University of Alabama
Department of Physics and Astronomy

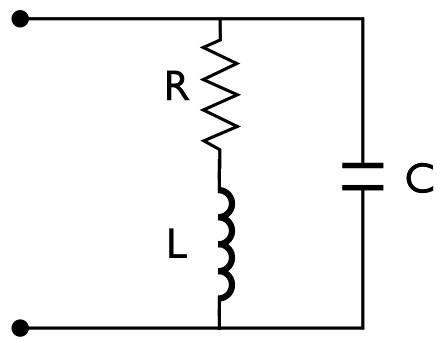
PH 126 LeClair | Fall 2011

Problem Set 8

Instructions:

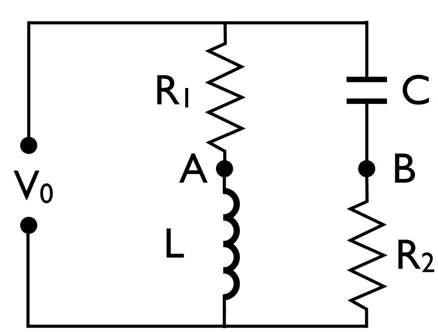
1. Answer all questions below. Show your work for full credit.
2. All problems are due 15 November 2011 by 11:59pm.
3. You may collaborate, but everyone must turn in their own work.

1. Is it possible to find a frequency at which the impedance at the terminals of the circuit below will be purely real? If so, find that frequency. If not, explain carefully why.

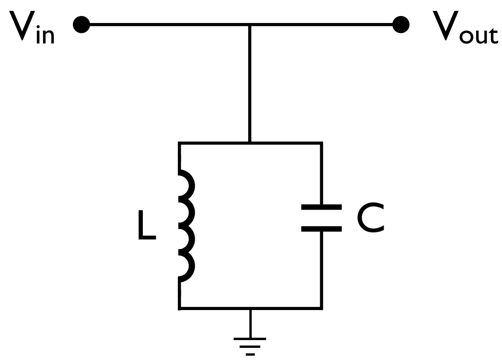


2. Show that, if the condition $R_1R_2 = L/C$ is satisfied by the components of the circuit below, the difference in voltage between points A and B will be zero at any frequency.

Discuss the suitability of this circuit as an ac bridge for measurement of an unknown inductance.



3. Calculate the amplitude and phase of the output for the filter below for all frequencies, assuming a sinusoidal input. What might one use a filter like this for?



4. Repeat the question above for a filter consisting of (a) a capacitor C and inductor L in series between input and output, and (b) a parallel L-C combination placed between input and output.

5. Two long coaxial cylindrical metal tubes (inner radius a, outer radius b) stand vertically in a tank of dielectric oil (susceptibility χ_e, mass density ρ). The inner one is maintained at potential V, and the outer one is grounded. To what height h does the oil rise in the space between the tubes?

6. Consider a charged parallel-plate capacitor, whose electric field (in its rest frame) is uniform (neglecting edge effects) between the plates and zero outside. Find the electric field according to an observer in motion at constant velocity v **(a)** along a line running through the center of the capacitor between the plates, and **(b)** along a line perpendicular to the plates.

7. A particle with electric charge q moves along a straight line in a uniform electric field $\vec{\mathbf{E}}$ with a speed of u. The electric force exerted on the charge is $q\vec{\mathbf{E}}$. The motion and the electric field are both in the x direction. Show that the acceleration of the particle in the x direction is given by

$$a = \frac{du}{dt} = \frac{qE}{m}\left(1 - \frac{u^2}{c^2}\right)^{3/2} \tag{1}$$

8. The equation for a driven damped oscillator is

$$\frac{d^2x}{dt^2} + 2\gamma\omega_o\frac{dx}{dt} + \omega_o^2 x = \frac{q}{m}E(t) \tag{2}$$

(a) Explain the significance of each term.
(b) Let $E = E_o e^{i\omega t}$ and $x = x_o e^{i(\omega t - \alpha)}$ where E_o and x_o are real quantities. Substitute into the

above expression and show that

$$x_o = \frac{qE_o/m}{\sqrt{(\omega_o^2 - \omega^2)^2 + (2\gamma\omega\omega_o)^2}} \tag{3}$$

(c) Derive an expression for the phase lag α, and sketch it as a function of ω, indicating ω_o on the sketch.