22nd September, 2016

Home Assignment – 7

[**Note:** DC Voltage = V_I (all capital letters); ac Voltage = v_i (all small letters); Net voltage = V_i (base is in capital and subscript is in small letter; device (A, X, Y or Z) is always in capital letter]

1. Determine the ac **voltage gain** of the amplifier '**A**' as shown in **Fig. 1(a**) using the **transistor model** shown in **Fig. 1(b)** and **Fig. 1(c)** as dotted region**.** Assume that the device '**A'** is biased properly.

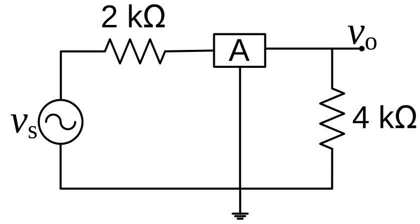


Fig. 1(a)

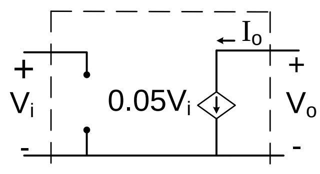


Fig. 1(b)

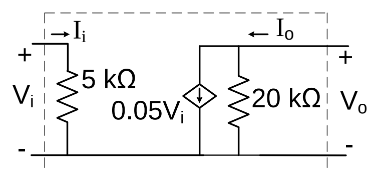


Fig. 1(c)

2. Carry out DC and AC analysis of the amplifier circuit, with amplifier '**X**', whose device characteristics are shown in **Fig. 2**. Also, sketch V_{iX}, V_{oX} and v_s for $v_S = 0.2\sin(\omega t)$.

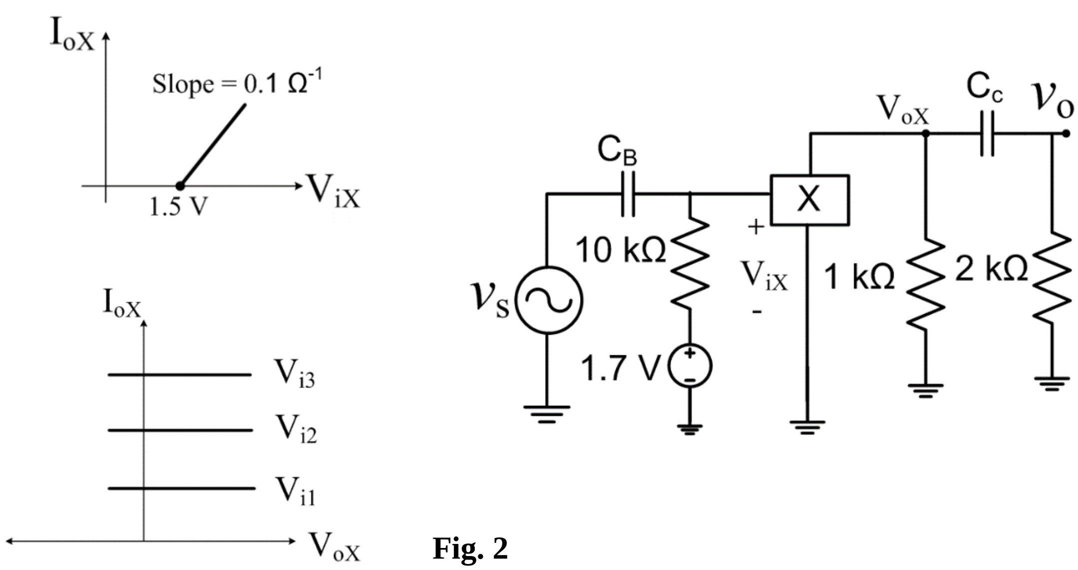


Fig. 2

3. Determine appropriate **Q point** (DC value of $\mathbf{V_{iY}}$ and $\mathbf{V_{oY}}$) so that amplifier shown in **Fig. 3** would properly amplify an input voltage of $v_S = 0.2\sin(\omega t)$. Also, determine minimum supply voltage $\mathbf{V_{CC}}$ for which the amplifier would work properly.

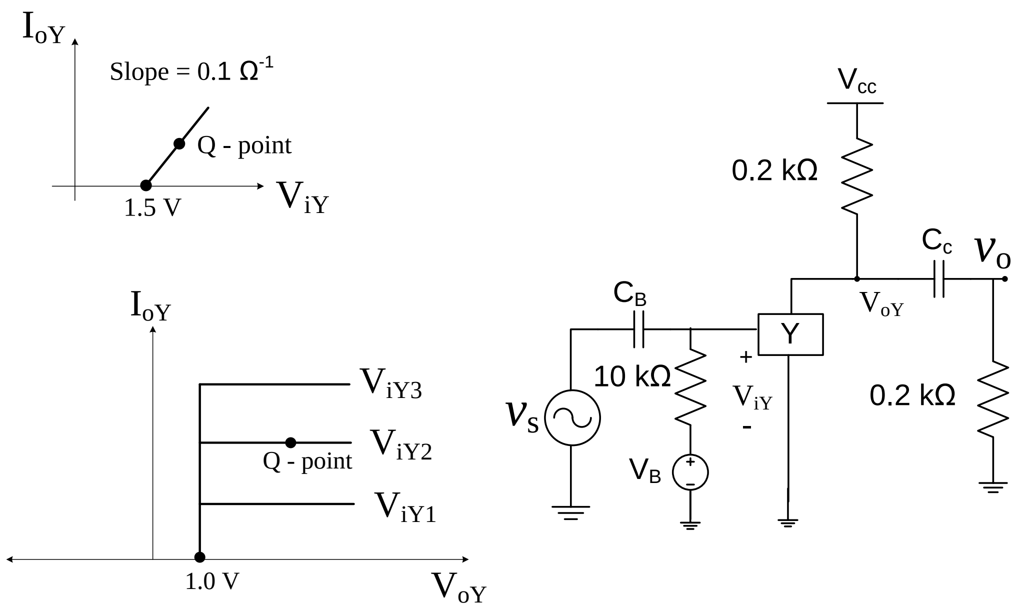


Fig. 3

4. Carry out DC and AC analysis of the amplifier circuit shown in **Fig. 4** to determine **bias** or **Q point** (DC value of $\mathbf{I_{oZ}}$ and $\mathbf{V_{oZ}}$) and **ac voltage gain**.

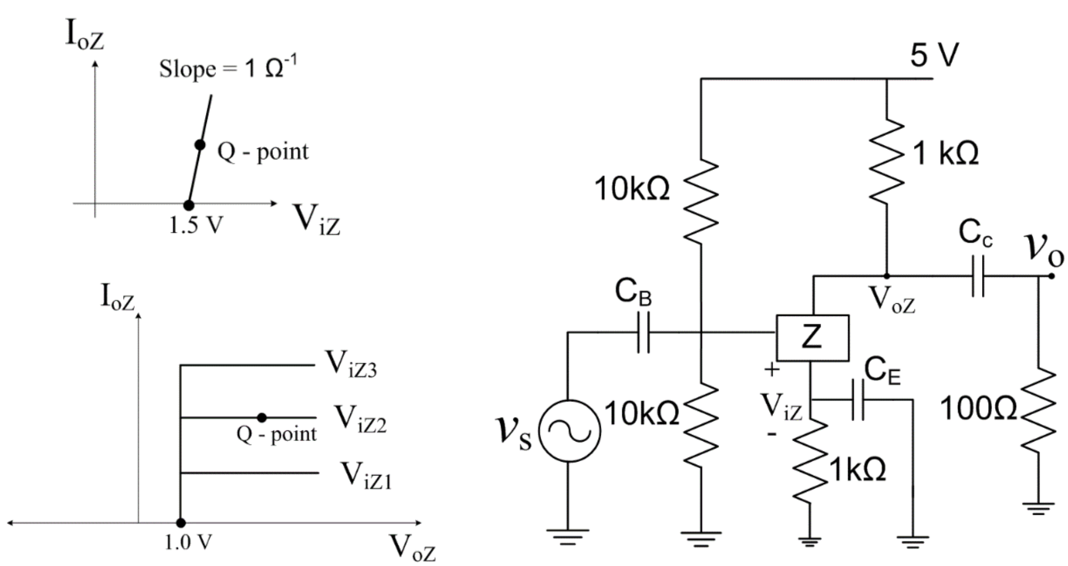
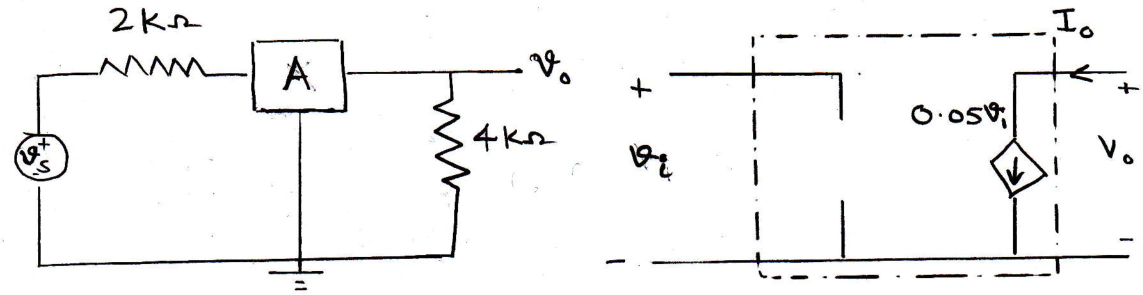
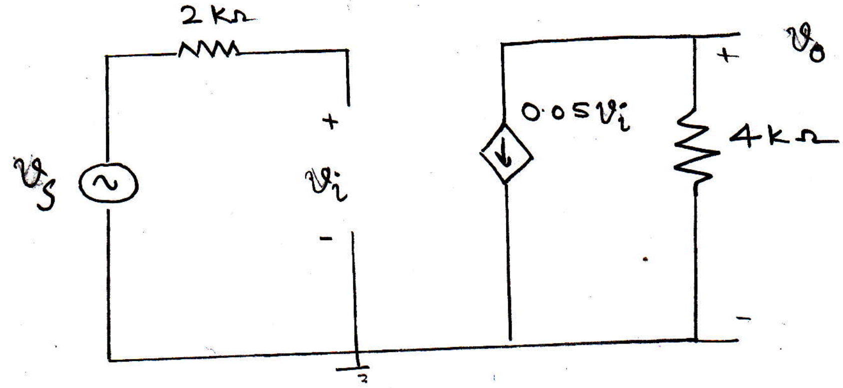


Fig.4

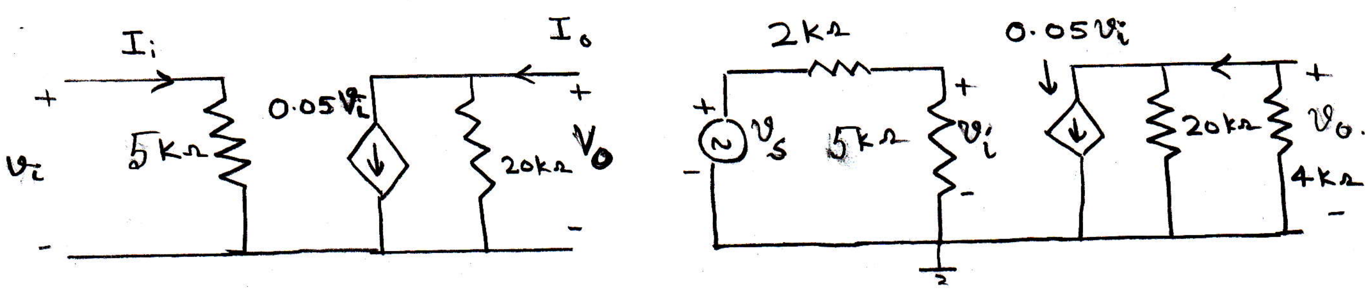




$\because\ v_i = v_s$ $\qquad v_o = -0.05\, v_i \times 4\times10^3$

$\Rightarrow v_o = -0.05\, v_s \times 4\times10^3$

$\Rightarrow$ Voltage Gain $= \dfrac{v_o}{v_s} = -200$



$\Rightarrow \because v_i = v_s \times \dfrac{5\times10^3}{5\times10^3 + 2\times10^3} = \dfrac{5V_s}{7}$

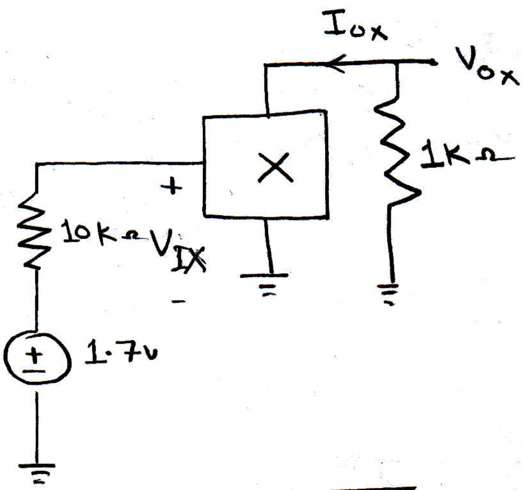
$\Rightarrow \because v_o = -0.05\, v_i \times R_{eq}.$ $\qquad R_{eq} = 20\,k\Omega \,||\, 4\,k\Omega.$

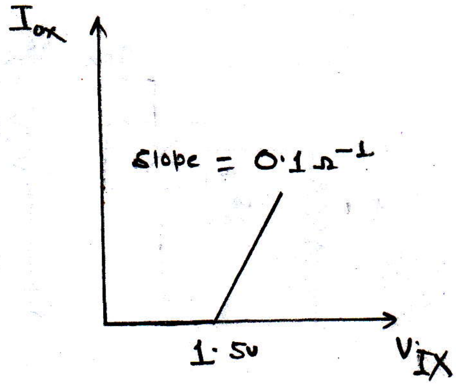
$= 3.33\ k\Omega$

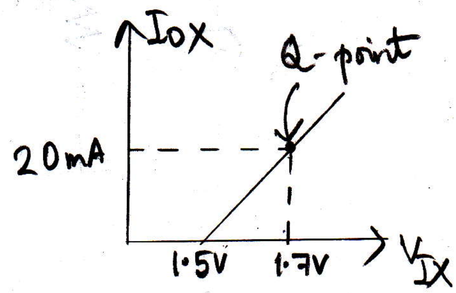
$\Rightarrow v_o = -0.05 \times \dfrac{5v_s}{7} \times 3.33\times10^3$

$\therefore$ Voltage Gain $= \dfrac{v_o}{v_s} = -0.05 \times \dfrac{5}{7} \times 3.33\times10^3 = -119.04$

1. DC Analysis:- for DC circuit analysis capacitors are open circuited.







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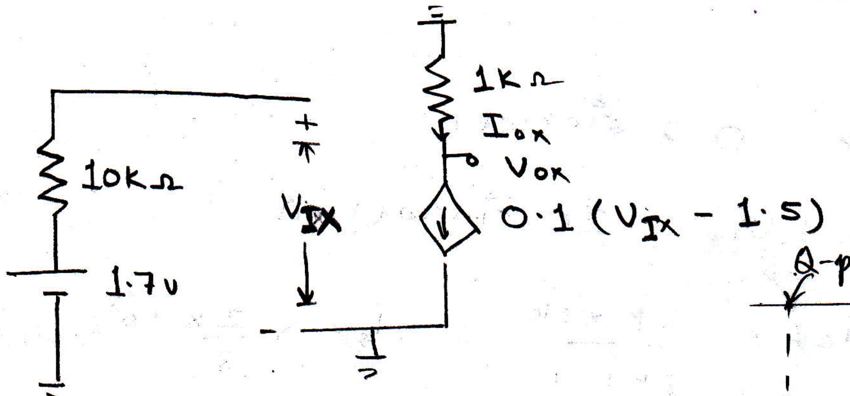
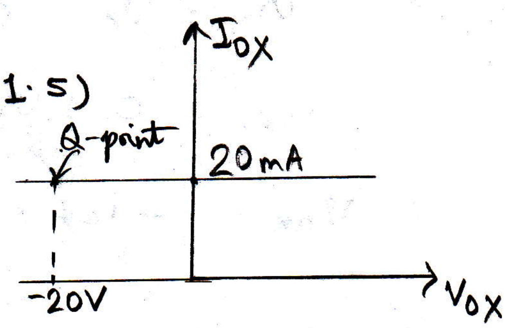




$\because V_{IX} = 1.7$ V. $\quad \therefore I_{ox} = 0.1 \times (1.7 - 1.5)$

$= 20$ mA

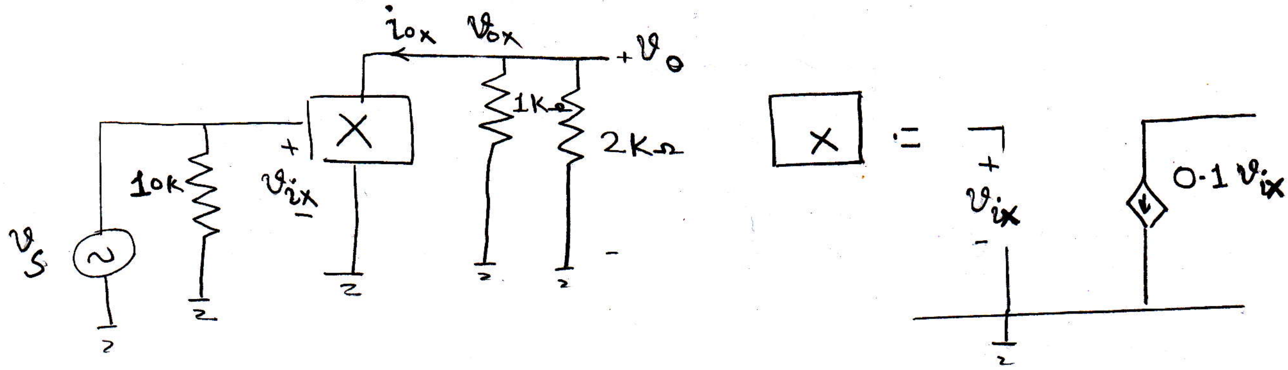
$\because V_{ox} = -I_{ox} \times 1 \times 10^3 = -20 \times 10^{-3} \times 1 \times 10^3$

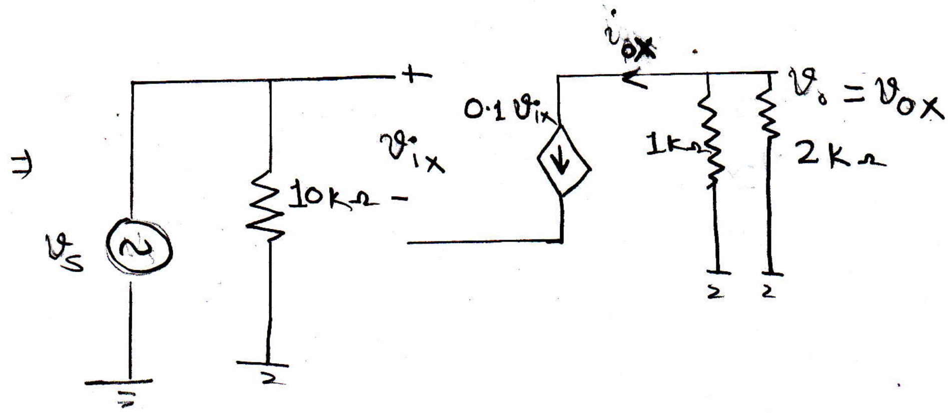
$\Rightarrow V_{ox} = -20$ V.

[dc voltage: V_I ; ac voltage: v_i ; Net voltage: V_i]

All Capital letters — All small letters — Subscript is small letters

AC Analysis:- All capacitors & DC voltage sources are short circuited.





$\Rightarrow \because v_{ix} = v_s = 0.2 \sin(\omega t)$

$i_{ox} = 0.1 v_{ix} = 20 \sin(\omega t)$ mA.

$\Rightarrow v_{ox} = -i_{ox} \times \dfrac{2k \times 1k}{2k + 1k} = -i_{ox} \times \dfrac{2}{3} \times 10^3 = -20 \times \dfrac{2}{3} \sin(\omega t)$

$\Rightarrow v_{ox} = v_o = -13.34 \sin(\omega t)$ V.

So, total V_{ix}, I_{ox}, V_{ox} can be written as,

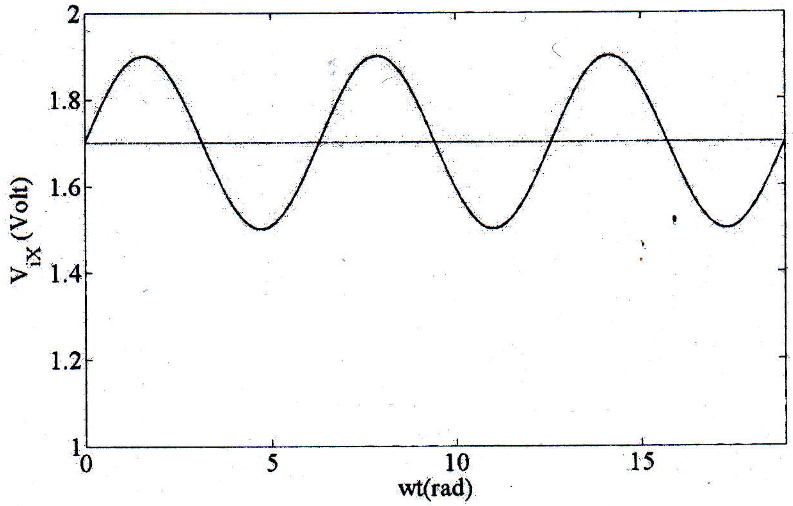
$\Rightarrow V_{ix} = V_{IX} + v_{ix} = 1.7 + 0.2 \sin(\omega t)$

$\Rightarrow I_{ox} = I_{ox} + i_{ox} = 20$ mA $+ 20 \sin(\omega t)$ mA

$\Rightarrow V_{ox} = V_{ox} + v_{ox} = -20 - 13.34 \sin(\omega t)$ V

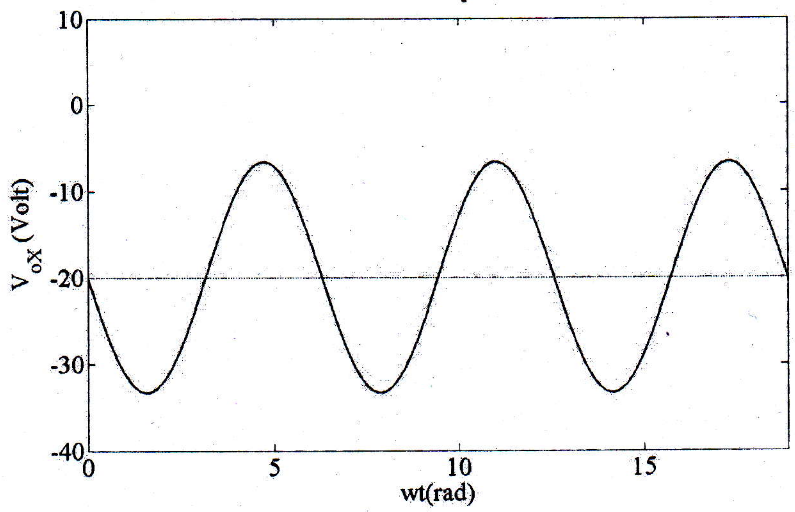
$\Rightarrow v_o = -13.34 \sin(\omega t)$ V. (due to capacitor C_c.) DC portion is blocked.

P- 4



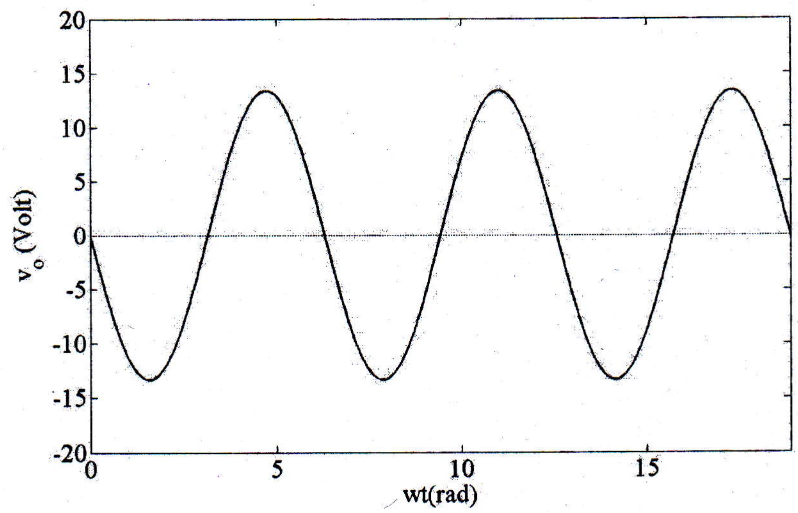
1.7+0.2=1.9

1.7-0.2=1.5

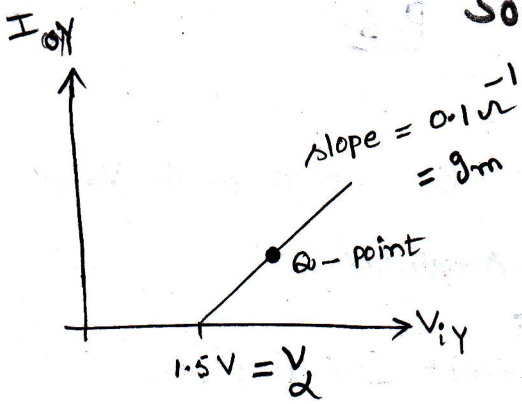


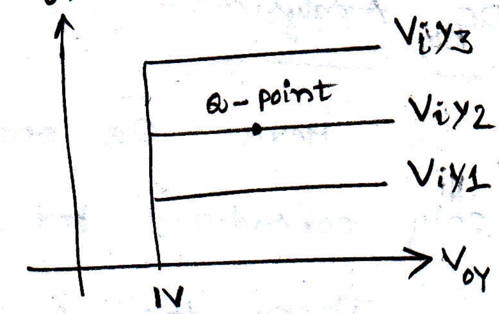
-20+13.34=-6.66

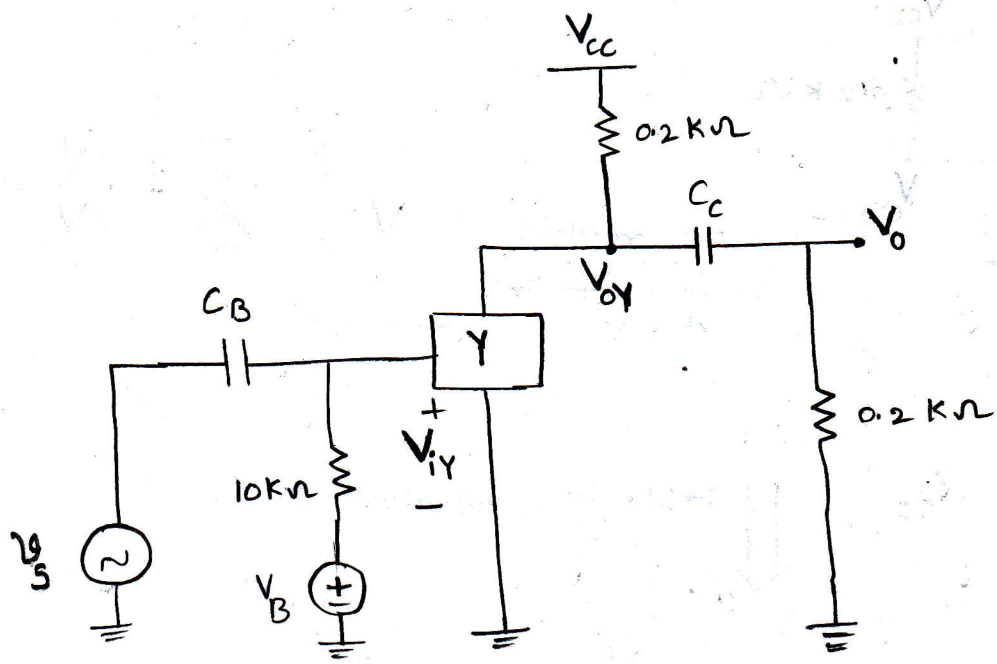
-20-13.34=-33.34



SOLN 3







From the device characteristics given above, we can see that transistor works properly,

when

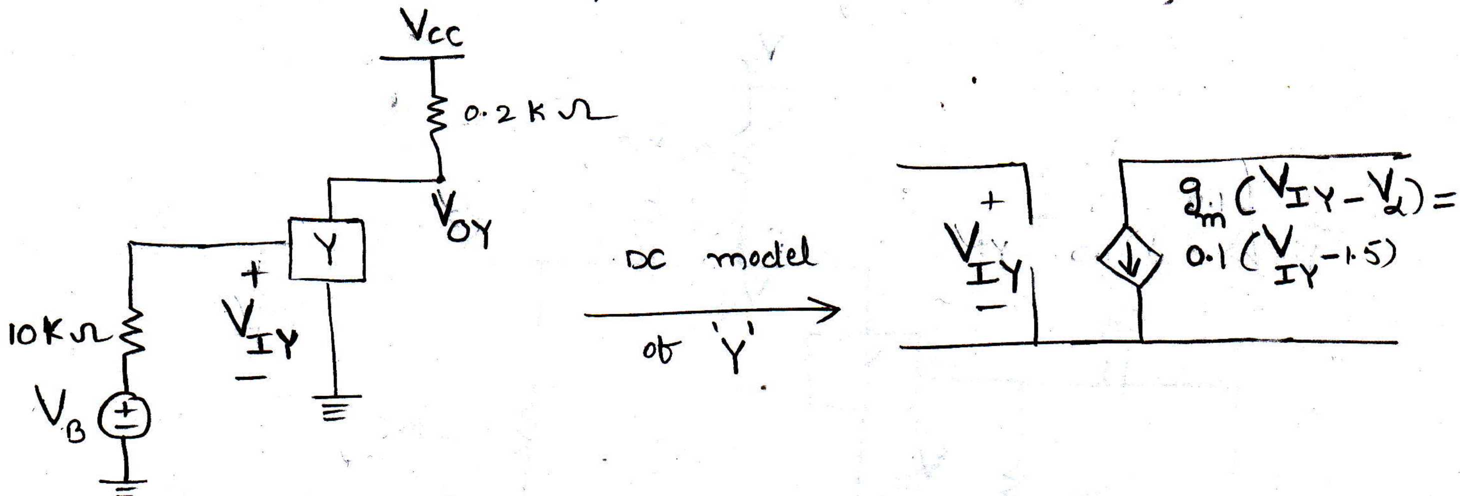
$$V_{iY} \geq 1.5\,V \quad \text{and} \quad V_{OY} \geq 1V \quad \left[\because \begin{matrix} V_{iY} = V_{IY} + v_{iY} \\ V_{OY} = V_{OY} + v_{oY} \end{matrix}\right]$$

Now to find out desired voltages we carry out 'DC' and 'AC' analysis as depicted below.

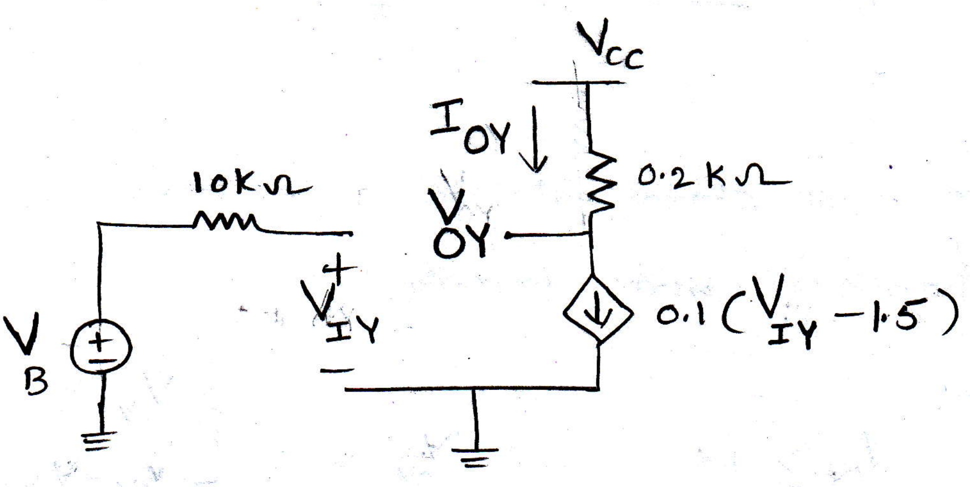
DC Analysis :-

Here C_B and C_c will be open and V_B is only considered for further analysis.

Then the Amplifier circuit reduces to,



This is equivalent to



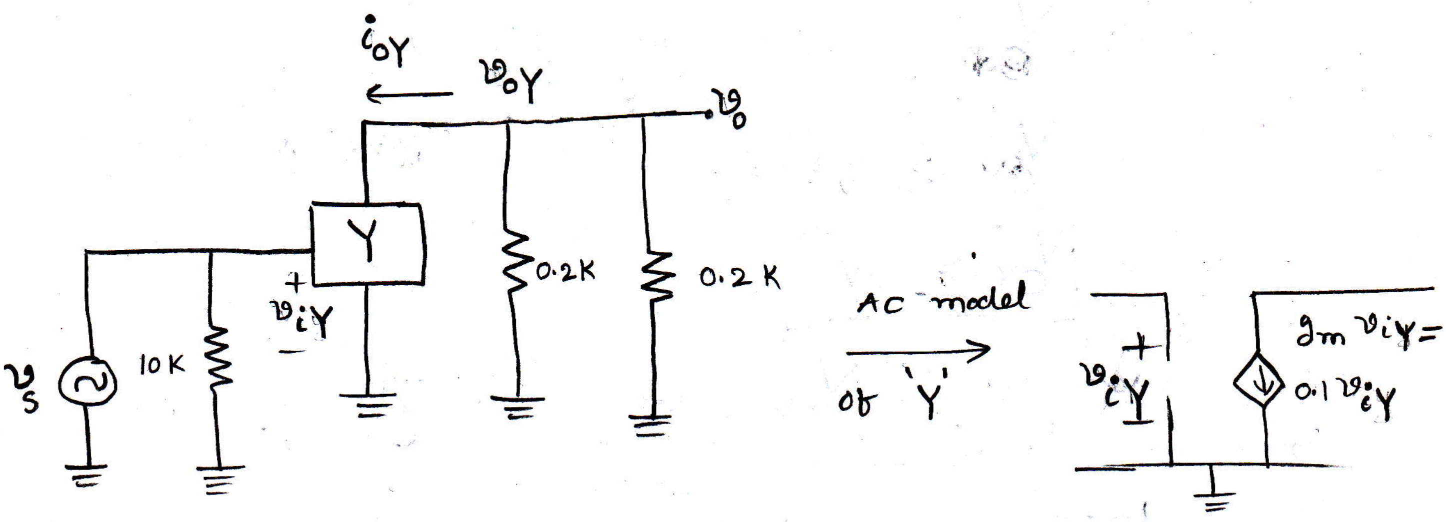
From the figure, $V_{IY} = V_B$

$$I_{OY} = 0.1(V_{IY} - 1.5) \quad \text{--------- (1)}$$

$$V_{OY} = V_{cc} - 200\, I_{OY} \quad \text{--------- (2)}$$

AC analysis:

Here 'V_B', 'C_B' and 'C_C' are shorted.



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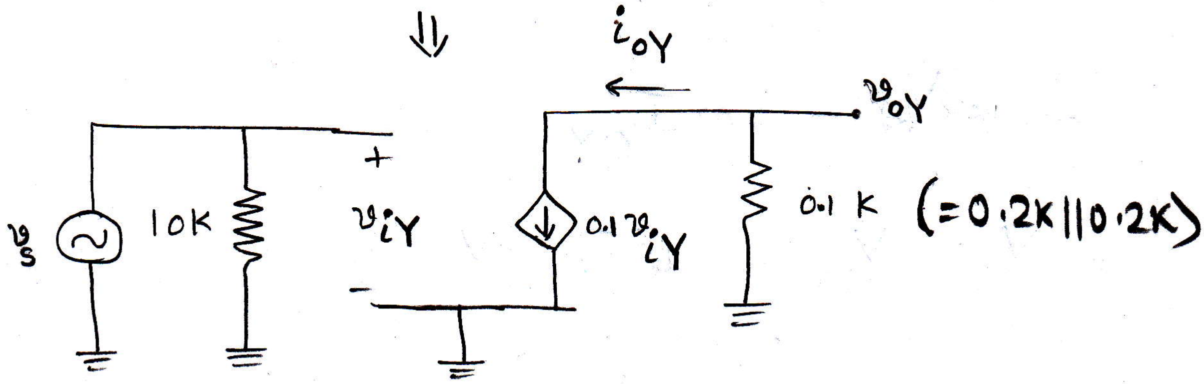
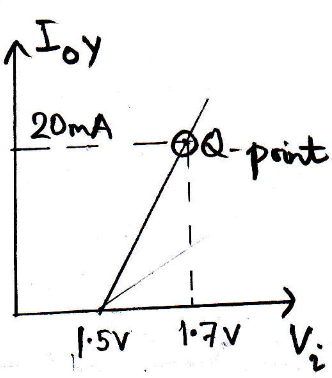


$$v_{iY} = v_s = 0.2 \sin(\omega t) \text{ Volts}$$

$$i_{oY} = 0.1\, v_{iY} = 0.02 \sin(\omega t) \text{ Amp.}$$

& $$v_{oY} = -0.1K \times i_{oY} = -2 \sin(\omega t) \text{ Volts}$$

Determination of Q-point :-



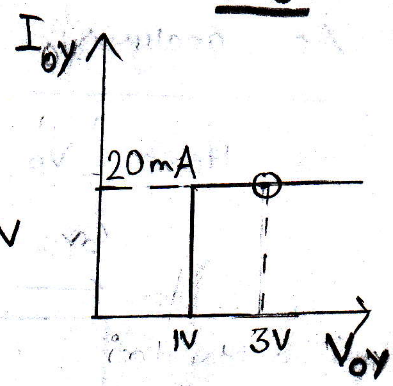
$$V_{iY} = V_{IY} + v_{iY} \geq 1.5\text{ V}$$

$$\Rightarrow V_{IY} + 0.2 \sin(\omega t) \geq 1.5\text{ V}$$

$$\Rightarrow V_{IY} - 0.2 \geq 1.5\text{ V}$$

$$\Rightarrow \boxed{V_{IY} \geq 1.7\text{ V}}$$

$$V_{OY} = V_{OY} + v_{oy} \geq 1V$$



$$\Rightarrow V_{OY} - 2\sin(\omega t) \geq 1V$$

$$\Rightarrow V_{OY} \geq (2+1)V$$

$$\Rightarrow \boxed{V_{OY} \geq 3V}$$

let us choose $V_{IY} = 1.7V$ and $V_{OY} = 3V$ (since we have to find minimum V_{cc})

Then, from ② we have,

$$V_{OY} = V_{cc} - 200\, I_{OY}$$

$$\Rightarrow V_{cc} = V_{OY} + 200\left[0.1\left(V_{IY} - 1.5\right)\right] \quad [\because \text{From } ①]$$

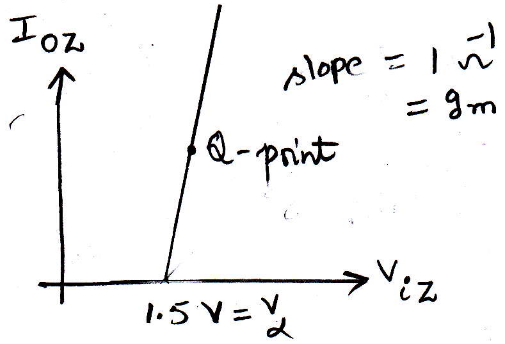
$$= 3 + 200 \times 0.1 \times (1.7 - 1.5)$$

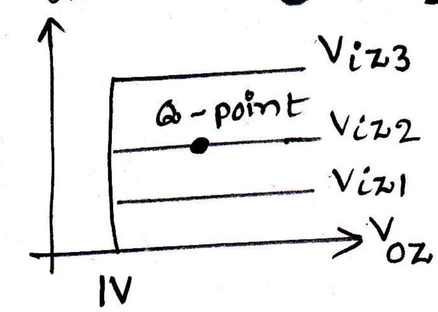
$$= 3 + (200 \times 0.1 \times 0.2)$$

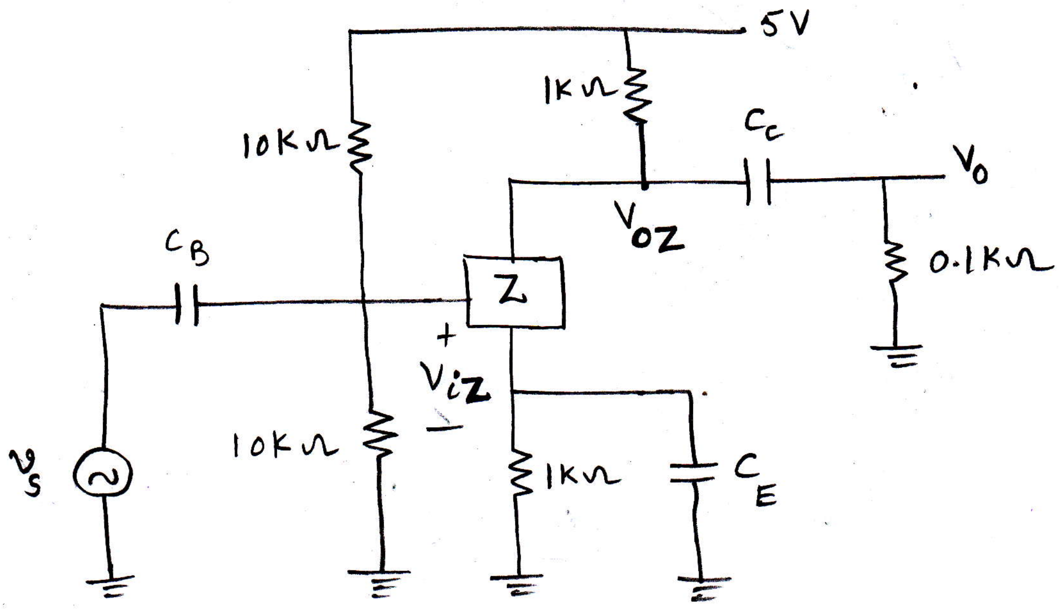
$$= 3 + 4 = 7\ V$$

$$\therefore \boxed{V_{cc} = 7V}$$

Minimum V_{cc} of 7Volts is needed for proper working of Amplifier.

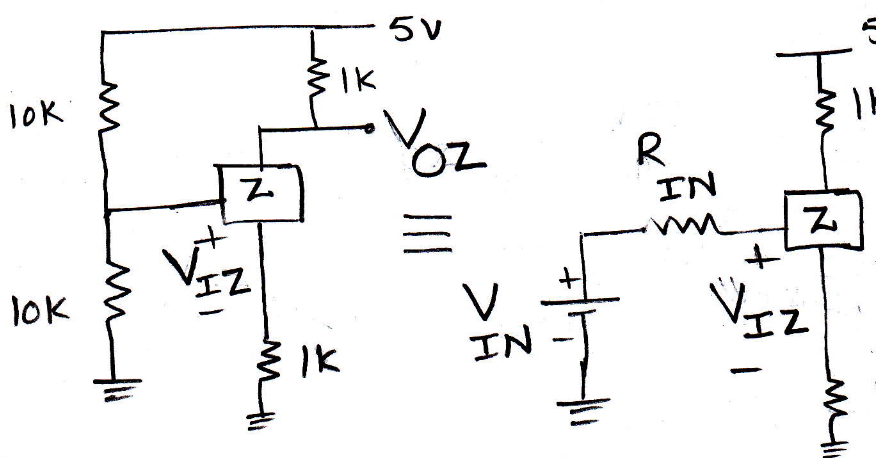






Dc Analysis :-

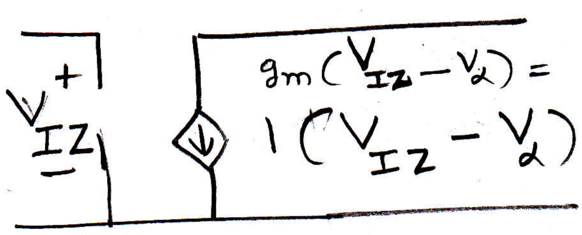
The equivalent circuit, after capacitors being opened, is



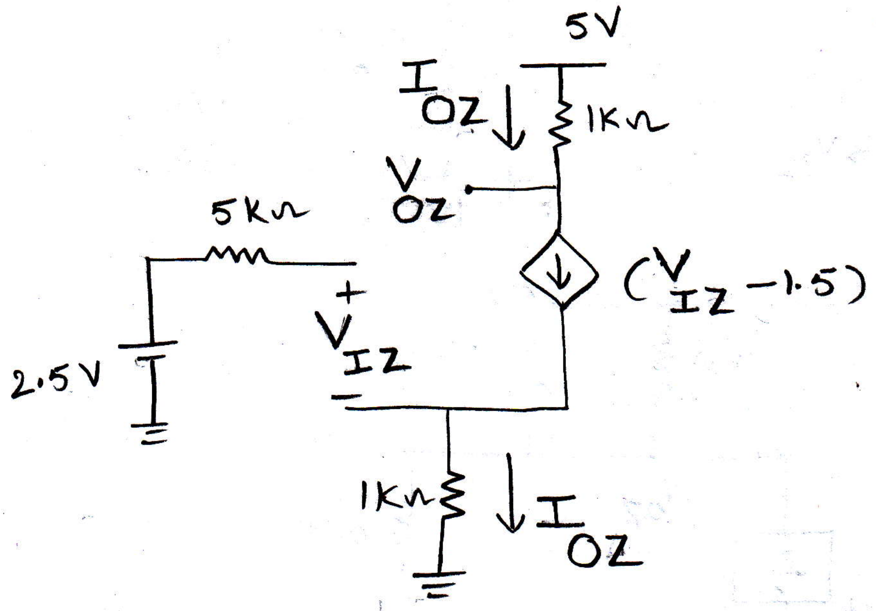
$$R_{IN} = 10K \parallel 10K = 5K\,\Omega$$

$$V_{IN} = 5 \times \frac{10K}{10K+10K} = \frac{5}{2} = 2.5\,V.$$

Moreover 'Z' is equivalent to,



Now the actual circuit looks like,



From the figure we can write that,

$$I_{OZ} = V_{IZ} - 1.5$$

and

$$-2.5 + V_{IZ} + 1000\, I_{OZ} = 0$$

$$\Rightarrow -2.5 + V_{IZ} + 1000\,(V_{IZ} - 1.5) = 0$$

$$\Rightarrow -2.5 + 1001\, V_{IZ} - 1500 = 0$$

$$\Rightarrow 1001\, V_{IZ} = 1502.5$$

$$\Rightarrow V_{IZ} = \frac{1502.5}{1001} = 1.501 \text{ Volts}$$

$$\therefore \boxed{V_{IZ} = 1.501\text{ V}}$$

Now,

$$V_{OZ} = 5 - 1000\, I_{OZ}$$

$$= 5 - 1000\,[V_{IZ} - 1.5]$$

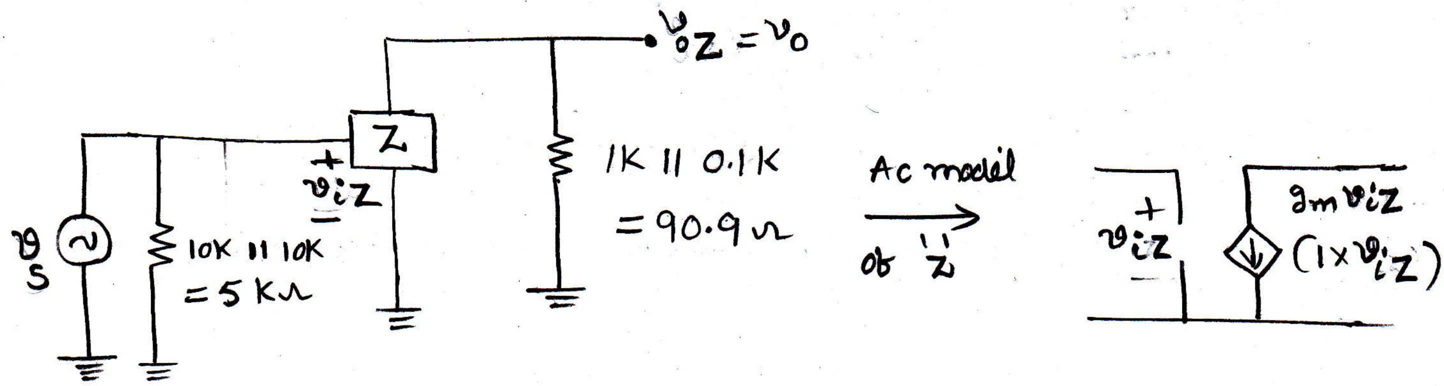
$$= 5 - 1000\,[1.501 - 1.5]$$

$$= 5 - 1000\,(0.001) = 5 - 1 = 4\text{ V}$$

$$\therefore \boxed{V_{OZ} = 4.0\text{ V}}$$

Ac Analysis :-

The equivalent circuit after shorting capacitors and dc sources is,



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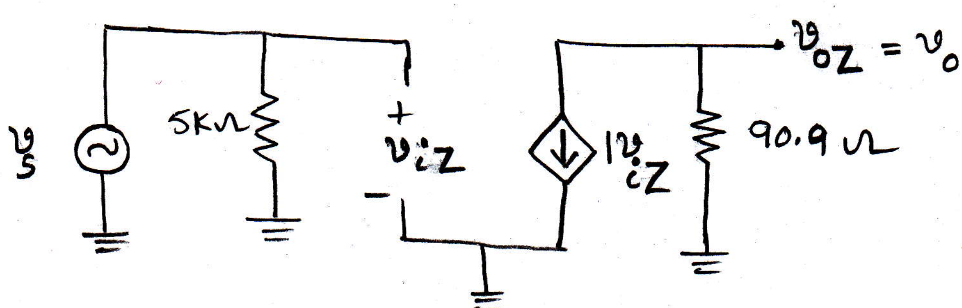

From this figure,

$$v_{iZ} = v_S$$

and $v_o = v_{oZ} = -90.9 \times v_{iZ}$

$\therefore$ Ac voltage gain, $A_v = \dfrac{v_{oZ}}{v_{iZ}} = -\dfrac{90.9\, v_{iZ}}{v_{iZ}}$

$$\therefore \boxed{A_v = -90.9}$$