Score: 60/60 Points 100 %

1.

Award: **13.33 out of 13.33 points**

Calculate the value of $|H(\omega)|$ for the following values of H_{dB}.

(i) If H_{dB} = 0.10 dB, then $|H(\omega)|$ = **1.0120**.

(ii) If H_{dB} = –3 dB, then $|H(\omega)|$ = **0.708**.

(iii) If H_{dB} = 210 dB, then $|H(\omega)|$ = **3.1620** × 10^{10}.

References

Numeric Response	Difficulty: Medium	Learning Objective: Understand the decibel scale, why we use it, and how to use it.

Calculate the value of $|H(\omega)|$ for the following values of H_{dB}.

(i) If H_{dB} = 0.10 dB, then $|H(\omega)|$ = *1.0116 ± 1%*.

(ii) If H_{dB} = –3 dB, then $|H(\omega)|$ = *0.708 ± 0.00101*.

(iii) If H_{dB} = 210 dB, then $|H(\omega)|$ = *3.1623 ± 1%* × 10^{10}.

Explanation:

$|H(\omega)|$ is calculated as follows:

(i) 0.10 dB = $20\log_{10}|H(\omega)|$ → $|H(\omega)|$ = 1.0116

(ii) –3 dB = $20\log_{10}|H(\omega)|$ → $|H(\omega)|$ = 0.7079

(iii) 210 dB = $20\log_{10}|H(\omega)|$ → $|H(\omega)| = 3.1623 \times 10^{10}$

2. Award: **13.33 out of 13.33 points**

A series *LR* circuit is a lowpass filter if the output is taken across the resistor.

- ◉ True ✔
- ○ False

$$\mathrm{H}(\omega) = \frac{\mathrm{V}_o}{\mathrm{V}_i} = \frac{R}{R + j\omega L} = \frac{1}{1 + j\omega L/R}$$

H(0) = 1 and H(∞) = 0, showing that this circuit is a lowpass filter.

References

True / False	Difficulty: Medium	Learning Objective: Understand passive filters.

3. Award: **13.34 out of 13.34 points**

For a series *LR* circuit, calculate the corner frequency f_c if L =7 mH and R = 10 kΩ.

The value of f_c for the series *LR* circuit is **227.36** kHz.

References

Numeric Response Difficulty: Medium Learning Objective: Understand passive filters.

For a series *LR* circuit, calculate the corner frequency f_c if L =7 mH and R = 10 kΩ.

The value of f_c for the series *LR* circuit is 227.36 ± 1% kHz.

Explanation:

For a series LR circuit, we have

$$\mathrm{H}(\omega) = \frac{\mathrm{V}_o}{\mathrm{V}_i} = \frac{R}{R + j\omega L} = \frac{1}{1 + j\omega L/R}$$

At the corner frequency, $\left|H(\omega_c)\right| = \frac{1}{\sqrt{2}}$, i.e.,

$$\frac{1}{\sqrt{2}} = \frac{1}{\sqrt{1 + \left(\frac{\omega_c L}{R}\right)^2}} \quad \rightarrow \quad 1 = \frac{\omega_c L}{R} \quad \text{or} \quad \omega_c = \frac{R}{L}$$

$$\omega_c = \frac{R}{L} = 2\pi f_c$$

$$f_c = \frac{1}{2\pi} \cdot \frac{R}{L} = \frac{1}{2\pi} \cdot \frac{10 \times 10^3\ \Omega}{7.00 \times 10^{-3}\ H} = 227.36\ \text{kHz}$$

4.

Award: **10 out of 10.00 points**

Design an active lowpass filter with a DC gain of –0.25 and a corner frequency of 500 Hz. Assume that R_f = 20 kΩ.

The value of R_i is **80** kΩ.

The value of C is **15.91** nF.

References

Numeric Response	Difficulty: Medium	Learning Objective: Understand active filters.

Design an active lowpass filter with a DC gain of –0.25 and a corner frequency of 500 Hz. Assume that R_f = 20 kΩ.

The value of R_i is *80 ± 1%* kΩ.

The value of C is *15.92 ± 1%* nF.

Explanation:

$$\text{DC gain} = -\frac{R_f}{R_i} = -\frac{1}{4} \qquad R_i = 4R_f$$

$$\text{Corner frequency} = \omega_c = \frac{1}{R_f C_f} = 2\pi(500) \text{ rad/s}$$

If R_f = 20 kΩ, then R_i = 80 kΩ and

$$C = \frac{1}{(2\pi)(500 \text{ rad/s})(20 \times 10^3\ \Omega)} = 15.92 \text{ nF}$$

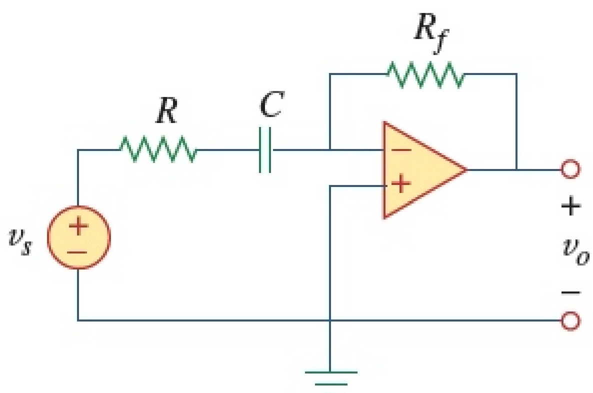
5.

Award: **10 out of 10.00 points**

Design the filter in the circuit given below to meet the following requirements:

(a) It must attenuate a signal at 2 kHz by 3 dB compared with its value at 10 MHz.

(b) It must provide a steady-state output of $v_o(t)$ = 10 sin ($2\pi \times 10^8 t$ + 180°) V for an input v_s (t) = 4 sin ($2\pi \times 10^8 t$) V. Assume R = 10 kΩ.



The value of R_f in the circuit is **25** kΩ.

The value of C in the circuit is **7.96** nF.

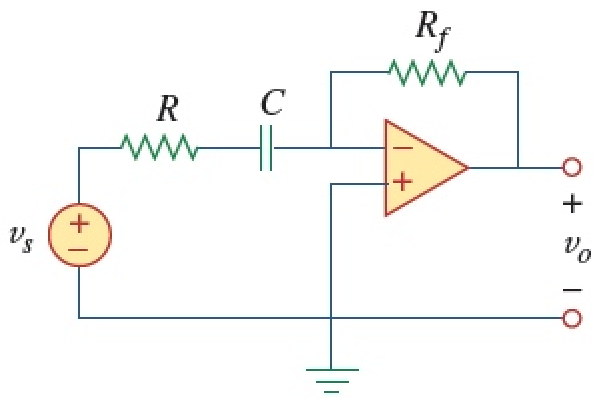
References

Numeric Response	Difficulty: Medium	Learning Objective: Understand active filters.

Design the filter in the circuit given below to meet the following requirements:

(a) It must attenuate a signal at 2 kHz by 3 dB compared with its value at 10 MHz.

(b) It must provide a steady-state output of $v_o(t)$ = 10 sin ($2\pi \times 10^8 t$ + 180°) V for an input v_s (t) = 4 sin ($2\pi \times 10^8 t$) V. Assume R = 10 kΩ.



The value of R_f in the circuit is 25 ± 1% kΩ.

The value of C in the circuit is 7.96 ± 1% nF.

Explanation:

This is a highpass filter with f_c = 2 kHz.

$$\omega_c = 2\pi f_c = \frac{1}{RC}$$

$$RC = \frac{1}{2\pi f_c} = \frac{1}{2 \times \pi \times 2 \times 10^3} = \frac{1}{4\pi \times 10^3}$$

10^8 Hz may be regarded as a high frequency. Hence, the high-frequency gain is

$$-\frac{R_f}{R} = -\frac{10}{4} \text{ or } R_f = 2.5R$$

If R = 10 kΩ, then R_f = 25.00 kΩ and

$$C = \frac{1}{(10\ \text{k}\Omega) \times (4.\pi \times 10^3)} = 7.96\ \text{nF}$$