Name_____ **ECE 2210 Homework Bode** Due: Tue, 10/24/23

Read the *Frequency Response, Filters & Bode Plots* handout and/or sections 2.31-33 in your textbook. c

1. Convert the following ratios to dB. Example: ratio = 12 $20 \cdot \log(12) = 21.6 \cdot dB$

   a) $\frac{4}{1}$

   b) $\frac{1}{4}$

   c) 500

   d) 20000

2. Convert 20 dB, 46 dB, -46 dB and 80 dB to voltage ratios. Example: 50 dB, voltage ratio = $10^{\frac{50}{20}} = 316.23$

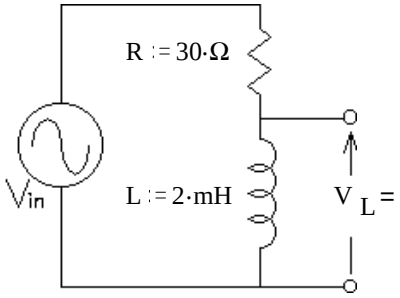
   a) $20 \cdot dB$

   b) $46 \cdot dB$

   c) $-46 \cdot dB$

   d) $80 \cdot dB$

3. a) Find the transfer function of the filter circuit shown. $\mathbf{V_{in}}$ is the input and $\mathbf{V_L}$ is the output. $H(\omega)$=?



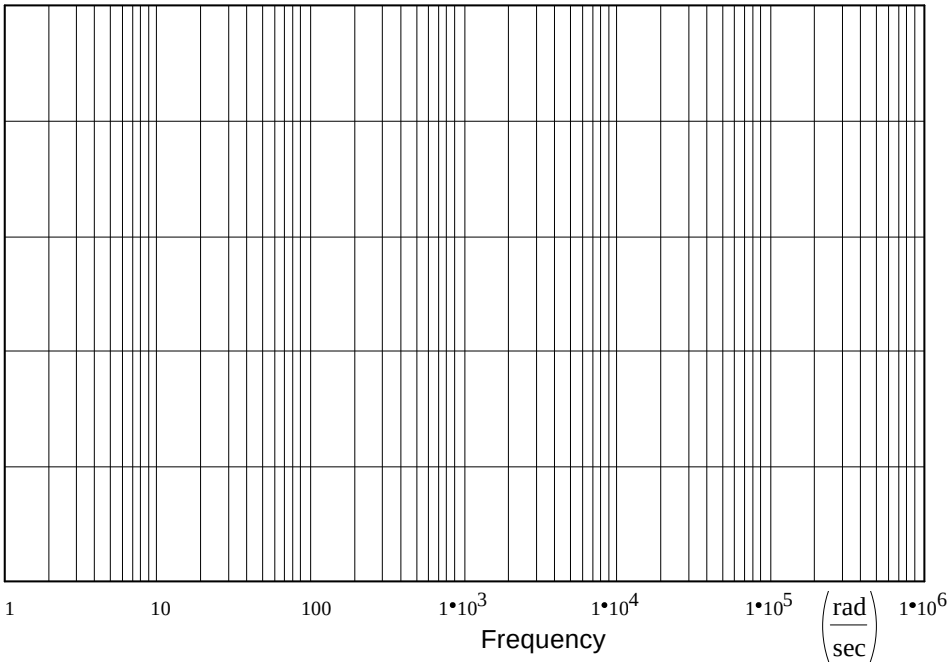
   b) Find the corner frequency(ies).

Transcribe the results of parts a) and b) here: $H(\omega) =$

Corner frequency(ies):

c) Find the approximations of the transfer function in each frequency region,
find magnitudes in dB, and slopes in dB/decade.

d) Draw the asymptotic Bode plot (the straight-line approximation) of the filter circuit shown above.
Accurately draw it on the graph paper provided. Label the vertical axis with numbers in dB.



e) The asymptotic Bode plot is not exact. Sketch the actual magnitude of the transfer function on the same plot.
For the frequency where this difference is largest (the corner frequency), calculate the actual magnitude.

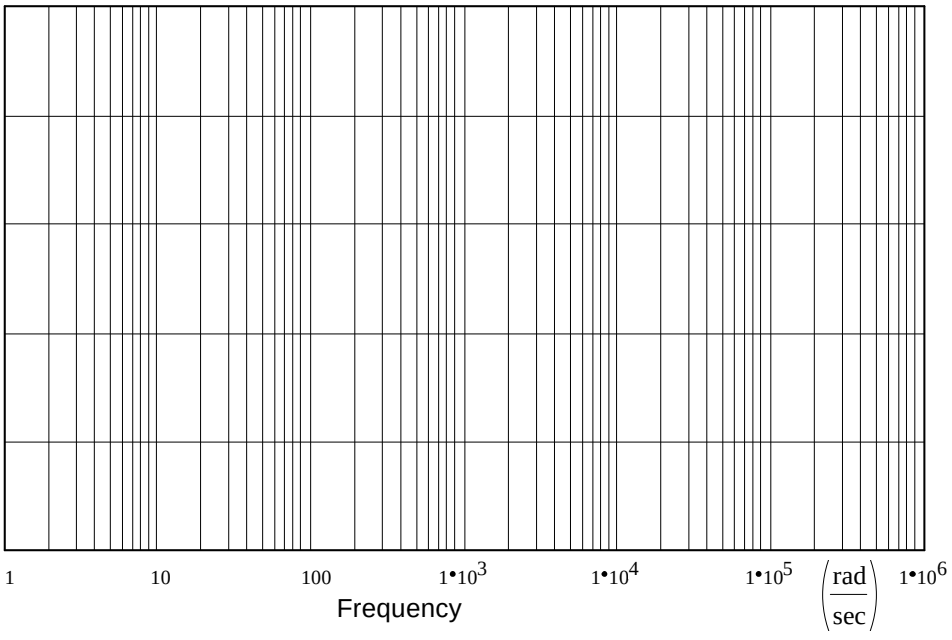
f) Calculate the actual magnitude of the transfer function at the corner frequency.

g) Calculate the actual magnitude of the transfer function at one octave above the corner frequency ($2\omega_c$).

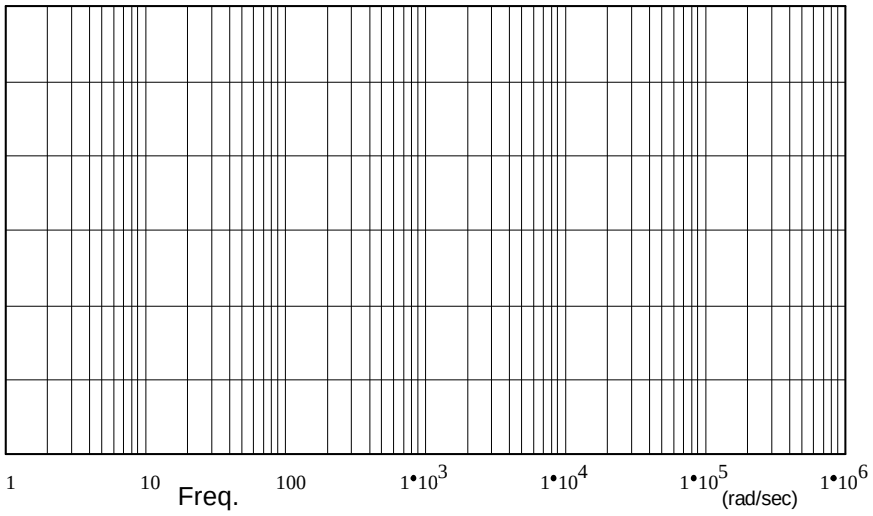
For **ALL** plotting problems, you must show the steps you use to get the Bode plot like I showed in lecture and the notes. That is, show things like the corner frequency(ies), the approximations of the transfer function in each frequency region, slopes and calculations of dB, numbers on plots, actual magnitude plots, etc..

4. Draw the asymptotic Bode plot (the straight-line approximation) of the following transfer functions.

a) $\mathbf{H_a}(\omega) := \dfrac{20}{1 + j\cdot\dfrac{\omega}{4000\cdot\dfrac{\text{rad}}{\text{sec}}}}$



b) $\mathbf{H_b}(\omega) := \dfrac{120 \cdot j \cdot \omega}{400 \cdot \dfrac{rad}{sec} + j \cdot 4 \cdot \omega}$



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Answers 1. 12dB, -12dB, 54dB, 86dB 2. 10, 200, 0.005, 10^4

3. a) $\dfrac{j \cdot \omega \cdot L}{j \cdot \omega \cdot L + R}$ b) $15000 \cdot \dfrac{rad}{sec}$ d) $|\mathbf{H}(\omega)|$

c) $\omega < \omega_c$ $\mathbf{H}(\omega) \simeq \dfrac{j \cdot \omega \cdot L}{R}$ proportional to ω slope +20 dB/dec

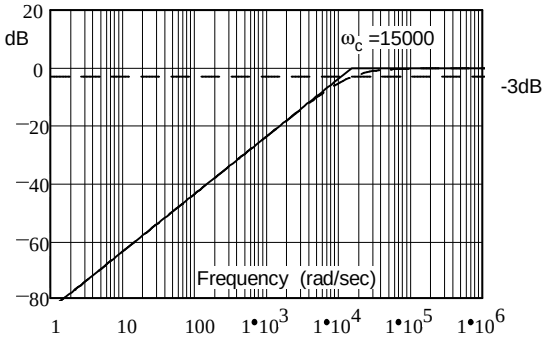
$\omega > \omega_c$ $\mathbf{H}(\omega) \simeq \dfrac{j \cdot \omega \cdot L}{j \cdot \omega \cdot L} = 1$ flat at $20 \cdot \log(1) = 0$ •dB

c) -3dB at 15000 rad/sec d) -1dB at 30000 rad/sec

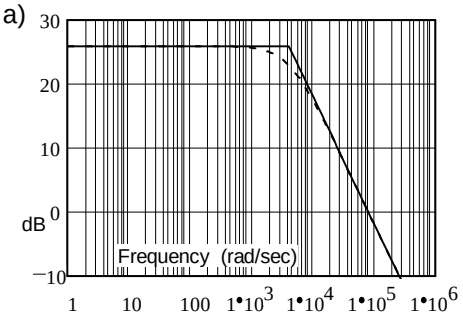
Magnitude plot

Straight-line approximation __

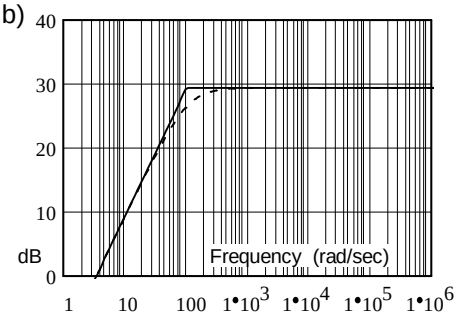
Actual _ _ _ _ (part e)



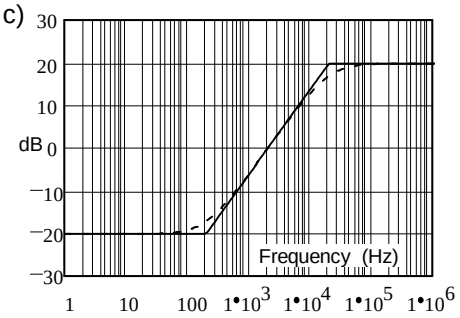
4. a)



b)



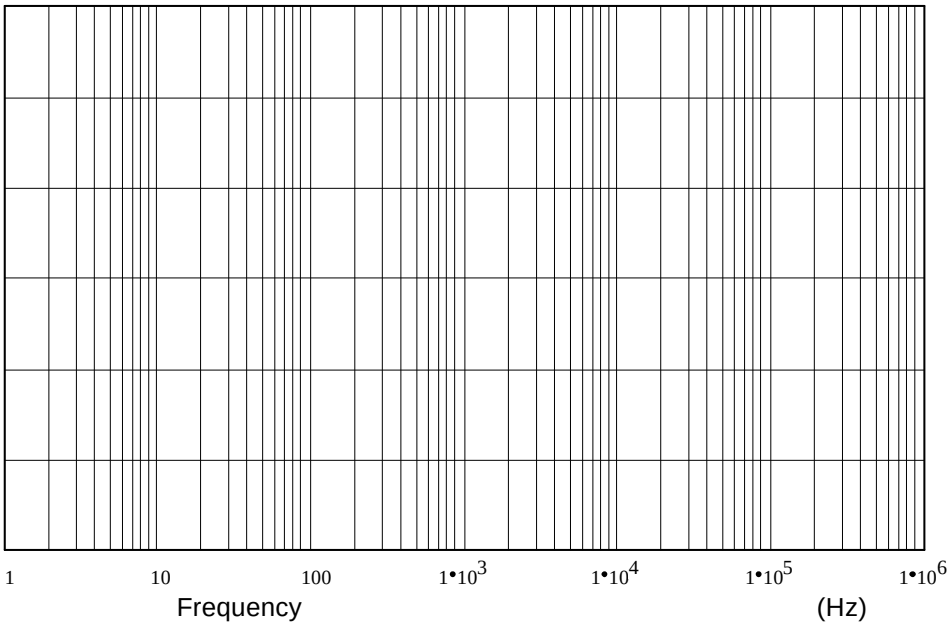
c)



5. 3. high-pass 4.a) low-pass b) high-pass c) high-pass

6. Slope -20dB/dec to 20Hz, flat at 3.5dB to 3kHz, slope +20dB/dec to 40kHz, rest flat at 26dB.
b) Actual magnitudes: 6.5dB at 20Hz, 6.5dB at 3kHz, 23dB/dec at 40kHz. c) zeros: 20Hz, 3kHz, pole: 40kHz

c) $\mathbf{H_c}(f) := 0.1 \cdot \dfrac{1 + j \cdot \dfrac{f}{200 \cdot Hz}}{1 + j \cdot \dfrac{f}{20000 \cdot Hz}}$



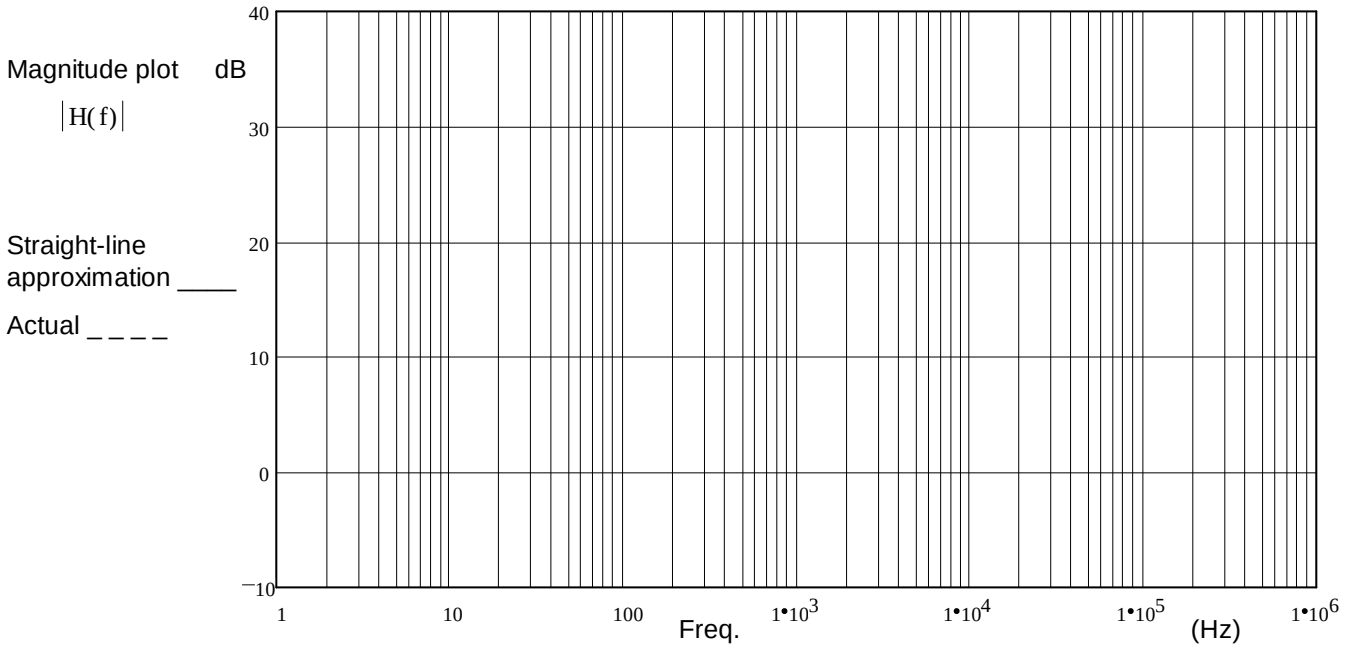
5. Determine the type of each of the filters in problems 3 and 4, low-pass, band-pass, or high-pass.

3. 4.a) b) c)

ECE 2210 homework Bode p6

6. a) Draw the asymptotic Bode plot (the straight-line approximation) of the transfer function shown. Accurately draw it on the graph provided.

$$H(f) = \frac{(3\cdot kHz + j\cdot f)\cdot\left(1\cdot Hz + \frac{j\cdot f}{20}\right)}{j\cdot f\cdot\left(\frac{j\cdot f}{400} + 100\cdot Hz\right)}$$



b) The asymptotic Bode plot is not exact. Using a dotted line, sketch the actual magnitude of the transfer function |H(f)| on the plot above. Indicate the point(s) where the difference between the two lines is the biggest (draw arrow(s)) and write down the actual magnitude(s) at that (those) point(s).

c) Identify all zeros and poles of the transfer function.

ECE 2210 homework Bode p6