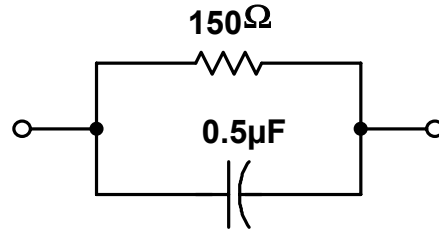


## Electronics

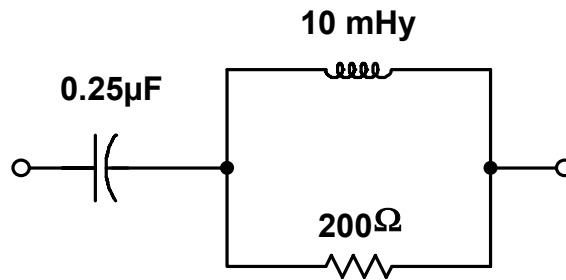
### Homework Set #2

1. Calculate the equivalent impedance of the circuits sketched below. Express your results in the  $a + jb$  format, and also in the  $|z|, \tan \theta$  format.

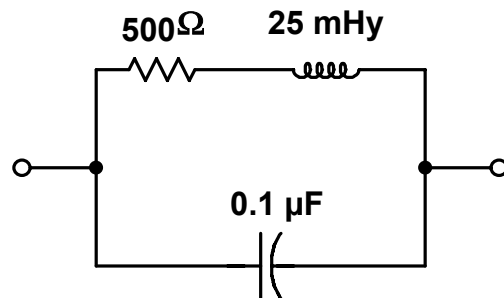
a.  $f = \frac{1 \times 10^4}{2\pi} \text{ Hz}$



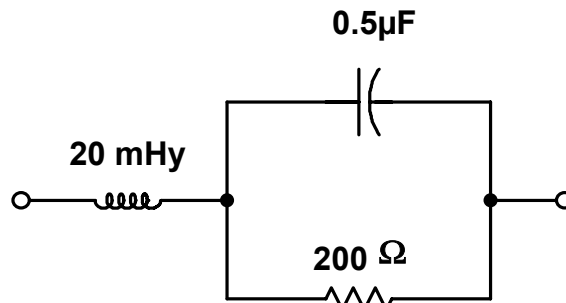
b.  $f = \frac{2 \times 10^4}{2\pi} \text{ Hz}$



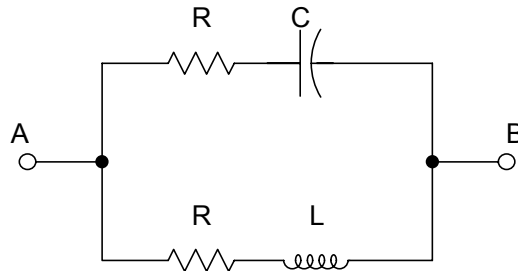
c.  $f = \frac{2 \times 10^4}{2\pi} \text{ Hz}$



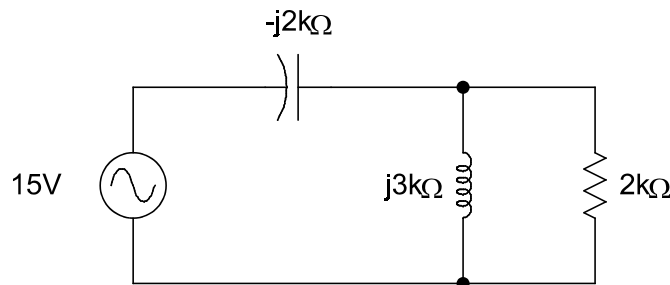
d.  $f = \frac{10^4}{2\pi} \text{ Hz}$



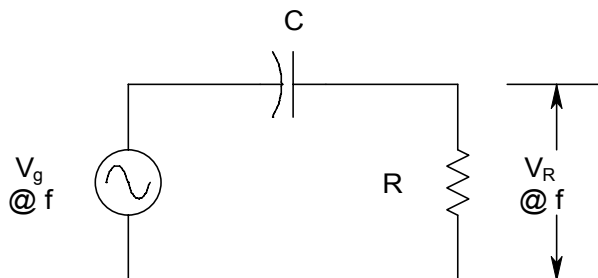
2.
  - a. Calculate an expression for the impedance between points **A** and **B** in the circuit below for any frequency  $\omega$ ;
  - b. Find the relationship between **R**, **L**, and **C** which eliminates **all** frequency dependence.



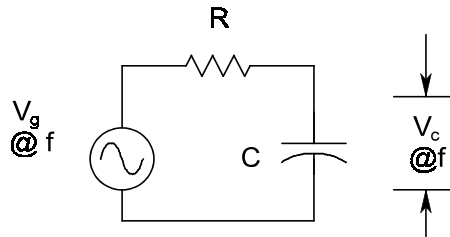
3. Calculate the current in the resistor below by
  - a. direct methods;
  - b. use of Thevenin's theorem.



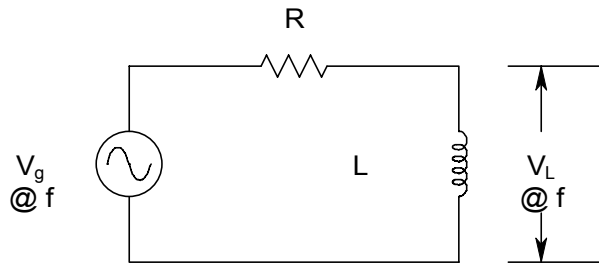
4. For the circuit below, calculate the ratio  $r = |V_R|/|V_g|$  and show that  $r$  is frequency-dependent. The parameter  $r$  is sometimes called the "transfer function" of the circuit. Analyze the ratio graphically to show that  $r$  increases with increasing  $f$  in this circuit.



5. With  $r$  defined as  $r = |V_C|/|V_g|$ , repeat the procedure of #4 for the circuit below to show that  $r$  decreases with increasing  $f$  (the same as “**increases with decreasing  $f$** ”).



6. With  $r$  defined as  $r = |V_L|/|V_g|$ , repeat the procedure of #4 for the RL circuit below to show that  $r$  increases with increasing  $f$  (the same as “**decreases with decreasing  $f$** ”).



7. The circuits of 4 and 5 are sometimes referred to as "high-pass" and "low-pass" filters, respectively. (They are actually frequency-dependent voltage dividers.) For a low-pass RC circuit such as #5, make the following calculations:
- the range of values for the product  $RC$  such that  $|V_C| \leq 0.1 |V_g|$  for  $f \geq 100 \text{ kHz}$ ;
  - the range of values for the product  $RC$  such that  $|V_C| \geq 0.7 |V_g|$  for  $f \leq 1 \text{ kHz}$ ;
  - the range of values for  $R$  and  $C$  such that  $|Z_R // Z_C| \leq 1 \text{ k}\Omega$  for all  $f$ .
  - choose specific  $R$  and  $C$  values simultaneously within all three ranges obtained in parts **a.** through **c.** above. (There will be a range of values which do so.)
8. For a high-pass RC circuit such as #4, repeat the analysis of #6 for the following:
- $|V_R| \leq 0.1 |V_g|$  for  $f \leq 1 \text{ kHz}$ ;
  - $|V_R| \geq 0.7 |V_g|$  for  $f \geq 100 \text{ kHz}$ ;
  - $|Z_R // Z_C| \leq 1 \text{ k}\Omega$  for all  $f$ ,
  - $R$  and  $C$  values falling simultaneously in all three ranges obtained in **a.** through **c.**
9. **a. Sketch and analyze a simple RC circuit** with the properties that a **100kHz** signal will

pass with very little reduction while a signal of 5 kHz will be reduced considerably. Calculate a capacitance value to be used in combination with a 1 k $\Omega$  resistor so that the the magnitude of the 100 kHz signal will be reduced to **no less than**  $\frac{1}{2}\sqrt{2} / V_{in}$  / (or  $0.7V_{in}$ ).

**b.** For the same circuit and resistor value, calculate a capacitance value which will reduce the magnitude of a **5kHz** signal so that the output is **no more than**  $0.1 / V_{in}$ .

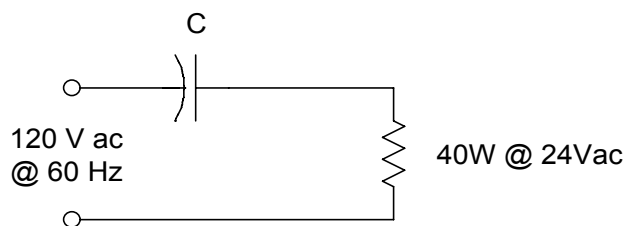
**c.** For the circuit of **(a)**, **calculate a "suitable" capacitance value** which will accomplish the tasks of both **(a) and (b)** at the same time. That is, the circuit should have the behavior that the magnitude of the output from a **100kHz** signal will be  $\frac{1}{2}\sqrt{2} / V_{in}$  / or more, while that from a **5kHz** signal will be  $0.1 / V_{in}$  / or less. Demonstrate by direct calculation that your circuit and set of values accomplish the objectives stated above.

10. **a.** **Sketch and analyze a simple RC circuit** with the properties that a **5kHz** signal will pass with very little reduction while a signal of **100 kHz** will be reduced considerably. Calculate a capacitance value to be used in combination with a 1 k $\Omega$  resistor so that the magnitude of a 5 kHz signal will be reduced to **no less than**  $\frac{1}{2}\sqrt{2} / V_{in}$  / (or  $0.7 / V_{in}$ ).

**b.** For the same circuit and resistor value, calculate a capacitance value which will reduce a **100kHz** signal so that the output is **no more than**  $0.1 / V_{in}$ .

**c.** For the circuit of **(a)**, **calculate a "suitable" capacitance value** which will accomplish the tasks of both **(a) and (b)** at the same time. That is, the circuit should have the behavior that the output from a **5kHz** signal will be  $\frac{1}{2}\sqrt{2} / V_{in}$  / or more, while that from a **100kHz** signal will be  $0.1 / V_{in}$  / or less. Demonstrate by direct calculation that your circuit and set of values accomplish the objectives stated above.

11. Sketched below is a circuit using a capacitor to "drop" the 120 V ac house supply (@ 60Hz) to that required by a light bulb represented by the resistor. Calculate the necessary capacitance value for a bulb with rating 40W @ 24 V ac.



12. Repeat #11 using an inductor instead of a capacitor. (Assume an "ideal" inductor with no resistance.)