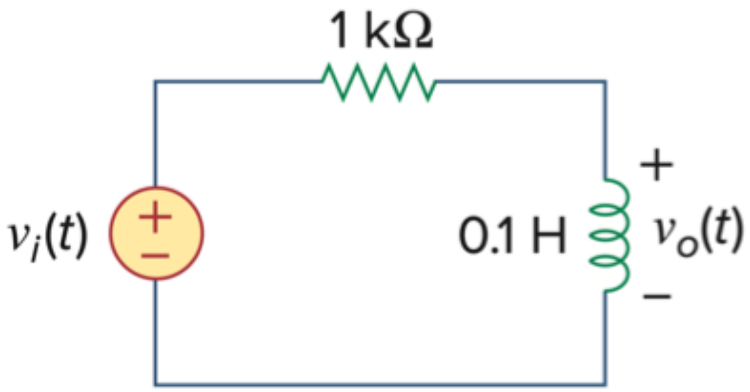
Q. What type of filter is shown below?
What is the cutoff / corner frequency?



A. $$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{sL}{R + sL}$$

$$\Rightarrow \quad H(j\omega) = \frac{j\omega L}{R + j\omega L}$$

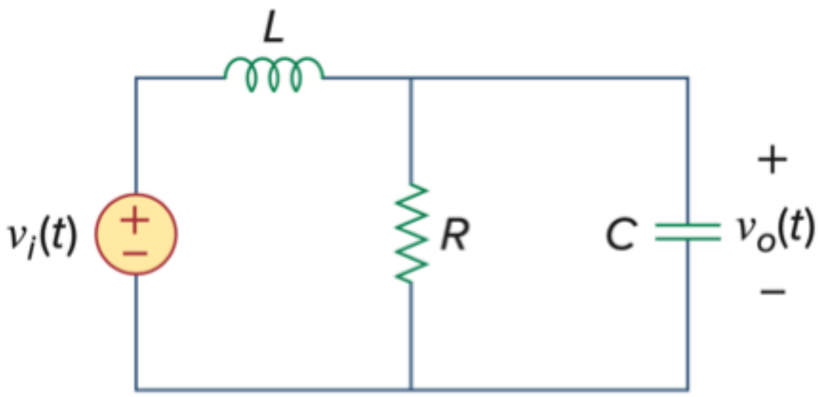
$$\Rightarrow \quad |H(j\omega)| = \frac{\omega L}{\sqrt{R^2 + \omega^2 L^2}}$$

Clearly, $|H(0)| = 0$, $|H(\infty)| = 1$

Hence, this is a high-pass filter.

The cut-off frequency $\omega_c = \dfrac{R}{L} = 10^4$ rad/s.

Q. What type of filter is shown below?
What is the cutoff / corner frequency?
Use $R = 2\,k\Omega$, $L = 2H$, and $C = 2\,\mu F$.



A. $$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{R}{s^2 RLC + sL + R}$$

$$\Rightarrow \quad |H(j\omega)| = \frac{R}{\sqrt{(R - \omega^2 RLC)^2 + \omega^2 L^2}}$$

$$H(0) = 1 \quad \text{and} \quad H(\infty) = 0$$

Hence, this is a second-order low pass filter.

Solving ω_c for cut-off frequency,

$$\omega_c^2 \simeq 0.55 \times 10^6 \quad \Rightarrow \quad \omega_c \simeq 742 \text{ rad/sec}$$

Q. Design a band-stop filter to reject a 200 Hz sinusoid while passing other frequencies and with a bandwidth of 100 Hz. (Use $R = 150\,\Omega$).

A. For an RLC band-stop filter,

$$|H(j\omega)| = \frac{(\omega L - 1/\omega C)}{\sqrt{R^2 + (\omega L - 1/\omega C)^2}}$$

Calculating half-power frequencies,

$$P_\omega = \frac{1}{2} P_{max} \Rightarrow \frac{R}{R^2 + (\omega L - 1/\omega C)^2} = \frac{1}{2R}$$

$$\Rightarrow \omega_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

(negative roots rejected)

$$\text{and} \quad \omega_2 = \frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 + \frac{1}{LC}}$$

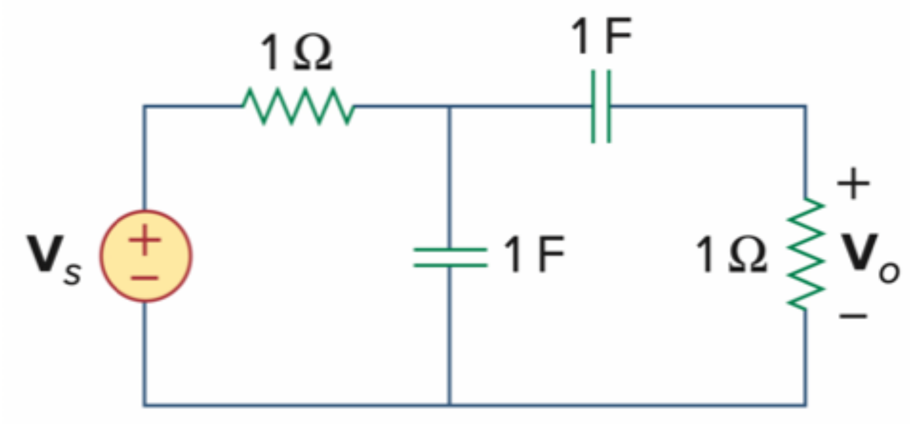
Hence, $B = \omega_2 - \omega_1 = \frac{R}{L}$ and $\omega_0 = \frac{1}{\sqrt{LC}}$

Substituting the values, $C \simeq 2.65\,\mu F$

and $L \simeq 240\,mH$

Q. What type of filter is shown below?

What is the center frequency and BW?



A. Solving the KCL/KVL equations,

$$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{sRC}{1 + 3sRC + s^2R^2C^2}$$

$$= \frac{1}{3}\left[\frac{\frac{3}{RC}s}{s^2 + \frac{3}{RC}s + \frac{1}{R^2C^2}}\right] \rightarrow \text{Band-Pass Filter}$$

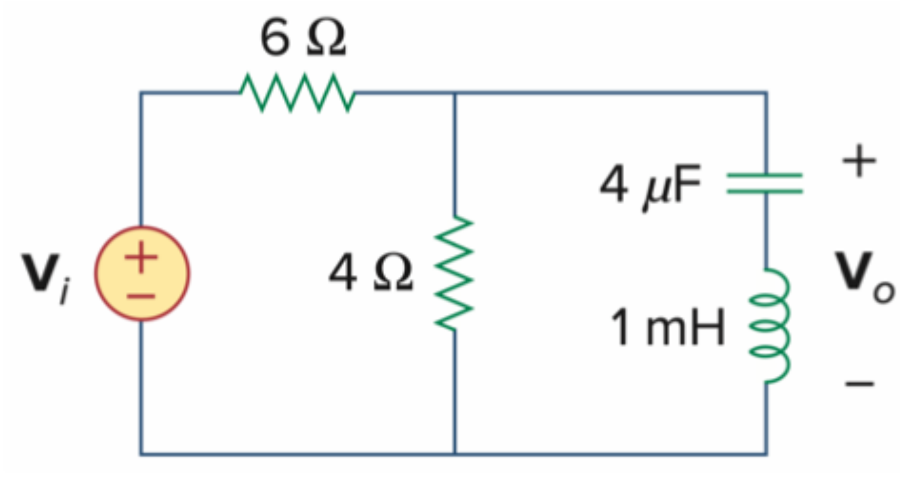
Comparing the equation with $K\left(\frac{Bs}{s^2 + Bs + \omega_0^2}\right)$

given $R = 1\,\Omega$, $C = 1F$

$$\omega_0^2 = \frac{1}{R^2C^2} \Rightarrow \omega_0 = 1 \text{ rad/sec}$$

$$B = \frac{3}{RC} = 3 \text{ rad/sec.}$$

Q. What type of filter is shown below? What is the center frequency and BW?



A. Solving the KCL/KVL equations,

$$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{R_1(1+s^2LC)}{(R_1+R_2) + sR_1R_2C + s^2LC(R_1+R_2)}$$

$$= \frac{R_1}{R_1+R_2}\,\frac{\left(s^2+\frac{1}{LC}\right)}{\left(s^2+\frac{R_1R_2}{R_1+R_2}\cdot\frac{1}{L}s+\frac{1}{LC}\right)} \rightarrow \text{Band-Stop Filter}$$

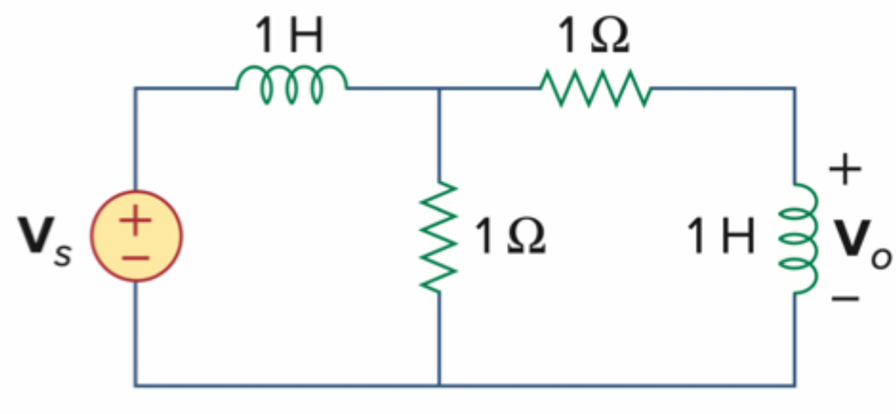
Comparing the equation with $K\left(\dfrac{s^2+\omega_0^2}{s^2+Bs+\omega_0^2}\right)$

given $R_1 = 4\Omega$, $R_2 = 6\Omega$, $C = 4\mu F$, $L = 1mH$

$$\omega_0^2 = \frac{1}{LC} \Rightarrow \omega_0 \approx 15.8 \text{ krad/sec}$$

$$B = \frac{R_1R_2}{R_1+R_2}\cdot\frac{1}{L} = 2.4 \text{ krad/sec}$$

Q. What type of filter is shown below? What is the center frequency and BW?



A. Solving the KCL/KVL equations,

$$H(s) = \frac{V_o(s)}{V_i(s)} = \frac{sRL}{R^2 + 3sRL + s^2L^2}$$

$$= \frac{1}{3}\left[\frac{3\frac{R}{L}s}{s^2 + 3\frac{R}{L}s + \frac{R^2}{L^2}}\right] \rightarrow \text{Band-Pass Filter}$$

Comparing the equation with $K\left(\frac{Bs}{s^2 + Bs + \omega_0^2}\right)$

given $R = 1\Omega$, $L = 1H$

$$\omega_0^2 = \frac{R^2}{L^2} \Rightarrow \omega_0 = 1 \text{ rad/sec}$$

$$B = 3\frac{R}{L} = 3 \text{ rad/sec}.$$