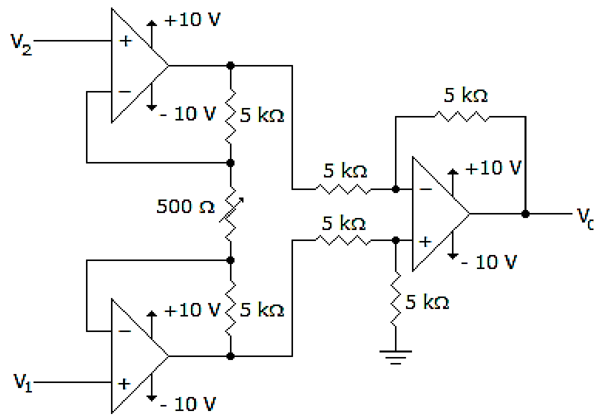
# OP-AMP Problems and Solutions

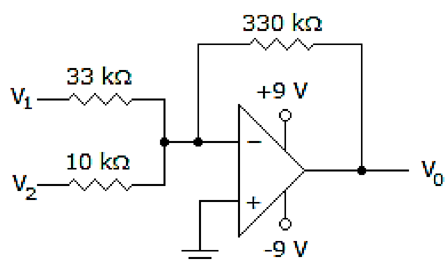
1. Calculate the output voltage for this circuit when $V_1$ = 2.5 V an




Solⁿ: ①

$$V_o = \left(1+\frac{2R}{R_p}\right)(V_1-V_2)$$
$$= \left(1+\frac{2\times 5000}{500}\right)(2.5-2.25)$$
$$= (1+20)(0.25)$$
$$= 21\times 0.25$$
$$= 5.25 \text{ Volt.}$$

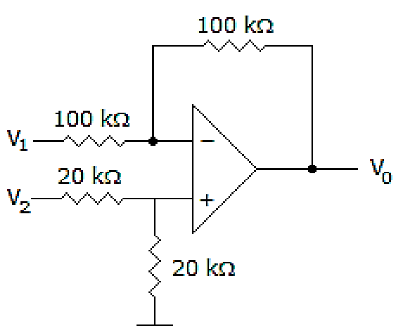
2. Calculate the output voltage if $V_1$ = –0.2 V and $V_2$ = 0 V.



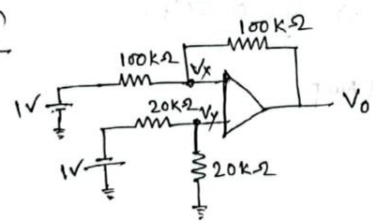

Solⁿ ②

$$\frac{0-V_1}{33}+\frac{0-V_2}{10}+\frac{0-V_o}{330}=0$$
$$\frac{0-(-0.2)}{33}+\frac{0-0}{10}+\frac{-V_o}{330}=0$$
$$\frac{0.2}{33}-\frac{V_o}{330}=0$$
$$\Rightarrow V_o = \frac{330\times 0.2}{33} = 2V.$$

4. Determine the output voltage when $V_1$ = –$V_2$ = 1 V.

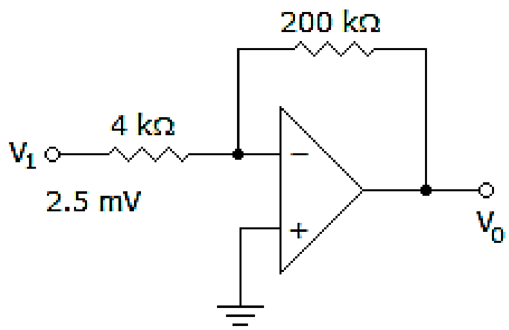



Solⁿ ④




$$V_y = \frac{-1}{40}\times 20 = -0.5$$
$$\frac{-0.5-1}{100}+\frac{-0.5-V_o}{100}=0$$
$$-1.5-0.5-V_o=0.$$
$$\Rightarrow V_o = -2V.$$

7. Determine the output voltage for this circuit with a sinusoidal input of 2.5 mV.




⑦ Sol^n

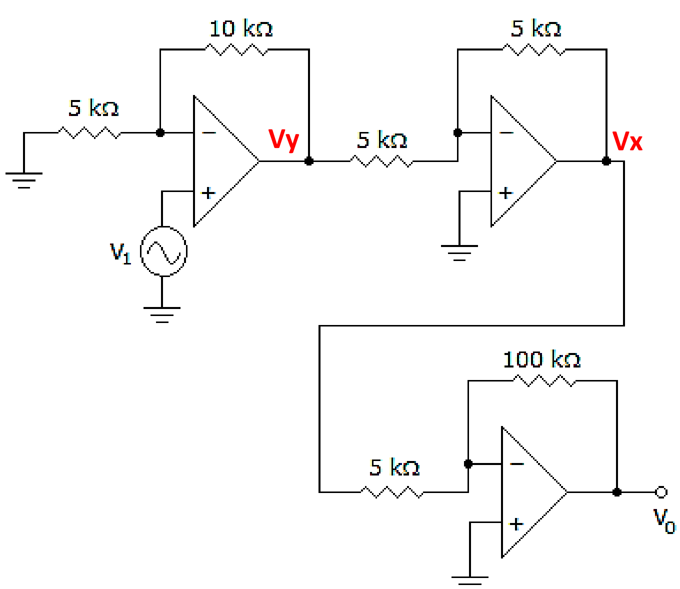
$$\frac{0-2.5\times10^{-3}}{4\times10^{3}}+\frac{0-V_o}{200\times10^{3}}=0$$

$$\frac{V_o}{2\times10^{5}}=-\frac{2.5}{4}\times10^{-6}$$

$$\Rightarrow V_o=-\frac{2.5\times\cancel{2}}{\cancel{4}\,2}\times10^{-1}$$

$$=-0.125\,V_i$$

10. Calculate the input voltage if the final output is 10.08 V.




⑩ Sol^n

$$\frac{0-V_x}{5}+\frac{0-V_o}{100}=0.$$

$$\frac{V_x}{5}+\frac{V_o}{100}=0 \Rightarrow 20V_x+V_o=0. \quad \text{—①}$$

$$V_x=-\frac{V_o}{20}=-\frac{10.08}{20}=-0.504\,V$$

$$\frac{0-V_y}{5}+\frac{0-V_x}{5}=0.$$

$$-\frac{V_y}{5}+\frac{0.504}{5}=0. \Rightarrow V_y=0.504\,V.$$

Apply KCL for 1st opAmp

$$\frac{V_1-0}{5}+\frac{V_1-V_y}{10}=0.$$

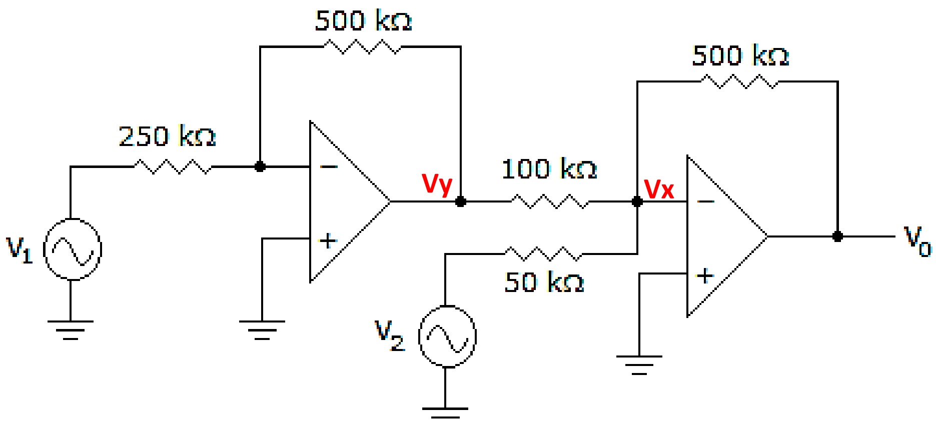
$$\Rightarrow \frac{V_1}{5}+\frac{V_1-0.504}{10}=0.$$

$$\Rightarrow 2V_1+V_1-0.504=0.$$

$$\Rightarrow 3V_1=0.504$$

$$\Rightarrow V_1=\frac{0.504}{3}=0.168\,V.$$

13. Calculate the output voltage if $V_1 = V_2 = 700$ mV.




(13) Sol

$$\frac{0-V_1}{250} + \frac{0-V_y}{500} = 0.$$

$$-\frac{V_1}{250} - \frac{V_y}{500} = 0.$$

$$-2V_1 - V_y = 0 \text{ --- } ①$$

$$V_y = -2V_1 = 1400\times10^{-3}\,V. = -1.4\,V.$$

$$\frac{0-V_y}{100} + \frac{0-V_2}{50} + \frac{0-V_o}{500} = 0.$$

$$\frac{V_y}{100} + \frac{V_2}{50} + \frac{V_o}{500} = 0.$$

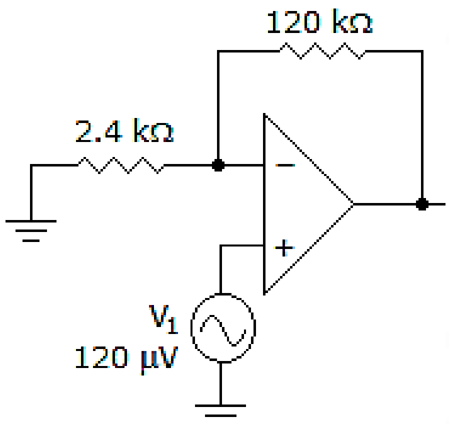
$$\frac{-1.4}{100} + \frac{700\times10^{-3}}{50} + \frac{V_o}{500} = 0.$$

$$\frac{-1.4}{100} + \frac{0.7}{50} = -\frac{V_o}{500}$$

$$\frac{-1.4+1.4}{100} = -\frac{V_o}{500}$$

$$\Rightarrow V_o = 0.V \quad \text{(Ans)}$$

16. Calculate the output voltage.




16 Sol$^{n}$

$$\frac{120\times10^{-6}-0}{2.4\times10^{3}}+\frac{0-V_o}{120\times10^{3}}=0.$$

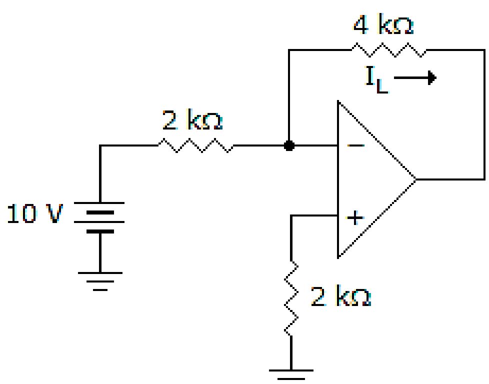
$$\frac{V_o}{120}=\frac{120\times10^{-6}}{2.4}$$

$$\Rightarrow V_o=\frac{120}{2.4}\times120\times10^{-6}$$

$$=\frac{1.44}{24}\times10^{3}\times10^{-6}$$

$$=6\text{ mV}.\ \text{(Ans)}$$

25. Calculate $I_L$ for this circuit.




Sol$^{n}$

$$\frac{0-10}{2\times10^{3}}+\frac{0-V_o}{4\times10^{3}}=0.$$

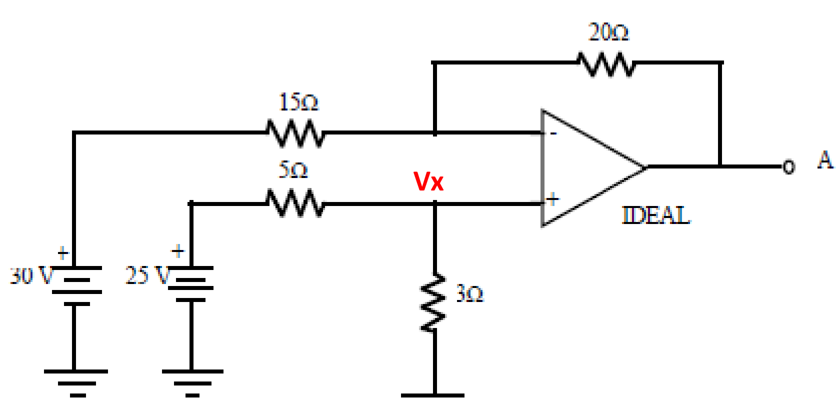
$$\frac{V_o}{4}=-\frac{10}{2}$$

$$\Rightarrow V_o=-20\text{ V}.$$

$$I_L=\frac{0-V_o}{4\times10^{3}}=\frac{20}{4}\times10^{-3}=5\text{ mA}.\ \text{(Ans)}$$

26.

For the difference amplifier circuit shown, determine the output voltage at terminal A.



$\underline{Sol^n}$ $V_x = \frac{25}{5+3} \times 3 = \frac{75}{8} = 9.375$

$$\frac{9.375-30}{15} + \frac{9.375-V_A}{20} = 0.$$

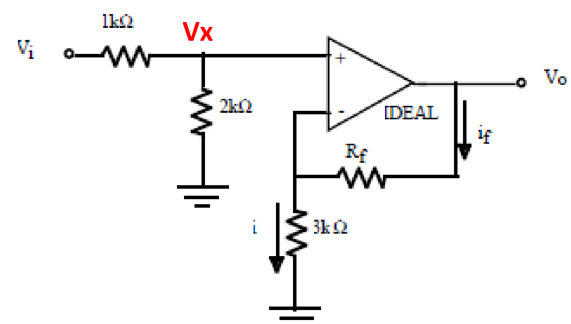
$$\Rightarrow -1.375 = -\frac{9.375-V_A}{20}$$

$$\Rightarrow -27.5 = -9.375 + V_A$$

$$\Rightarrow \cancel{550 + 9.375 = V_A} \Rightarrow V_A = -18.125\ V.$$

27.

For the ideal op amp shown, what should be the value of resistor $R_f$ to obtain a gain of 5?




(27) $V_x = \frac{V_i \times 2}{3}$

$$\frac{V_x - V_o}{R_f} + \frac{V_x - 0}{3} = 0$$

$$\frac{V_x}{R_f} - \frac{V_o}{R_f} + \frac{V_x}{3} = 0.$$

$$V_x\left(\frac{1}{R_f} + \frac{1}{3}\right) = \frac{V_o}{R_f}$$

$$\frac{2V_i}{3}\left(\frac{1}{R_f} + \frac{1}{3}\right) = \frac{V_o}{R_f}.$$

$$\frac{V_o}{V_i} = R_f \cdot \frac{2}{3}\left(\frac{1}{R_f} + \frac{1}{3}\right)$$

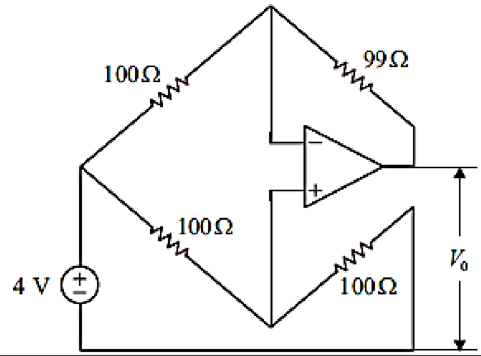
$$\Rightarrow 5 = \frac{2}{3}\left(\frac{R_f}{R_f} + \frac{R_f}{3}\right)$$

$$\Rightarrow R_f = \frac{39}{2} = 19.5$$

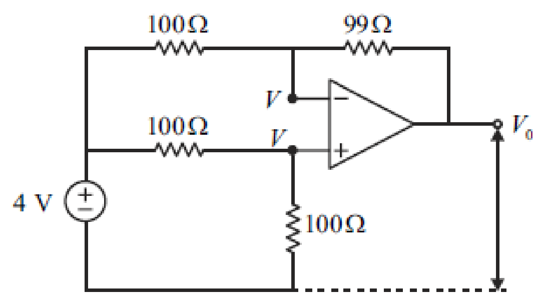
Q-28.

For the ideal Op-Amp circuit of figure. Determine the output voltage $V_0$

**[GATE EC 1993, IIT-Bombay]**




**Sol.** Circuit will reduce as follows




Due to virtual ground condition

$$V_+ = V_- = V$$

Apply KCL at non-inverting terminals

$$\frac{V-4}{100} + \frac{V}{100} = 0$$

$$\frac{2V}{100} = \frac{4}{100} \quad \Rightarrow \quad V = 2 \text{ Volts}$$

Apply KCL at inverting terminal

$$\frac{V-4}{100} + \frac{V-V_0}{99} = 0$$

Put $V = 2$ Volts.

$$\frac{2-4}{100} + \frac{2-V_0}{99} = 0$$

$$\frac{2-V_0}{99} = \frac{2}{100}$$

$$200 - 100V_0 = 198$$

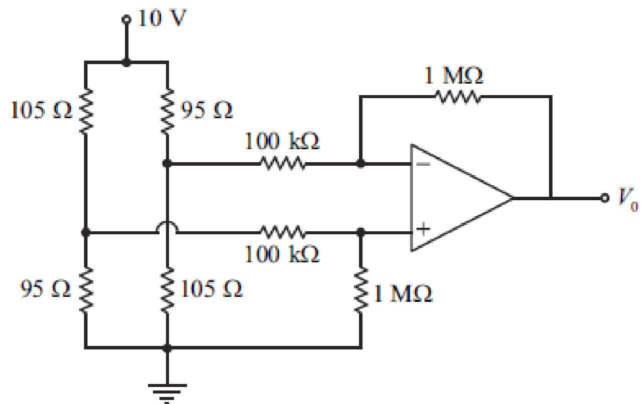
$$100V_0 = 2$$

$$V_0 = 0.02 \text{ Volt}$$

Q-29.

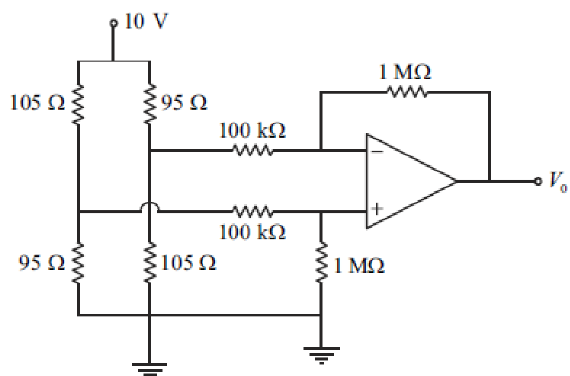
For the Op-Amp circuit shown below, $V_0$ is approximately equal to

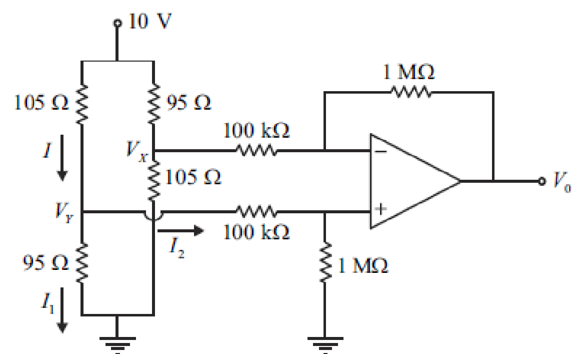
**[GATE IN 2008, IIT-Bangalore]**




(A) −10 V (B) − 5 V (C) + 5 V (D) + 10 V

**Sol.**



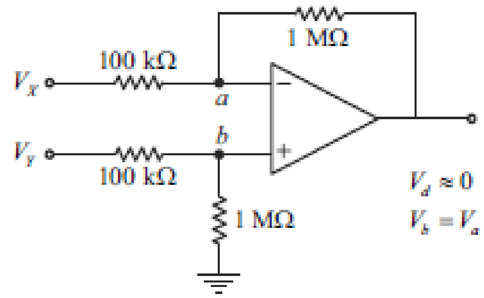
$$V_X = 10\left(\frac{105}{200}\right) = 5.25 \text{ V}$$

$$I = I_1 + I_2$$

$I_1 >> I_2$ [Due to small resistance 95 Ω]

$\Rightarrow$ 95 Ω and 105 Ω will be in series

$$V_Y = 10\left(\frac{95}{200}\right) = 4.75 \text{ V} \quad \text{[By VDR]}$$




Apply KCL at '$b$'

$$\frac{V_Y - V_b}{100} = \frac{V_b}{1000} \quad \Rightarrow \quad 10V_Y = 11V_b$$

$$V_b = \left(\frac{10}{11}\right)V_Y = 4.31817 \text{ Volts}$$

Apply KCL at '$a$'

$$\frac{V_X - V_a}{100} = \frac{V_a - V_0}{1000}$$

$$10V_X = 11V_a - V_0$$

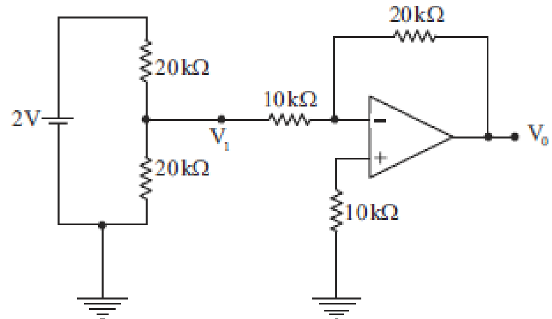
$$V_0 = 11V_a - 10V_X$$

$$V_0 = 10(4.31187) - 10(5.25) = 47.5 - 52.5$$

$$V_0 = -5 \text{ V}$$

In the circuit given below, the OP-AMP is ideal. The output voltage $V_0$ in volt is ________.

**[GATE IN 2016, IISc Bangalore]**




**Sol.**

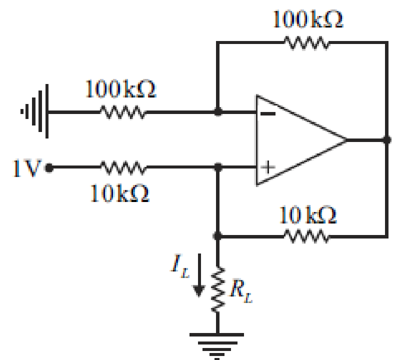
$$\frac{V_1 - 2}{20} + \frac{V_1}{20} + \frac{V_1}{10} = 0$$

$$V_1 = 0.5\ V$$

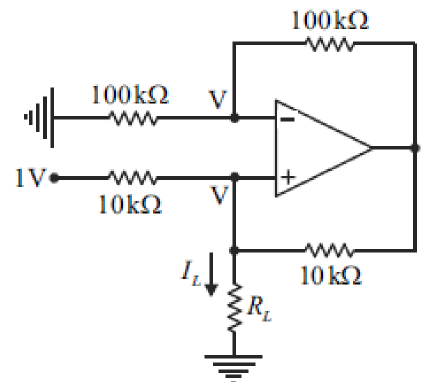
$$V_0 = \frac{-20}{10} \times 0.5 = -1\text{V}$$

In the circuit given below, the OP-AMP is ideal. The value of current $I_L$ in microampere is _______

**[GATE IN 2016, IISc Bangalore]**




**Sol.** Applying KCL at inverting terminal,




$$\frac{V-0}{100\,K}+\frac{V-V_0}{100\,K}=0$$

$$\frac{2V}{100\,K}=\frac{V_0}{100\,K}$$

$$V_0=2V$$

Applying KCL at non inverting,

$$\frac{V-1}{10\,K}+I_L+\frac{V-V_0}{10\,K}=0$$

$$\frac{V}{10\,K}-\frac{1}{10\,K}+I_L-\frac{V}{10\,K}=0$$

$$I_L=0.1\text{mA}=100\ \mu\text{A}$$