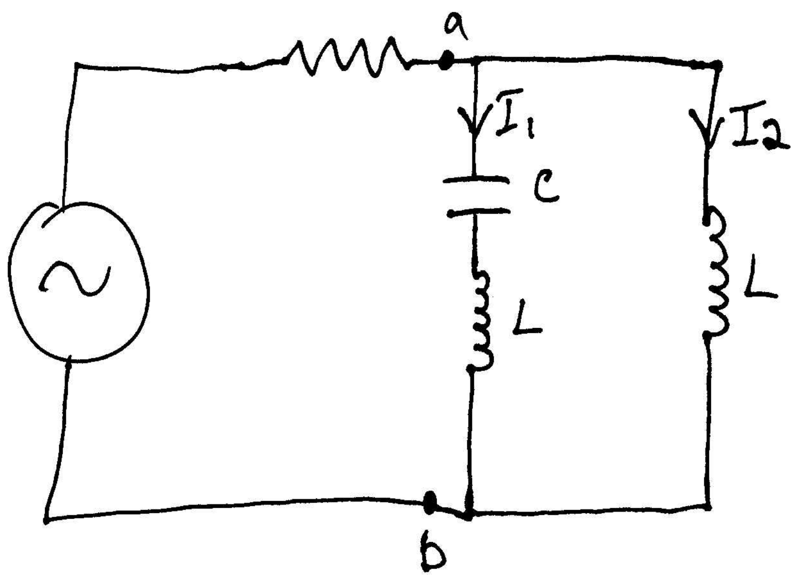
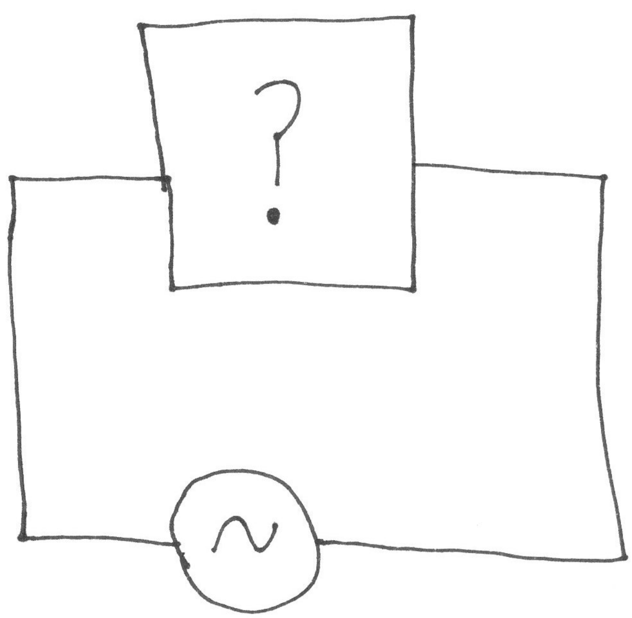
PHY 122 HW 12

1. For the circuit below, draw phasors for I_1, I_2 with V_{ab}. Hint: start with V_{ab} and I_1. Write an expression relating I_1 and I_2.



2. You are being held hostage on a jungle island by guerillas, not gorillas (bonus points if you know what movie that came from). They have 3 mystery boxes which can be connected to a sinusoidal voltage source and an ammeter they happen to have. The guerillas tell you that if you are able to give some plausible explanation for what is inside the boxes, they will let you go. What is in boxes a through c?

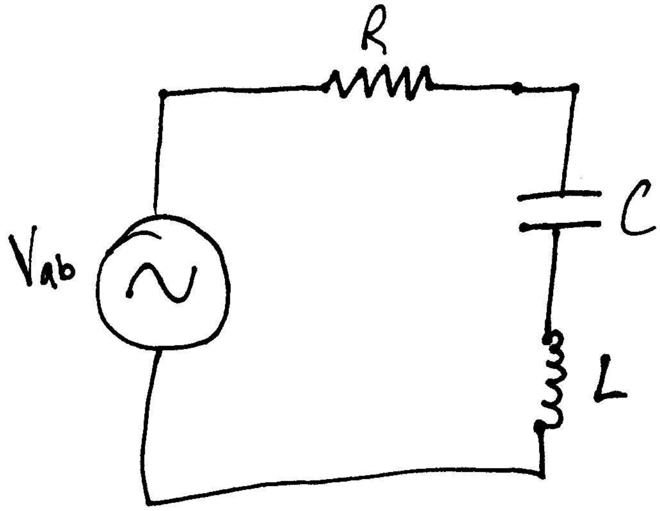


(a) The current measured differs from the voltage by a constant factor, regardless of input frequency.

(b) The current and voltage are out of phase, and as the frequency is turned down very low, the voltage and current again only differ by a constant factor.

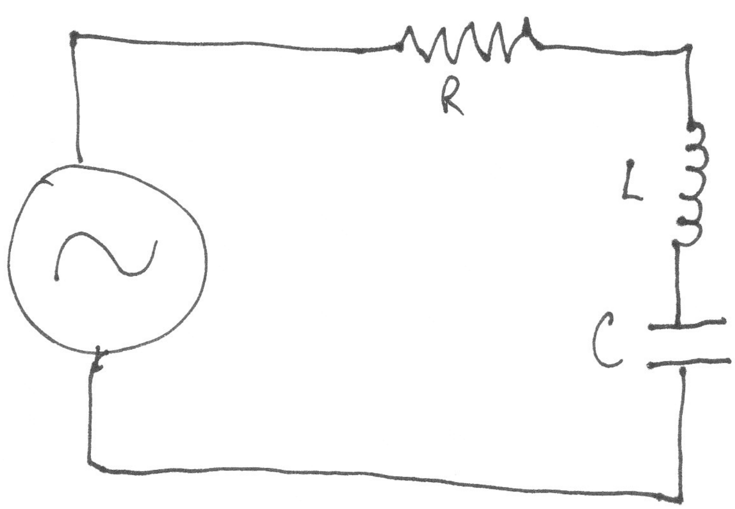
(c) The current and voltage are in phase at one frequency, but shift out of phase as you move away from this freqency.

3. Using the following circuit with $\omega = 2\omega_0 = 2/\sqrt{LC}$,



Find a relationship between V_L and V_C. What is V_{ab} when I is at its maximum value?

4. RLC circuits are often used to tune devices that transmit and/or receive data at specific frequencies (i.e. radios, televisions, etc.). You are designing an RLC circuit onboard an infrared space telescope which will be used to send data back to Earth on a given channel. The circuit will consist of a resistive load, an inductor, and a capacitor in series being driven by an AC voltage source.



(a) At what frequency is the maximum power dissapated by the load?

(b) What is the maximum power dissapated at a frequency of $\omega = 7/\sqrt{LC}$?

(c) Infrared telescopes are very sensitive to increases in temperature. If the temperature rises above a certain point, the telescope is blinded because it becomes a bright source of infrared light itself (if that doesn't immediately make sense, it is similar to looking at a star with the naked eye during the daytime). With this in mind, you need to design your circuit in such a way that the load does not heat up too much. To do this, use the formula $P = \sigma A T^4$, where P is the power dissapated by the load, A is the surface area of the load, T is the temperature in Kelvin, and $\sigma = 5.67 \cdot 10^{-8} W m^2 K^{-4}$ is the Stefan-Boltzmann constant. If we need to construct the circuit so that the load never gets hotter than 120 Kelvin, what is the minimum value we can use for the resistance of the load? Use the values $L = 1\ mH$, $C = 1\ \mu F$ $A = 10\ cm$, and the maximum voltage across the source is 12 V.

5. You are a mad scientist who just created the first magnetic monopole. Do we need to change the Maxwell equations to account for your discovery? If so, which ones need to be changed?

6. In a region of empty space (no I_{encl} or Q_{encl}), is the right hand side of each of the Maxwell equations zero? If yes, explain why each one is zero, if no, provide an example of a region with no charge or current where at least one of the Maxwell equations is nonzero.

7. A current of 10 A flows into a parallel plate capacitor with square plates with area .5 m^2.

   (a) What is dE/dt between the plates?

   (b) What is the line integral $\int \vec{B} \cdot d\vec{\ell}$ around a circular closed contour with a diameter of 10 cm perpendicular to the electric field?

8. In a given electromagnetic plane wave the maximumelectric field strength is 400 V/m.

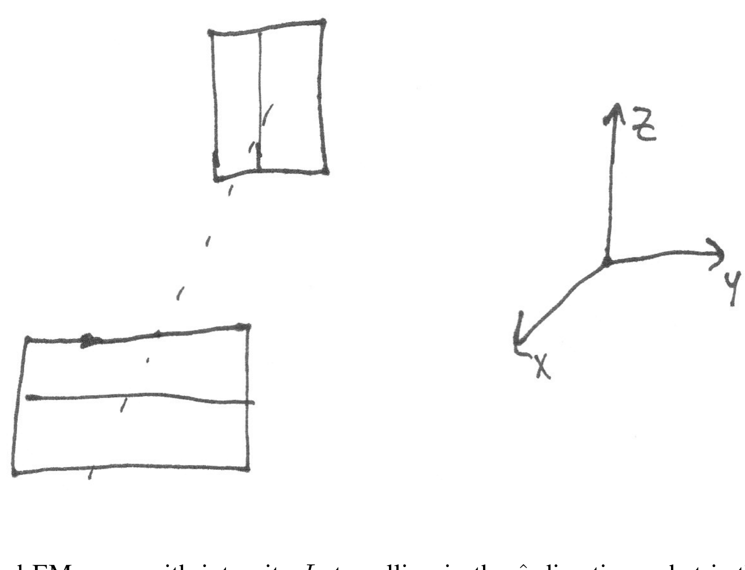
   (a) What is the maximum magnetic field strength? How does the energy stored in the magnetic field compare with the energy stored in the electric field at any given time?

   (b) Calculate the average intensity of the wave.

   (c) Calculate the average energy density of the wave.

9. For a microwave with a wavelength of 3 cm, calculate the frequency. Would this number change if physics suddenly broke and the speed of light in air decreased by a factor of 2?

10. In the figure shown below, we have 2 polarizers oriented at 90° to one another.



   (a) For an unpolarized EM wave with intensity I_0 travelling in the $\hat{x}$ direction, what is the intensity after passing through both polarizers?

   (b) If we place a third polarizer between the two shown above that makes an angle θ_1 with the y-axis, plot the intensity of the resulting wave as a function of angle.

(c) Now if we insert one more polarizer into the system which makes an angle θ_2 with the y-axis, make a guess as to what angles θ_1 and θ_2 will maximize the outgoing intensity. After doing this, calculate the resulting intensity of your configuration.