

Section A

1. b (the peak must be greater than the rms)
2. e (the relationship between rms voltage and rms current is the same as the one between voltage and current used in DC circuits, i.e., it depends on the impedance).
3. c (adding a dielectric increases the capacitance)
4. d (1/4 of a cycle is 1 ms in this case; due to the capacitor, the max current comes before the max voltage; without the resistor it would be 1/4 cycle earlier but there is a resistor in this case)
5. d (since it is less than the smaller capacitance, it may indeed be possible if you put them in series; add 1/2 plus 1/6 to get 4/6 and then invert to get 1.5)
6. c (the resonant frequency only depends upon the inductance and capacitance)

Section B

1. The energy stored in a capacitor equals $\frac{1}{2}QV$. Since $Q = CV$, we can plug in and get $E_{\text{cap}} = \frac{1}{2}CV^2$. The energy is given as 200 J and the voltage is 6000 V, so we can solve for

$$\begin{aligned}
 C &= 2E/V^2 \\
 &= 2(200 \text{ J})/(6000 \text{ V})^2 \\
 &= 1.1 \times 10^{-5} \text{ F} \\
 &= 11 \mu\text{F}.
 \end{aligned}$$

2. (a) Before calculating the total impedance, first determine the impedance of each element. The resistor has an impedance of 4Ω (that is easy). The capacitor has an impedance of $1/(2\pi fC)$, where f is 1000 Hz and C is $4 \mu\text{F}$. Plug in to get an impedance of 40Ω . The inductor has an impedance of $(2\pi fL)$, where f is 1000 Hz and L is 4 mH. Plug in to get an impedance of 25Ω .

To get the total impedance, first take the difference between Z_{ind} and Z_{cap} to get 15Ω . Then combine this with resistance, according to equation 13.1, to get

$$\begin{aligned} Z_{\text{total}} &= \sqrt{(15\Omega)^2 + (4\Omega)^2} \\ &= 15.5 \Omega. \end{aligned}$$

- (b) When the frequency is zero, the capacitor has an infinite impedance and the inductor has zero impedance. Consequently, the impedance of the circuit must be infinity.
 - (c) When the frequency is infinity, the capacitor has zero impedance and the inductor has an infinite impedance. Consequently, the impedance of the circuit must be infinity.
 - (d) At resonance the inductor's impedance equals the capacitor's impedance and the total impedance of the circuit is simply the impedance of the resistor. Using $V = IZ$, with Z equal to 4Ω and V equal to 4 V , one gets a current of 1 A . Note, however, that the 4 V is the maximum (or amplitude) of the voltage. Consequently, 1 A is the maximum (or amplitude) of the current. Since the question asks for the rms current, we must divide by the square root of 2 to get an rms current of 0.71 A .
3. The total impedance of the circuit is $Z = \sqrt{R^2 + Z_{\text{ind}}^2}$. With the battery, the frequency is zero and $Z_{\text{ind}} = 0$. When the voltage has a frequency of 1200 Hz , the inductive reactance is $2\pi fL = 2\pi(1200 \text{ Hz})(4.5 \times 10^{-3} \text{ H}) = 33.9 \Omega$.

In each case, the voltage across the circuit V equals the current through the circuit times the impedance. In other words IZ must be the same in each case:

$$I_0\sqrt{R^2 + 0^2} = \frac{I_0}{4}\sqrt{R^2 + (33.9\Omega)^2}$$

Solve for R (i.e., divide through by I_0 to get rid of I_0 and square both sides) to get

$$R^2 = \frac{R^2 + (33.9\Omega)^2}{16}$$

then multiply by 16 and get the R^2 on the left

$$15R^2 = (33.9\Omega)^2$$

then divide by 15 and take the square root

$$R = \frac{33.9\Omega}{\sqrt{15}} = 8.75\Omega$$