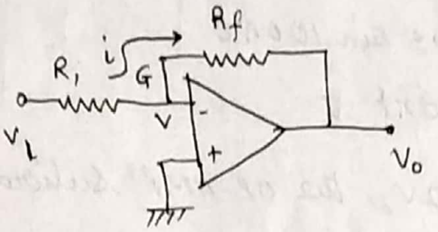
Problems (OP AMP)

Prob 1: In the inverting amplifier circuit, $R_1 = 1K\Omega$, and $R_f = 3K\Omega$. Determine the output voltage, the input resistance and the input current for an input voltage of 2V.



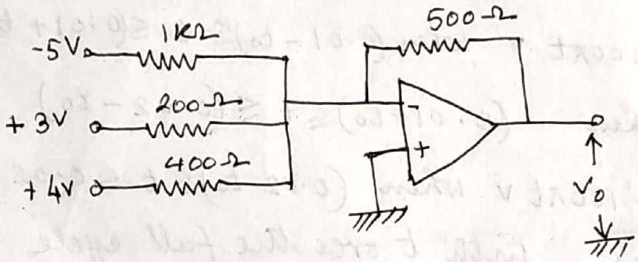
Soln: The output voltage is,

$$V_0 = -(R_f/R_1)V_1 = -(3/1) \times 2 = 6V$$

The input resistance $R_{in} = R_1 = 1K\Omega$

The input current, $i = \frac{V_1}{R_1} = \frac{2}{1} mA = 2mA$. (Ans)

Prob 2: Find the output voltage V_o of the three input summing amplifier circuit as in figure below.



Soln: The output voltage should be,

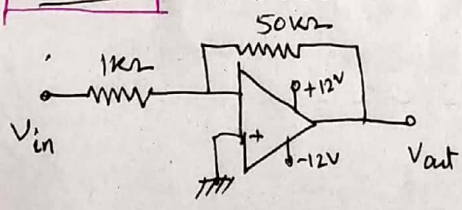
$$V_0 = -\left[\frac{500}{1000} \times (-5) + \frac{500}{200} \times 3 + \frac{500}{400} \times 4\right]$$

$$= -(-2.5 + 7.5 + 5) = 10V.$$

$\therefore$ $\boxed{V_0 = 10V}$ (Ans).

Prob 3: Consider the OP AMP circuit as in figure below with a supply voltage of ±12V. Compute the gain and find the output if the input is given as,

$$V_{in} = 0.5 \sin 100\pi t \text{ volt}.$$



soln: Voltage gain of the given inverting amplifier is,

$$A = -\frac{50K\Omega}{1K\Omega} = -50$$

If the OP AMP were within linear region over the whole range of input, then the output voltage is,

$$V_{out} = AV_{in} = -50 \times 0.5 \sin 100\pi t$$
$$= -25 \sin 100\pi t \ V$$

Since the supply voltage is ±12V, the OP AMP saturates when V_{out} reaches 12V

Let at time $t = t_0$, $V_{out} = -12V$, Then

$$-12 = -25 \sin 100\pi t_0$$
$$\therefore t_0 = \frac{1}{100\pi} \sin^{-1}\left(\frac{12}{25}\right) = 1.59 \times 10^{-3} \ s.$$

Thus, over the entire cycle we have

$V_{out} = -25 \sin 100\pi t \ V$ when $0 \leq t \leq t_0$

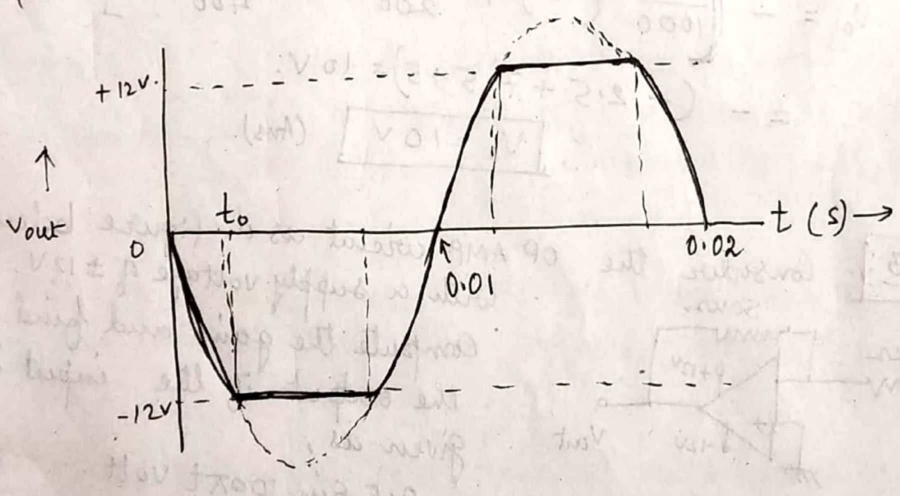
$= -12V$ when $t_0 \leq t \leq (0.01 - t_0)$

$= -25 \sin 100\pi t \ V$ when $(0.01 - t_0) \leq t \leq (0.01 + t_0)$

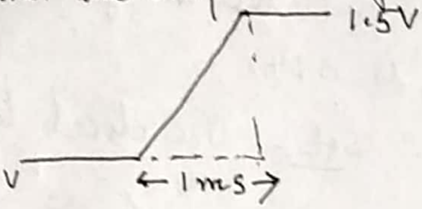
$= +12V$ when $(0.01 + t_0) \leq t \leq (0.02 - t_0)$

$= -25 \sin 100\pi t \ V$ when $(0.02 - t_0) \leq t \leq 0.02 \ s.$

The variation of V_{out} with t over the full cycle $(0 \leq t \leq 0.02 \ s)$ is shown in figure below.



Prob 4: A ramp voltage of 1.5 V (as shown in fig) per millisecond is applied to an OP AMP differentiator having $R = 2\,k\Omega$ and $C = 0.01\,\mu F$. Find the output voltage and its waveform.



Input voltage, v_i

Soln:

The output voltage is

$$V_o = -RC\frac{dv_i}{dt}$$

Here v_i is shown in figure

For $0 < t < 1$ ms, $\frac{dv_i}{dt} = \frac{1.5V}{1ms}$

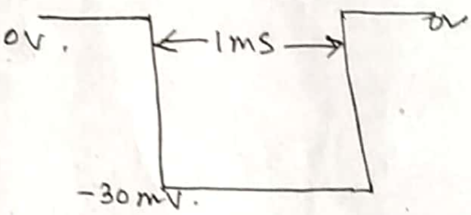
otherwise, $\frac{dv_i}{dt} = 0$.

Also, $RC = 2 \times 0.01 = 0.02$ ms.

Hence, $V_0 = -0.02 \times 1.5$ V

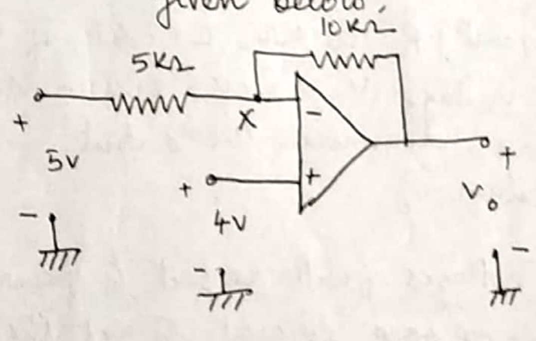
$= -0.03V = -30$ mV for $0 < t < 1$ ms

$V_o = 0$ otherwise



Output voltage, V_o

Prob 5: Calculate V_o of the circuit given below.



Soln: The gain of the OP AMP being infinite, the potential at the point X in the circuit is 4V. Applying Kirchhoff's current law at X, we obtain

$$\frac{V_0 - 4}{10\,K\Omega} = \frac{4-5}{5K\Omega} \Rightarrow V_o = 2V$$

(since input impedance of the OP AMP is infinite)

Prob 6: Find the bandwidth of the inverting OP AMP of $R_1 = 1k\Omega$ and $R_2 = 30k\Omega$, Assume that the unity gain bandwidth of the OP AMP is 3 MHz

Soln:- The closed loop gain of inverting OP AMP is

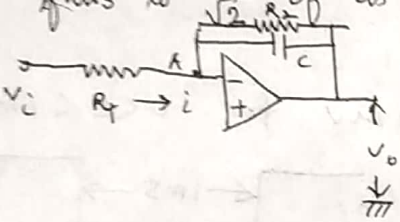
$$A_{vf} = -\frac{R_2}{R_1} = -30$$

Now, $|A_{vf}| \times$ bandwidth = unity gain bandwidth

∴ The required bandwidth $= \frac{3\,MHz}{30}$

$= 100$ KHz.

Prob 7: Show that in the practical OP AMP integrator circuit below, the frequency at which the voltage gain falls to $\frac{1}{\sqrt{2}}$ of its low frequency value is given by $1/2\pi CR_2$



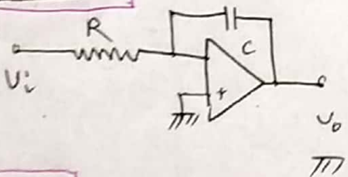
Soln: $$\frac{V_0}{V_i} = \frac{R_2 \times \frac{1}{j\omega C}}{R_1\left(R_2 + \frac{1}{j\omega C}\right)} = \frac{R_2/R_1}{1 + j\omega C R_2}$$

For $\omega = 0$, $\left|\frac{V_0}{V_i}\right| = \frac{R_2}{R_1}$ and

for $\omega C R_2 = 1$, $\left|\frac{V_0}{V_i}\right| = \frac{1}{\sqrt{2}}\frac{R_2}{R_1}$

∴ The required frequency, $f = \frac{\omega}{2\pi} = 1/2\pi C R_2$

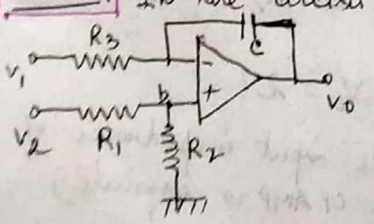
Prob 8:



In this circuit $R = 100\,k\Omega$, $C = 1\,\mu F$. If the input voltage V_i is $\pm 10V$, 250 Hz square wave, determine the output voltage V_0.

Prob 9: If V_1 and V_2 are two voltages (with respect to ground), how would you construct an OP AMP circuit to get the voltage $V_0 = 2V_1 - V_2$?

Prob 10: In the circuit below, express V_0 in terms of V_1 and V_2



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