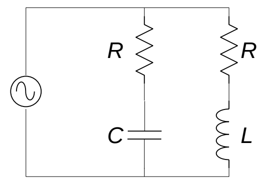
20. Express the following complex numbers in $r\angle\theta$ format (I bet your calculator can do this automatically):
(a) $\dfrac{1}{1+i}$ (b) $\dfrac{3+i}{1+3i}$ (c) $25e^{2i}$ (d) $(1/(1+i))^*$ (e) $\left|\dfrac{1}{(1+i)}\right|$

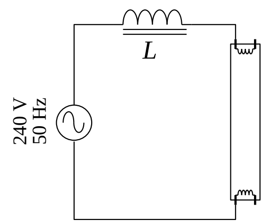
21. Find the following in (a,b) format (I bet your calculator can do this automatically):
(a) $\dfrac{3i-7}{i+4}$ (b) $(.64+.77i)^4$ (c) $\sqrt{3+4i}$ (d) $25e^{2i}$ (e) $\ln(-1)$

22. *LRC* Circuit



The circuit shown right includes two identical resistors (resistance R), an inductor (L), and a capacitor (C). Find the equivalent impedance, and show that if $R=\sqrt{L/C}$. the equivalent impedance does not depend on ω!

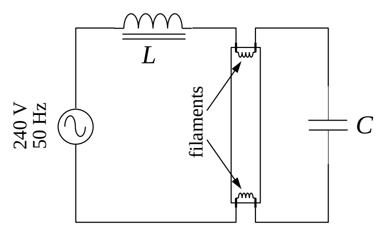
23. Fluorescent Lamp: run



In England (where the "mains" supply is 240 V at 50 Hz) fluorescent tubes are powered with the circuit shown. The inductor L ("ballast") is used as part of a voltage divider to supply the tube with less than 240 V. Consider the case of the T12 24" 20 Watt tubes used in our halls. When lit, these tubes draw 0.37 A. Assuming the tube acts just like a resistor, what is the voltage across the tube? What value of L would provide this current and voltage in England?

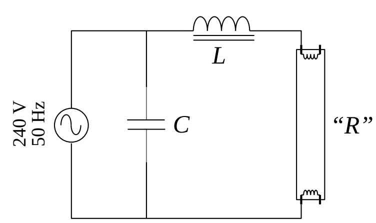
24. Fluorescent Lamp: *LRC* start?

In order to ignite the arc inside the fluorescent tube the filaments are heated (by sending a current through them) and then a high voltage pulse is applied. While not the usual method used, an *LRC* resonant circuit could be used to produce both a large filament current and a voltage well above 240 V, and thus facilitate the ignition. (The unlit tube acts is an insulator; the filaments are the R; use the value found in the previous problem for L.) If run exactly at resonance, what value of C is required? If the total filament resistance is 40 Ω how much current will flow? Find the voltage across the tube. Exact resonance would actually produce too much current. What value of C is required if the current is to be limited to 0.5 A?



25. Fluorescent Lamp: power factor

As in the previous problems, a 20 Watt fluorescent tube, when lit, will draw 0.37 A from the assumed 240 V supply. The power company will then bill you for 0.37 A × 240 V = 90 "Watts" whereas you are only using 20 W. Oddly enough you can reduce the current drawn from the receptacle by adding a capacitor in parallel to the tube+ballast. This "power factor correcting" capacitor results in a total impedance ($\mathbf{Z}_{\text{total}}$) that is real (i.e., the current drawn from the receptacle is in phase with the voltage). Show that the required C is given by:



$$\omega RC = \frac{1}{\frac{R}{\omega L}+\frac{\omega L}{R}}$$

where R is the effective resistance of the tube. Calculate the value of C needed in England. Note: some algebraic tricks will give you a fast solution, however the tedious, but direct, approach of finding C to maximize $|\mathbf{Z}_{\text{total}}|$ (and hence minimize the current) will also produce the correct answer.