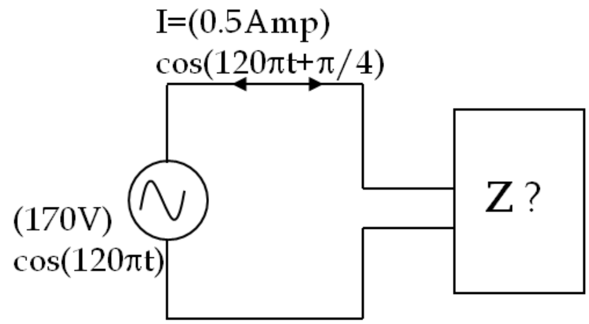
12.9 PROBLEMS

Problem 12.9.1. An AC generator is connected to a device whose internal circuits are not known.

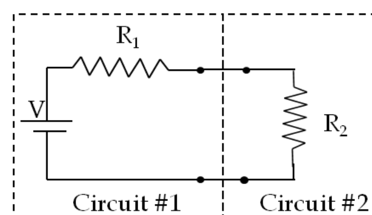
We only know current and voltage outside the device as shown in the Figure. Based on the information given what can you infer about the electrical nature of the device and its power usage.



Ans: 30 W.

Problem 12.9.2. Impedance matching in a DC circuit. In many instances we are interested in connecting two circuits such that maximum power is delivered from one to the other. Consider circuit shown in the Figure.

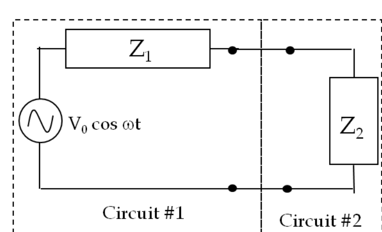
For the purpose of this problem we think of DC power supply V and the resistor R_1 as Circuit # 1 and resistor R_2 as Circuit #2. For fixed values of V and R_1, find the value of R_2 so that power delivered to R_2 is greatest. Note circuits 1 and 2 are open and when they are connected they form a closed circuit.



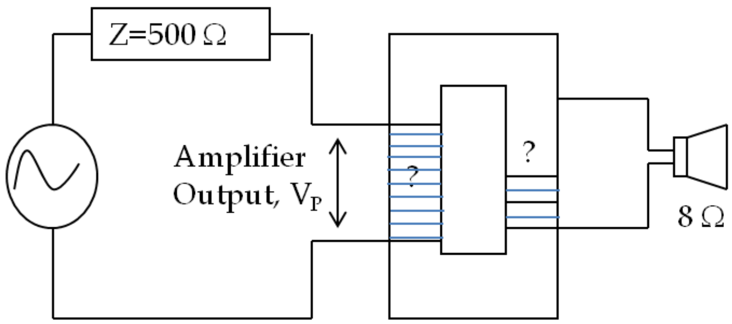
Ans: $R_2 = R_1$.

Problem 12.9.3. Impedance matching in an AC circuit. To study the impedance matching in an AC circuit consider circuit shown in the Figure. For the purpose of this problem we think of the AC power supply $V_0\ \cos(\omega t)$ and circuit elements whose equivalent impedance is Z_1 as Circuit # 1 and circuit elements whose impedance is Z_2 as Circuit #2.

For fixed values of V_0, ω, and Z_1, find the value of Z_2 so that the average power delivered to Z_2 is greatest. Note circuits 1 and 2 are open and when they are connected they form a closed circuit.



Problem 12.9.4. An output impedance of an audio amplifier has a impedance of 500 Ω and has a mismatch with a low impedance 8 Ω loudspeaker. You are asked to insert an appropriate transformer to match the impedances. What turns ratio will you use and why? Use the following simplified circuit. (Ans: $N_p : N_s = 8 : 1$.)



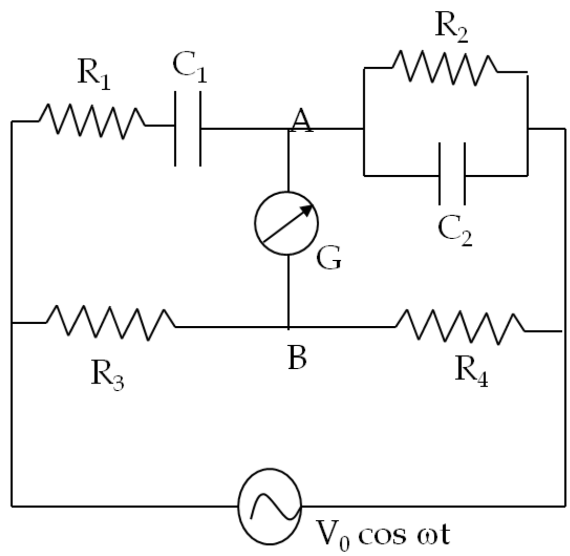
Problem 12.9.5. A resistor R (200 Ω), a capacitor C (20 pF) and an inductor L (30 mH) are connected in parallel to an AC voltage source $V_0\ \cos(\omega t)$ with $V_0 = 256$ V and $\omega = 120$ rad per sec. (a) Find complex impedance of the circuit. (b) Find current in each branch. (c) Find the power factor. (d) Find the power dissipated.

Ans: (a) $0.647\,\Omega\angle 1.55\,\mathrm{rad}$, (b) $I = (396\text{ A})\ \cos(\omega t - 1.55)$, $I_R = (1.28\,\mathrm{A})\cos(\omega t)$, $I_C = (0.61\,\mu\mathrm{A})\cos(\omega t + \pi/2)$, $I_L = (71.1\,\mathrm{A})\cos(\omega t - \pi/2)$, c) 0.02, (d) 164 W.

Problem 12.9.6. Consider an AC circuit with R, L and C in series with an AC power supply. (a) Find the frequency ω at which the average power delivered is a maximum. (b) Find the width $\Delta\omega$ of the resonance peak defined as width at half the height in the average power versus frequency ω plot. Hint: Work out the resonance of power as explained in the text.

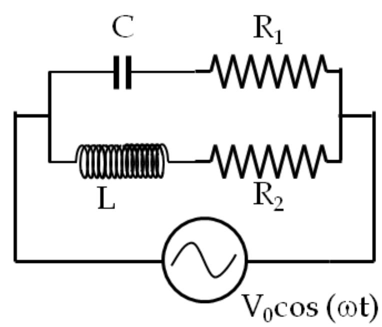
Problem 12.9.7. RC oscillators commonly use a Wein bridge circuit shown in the Figure below. A galvanometer G is connected between the points marked A and B to detect any current flow between A and B. The Wein bridge circuit is said to be balanced when no current flows between A and B. Prove that the following relations must hold true when the circuit is balanced.

$$1.\ \ \frac{R_1}{R_2} + \frac{C_2}{C_1} = \frac{R_3}{R_4}, \qquad 2.\ \ \omega = \frac{1}{\sqrt{R_1 R_2 C_1 C_2}}.$$



Problem 12.9.8. A cross-over circuit is used deliver power to two different parts of the circuit depending on the frequency of the driving signal.

For instance one would want more power be delivered to woofer at low frequency and to tweeter at high frequency. For given L, C, R_1 and R_2, find the cross-over frequency such that below that frequency more power goes to R_2 and above that frequency more power goes to R_1.



Ans: $\dfrac{1}{\sqrt{2}\,LC}\left[\left(R_1R_2 - R_2^2\right)C^2 + \sqrt{\left(R_2^2 - R_1R_2\right)^2 C^4 + \dfrac{4R_2L^2C^2}{R_1}}\right]$.