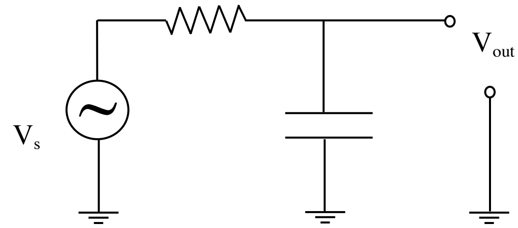
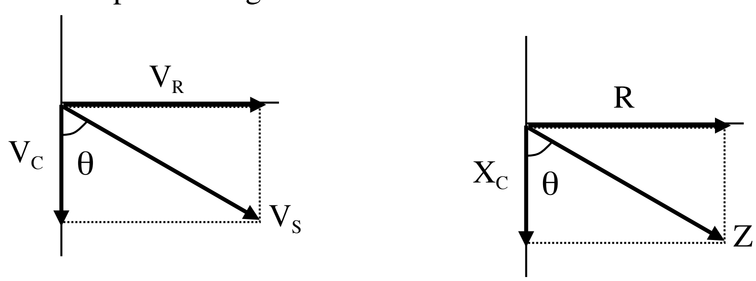
**PHY2250 "Homework 6". Dr. Hawley's answers.**

1. Part of the crossover for a 2-way loudspeaker system has a capacitance of 2 μF and a resistance of 1 kΩ, and has the following schematic:




   a. What is the time constant τ for this part of the circuit?
   b. Calculate the turnover frequency $f_0 = 1/(2\pi\tau)$ and explain briefly what happens to the ratio $V_{out}/V_s$ (just the amplitudes, ignore phase effects) for freq's above & below this frequency.
   c. Which signals are phase-shifted more relative to the source voltage: low or high frequencies?
   d. Calculate the phase shift in degrees from $V_s$ to $V_{out}$ for a 150 Hz sine wave. Include the sign (+ or -) of the shift to indicate leading or lagging.

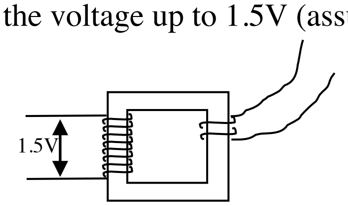
   Hint: Use a phasor diagram!




**Answer:**

**a.** $\tau = RC = (1000)(2*10^{-6}) =$ **2ms**
**b.** $f_0 = 1/(2\pi\tau) =$ **79.6s**. **Below this, the amplitude doesn't depend much on frequency. Above** $f_0$, **the frequency falls off like** $1/f$.
**c. High frequencies.**
**d.** $X_c = 1/(2\pi f C) = 1/((2\pi)(150)(2*10^{-6})) =$ **531Ω**
$\theta = \tan^{-1}(R/X_C) = \tan^{-1}(1000/531) =$ **-62.0°**,
**where we've tacked on the – sign to indicate lagging.**

2. A signal from a mic is coming in at 20mV. It then connects to a transformer… What turns ratio is needed to step the voltage up to 1.5V (assuming an ideal transformer)?




**Answer:**

$$V_2 = nV_1, \text{ where } n = \frac{N_2}{N_1}.$$

$$n = \frac{V_2}{V_1} = \frac{1.5V}{0.02V} = 75$$

3. Describe Faraday's Law of induction, and list three different examples of how it arises (or is used) in audio engineering.

**Answer: A time-changing magnetic flux induces a voltage in a loop of wire. The direction of the induced current is so as to oppose the change in flux. Examples: dynamic microphones, play heads, transformers, guitar pickups.**

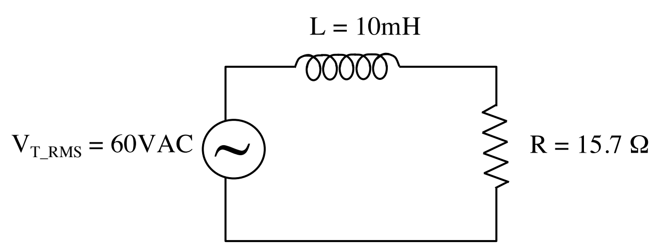
4. Given your answer to #3, would you expect induction to be a more significant effect at *high* or *low* frequencies, and why?

**Answer: High frequencies, because with higher frequencies the flux is changing faster than for low frequencies.**

5. Some people like to say that "and inductor is like the opposite of a capacitor." Describe in what sense(s) this can be true.

**Answer:**
**Phase: Inductor voltage is 90º *ahead* of the current, whereas capacitor voltage is 90º *behind* the current.**
**Frequency dependence: Inductve reactance is proportional to frequency, whereas capacitve reactance is *inversely* proportional to frequency.**

6.




For the circuit shown, find

a) $V_T$ (peak)

  **$V_T = V_{T\_RMS} / 0.707 = 84.9$ V**

b) For the frequency $f$ = 63 Hz, find

  i. $X_L$ **$= 2\pi f L = 2\pi(63 \text{ Hz})(0.01 \text{ H}) = 3.96\ \Omega$**

  ii. The angle $\theta$ between $Z_T$ and R, and the cosine of $\theta$.

  **$\theta = \tan^{-1}(X_L / R) = \tan^{-1}(3.96 / 15.7) = 14.16^{\circ}$**

  **$\cos\theta = 0.9696$**

  iii. $\boldsymbol{Z_T = \sqrt{R^2 + X_L^2} = 16.2\ \Omega}$

  iv. $V_R$ **$= V_T \cos\theta = 82.3$ V**

c) Repeat (b) for $f$ = 250 Hz

i. $\mathbf{X_L = 15.7\ \Omega}$

ii. $\boldsymbol{\theta = 45.0^{o},\ \cos\theta = 0.7069}$

iii. $\mathbf{Z = 22.2\ \Omega}$

iv. $\mathbf{V_R = 60V}$

d) Repeat (b) for $f$ = 2000 Hz

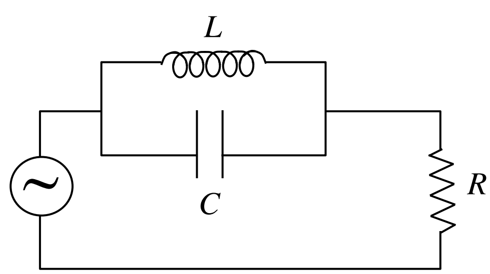
i. $\mathbf{X_L = 125.6\ \Omega}$

ii. $\boldsymbol{\theta = 82.9^{o},\ \cos\theta = 0.1240}$

iii. $\mathbf{Z = 126.6\ \Omega}$

iv. $\mathbf{V_R = 10.5\ V}$

7. Notch Filter




In the schematic shown, $V_T$ = 100 V, $L$ = 1 mH, $C$ = 0.1 mF, and $R$ = 8 Ω.

a) At what frequency $f_n$ is $X_C = X_L$?

$$\boldsymbol{f_n = \frac{1}{2\pi\sqrt{LC}} = 503\ Hz}$$

*b)* Show that the impedance value at this frequency is equal to $X_n = \sqrt{L/C}$ and find the value of $X_n$

$\mathbf{X_n = 10\ \Omega}$

8. Do the exercise at the end in the Phasor Diagram handout. (Answers at bottom of handout.)