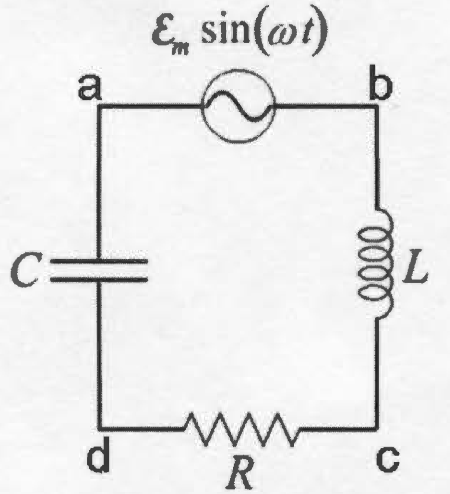
HW 20

The next seven questions pertain to the situation described below.



A circuit is constructed with an AC generator, a resistor, capacitor and inductor as shown. The generator voltage varies in time as $\varepsilon = V_a - V_b = \varepsilon_m \sin\omega t$, where $\varepsilon_m = 120$ V and $\omega = 682$ radians/second. The values for the remaining circuit components are: R = 80 Ω, L = 149.8 mH, and C = 10.2μF.

1)What is Z, the impedance of the circuit?

✓90.164504692951 Ω

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2} = 90.2\,\Omega$$

2)What is I_{max}, the magnitude of the maximum value of the current in the circuit?

✓1.33090067325997 A

$$I_{max} = \frac{\mathcal{E}}{Z} = \frac{120}{90.2} = \underline{1.33\text{ A}}$$

3)What is φ, the phase angle between the generator voltage and the current in this circuit. The phase φ is defined to be positive if the generator voltage the current leads, and negative otherwise.

✓-27.4682056010489 degrees

$$\phi = \tan^{-1}\left(\frac{\omega L - 1/\omega C}{R}\right)$$

$$= -27.5^\circ$$

4)What is t_1, the first time after t = 0 when the voltage across the inductor is zero?

✓0.00300616601526718 seconds

$$I = I_{max} \sin(\omega t - \phi)$$

voltage is 0 when I is at maximum (or minimum) since

$$\mathcal{E} = -L\frac{\partial I}{\partial t}$$

so find when $\omega t - \phi = 90^\circ$

Convert ω to degrees

682 rad/s = 39,075 degrees/second

$$90^\circ = (39{,}075^\circ/s)(t) - 27.5^\circ$$

$$\underline{t = .00301\text{ s}}$$

5)Which of the following statements is true? yes because

1. ✓The current in the circuit is zero when the magnitudes of the voltages across the inductor and the capacitor are maximum. $V_L = -L\frac{\partial I}{\partial t}$
2. There is no time when the magnitudes of the voltages across the inductor and capacitor are maximum.
3. The magnitude of the voltage across the generator is maximum when the magnitudes of the voltages across the inductor and the capacitor are maximum.
4. The voltage across the generator is zero when the magnitudes of the voltages across the inductor and the capacitor are maximum.
5. The magnitude of the current in the circuit is maximum when the magnitudes of the voltages across the inductor and the capacitor are maximum.

2. not true

3. $V_{generator}$ maximum when V_R is max.

4. Not according to Kirchoff's voltage rule (loop)

5. No, current = 0 when V_C, V_L are max

6)What is $V_C = V_d - V_a$, the voltage across the capacitor, at time t = 0? Note that V_C is a signed number.

✓-169.752228363697 V

$$V_{C\,max} = \frac{I_{max}}{\omega C} = 191.3\ V$$

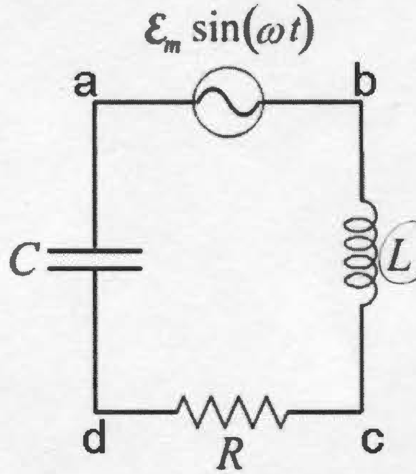
V_C lags current by 90°

so $V_C(t) = -V_{C\,max}\cos(\omega t - \phi)$

$$V_C(0) = -(191.3\ V)\cos(+27.5°)$$

$$= \underline{169.8\ V}$$

The next seven questions pertain to the situation described below.



- unknown

$\phi = +54°$

A circuit is constructed with an AC generator, a resistor, capacitor and inductor as shown. The generator voltage varies in time as $\varepsilon = V_a - V_b = \varepsilon_m \sin\omega t$, where $\varepsilon_m = 120$ V and $\omega = 600$ radians/second. The values for the remaining circuit components are: R = 132 Ω, C = 382 μF. The value for L is unkown. What is known is that the voltage across the generator leads the current in the circuit by φ = 54 degrees.

8)What is t_1, the first time after t = 0 when the magnitude of the voltage across the inductor is maximum?

✓0.001570795 seconds

$I = I_{max} \sin(\omega t - \phi)$

$|V_L|$ max when I is 0, $\left|\frac{\partial I}{\partial t}\right|$ is max

so when $\omega t - \phi = 0$

$t = \frac{\phi}{\omega} = .00157$ s

convert ω to degrees 600 rad/s $= 34{,}377$ degrees/s

9)What is Z, the impedance of ~~the circuit~~?

✓224.571567340618 Ω

from $Z = \sqrt{R^2 + (X_L - X_C)^2}$ and $\tan\phi = \frac{X_L - X_C}{R}$

get $Z = R\sqrt{1 + \left(\frac{X_L - X_C}{R}\right)^2} = R\sqrt{1 + \tan^2\phi} = \frac{R}{|\cos\phi|}$

$Z = 225.\ \Omega$

10)What is L, the value of the inductor?

✓310.075185158465 mH

from $\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$ get $L = \frac{R\tan\phi + \left(\frac{1}{\omega C}\right)}{\omega}$

$L = .310$ H
$= 310$ mH

11)What is $V_{L,max}$, the magnitude of the maximum voltage across the inductor?
✓99.4133567120165 V

$$I_{max} = \frac{\varepsilon_m}{Z}$$

$$V_{L\,max} = I_{max}(\omega L)$$

$$= \frac{\varepsilon_m \omega L}{Z} = \underline{99.4\ V}$$

12)What is $V_L = V_b - V_c$, the voltage across the inductor, at time t = 0? Note that V_L is a signed number.
✓58.4337689823512 V

$$I = I_{max} \sin(\omega t - \phi)$$

V leads current by 90° so

$$V_L = V_{L\,max} \cos(\omega t - \phi)$$

$$V_L(0) = V_{L\,max} \cos(-54°)$$

$$= +\underline{58.4\ V}$$

13)In order to make the votage across the generator become in phase with the current in the circuit (i.e., make the phase φ equal to zero), how would the value of C have to change, keeping all other circuit parameters the same?

1. It is impossible to bring the voltage across the generator in phase with the current in the circuit by only changing the value of C, keeping all other circuit parameters fixed.
2. The value of C would need to be increased.
3. ✓ The value of C would need to be decreased

since ϕ is positive $(X_L - X_c)$ is positive

so X_L is greater than X_c

to increase $X_c = \frac{1}{\omega C}$ you need

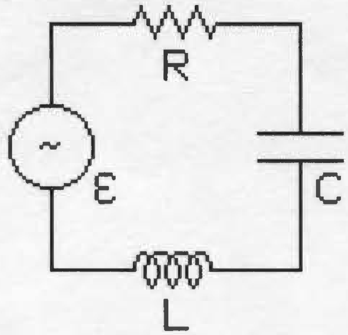
to <u>decrease</u> C

AC Circuit 1

AC CIRCUIT 1 BASE

Welcome to this IE. You may navigate to any page you've seen already using the IE tab on the right.

AC Circuit 1



Known	unknown
L	R
C	ϕ
ω	
$\mathcal{E}_{max}$	
I_{max}	

A series RLC circuit (L = 24 mH, C = 40 μF, and R = unknown) has an AC generator with frequency f = 310 Hz and amplitude E_{max} = 120 V. The peak instantaneous current in the circuit is I_{max} = 1.4 A.

What is φ = the phase angle between the driving EMF and the current in the circuit? Define φ to be positive if the voltage leads the current and φ to be negative if the current leads the voltage. φ =

degrees Submit Graph

Help

Right Answer: 23.30575 degrees ✓

we have equations $Z = \sqrt{R^2 + (X_L - X_C)^2}$

and $I_{max} = \dfrac{\mathcal{E}_{max}}{Z}$

so solve for R: $Z = \dfrac{\mathcal{E}_{max}}{I_{max}} = \sqrt{R^2 + (X_L - X_C)^2}$

$$R^2 = \frac{\mathcal{E}^2}{I^2} - (X_L - X_C)^2$$

then insert into $\tan\phi = \dfrac{X_L - X_C}{R}$

$$\phi = \tan^{-1}\left[\frac{X_L - X_C}{\sqrt{\frac{\mathcal{E}^2}{I^2} - (X_L - X_C)^2}}\right]$$

where $X_L = \omega L$ and $X_C = 1/\omega C$

and $\omega = 2\pi f$ $f = 310 \frac{\text{degrees}}{s}$

all values on the right are known, so just plugging everything in gives

$$\phi = 23.3^\circ$$