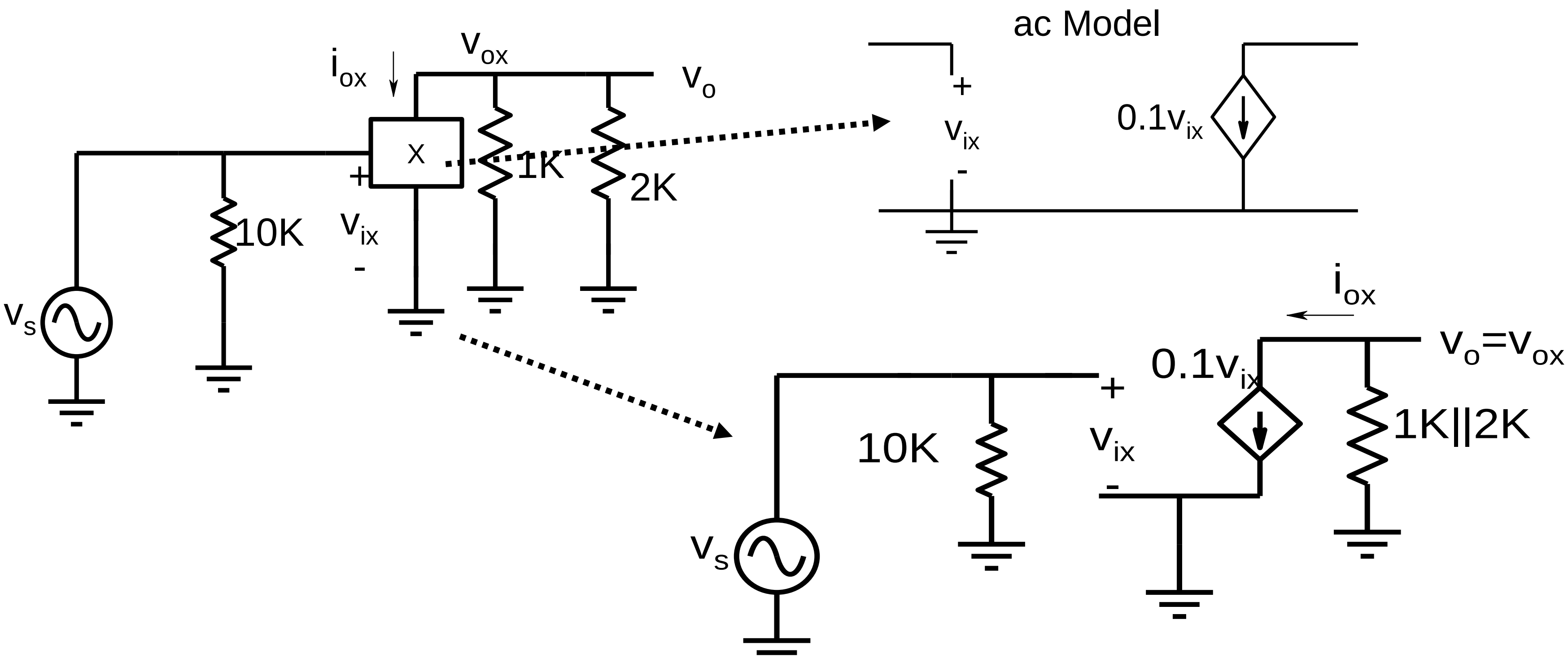


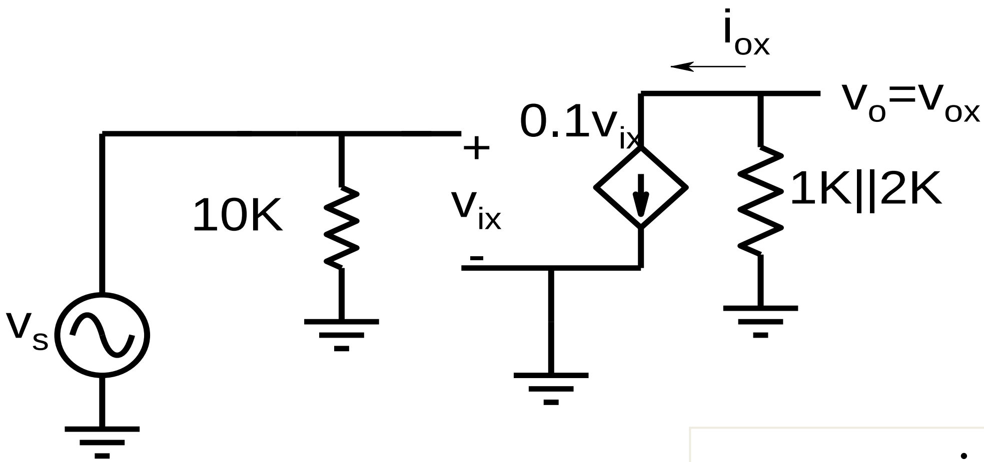
$$V_{IX} = 1.7V$$

$$I_{OX} = 0.1 \times (1.7 - 1.5) = 20mA$$

$$V_{OX} = -20mA \times 1K = -20V$$

Ac Analysis: draw the ac circuit by shorting the dc sources and capacitors





$$v_{ix} = v_s = 0.2Sin(\omega t)$$

$$i_{ox} = 0.1v_{ix} = 20mASin(\omega t)$$

$$v_{ox} = v_o = -i_{ox}1K \| 2K = -13.34V\ Sin(\omega t)$$

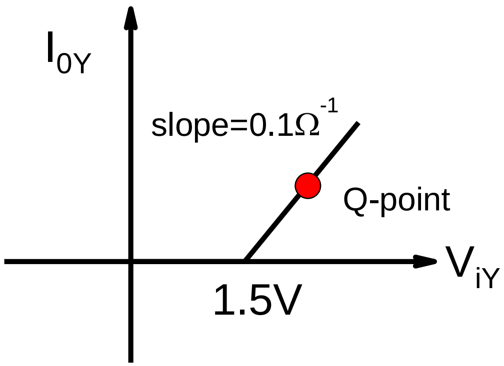
$$V_{ix} = V_{IX} + v_{ix} = 1.7 + 0.2Sin(\omega t)$$

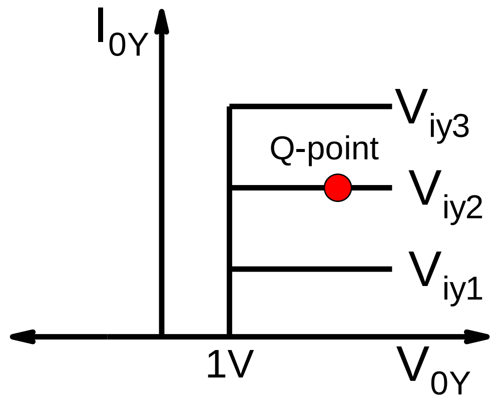
$$I_{ox} = I_{OX} + i_{ox} = 20mA + 20mASin(\omega t)$$

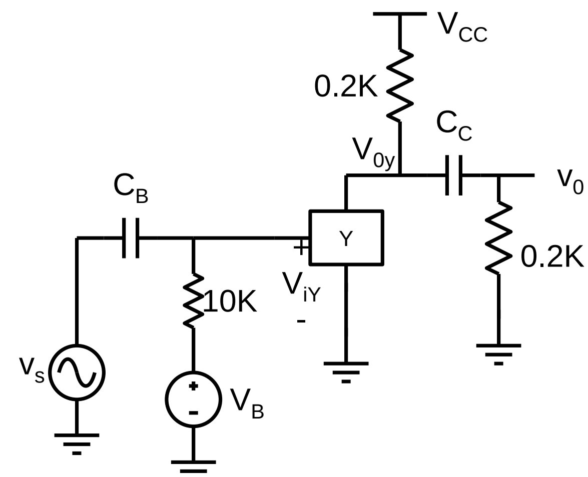
$$V_{ox} = V_{OX} + v_{ox} = -20 - 13.34Sin(\omega t)$$

$$v_o = -13.34V\ Sin(\omega t)$$

Q.4 Determine appropriate Q point (dc value of V_{iY} and V_{OY}) so that the amplifier shown below on the right would properly amplify an input voltage of $v_s = 0.2\text{Sin}(\omega t)$. Determine minimum supply voltage V_{CC} for which the amplifier would work properly.







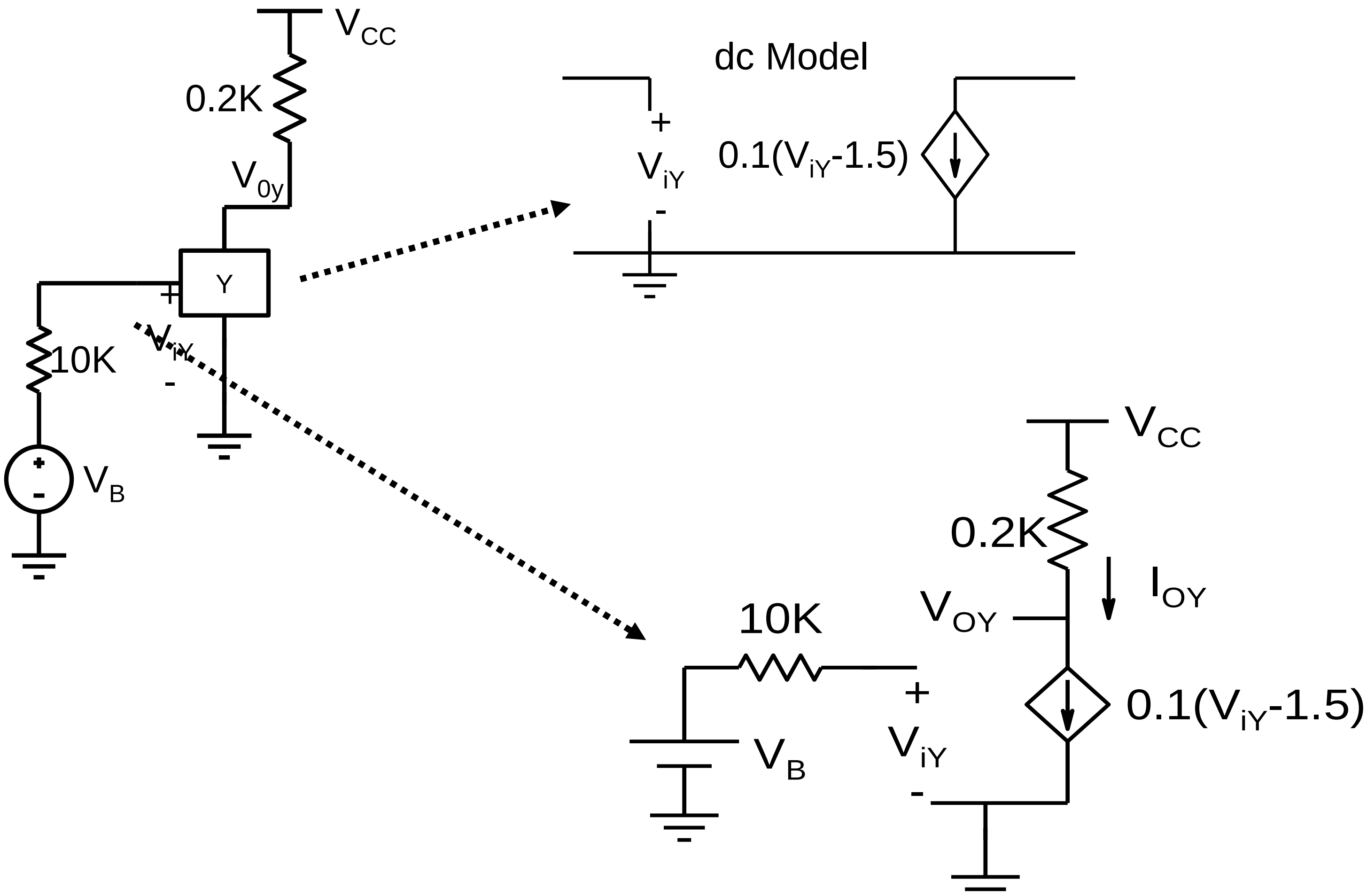
To ensure proper operation of the amplifier we have to make sure that device Y always operates in the region $V_{iy} > 1.5V$ and $V_{oy} > 1V$

$$V_{iy} = V_{IY} + v_{iy} > 1.5V$$

$$V_{oy} = V_{OY} + v_{oy} > 1V$$

We need to carry out dc and ac analysis to find dc and ac components of voltages

Dc analysis

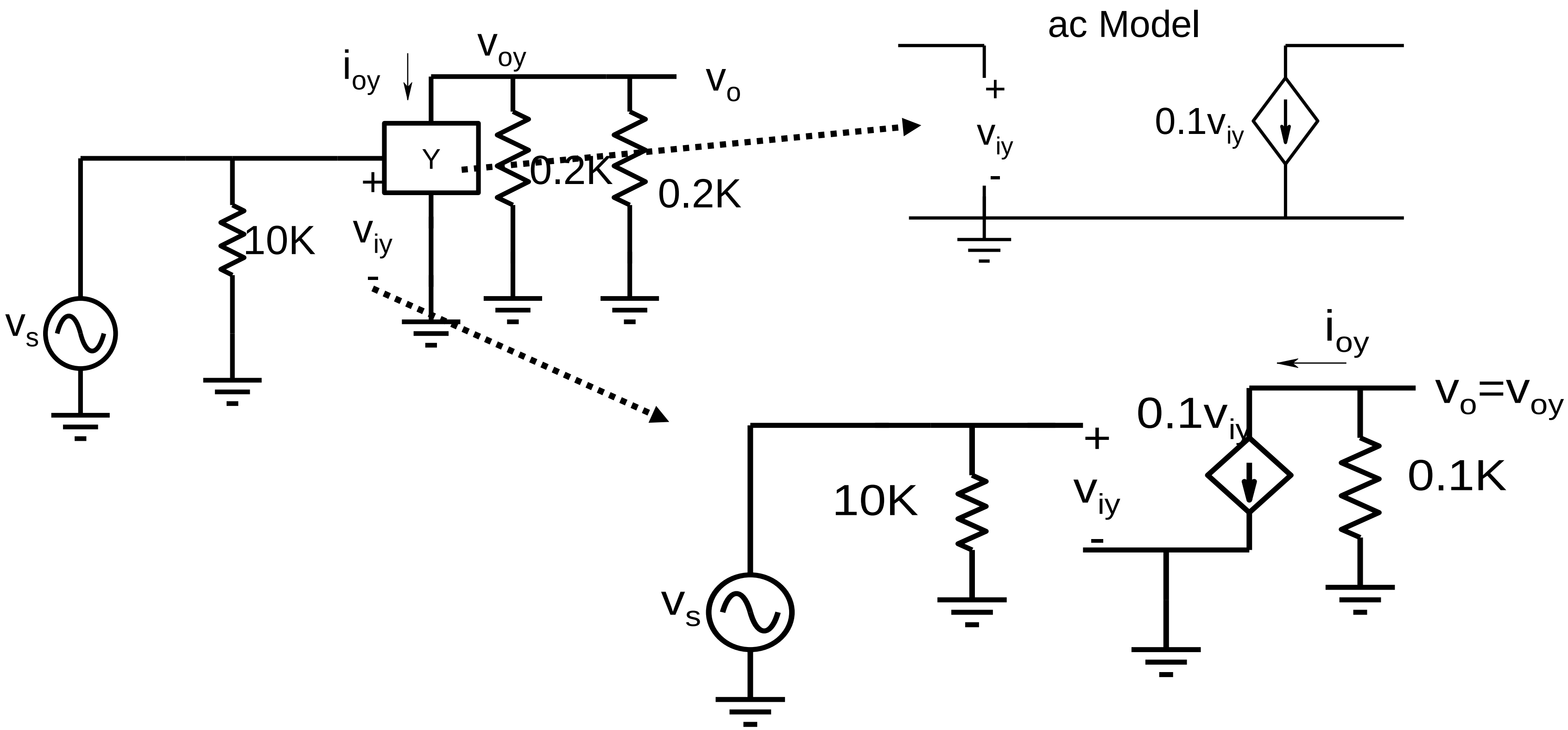


$V_{IY} = V_B$

$V_{OY} = V_{CC} - I_{OY} \times 0.2K$

$I_{OY} = 0.1 \times (V_{IY} - 1.5)$

Ac analysis



$$v_{iy} = v_s = 0.2Sin(\omega t)$$

$$i_{oy} = 0.1v_{iy} = 20mASin(\omega t)$$

$$v_{oy} = v_o = -i_{oy}0.1K = -2V\ Sin(\omega t)$$

Proper Q-point for Amplification

$$V_{iy} = V_{IY} + v_{iy} > 1.5V \Rightarrow V_{IY} - 0.2Sin(\omega t) > 1.5$$

$$\Rightarrow V_{IY} > 1.7$$

$$V_{oy} = V_{OY} + v_{oy} > 1V$$

$$v_{oy} = v_o = -2V\,Sin(\omega t)$$

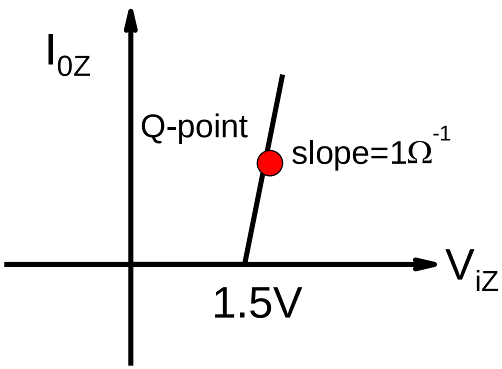
$$V_{OY} - 2VSin(\omega t) > 1V$$

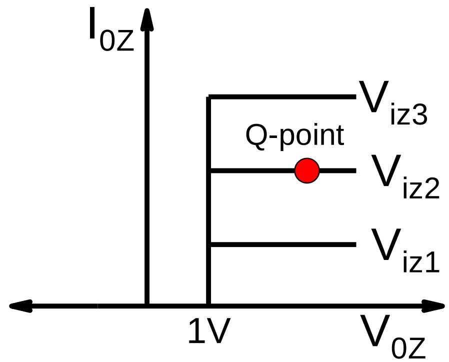
$$\Rightarrow V_{OY} > 3V$$

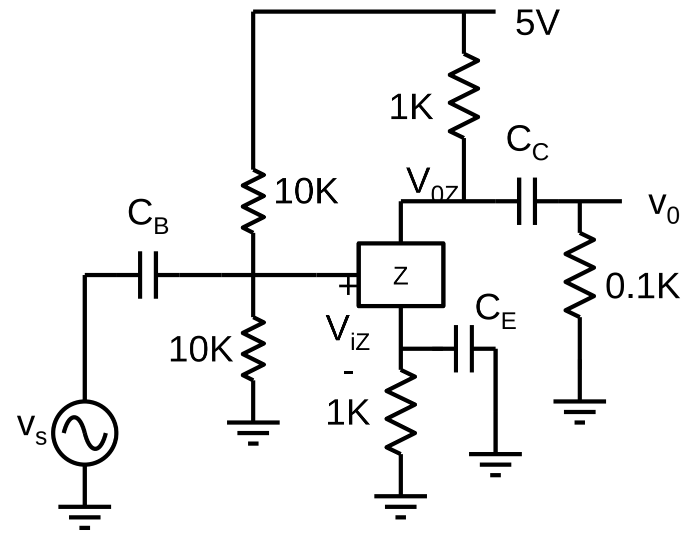
Let us choose $V_{IY} = 1.8$ and $V_{OY} = 4$

$$V_{OY} = V_{CC} - I_{OY} \times 0.2K \Rightarrow V_{CC} = 4 + 0.03 \times 200 = 10V$$

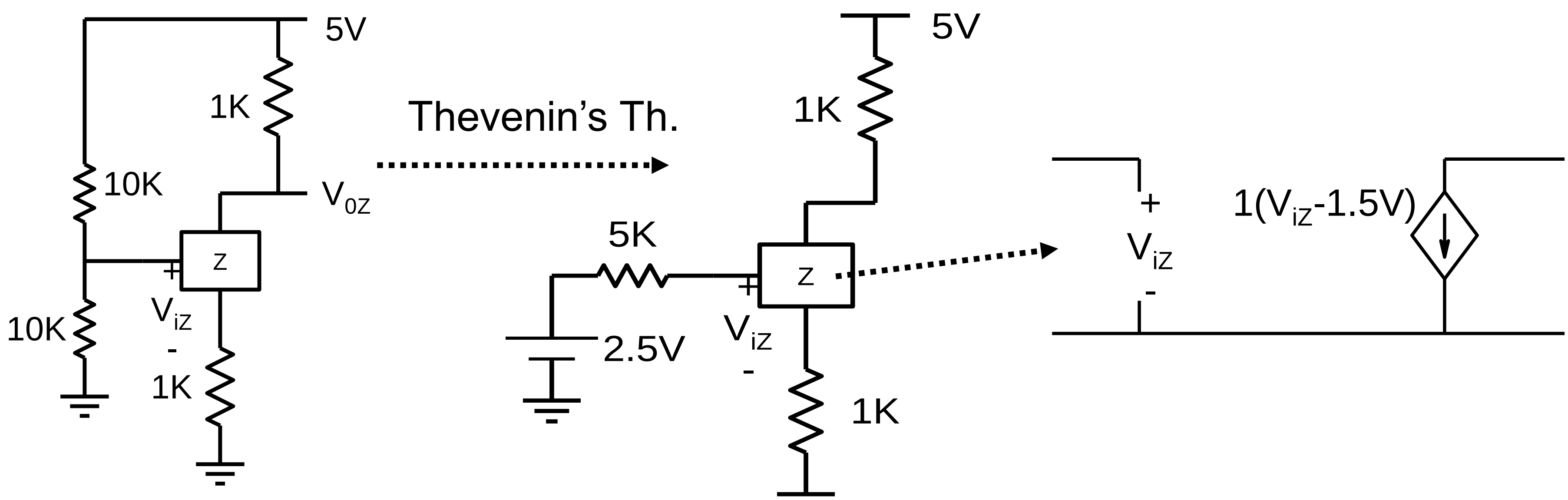
Q.5 Carry out dc and ac analysis of the amplifier circuit shown below on the right to determine bias or Q- point (dc value of I_{OZ} and V_{OZ}) and ac voltage gain.

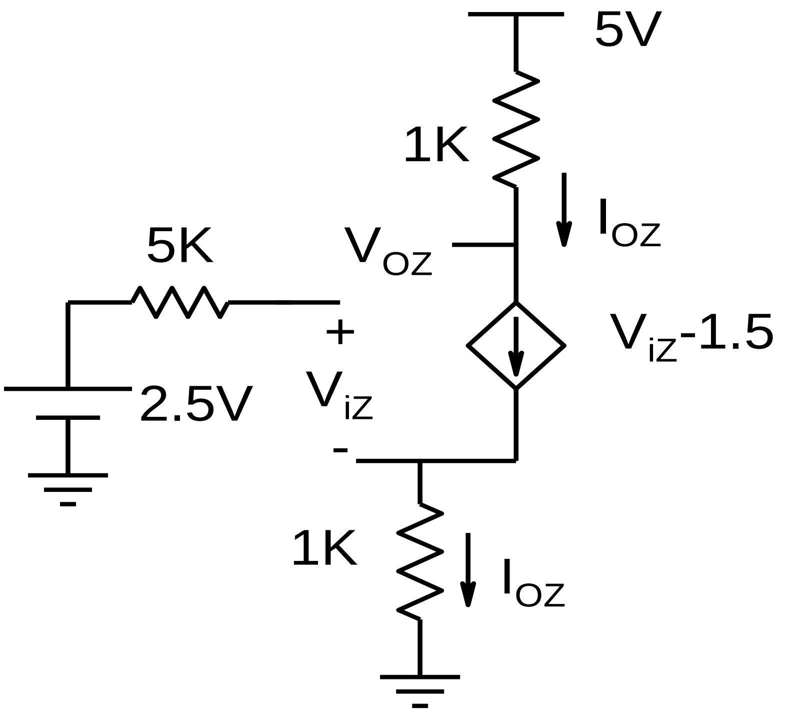






Dc analysis: draw the dc circuit obtained by open circuiting the capacitors





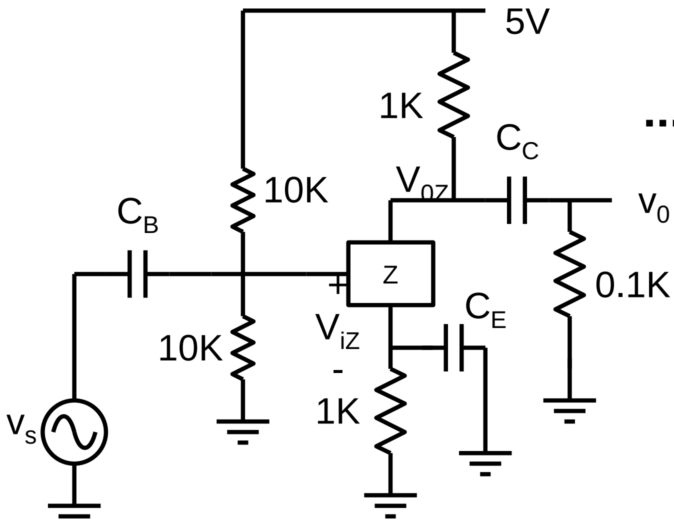
$$-2.5V + V_{iz} + I_{OZ} \times 10^3 = 0$$

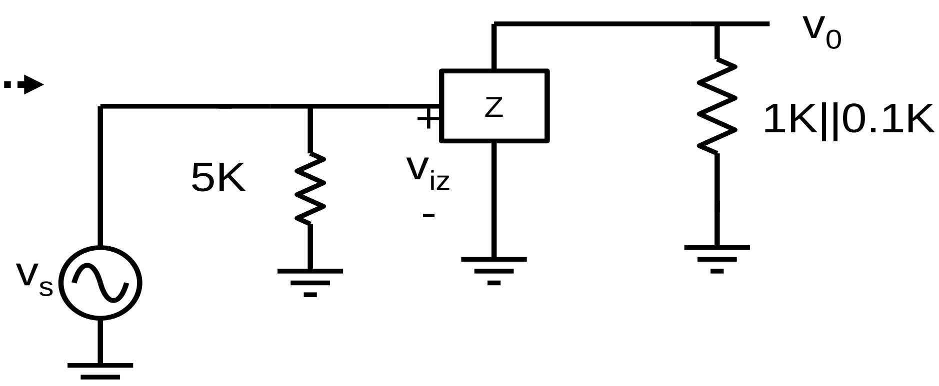
Since I_{oZ} vs. V_{iZ} characteristics is very sharp, V_{iZ} ~ 1.5V

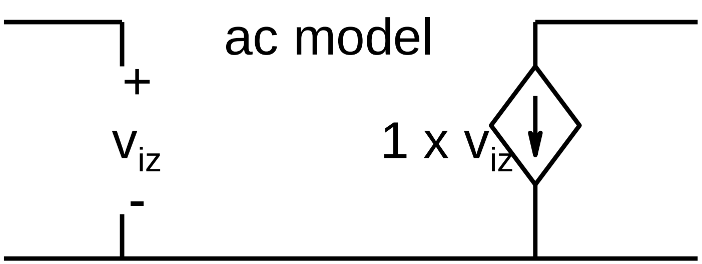
$$I_{OZ} \cong 1mA$$

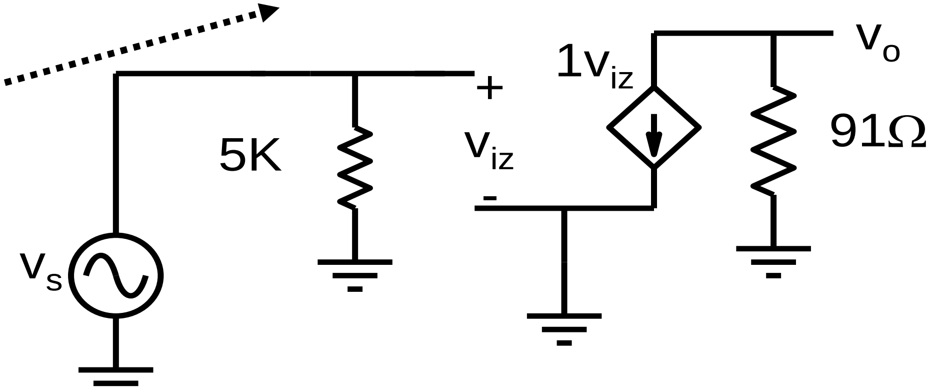
$$V_{OZ} = 5 - 1 = 4V$$

Ac Analysis: draw the ac circuit by shorting the dc sources and capacitors









$$\frac{v_o}{v_s} = -1 \times 91$$