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Problems set # 11 **Physics 169** May 5, 2015

1. A semicircular conductor of radius $R = 0.250$ m is rotated about the axis AC at a constant rate of 120 rev/min (Fig. 1). A uniform magnetic field in all of the lower half of the figure is directed out of the plane of rotation and has a magnitude of 1.30 T. *(i)* Calculate the maximum value of the emf induced in the conductor. *(ii)* What is the value of the average induced emf for each complete rotation? *(iii)* How would the answers to (i) and (ii) change if B were allowed to extend a distance R above the axis of rotation? Sketch the emf versus time *(iv)* when the field is as drawn in Fig. 1 and *(v)* when the field is extended as described in (iii).

2. An AC power supply produces a maximum voltage of $V_0 = 100$ V. This power supply is connected to a $24.0 - \Omega$ resistor, and the current and resistor voltage are measured with an ideal AC ammeter and an ideal AC voltmeter, as shown in Fig. 2 What does each meter read? Recall that an ideal ammeter has zero resistance and an ideal voltmeter has infinite resistance.

3. *(i)* For the series RLC connection of Fig. 3, draw a phasor diagram for the voltages assuming $X_L > X_C$ and $X_c > X_L$. The amplitudes of the voltage drop across all the circuit elements involved should be represented with phasors. *(ii)* An RLC circuit consists of a 150-Ω resistor, a 21-μF capacitor and a 460-mH inductor, connected in series with a 120-V, 60-Hz power supply. What is the phase angle between the current and the applied voltage? *(iii)* Which reaches its maximum earlier, the current or the voltage?

4. Figure 4 shows a parallel RLC circuit. The instantaneous voltage (and rms voltage) across each of the three circuit elements is the same, and each is in phase with the current through the resistor. The currents in the capacitor and the inductor lead or lag behind the current in the resistor. *(i)* Show that the rms current delivered by the source is $I_{\rm rms} = V_{\rm rms} \left[\frac{1}{R^2} + \left(\omega C - \frac{1}{\omega L}\right)^2\right]^{1/2}$. *(ii)* Show that the phase angle between the voltage and the current is $\tan\varphi = -R\left(\frac{1}{X_C} - \frac{1}{X_L}\right)$. *(iii)* Draw a phasor diagram for the currents. The amplitudes of the currents across all the circuit elements involved should be represented with phasors.

5. Draw to scale a phasor diagram showing Z, X_L, X_C, and φ for an AC series circuit for which $R = 300\ \Omega$, $C = 11\ \mu$F, $L = 0.2$ H, and $f = 500/\pi$ Hz.

6. Draw to scale a phasor diagram showing the relationship between the current (common for all elements) and the voltages in an AC series circuit for which $R = 300\ \Omega$, $C = 11\ \mu$F, $L = 0.2$ H, $f = 500/\pi$ Hz, and $I_0 = 20$ mA.

7. A coil of inductance 0.12 H and resistance 3 kΩ is connected in parallel with a 0.02 μF capacitor and is supplied at 40 V at a frequency of 5 kHz. Determine *(i)* the current in the coil, and *(ii)* the current in the capacitor. *(iii)* Draw to scale the phasor diagram and measure the supply current and its phase angle; check the answer by calculation. Determine *(iv)* the circuit impedance and *(v)* the power consumed.

8. A transmission line that has a resistance per unit length of $4.5 \times 10^{-4}\ \Omega$/m is to be used to transmit 5 MW over 400 miles (6.44×10^5 m); see Fig. 8. The output voltage of the generator is 4.5 kV. *(i)* What is the line loss if a transformer is used to step up the voltage to 500 kV? *(ii)* What fraction of the input power is lost to the line under these circumstances? *(iii)* What difficulties

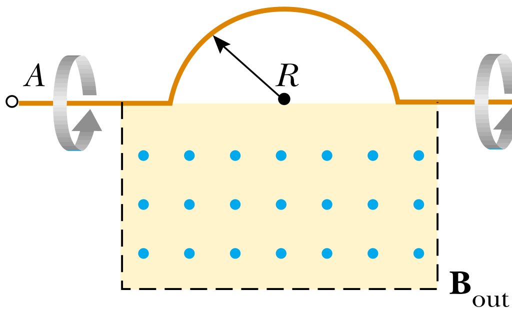

Figure 1: Problem 1.

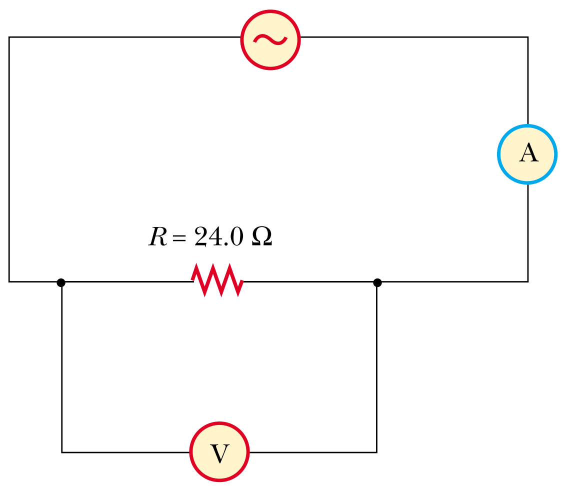

Figure 2: Problem 2.

would be encountered in attempting to transmit the 5 MW at the generator voltage of 4.5 kV.

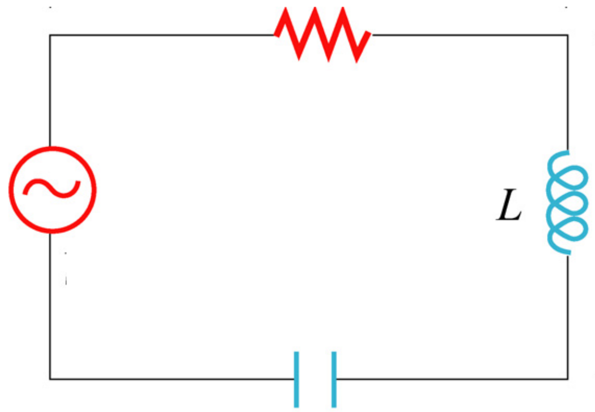

Figure 3: Problem 3.

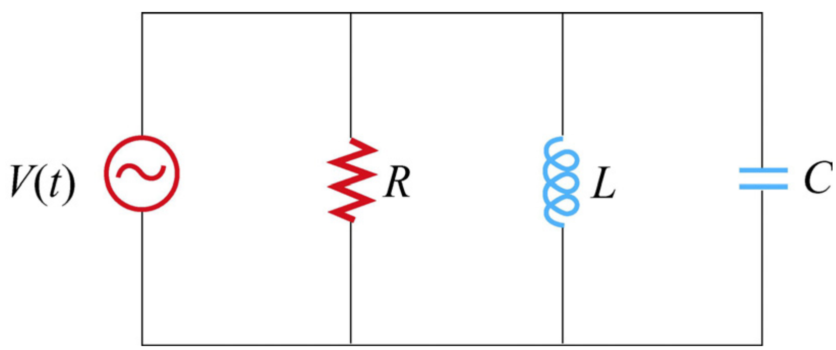

Figure 4: Problem 4.

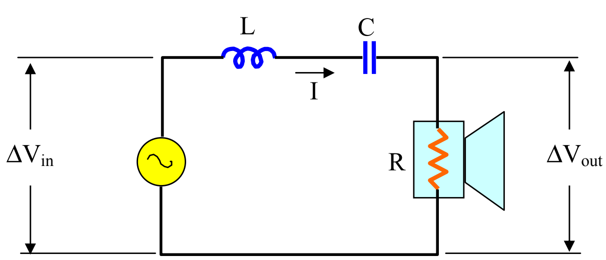

Figure 5: Problem 7.

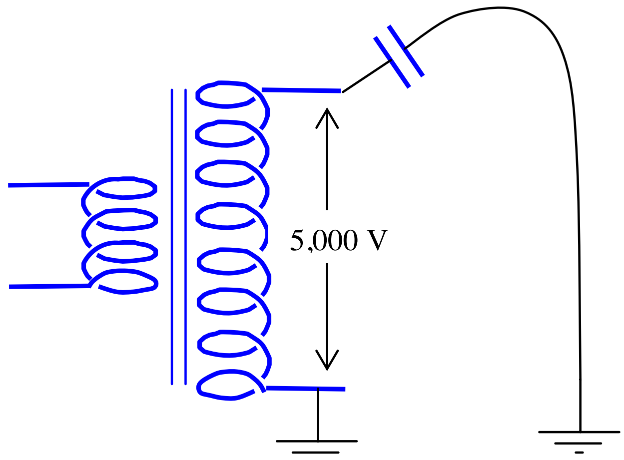

Figure 6: Problem 8.

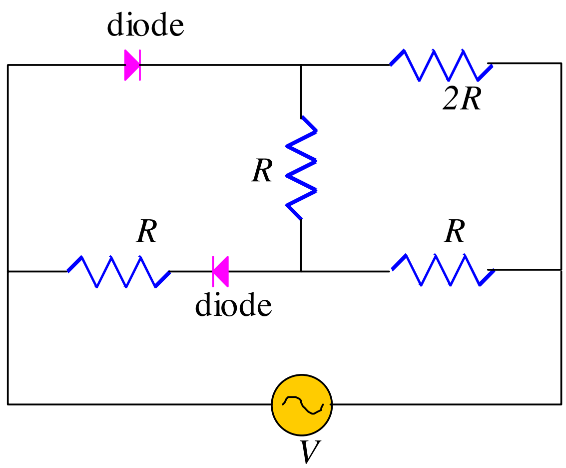

Figure 7: Problem 9.

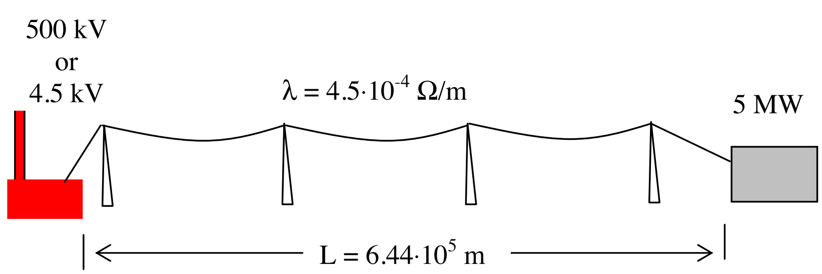

Figure 8: Problem 10.