Physics 313 Assignment 4

1) a) high-pass RC, \( f_c = 600 \text{ Hz} \); \( C = 560 \text{ pF} \)

\[
\frac{1}{R} = \frac{1}{2\pi f_c R C} \quad \text{Vout} = \text{Vin} \quad \text{for} \quad f_c = 600 \text{ Hz} = \frac{1}{2\pi R C} \]

\[
R = \frac{1}{2\pi (600 \text{ Hz}) (560 \times 10^{-12} \text{ F})} = 470 \text{ k}\Omega
\]

b) see attached: \( \frac{\text{Vout}}{\text{Vin}} = \frac{2\pi f L C}{\text{Vin} + (2\pi f L C)^2} \)

c) at \( f = 200 \text{ Hz} \), \( \frac{\text{Vout}}{\text{Vin}} = 0.32 \rightarrow \text{Vout} = 1.6 \text{ V} \); in dB, \( 20 \log (0.32) = -9.9 \)

d) at \( f = 1200 \text{ Hz} \), \( \frac{\text{Vout}}{\text{Vin}} = 0.89 \rightarrow \text{Vout} = 4.5 \text{ V} \); in dB, \( 20 \log (0.89) = -1.0 \)

e) \( \begin{align*}
&< 600 \text{ Hz} \\
&600 \text{ Hz} \\
&> 600 \text{ Hz}
\end{align*} \)

\( \begin{align*}
&\approx 0 \\
&1 \\
&\approx 0
\end{align*} \)

\( V_{\text{out}} \) leads \( V_{\text{in}} \); phase \( V_{\text{out}} \approx 90^\circ \\
45^\circ \quad \text{leads} \\
0^\circ \quad \text{leads}
\)

2a) high-pass RL \( f_c = \frac{R}{2\pi L} \)

\[
\text{Comparable RC filter looks like} \quad \frac{1}{R C} = \frac{1}{2\pi L} \quad \Rightarrow \quad \frac{1}{\pi L} = \frac{2\pi L}{2\pi L} = 10 \text{ kHz}
\]

\[ R = 16 \times 10^{-5} \Omega \]

\( \Rightarrow \) \( \text{let's say} \ R = 1 \text{k} \); then \( C = 1.6 \times 10^{-8} \text{ F} = 16 \text{ nF} = 0.016 \mu \text{F} \)

b) RL high-pass filter above has \( \text{Vout} = \pm X_L \), \( \text{Vin} = \mp \sqrt{R^2 + X_L^2} \)

so \( \frac{\text{Vout}}{\text{Vin}} = \frac{X_L}{\sqrt{R^2 + X_L^2}} = \frac{XL}{\sqrt{R^2 + (XL)^2}} = \frac{2\pi f L}{\sqrt{1 + (2\pi f L)^2}} \)

c) \( f_c \) occurs when \( \frac{\text{Vout}}{\text{Vin}} = \frac{1}{\sqrt{2}} \)

so \( \frac{2\pi f L}{R} = 1 \rightarrow f_c = \frac{R}{2\pi L} \)
3) Bandpass filter with 15-25 kHz range.

This means we need to pass frequencies higher than 15 kHz and lower than 25 kHz.

⇒ high-pass with \( f_c = 15 \text{ kHz} \) and low-pass with \( f_c = 25 \text{ kHz} \).

Also, second filter has to have \( R > 10 \times R \) in 1st filter.

So let's put low-pass 1st with \( R = 10 \text{k} \)

⇒ \( C = \frac{1}{2\pi f_c R} = 640 \text{ pF} \)

Then high-pass has to have \( R \geq 100 \text{k} \) and choose 100 k

⇒ \( C = 110 \text{ pF} \)

So we have

\[
\begin{array}{c}
\text{Vin} \quad \frac{10k}{640pF} \quad \frac{110pF}{100k} \quad \text{Vout}
\end{array}
\]

With \( \text{Vin} \leq 15 \text{ V} \), the most power that could be dissipated in either resistor is \( \frac{(15 \text{ V})^2}{10k} = 0.02 \text{ W} \).

So even 1/8 W resistors OK in this case.