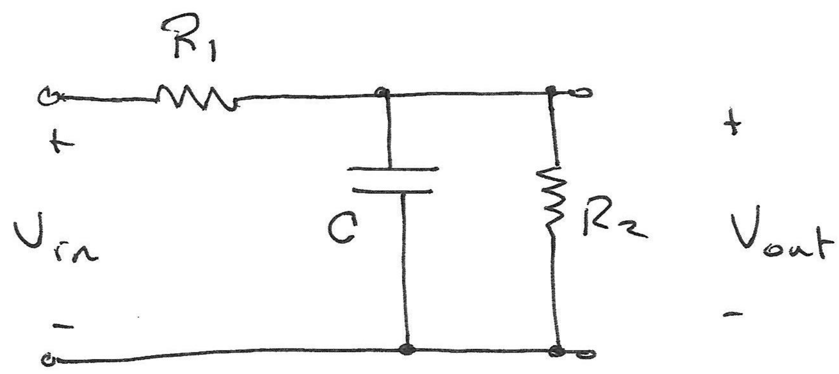
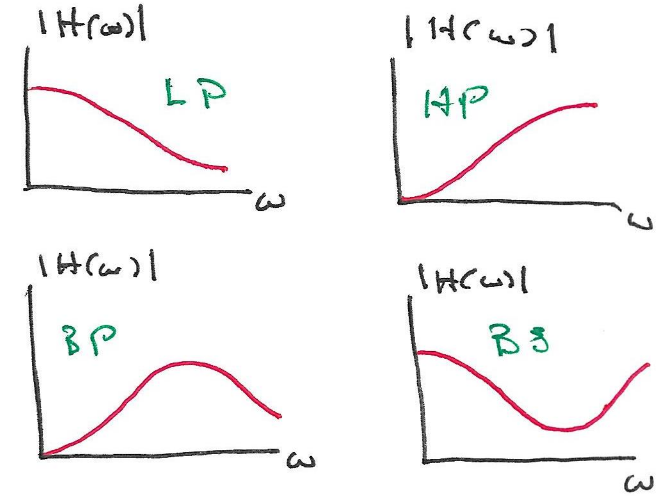
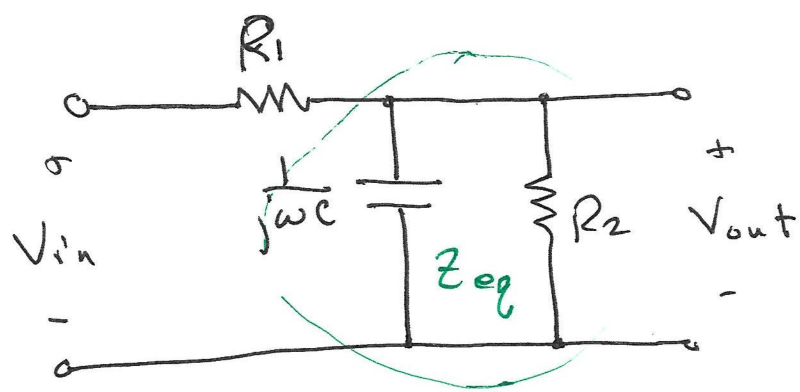


Determine the transfer function and classify in terms of frequency response.



$H(\omega) = ?$

Method 1 Voltage divider approach.



$$Z_{eq} = \frac{\left(\frac{1}{j\omega C}\right) R_2}{\frac{1}{j\omega C} + R_2} = \frac{R_2}{1 + j\omega R_2 C}$$

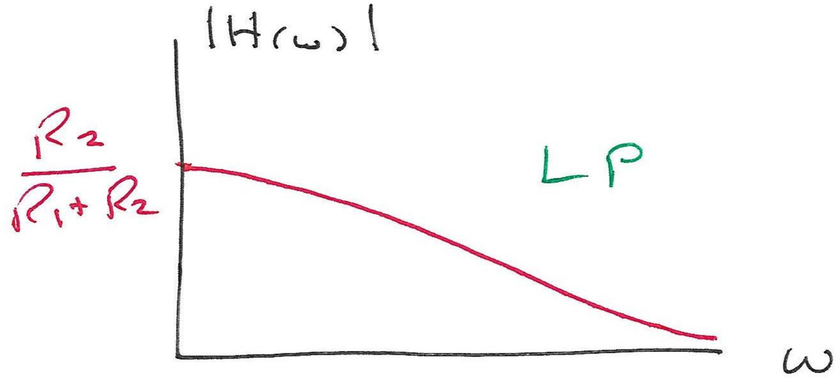
$$H(\omega) = \frac{Z_{eq}}{R_1 + Z_{eq}} = \frac{\dfrac{R_2}{1 + j\omega R_2 C}}{R_1 + \dfrac{R_2}{1 + j\omega R_2 C}} \cdot \frac{1 + j\omega R_2 C}{1 + j\omega R_2 C}$$

$$= \frac{R_2}{R_2 + R_1 (1 + j\omega R_2 C)}$$

$$= \frac{R_2}{(R_1 + R_2) + j\omega R_1 R_2 C}$$

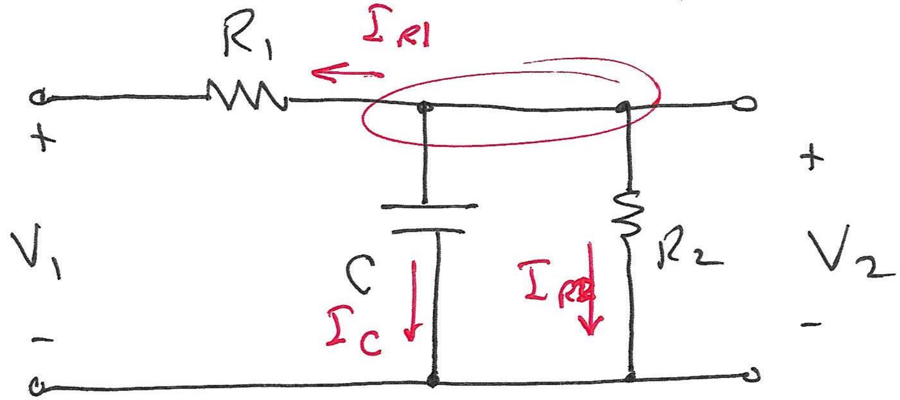
$$\lim_{\omega \to 0} |H(\omega)| = \frac{R_2}{R_1 + R_2}$$

$$\lim_{\omega \to \infty} |H(\omega)| = \left| \frac{\cancel{R_2}}{j\omega R_1 \cancel{R_2} C} \right| = \left| \frac{1}{j\omega R_1 C} \right| = \frac{1}{\omega R_1 C} = 0$$



Method 2

KCL approach



$$I_{R1} = \frac{V_2 - V_1}{R_1}$$

$$I_C = \frac{V_2}{\left(\frac{1}{j\omega C}\right)} = j\omega C V_2$$

$$I_{R2} = \frac{V_2}{R_2}$$

KCL: $$I_{R1} + I_C + I_{R2} = 0$$

$$\frac{V_2 - V_1}{R_1} + j\omega C V_2 + \frac{V_2}{R_2} = 0$$

$$\left(\frac{1}{R_1} + j\omega C + \frac{1}{R_2}\right) V_2 = \frac{1}{R_1} V_1$$

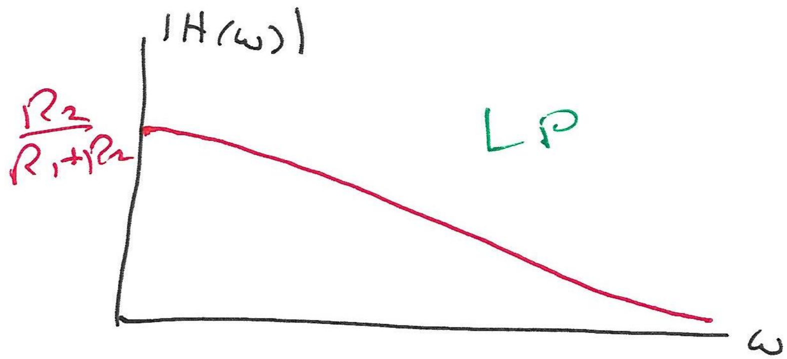
$$\frac{V_2}{V_1} = \frac{\frac{1}{R_1}}{\frac{1}{R_1} + j\omega C + \frac{1}{R_2}} \cdot \frac{R_1 R_2}{R_1 R_2}$$

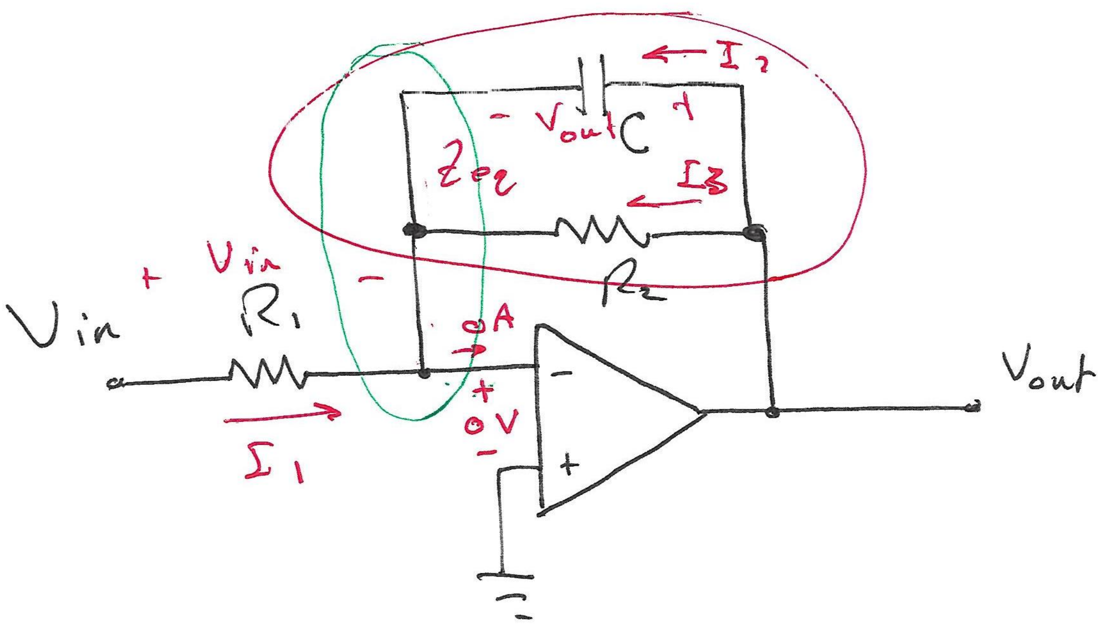
$$\frac{V_2}{V_1} = \frac{R_2}{R_2 + R_1 + j\omega R_1 R_2 C}$$

$$H(\omega) = \left| \frac{V_2}{V_1} \right| = \frac{R_2}{\sqrt{(R_1+R_2)^2 + (\omega R_1 R_2 C)^2}}$$

$$\lim_{\omega \to 0} |H(\omega)| = \frac{R_2}{R_1 + R_2}$$

$$\lim_{\omega \to \infty} |H(\omega)| = \frac{R_2}{\omega R_1 R_2 C} = \frac{1}{\omega R_1 C} \to 0$$





Determine the transfer function, $H(\omega) = \frac{V_{out}}{V_{in}}$,
and classify as a filter type.

Method 1

$$V_{out} = -\frac{Z_{eq}}{R_1} V_{in}$$

Method 2

$$I_1 + I_2 + I_3 = 0$$

$$I_1 = \frac{V_{in}}{R_1}$$

$$I_2 = \frac{V_{out}}{\left(\frac{1}{j\omega C}\right)} = j\omega C V_{out}$$

$$I_3 = \frac{V_{out}}{R_2}$$

$$\frac{V_{in}}{R_1} + j\omega C V_{out} + \frac{V_{out}}{R_2} = 0 \qquad (KCL)$$

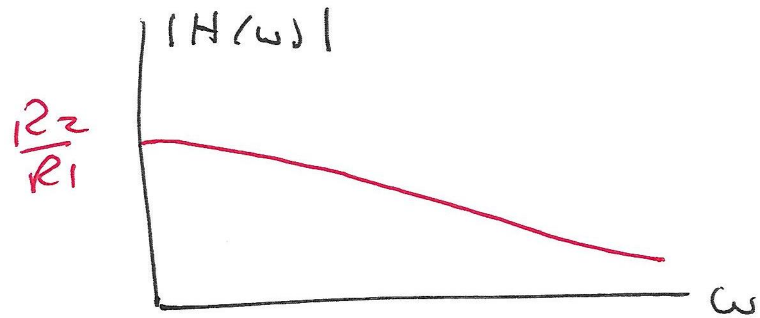
$$\left(\frac{1}{R_2} + j\omega C\right) V_{out} = -\frac{1}{R_1} V_{in}$$

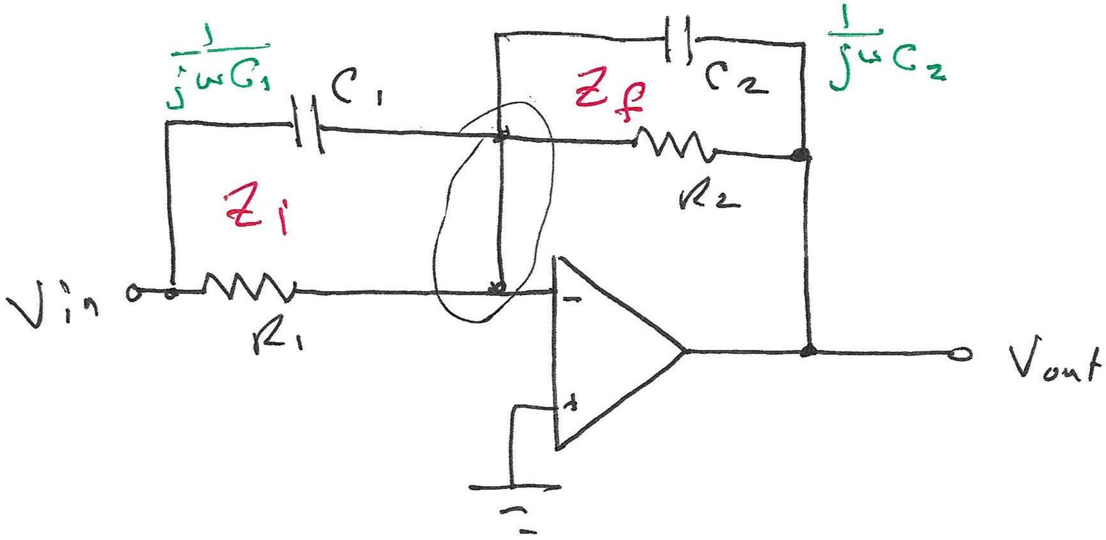
$$H(\omega) = \frac{V_{out}}{V_{in}} = \frac{-\frac{1}{R_1}}{\frac{1}{R_2} + j\omega C}$$

$$|H(\omega)| = \frac{\frac{1}{R_1}}{\frac{1}{R_2} + j\omega C}$$

$$\lim_{\omega \to 0} |H(\omega)| = \frac{\frac{1}{R_1}}{\frac{1}{R_2}} = \frac{R_2}{R_1}$$

$$\lim_{\omega \to \infty} |H(\omega)| = \frac{\frac{1}{R_1}}{j\omega C} = 0$$





Determine H(ω).

$$Z_f = \frac{R_2\left(\frac{1}{j\omega C_2}\right)}{R_2 + \frac{1}{j\omega C_2}} = \frac{R_2}{1 + j\omega R_2 C_2}$$

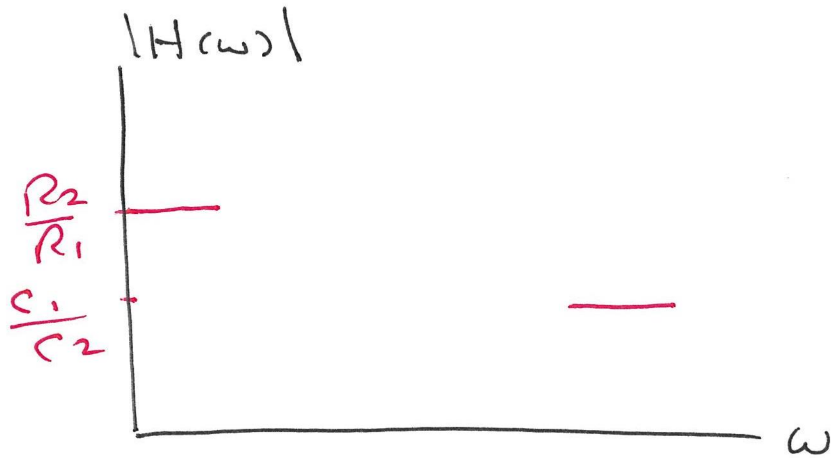
$$Z_i = \frac{R_1\left(\frac{1}{j\omega C_1}\right)}{R_1 + \frac{1}{j\omega C_1}} = \frac{R_1}{1 + j\omega R_1 C_1}$$

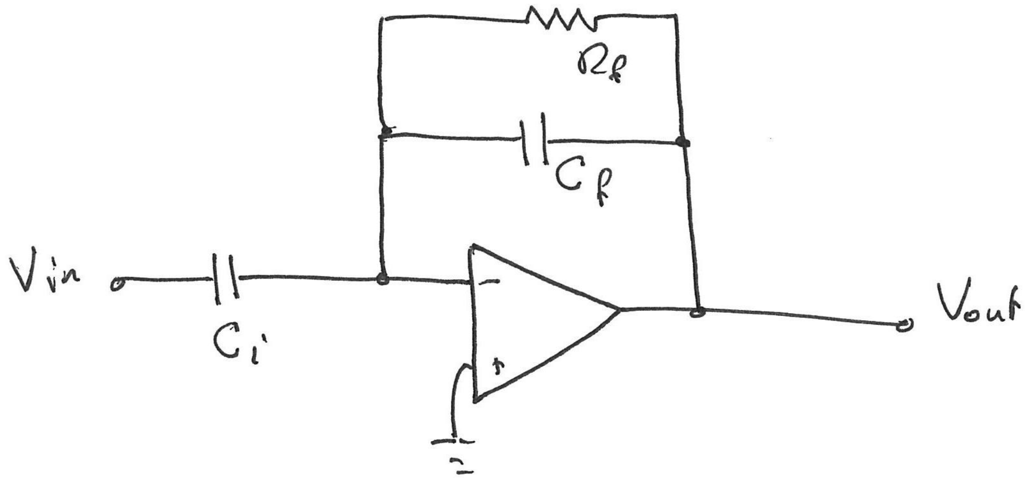
$$H(\omega) = -\frac{Z_f}{Z_i}$$

$$H(\omega) = -\frac{\left(\dfrac{R_2}{1+j\omega R_2 C_2}\right)}{\left(\dfrac{R_1}{1+j\omega R_1 C_1}\right)} = -\frac{R_2\,(1+j\omega R_1 C_1)}{R_1\,(1+j\omega R_2 C_2)}$$

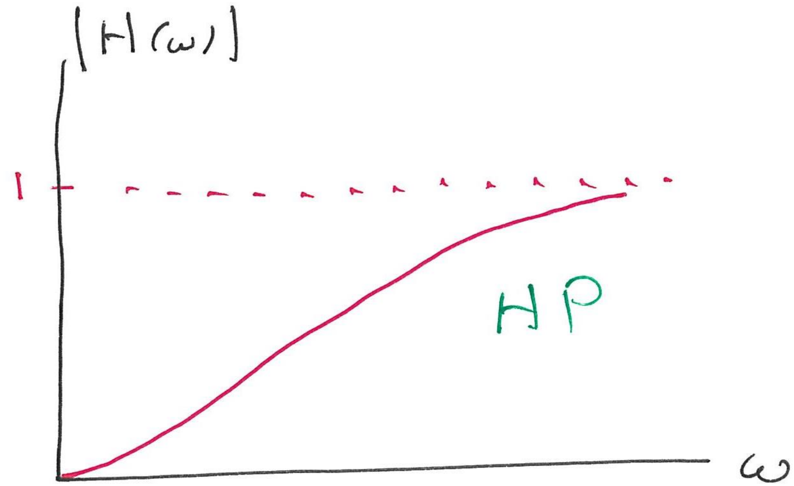
$$\lim_{\omega \to 0} H(\omega) = -\frac{R_2}{R_1}$$

$$\lim_{\omega \to \infty} H(\omega) = -\frac{\cancel{R_2}\,\cancel{j\omega}\,\cancel{R_1}\,C_1}{\cancel{R_1}\,\cancel{j\omega}\,\cancel{R_2}\,C_2} = -\frac{C_1}{C_2}$$

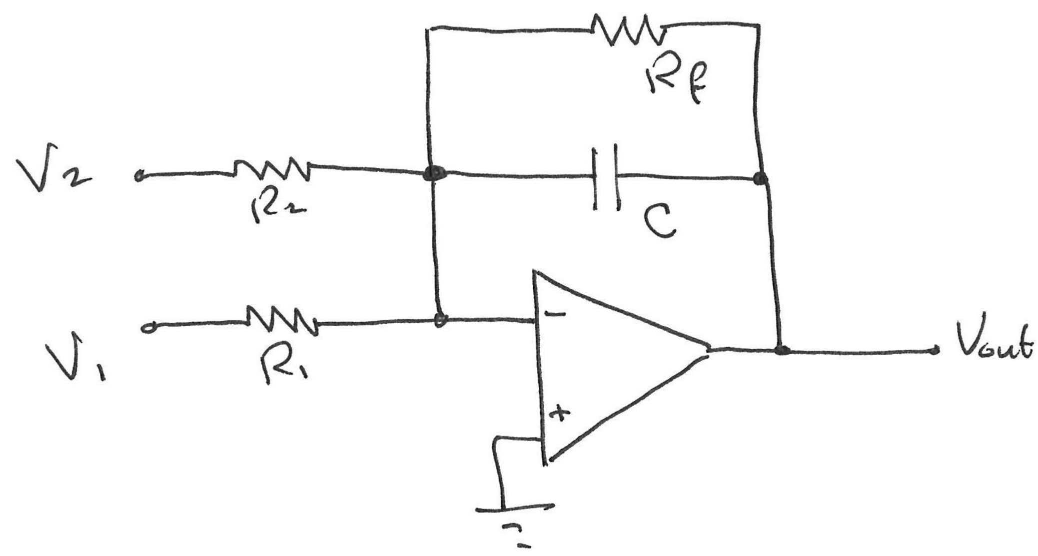




R_f
C_f
V_{in}
C_i
V_{out}



$|H(\omega)|$
1
HP
ω



$$V_{out} = H_1(\omega)\, V_1 + H_2(\omega)\, V_2$$

$$= -\frac{\frac{1}{R_1}}{\frac{1}{R_f} + j\omega C} V_1 - \frac{\frac{1}{R_2}}{\frac{1}{R_f} + j\omega C} V_2$$