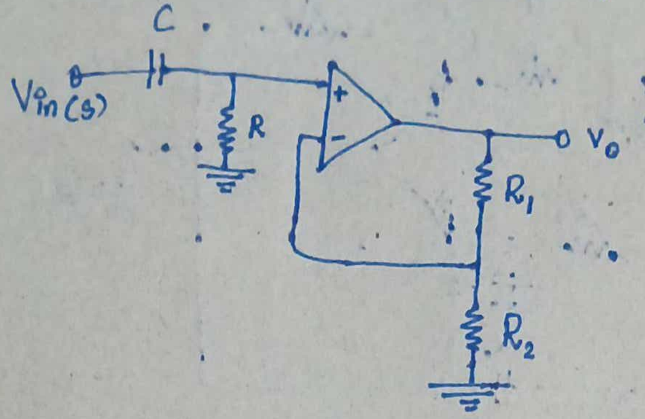
Q1. Determine the cuttoff frequency for the given ckt :



Cuttoff freq (or) 3-dB frequency.

Sol : $T(s) = \dfrac{V_o(s)}{V_{in}(s)}$

$V_{NI} = V_I$ (ideal op-amp) - ①

$\dfrac{V_{NI} - 0}{R} = \dfrac{V_{in} - V_{off}}{1/Cs}$

$RCs\, V_{in} = V_{NI}(1 + RCs)$

$V_{NI} = \dfrac{V_{in(s)} \cdot R}{R + 1/Cs}$ - ②

$V_I = V_o(s) R_2 / R_1 + R_2$ - ③

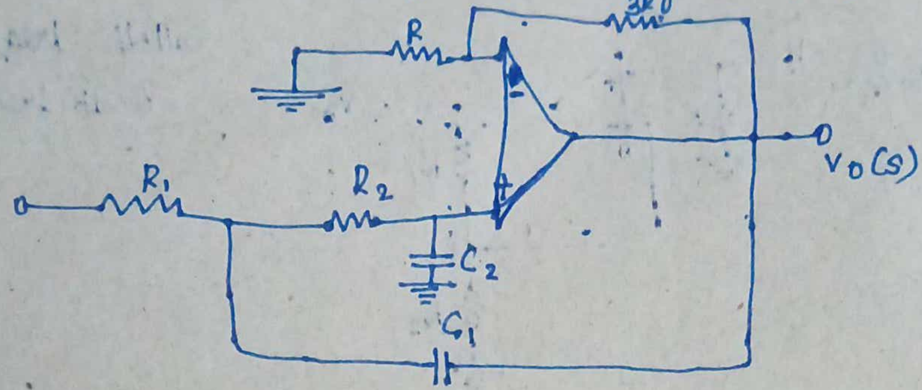
①, ② & ③ $\Rightarrow$ $\dfrac{V_o(s) R_2}{R_1 + R_2} = \dfrac{V_{in}(s) \cdot R}{R + 1/Cs}$

$T(s) = \dfrac{V_o(s)}{V_{in}(s)} = \left(1 + \dfrac{R_1}{R_2}\right)\left(\dfrac{1}{1 + \frac{1}{sRC}}\right)$; Let $A = 1 + \dfrac{R_1}{R_2}$

& put $s = j\omega$, then $T(j\omega) = A / 1 + \dfrac{1}{j\omega RC}$

$|T(j\omega)| = \dfrac{A}{\sqrt{1 + \frac{1}{\omega^2 R^2 C^2}}} = \dfrac{A}{\sqrt{1 + \left(\frac{\omega_H}{\omega}\right)^2}}$ (where $\omega_H = \dfrac{1}{RC}$).

Q2: Determine the type of the following filter circuit?



Sol: $Z_C = \frac{1}{CS}$, $S = j\omega$, $Z_C = \frac{1}{j\omega C}$

The shortcut method!!! ☺

Low pass	High pass	Band Pass
$\lvert T(j\omega)\rvert_{\omega \to \infty} \to 0$	$\lvert T(j\omega)\rvert_{\omega \to 0} \to 0$	$\lvert T(j\omega)\rvert_{\omega \to 0} \to 0$
$\lvert T(j\omega)\rvert_{\omega \to 0} = \text{finite}$	$\lvert T(j\omega)\rvert_{\omega \to \infty} = \text{finite}$	$\lvert T(j\omega)\rvert_{\omega \to \infty} \to$

$$\frac{0 - V_{in}(S)}{R} = \frac{V_{in}(S) - V_o(S)}{3R}$$

$$\frac{V_o(S)}{V_{in}(S)} = 4$$

$Z_C = \frac{1}{CS}$, $\omega \to 0$, $Z_C \to \infty$

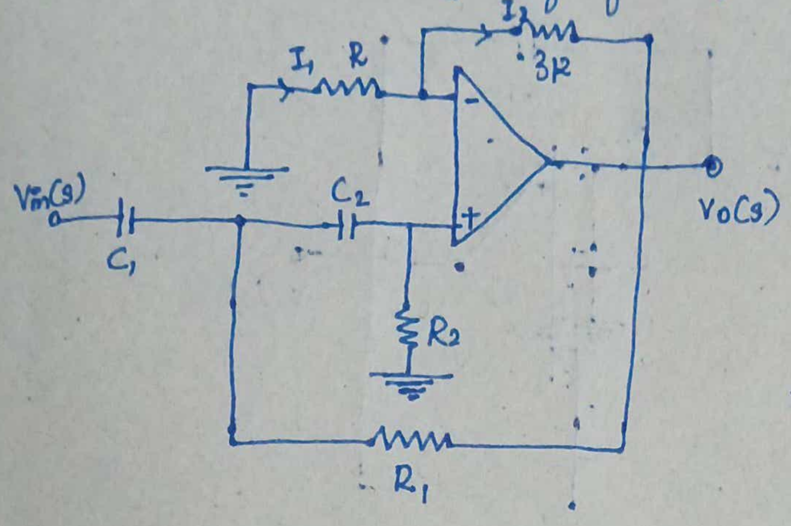
$= \frac{1}{j\omega C}$. $\lvert T(j\omega)\rvert = \text{finite}$

$\omega \to \infty$, $Z_C \to 0$

$\lvert T(j\omega)\rvert \to 0$

So it is a low pass filter.

Q3. Determine the type of filter?



$$Z = \frac{1}{j\omega C}$$

Sol: For $\omega \to 0$, $Z_C \to \infty$ (open circuit)

(no input connected), so $V_o(S) = 0$

(low freq) so $\frac{V_o(s)}{V_{in}(s)} = 0 = T(s)$

(high freq) $\omega \to \infty$, $Z_C \to 0$ (short circuit)

$$V_I = V_{NI} = V_{in}(s)$$

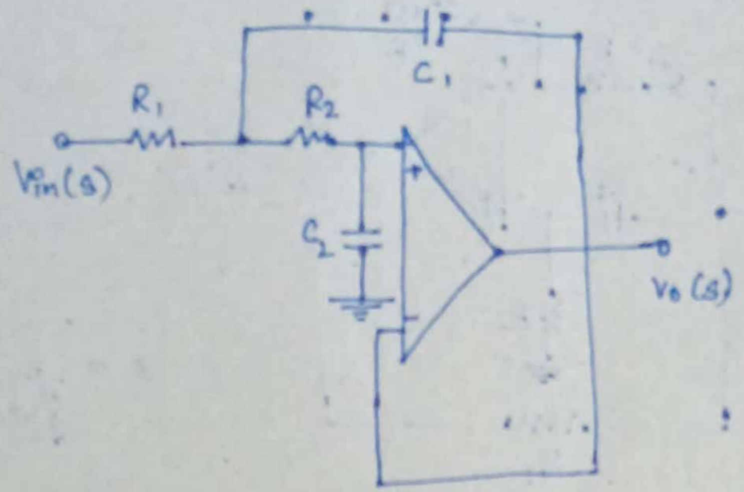
$$I_1 = I_2$$

$$\frac{0 - V_{in}(s)}{R} = \frac{V_{in}(s) - V_o(s)}{3R}$$

$$\frac{V_o(s)}{V_{in}(s)} = \left(1 + \frac{3R}{R}\right) = 4$$

So this is a ~~low~~ high pass filter

Q4. Determine the nature of the filter ?



Sol:

low freq

$\omega \to 0$

$Z_C \to \infty$

$V_o(s) = V_{in}(s)$

$$\frac{V_o(s)}{V_{in}(s)} = 1$$

high pass freq

$\omega \to \infty$

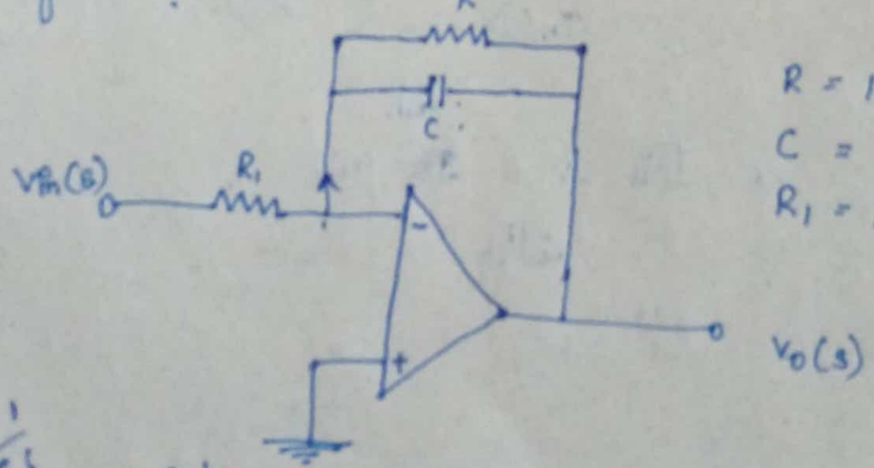
$Z_C \to 0$

$V_o(s) = 0$

$$\frac{V_o(s)}{V_{in}(s)} = 0$$

So it is a low pass filter.

Q5. Find the cutoff (3-dB) frequency of the following filter ?



$R = 10\,k\Omega$

$C = 1\,nF$

$R_1 = 2\,k\Omega$

$Z = \frac{1}{Cs}$

$$\Rightarrow \frac{R \cdot \frac{1}{Cs}}{R + \frac{1}{Cs}}$$

$$\Rightarrow \frac{R}{1 + RCs}$$