PH 220

Lance Nelson

Important for today

Remember:

— Try to minimize time when I am imparting information and maximiz
the time when the student is explaining, thinking and doing.

— Ensure that every slide has a clearly-defined purpose.

—Ask concise, well thought-out, and thought-provoking questions that
cause the student to ponder and ask why.

—Give the student time to ponder silently, ask their neighbor questions
and receive instruction from them.

Outcomes

What is a phasor? Difference between instantaneous value and pe
value. Rotating phasor illustrates concept of oscillating currents an
voltages.

-AC resistor circuit

Summary

State in words and in math, the meaning of these laws.

Gauss's Law

Gauss's Law for magnetism

Faraday's Law

Ampere-Maxwell

Lorentz force law

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$$(\Phi_e)_{\text{closed surface}} = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{in}}}{\epsilon_0}$$

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$$(\Phi_m)_{\text{closed surface}} = \oint \vec{B} \cdot d\vec{A} = 0$$ Gauss's Law for magnetism

$$\mathcal{E} = \oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_m}{dt}$$ Faraday's Law

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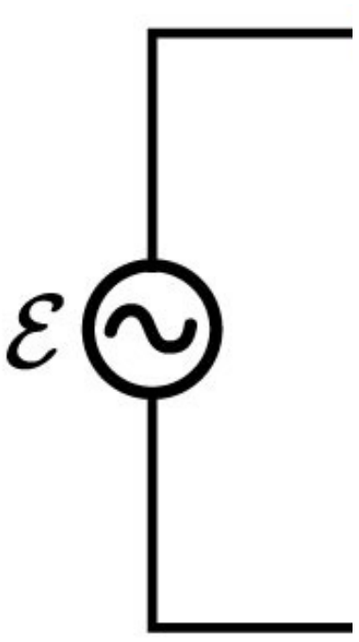
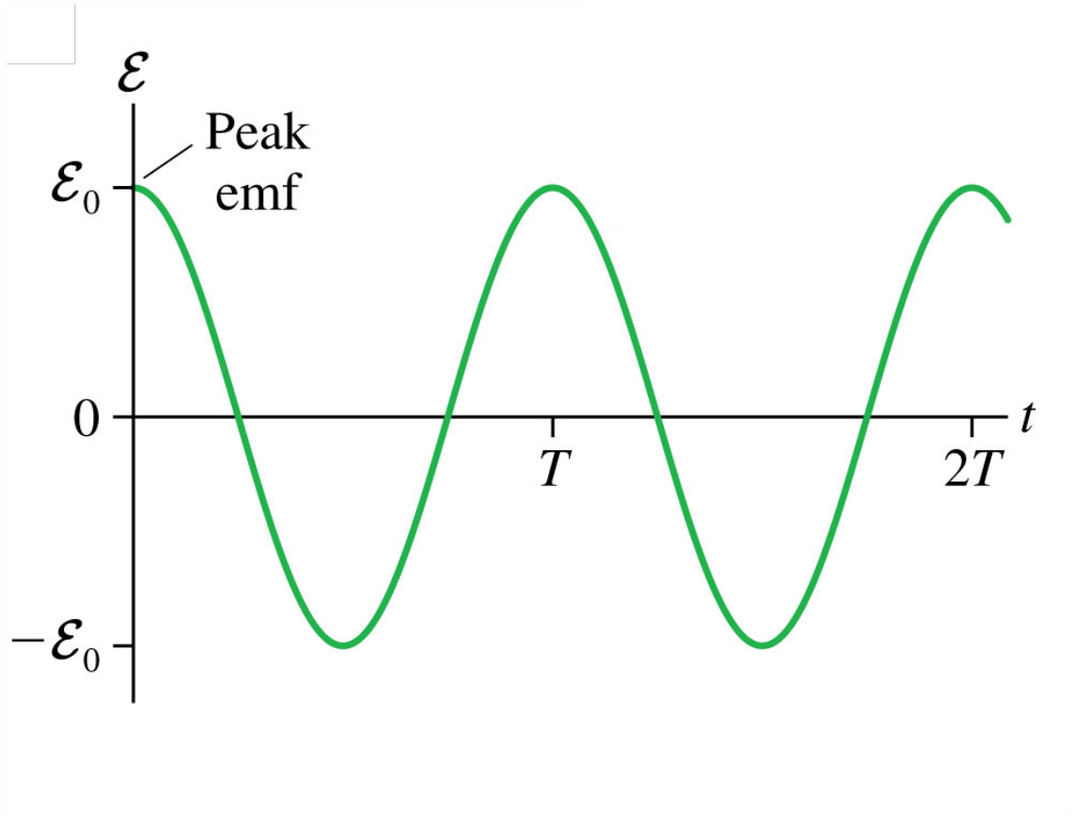
$$F = q(\vec{E} + \vec{v} \times \vec{B})$$ Lorentz force law

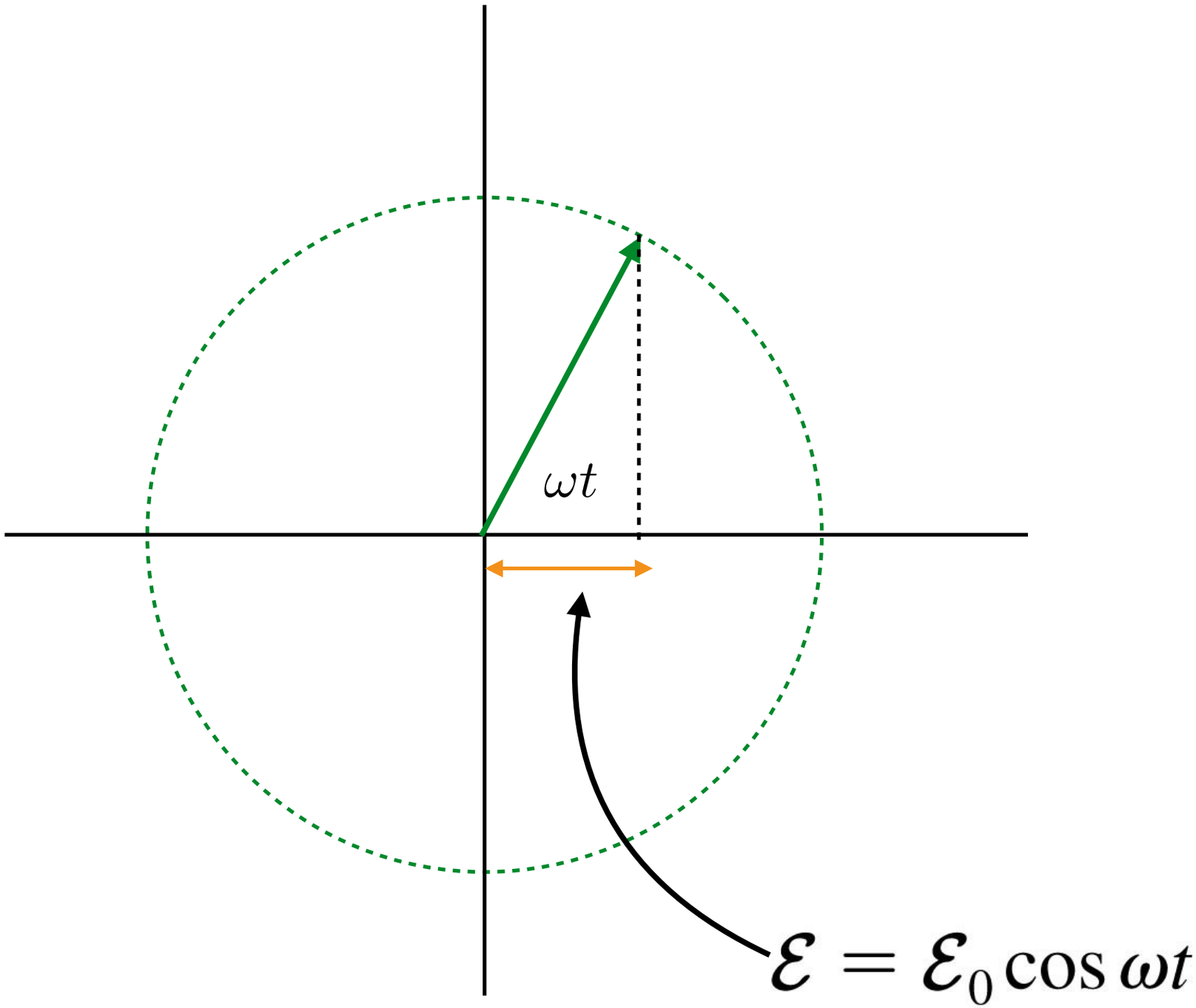
AC sources

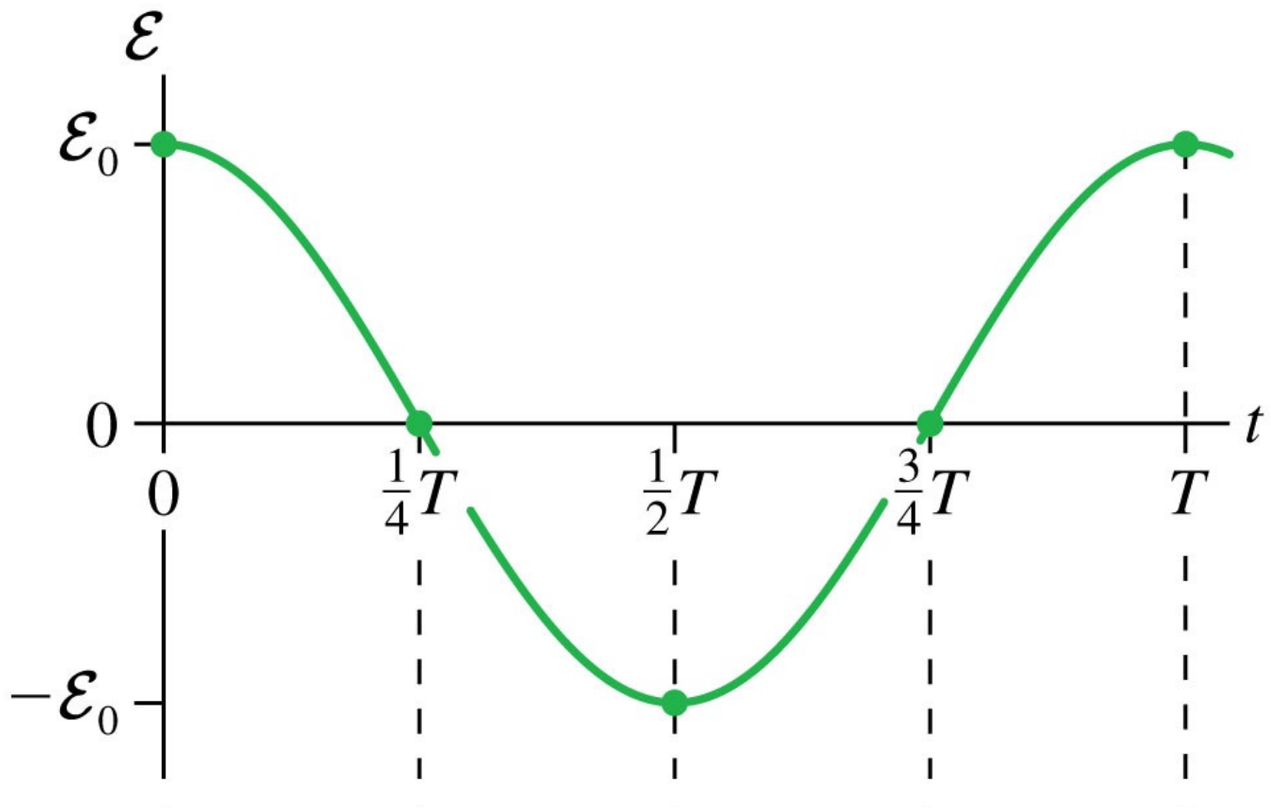




$$\mathcal{E} = \mathcal{E}_0 \cos \omega t$$

Phasors: Not something from Star Trek




$\mathcal{E}$
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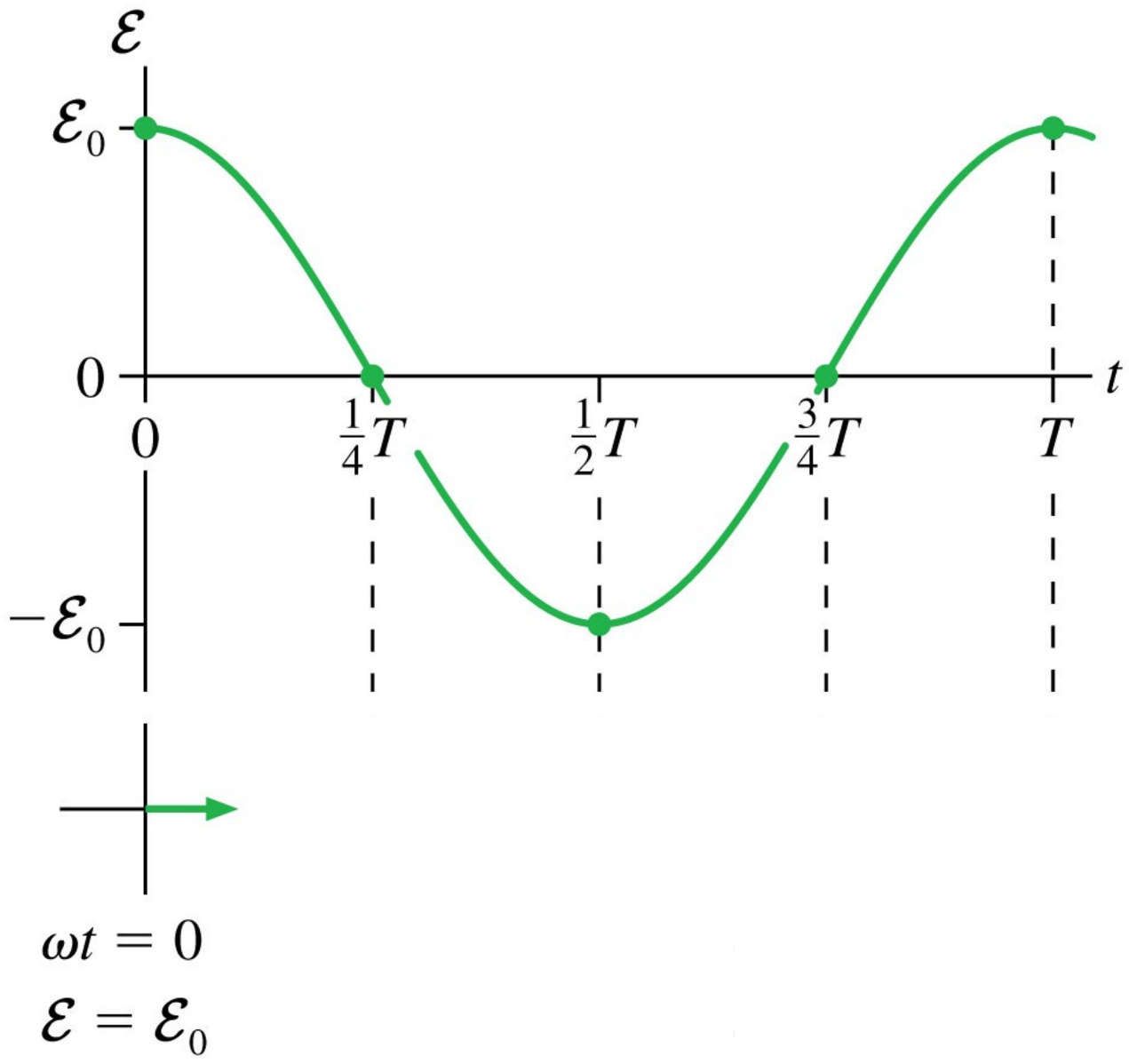
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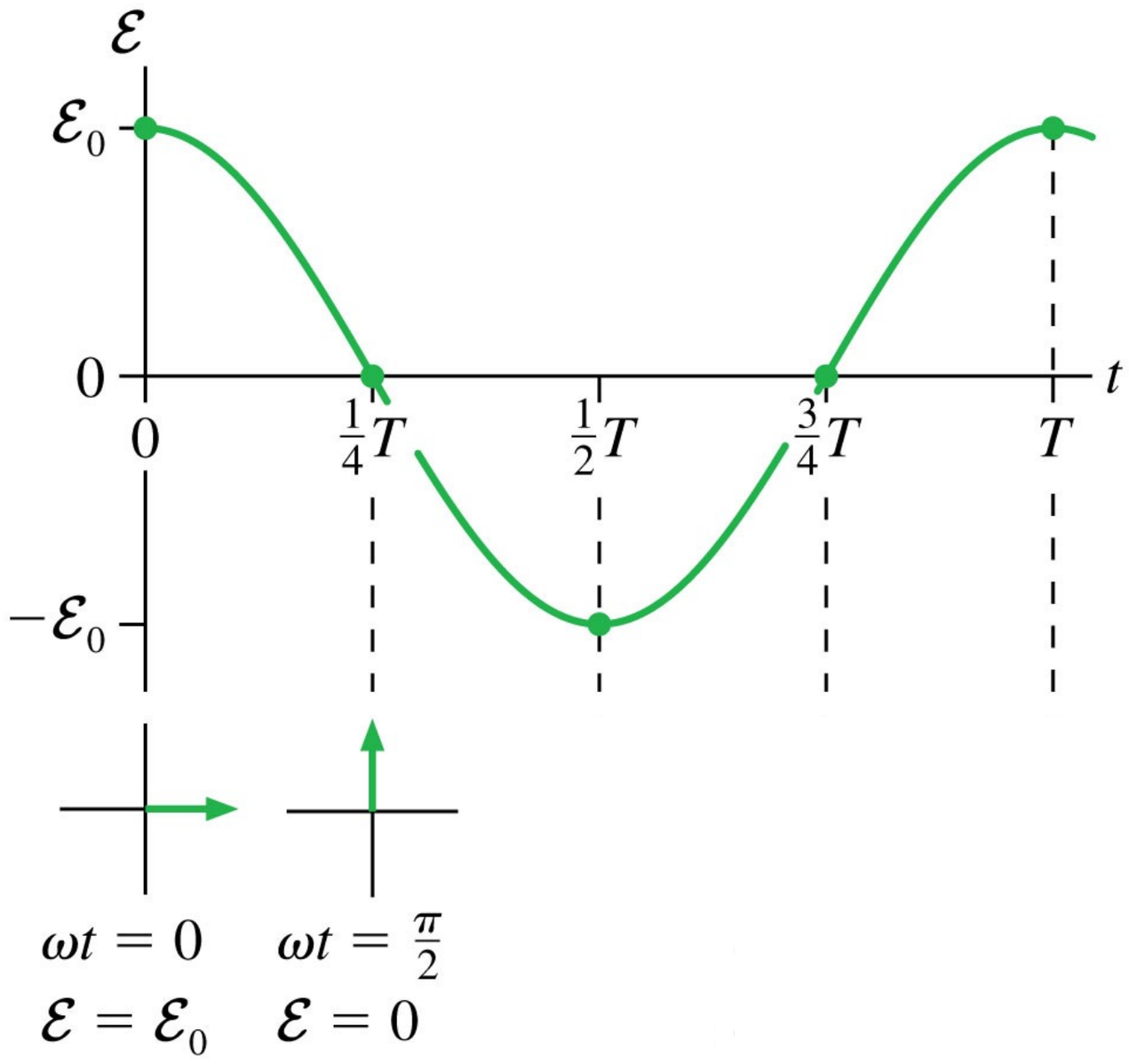
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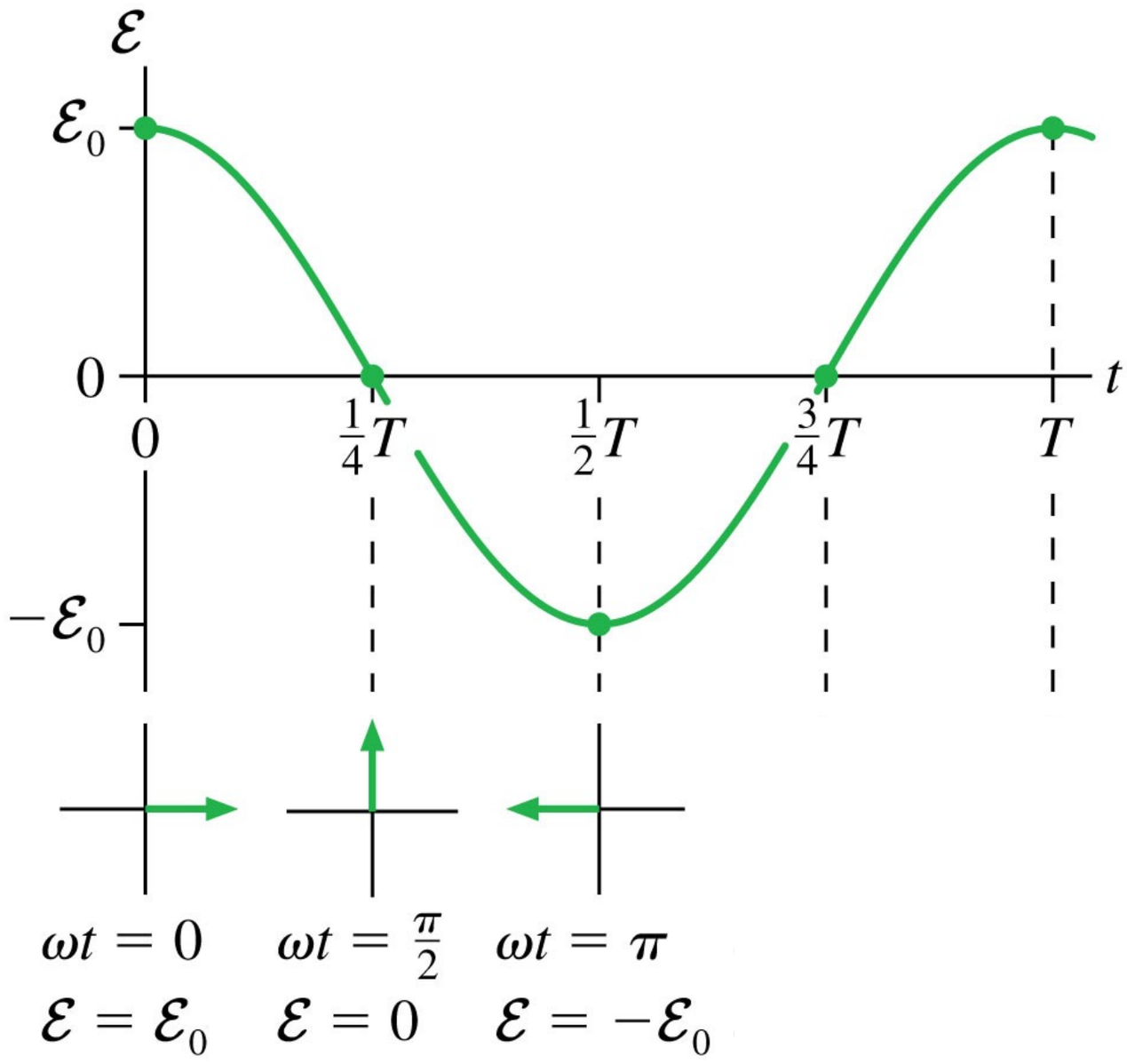
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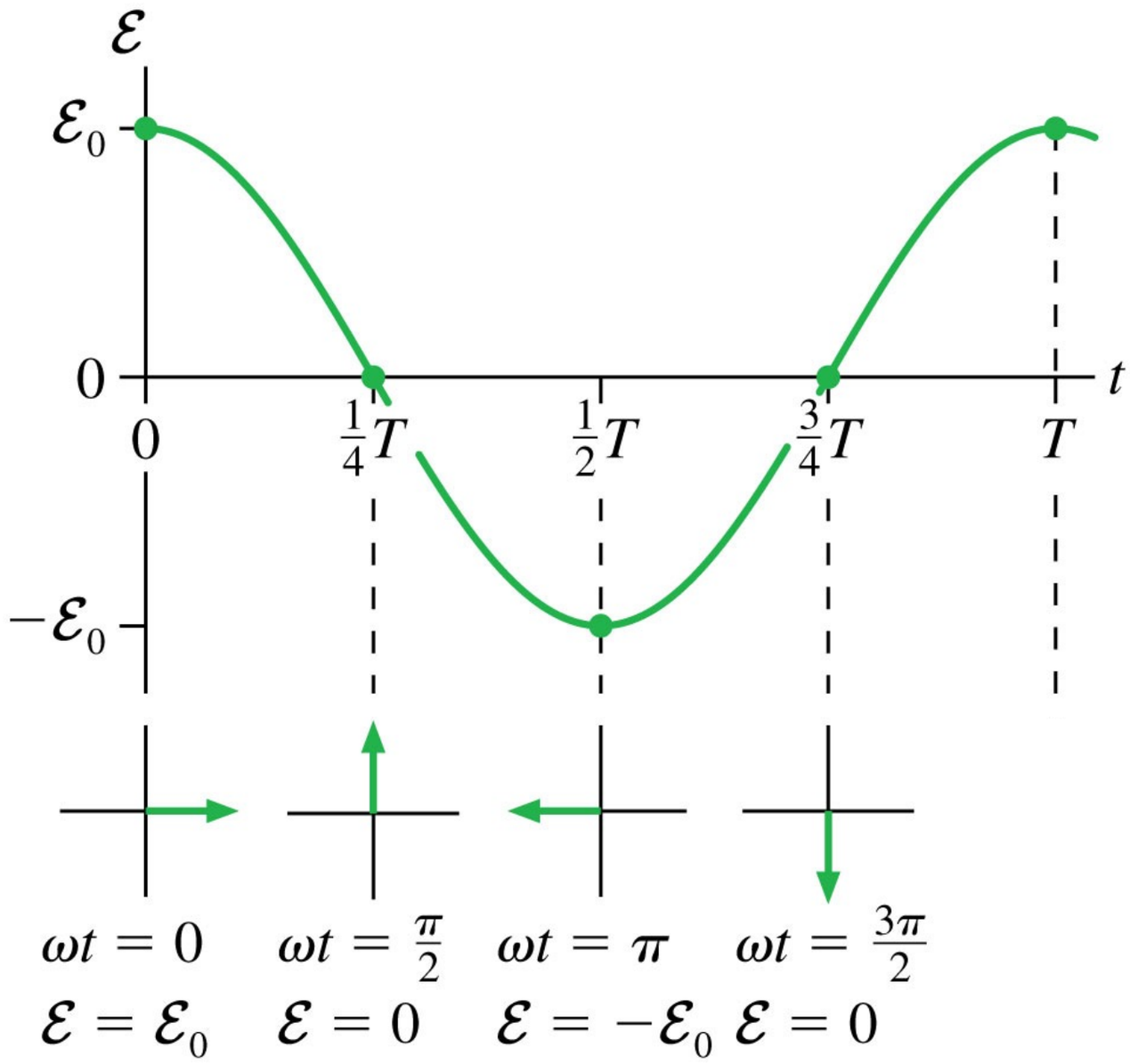
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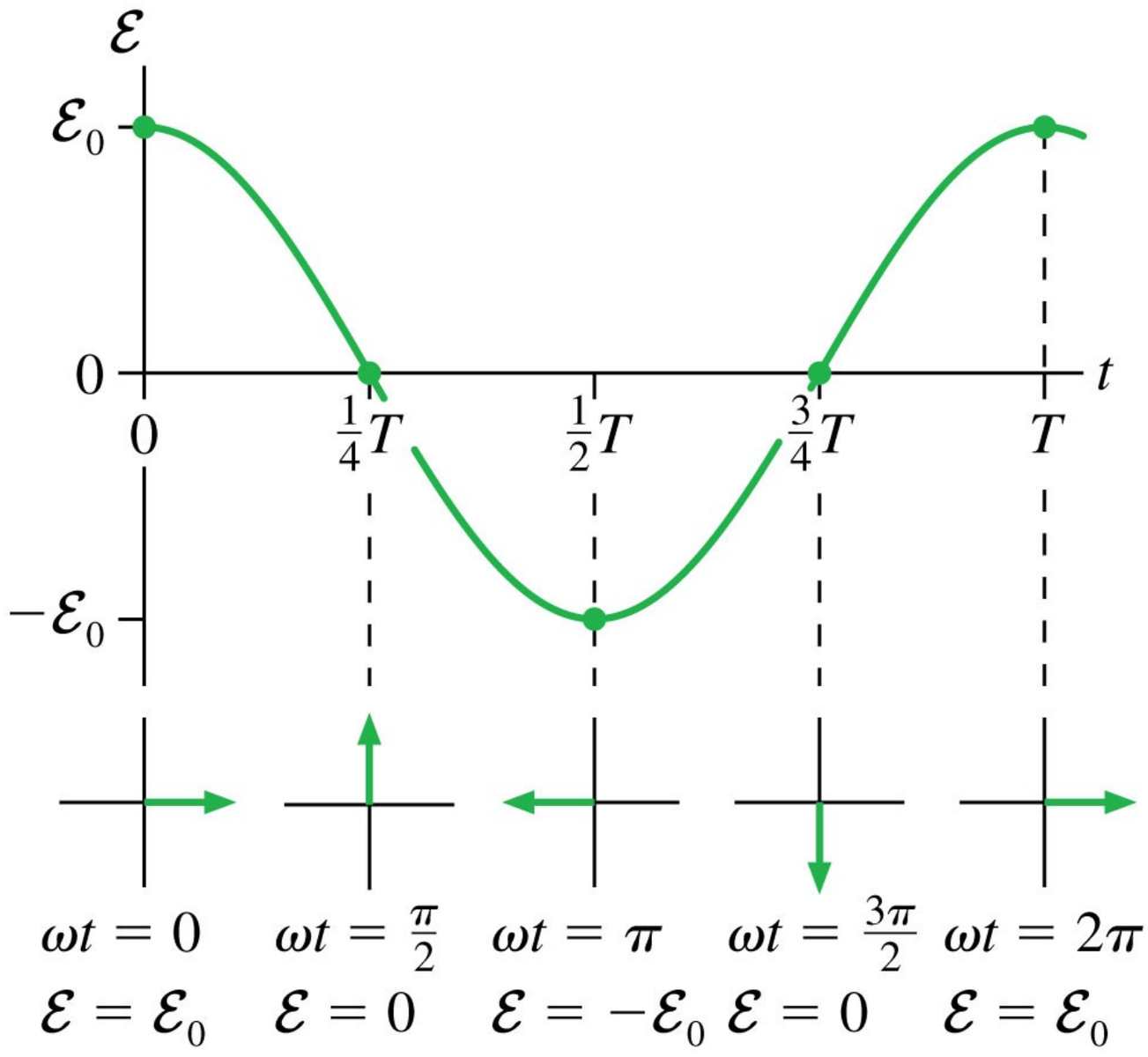
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$\omega t = \pi$
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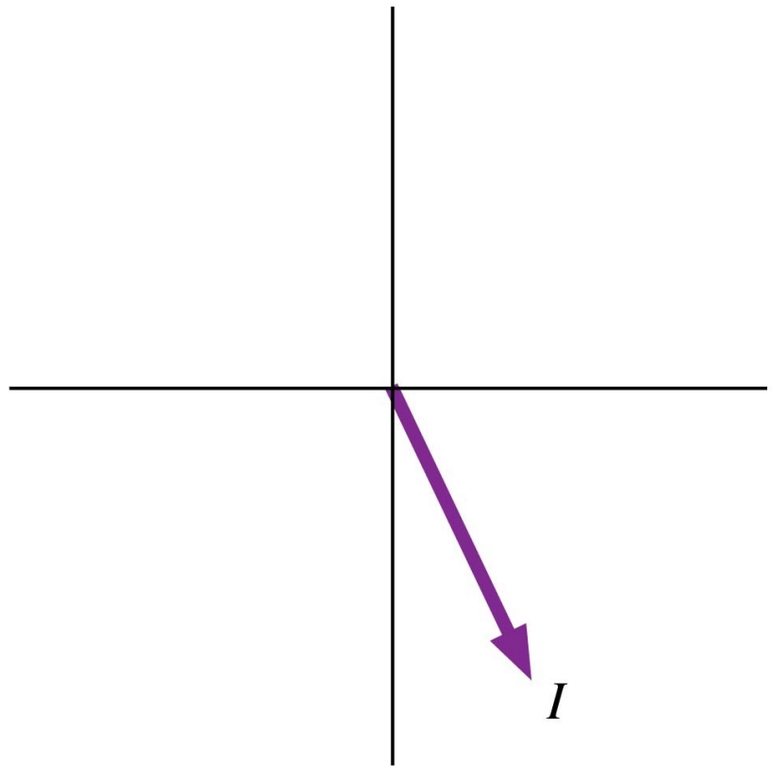
$\omega t = \frac{3\pi}{2}$
$\mathcal{E} = 0$
$\omega t = 2\pi$
$\mathcal{E} = \mathcal{E}_0$

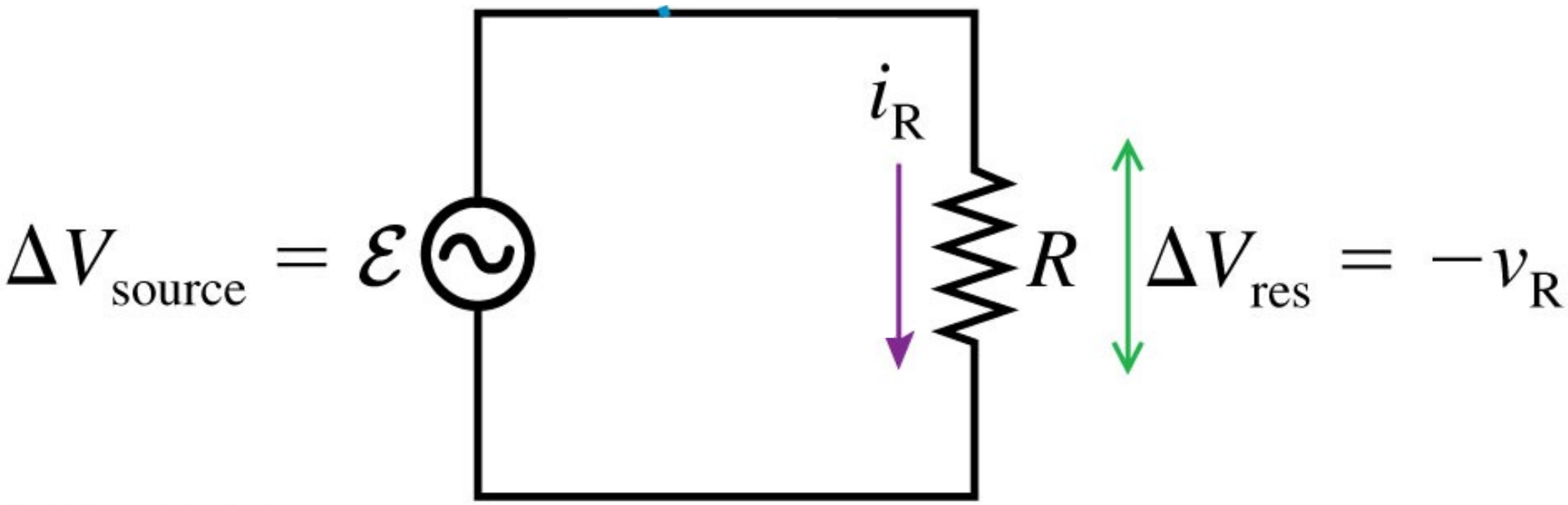
Question #25

This is a current phasor. The magnitude of the instantaneous value of the current is

A. Increasing.
B. Decreasing.
C. Constant.

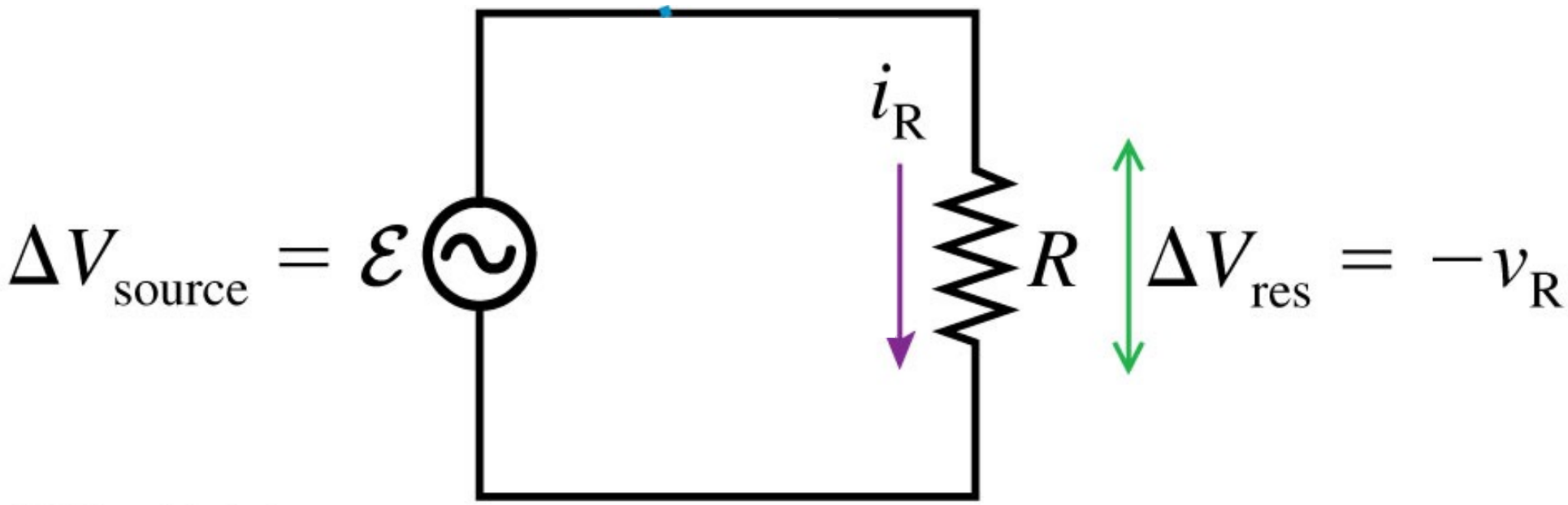


Resistor Circuit



Why little i and little v?

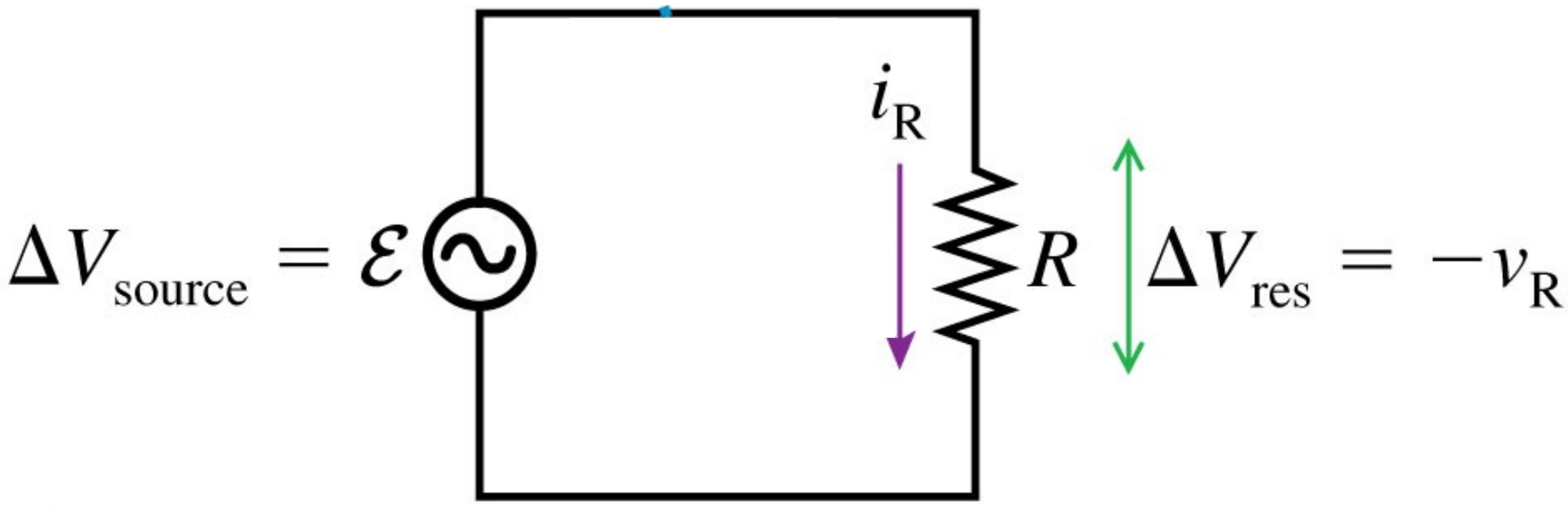
Resistor Circuit



Why little i and little v?

When the current through the resistor is a max/min is the voltage across the resistor a max or a min?

Resistor Circuit

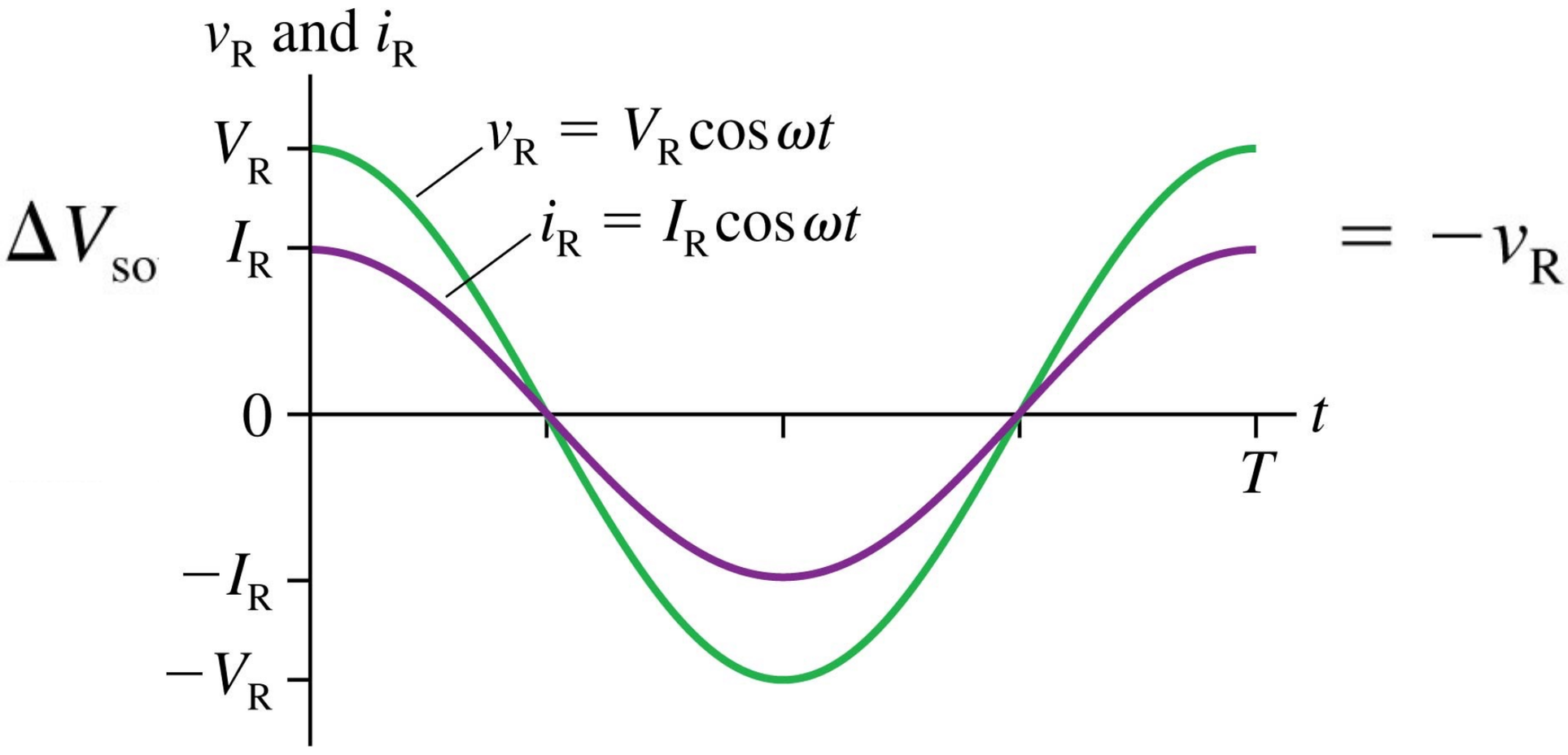


Why little i and little v?

When the current through the resistor is a max/min is the voltage across the resistor a max or a min?

$$i_{\text{R}} = \frac{v_{\text{R}}}{R} = \frac{V_{\text{R}} \cos \omega t}{R} = I_{\text{R}} \cos \omega t$$

Resistor Circuit



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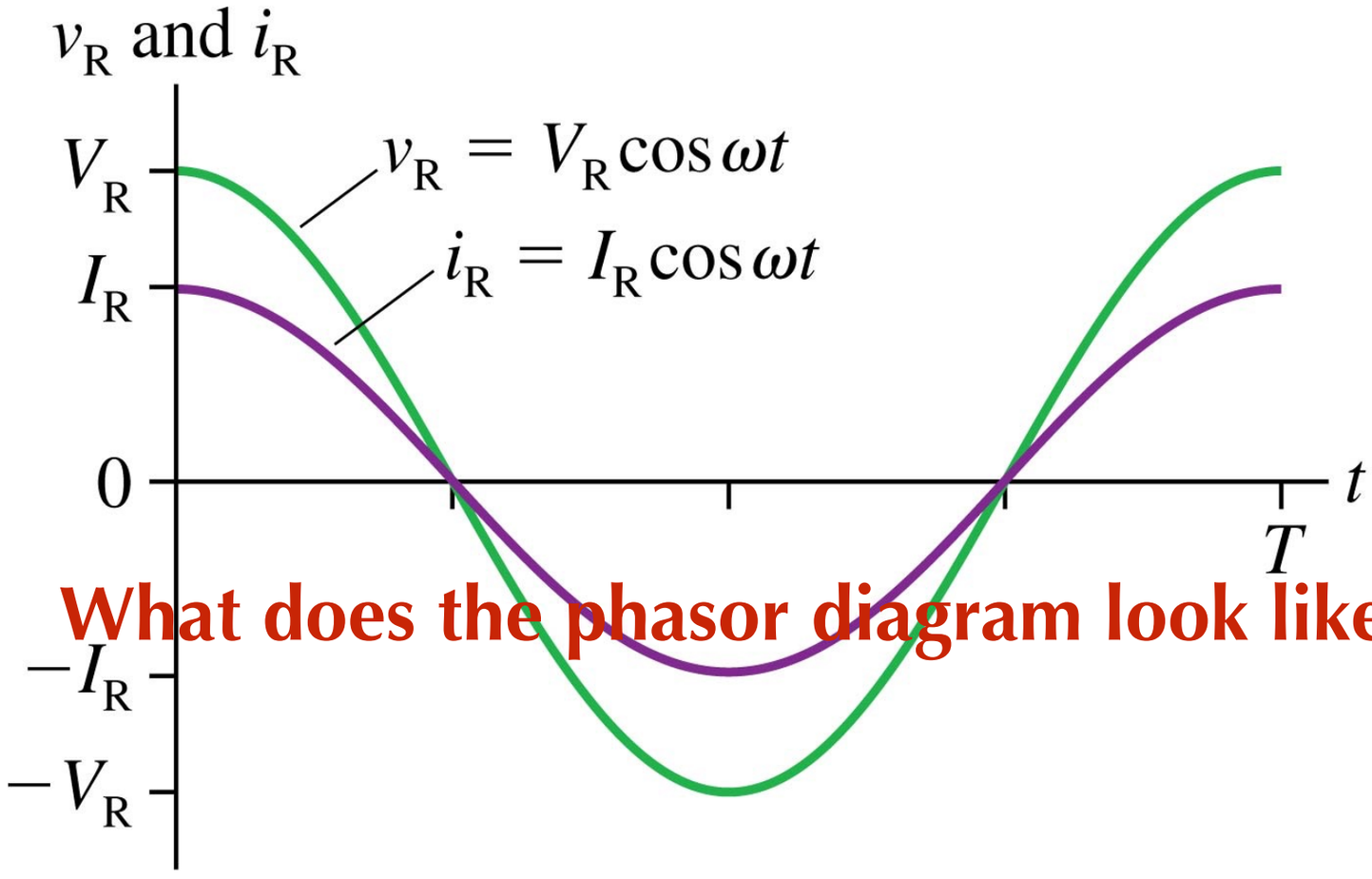
$$i_R = \frac{v_R}{R} = \frac{V_R \cos \omega t}{R} = I_R \cos \omega t$$

Resistor Circuit



$$\Delta V_{so} = -v_R$$

What does the phasor diagram look like?

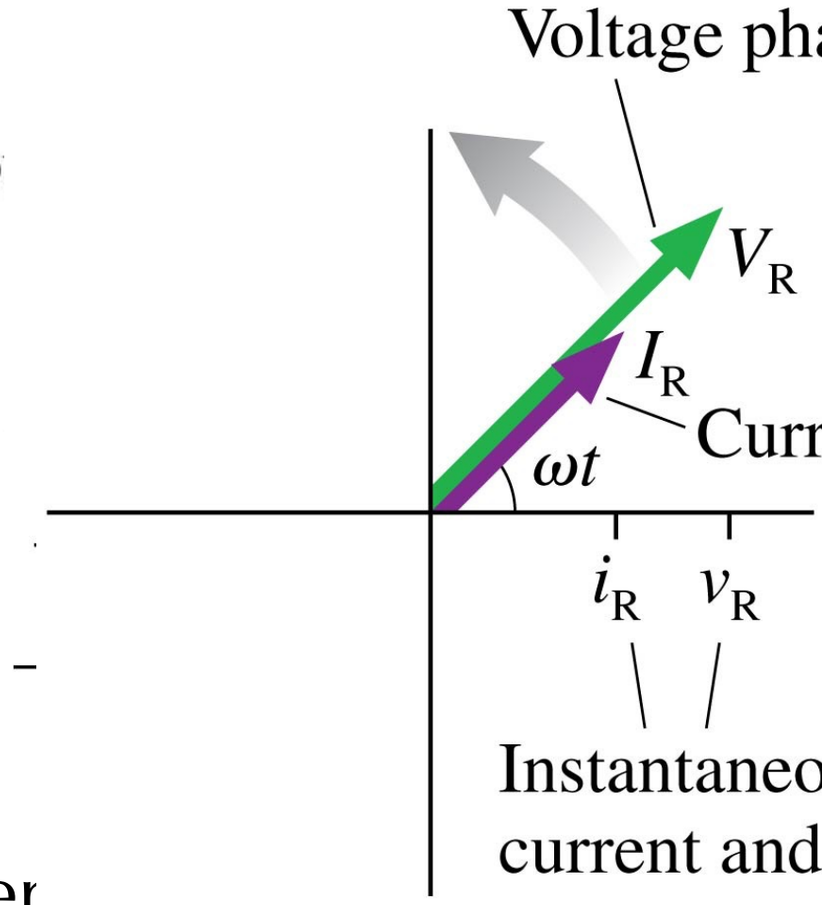
When the current through the resistor is a max/min is the voltage across the resistor a max or a min?

$$i_R = \frac{v_R}{R} = \frac{V_R \cos \omega t}{R} = I_R \cos \omega t$$

Resistor Circuit

v_R and i_R

ΔV_{so}



$= -v_R$

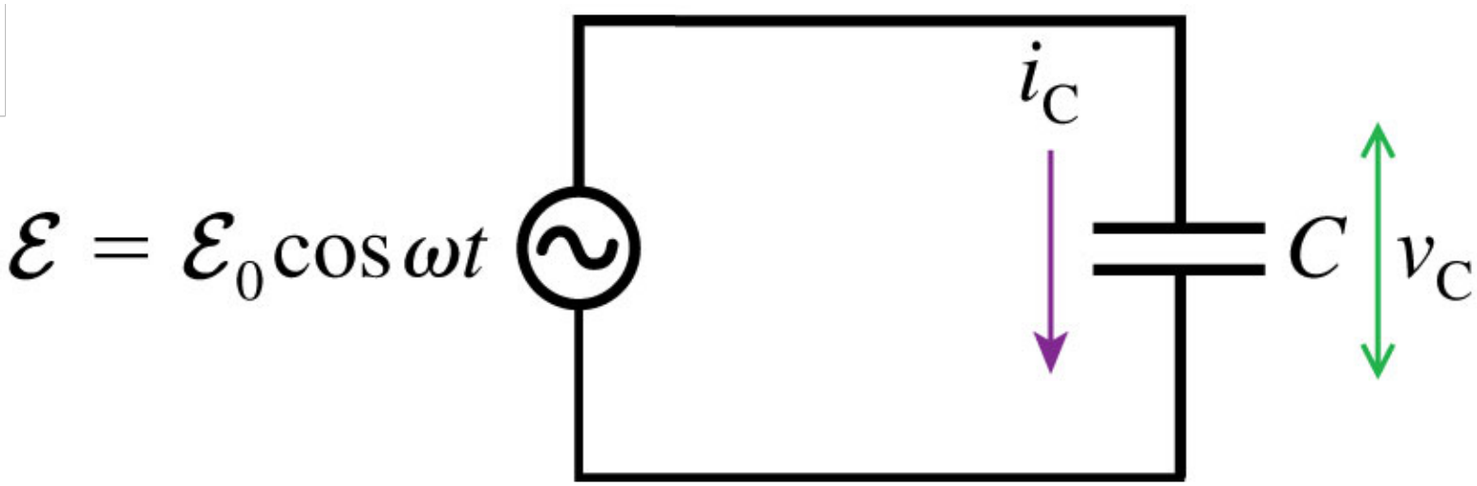
t

e?

Wher[illegible]x/min is the voltage across the resistor a max or a min?

$$i_R = \frac{v_R}{R} = \frac{V_R \cos \omega t}{R} = I_R \cos \omega t$$

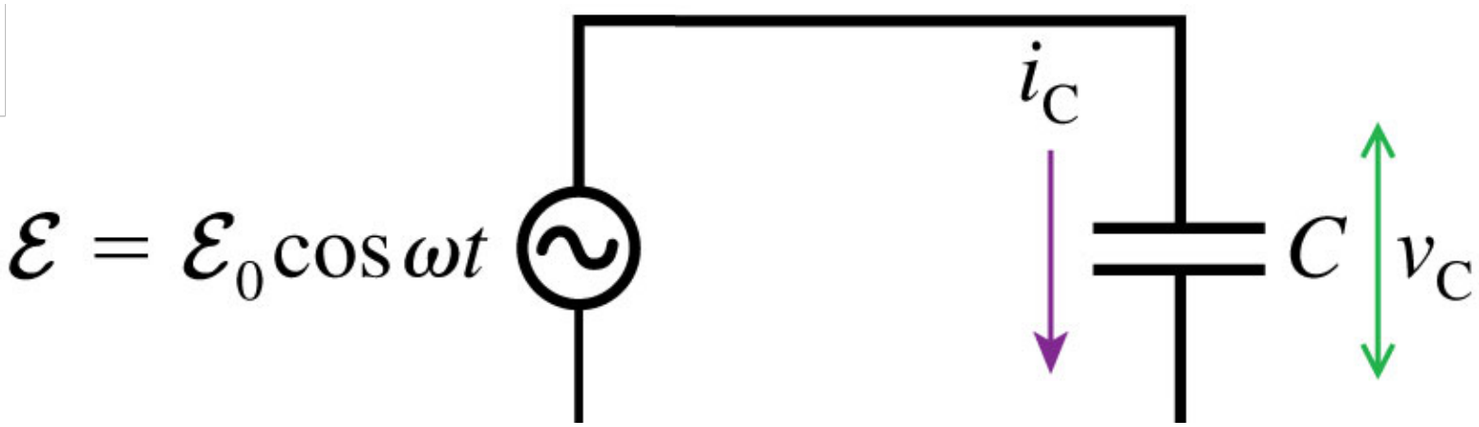
Capacitor Circuit

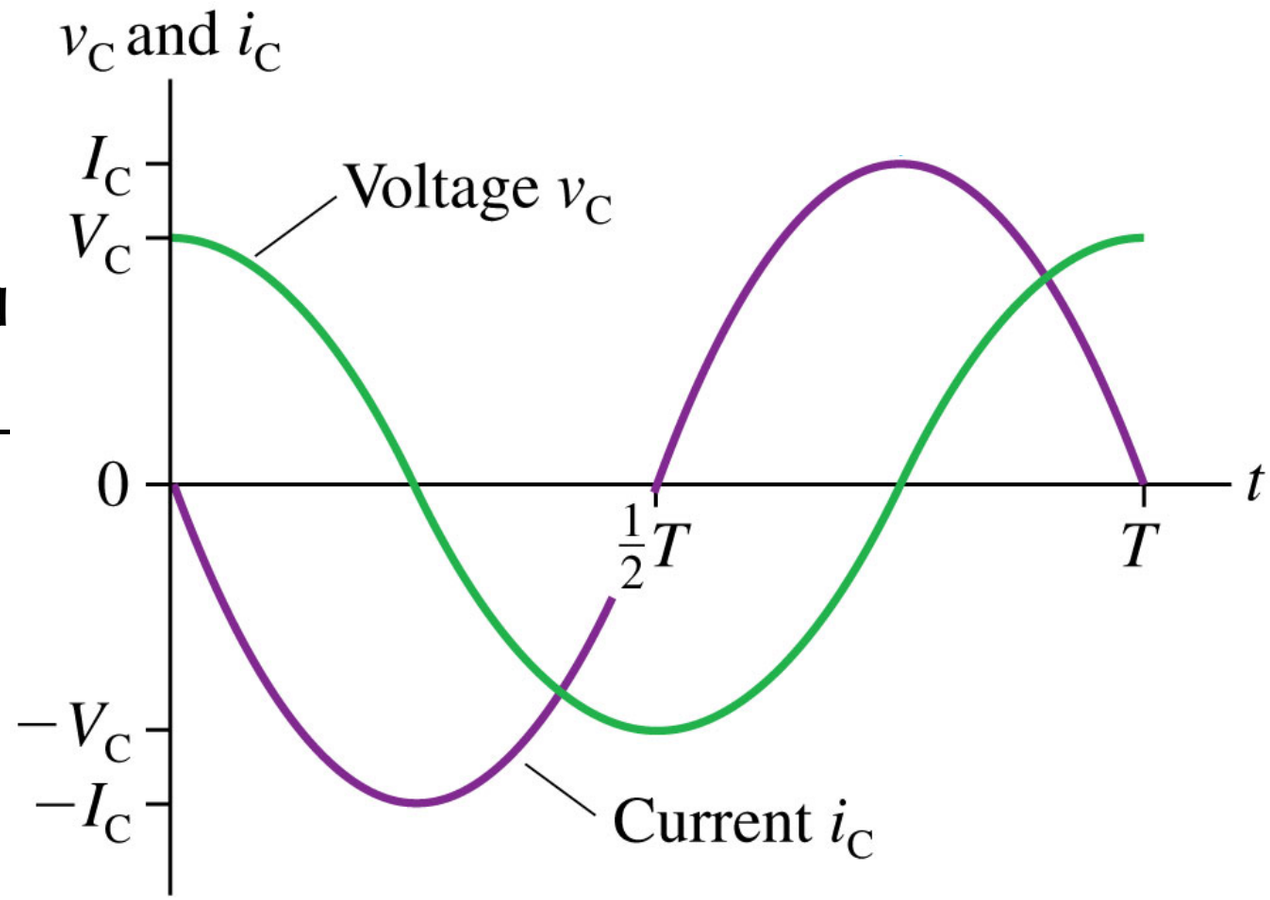


When the current in the circuit is high, the voltage across the capacitor is _____?

A- Low
B- High

Capacitor Circuit

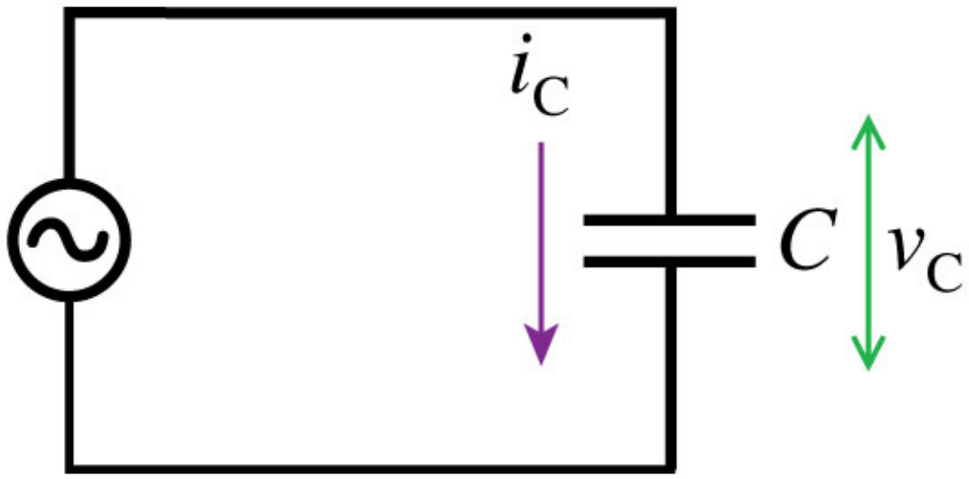




When the cu e across the capacitor is _

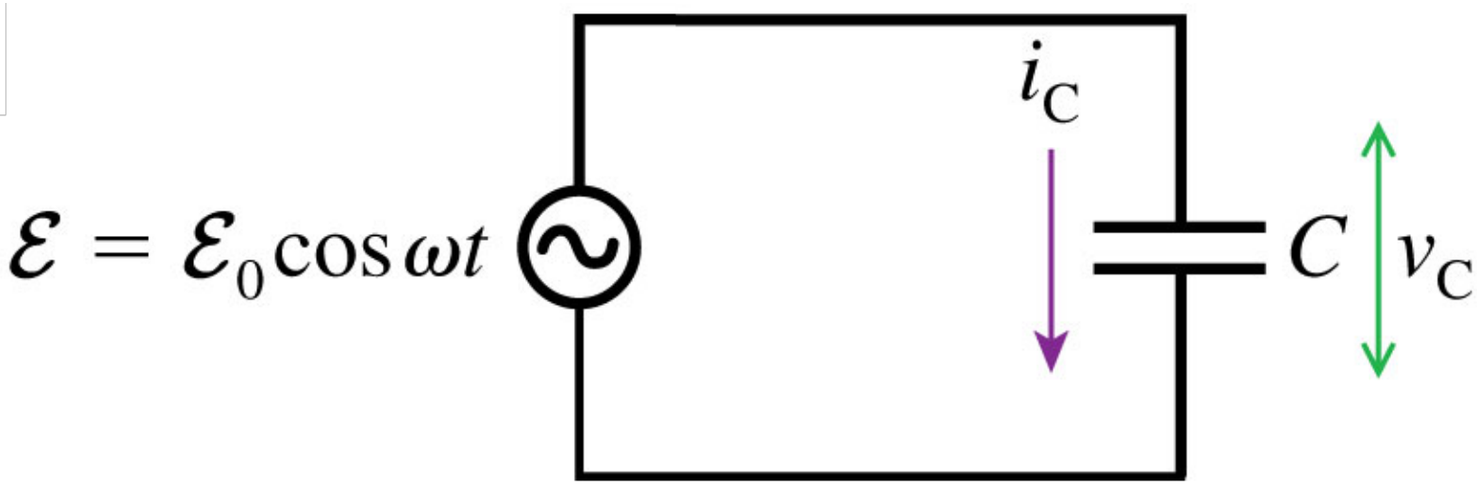
The Math

$$\mathcal{E} = \mathcal{E}_0 \cos \omega t$$



$$q = Cv_C = CV_C \cos \omega t$$

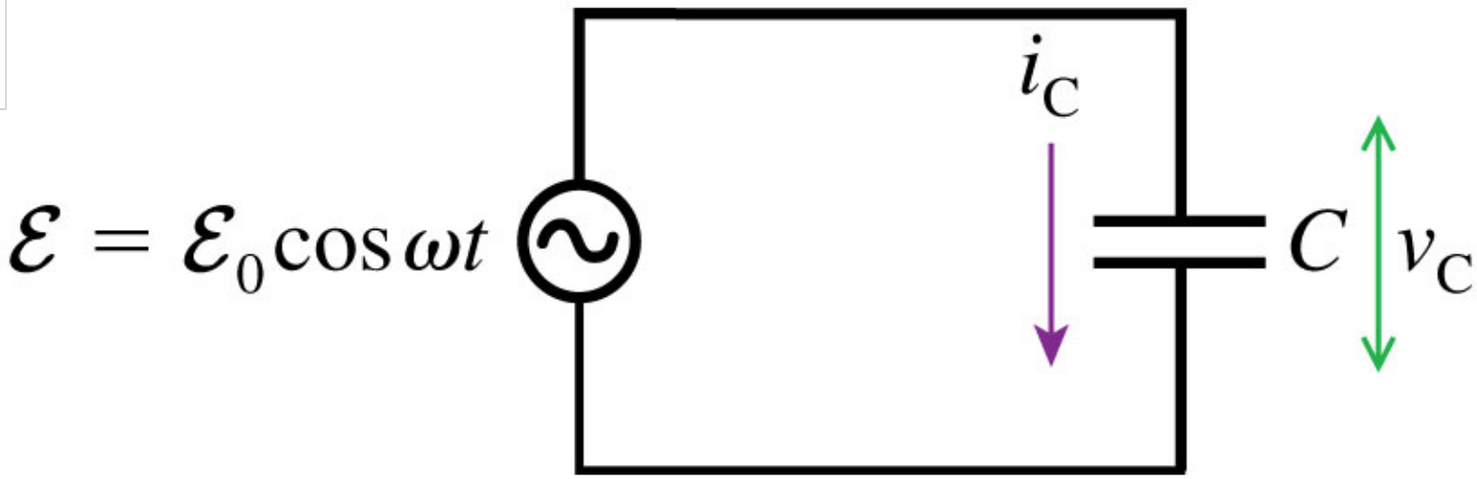
The Math



$$q = Cv_C = CV_C \cos \omega t$$

$$i_C = \frac{dq}{dt}$$

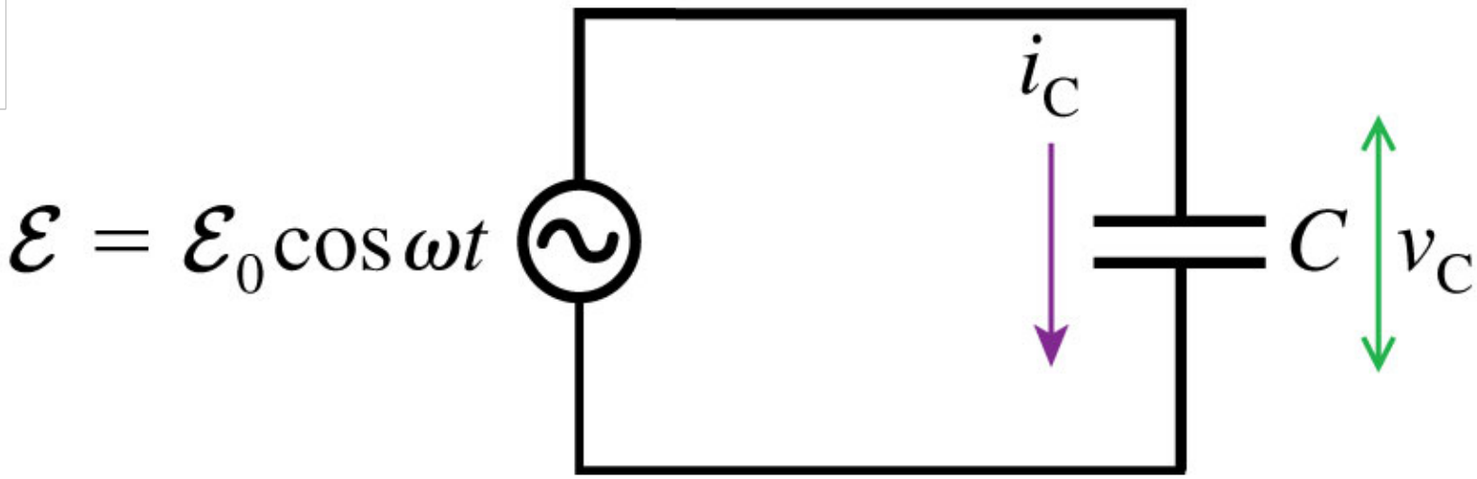
The Math



$$q = Cv_C = CV_C \cos \omega t$$

$$i_C = \frac{dq}{dt} = \frac{d}{dt}(CV_C \cos \omega t) = -\omega CV_C \sin \omega t$$

The Math



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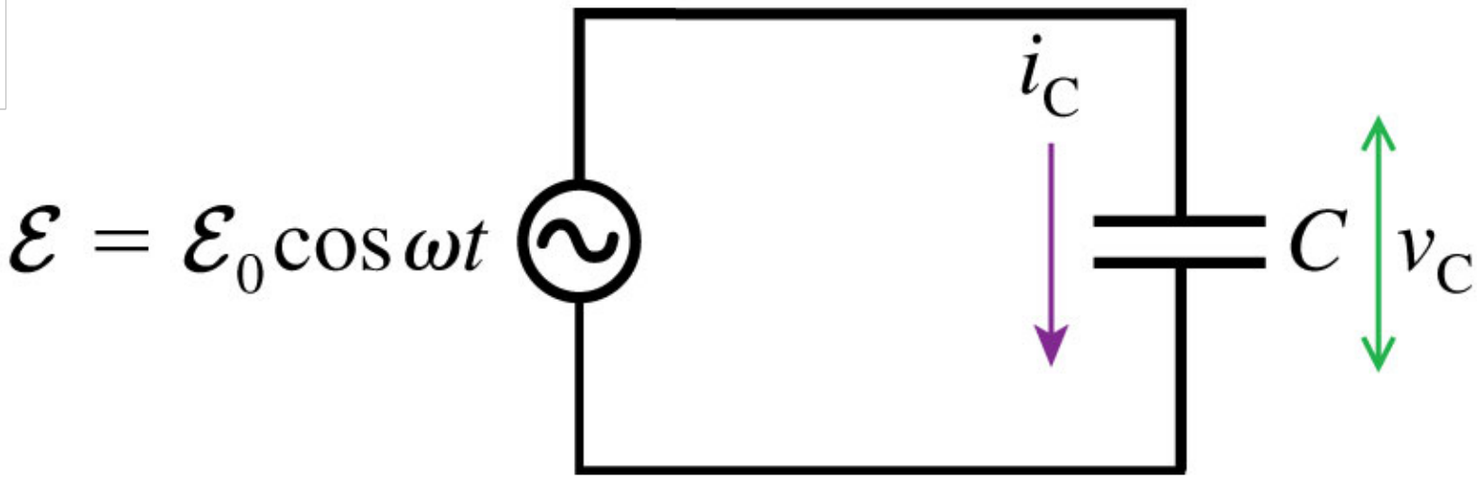
$$i_C = \frac{dq}{dt} = \frac{d}{dt}(CV_C \cos \omega t) = -\omega CV_C \sin \omega t \qquad -\sin(x) = \cos(x + \pi/2)$$

The Math



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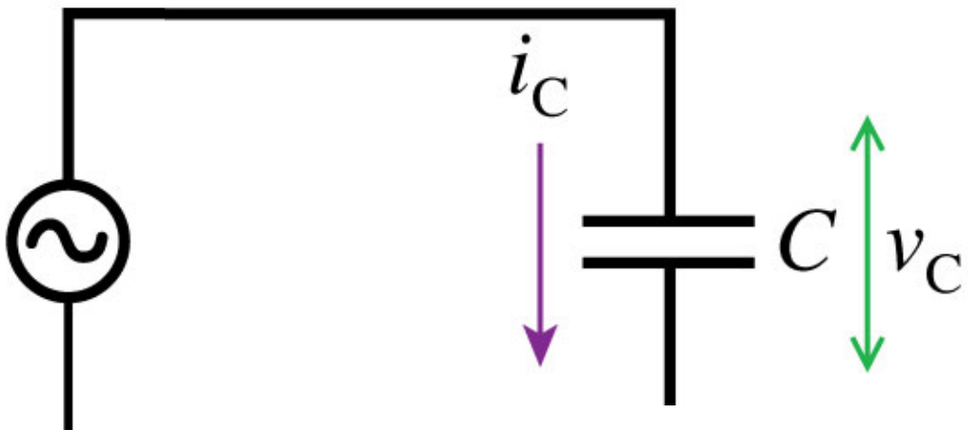
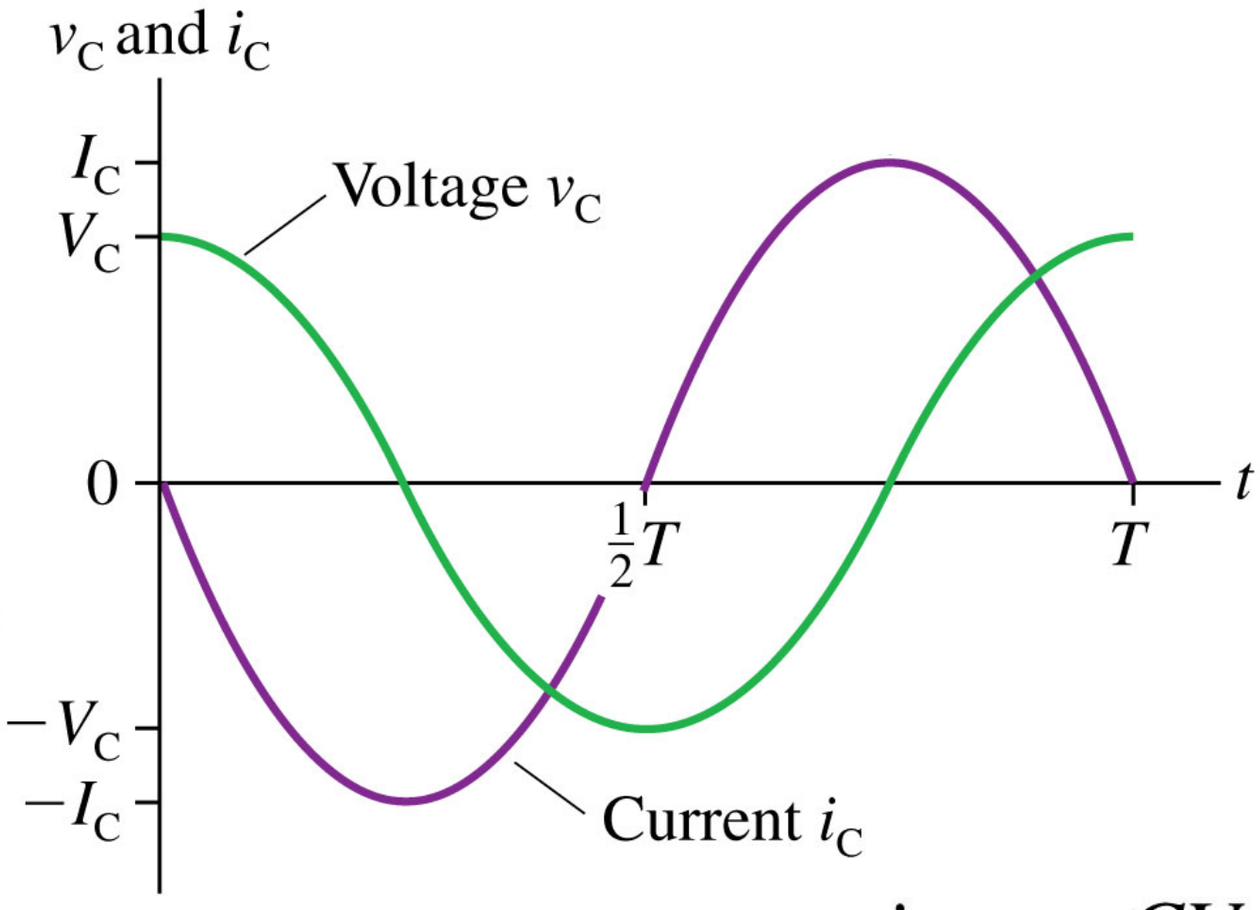
$$i_C = \omega CV_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

The Math

$$\mathcal{E} = \mathcal{E}_0 \cos \omega t$$



$$q = Cv_C =$$



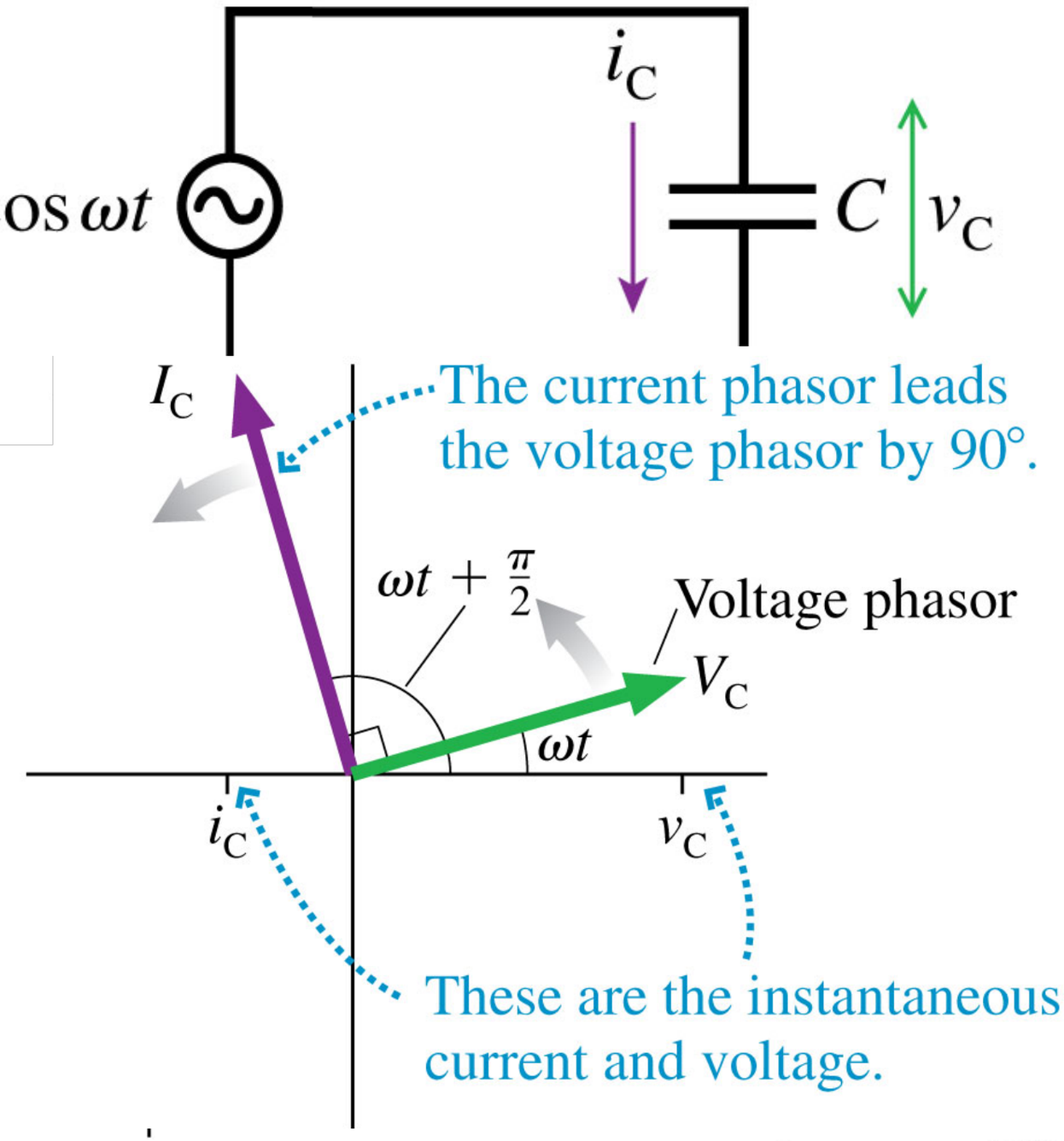
$$i_C = \frac{dq}{dt} = -$$

$-\sin(x) = \cos(x + \pi/2)$

$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

The Math

$\mathcal{E} = \mathcal{E}_0 \cos \omega t$



$q = Cv_C =$

$i_C = \frac{dq}{dt} =$

t

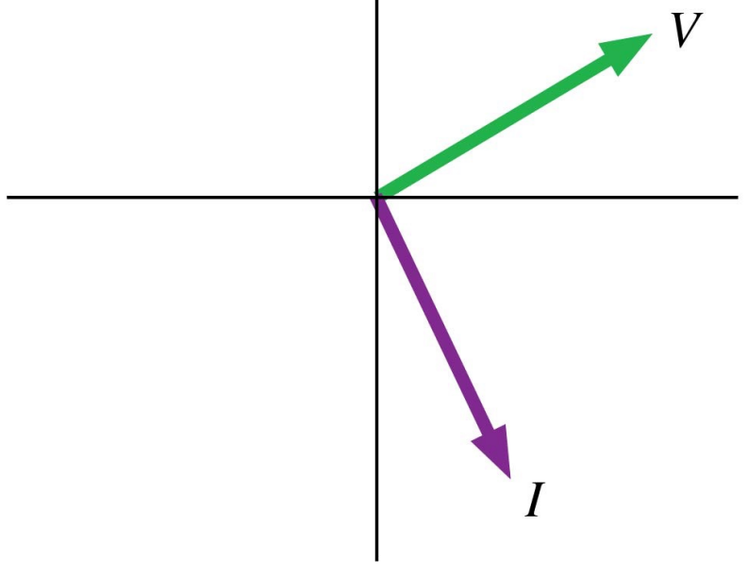
$-\sin(x) = \cos(x + \pi/2)$

$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

Quiz Question

In the circuit represented by these phasors, the current ____ the voltage

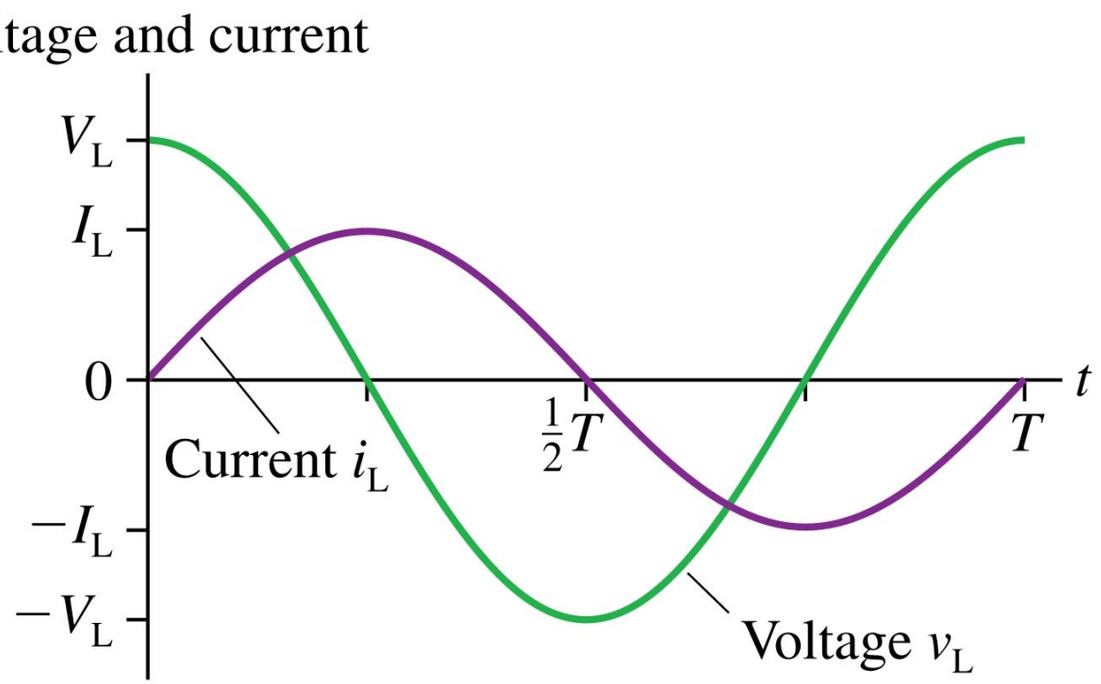
A. leads
B. is perpendicular to
C. lags
D. is out of phase with



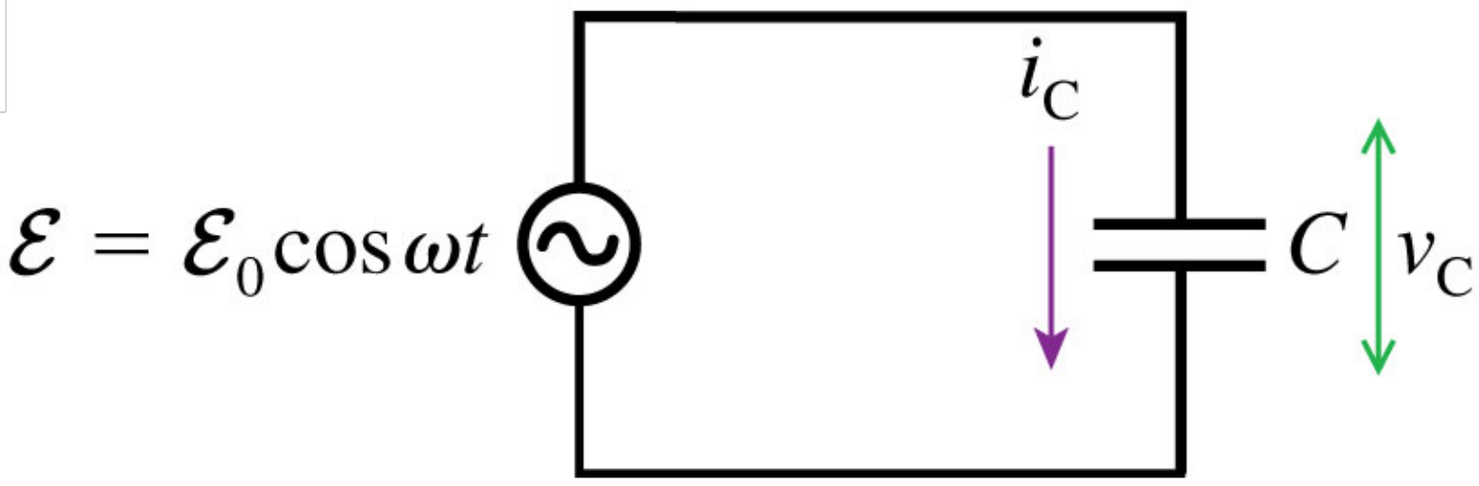
Quiz Question

In the circuit represented by these graphs, the current ____ the voltage

A. leads
B. is less than
C. is out of phase with
D. lags



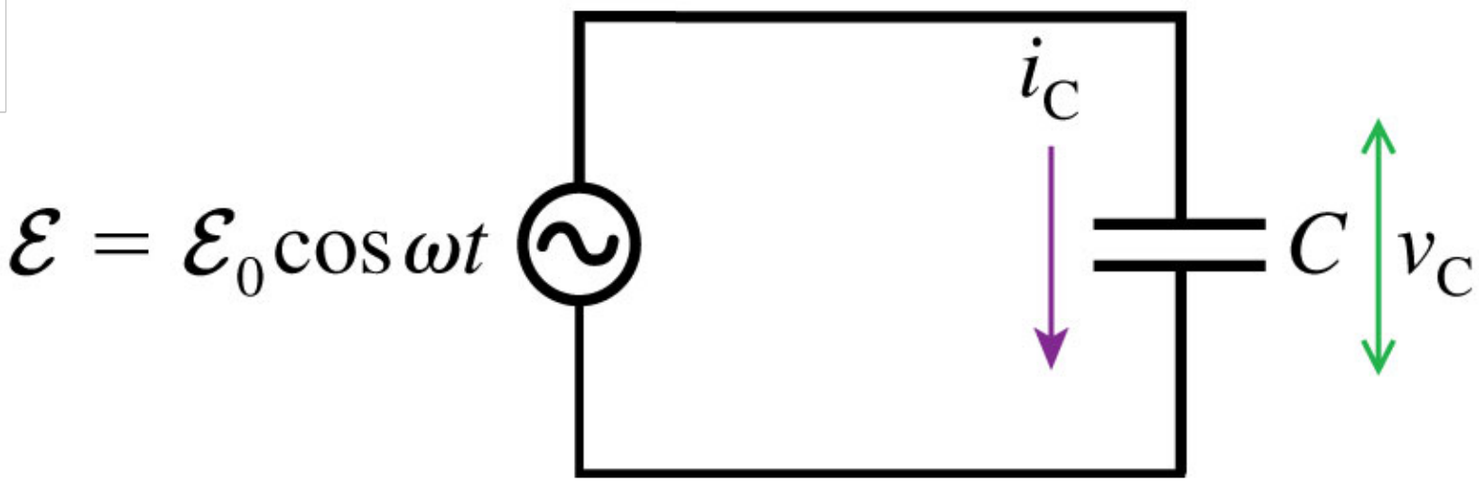
What about the frequency of the source



If the frequency of the source is high will the max current in the circuit be high or low?

A- Low
B- High

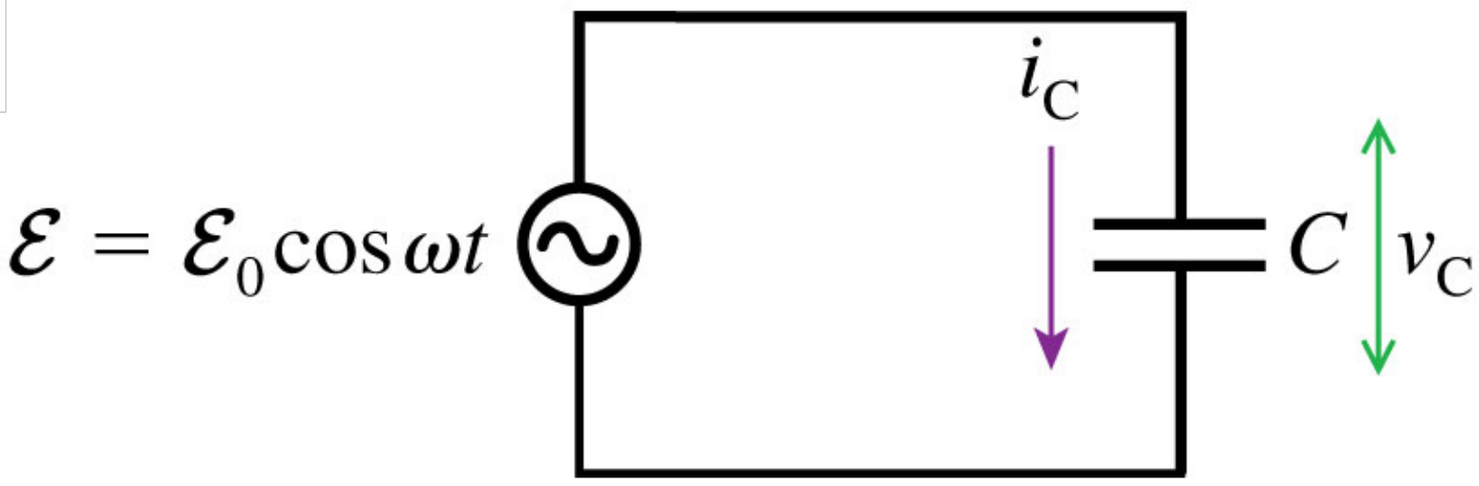
What about the frequency of the source



If the frequency of the source is high will the max current in the circuit be high or low?

$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

What about the frequency of the source



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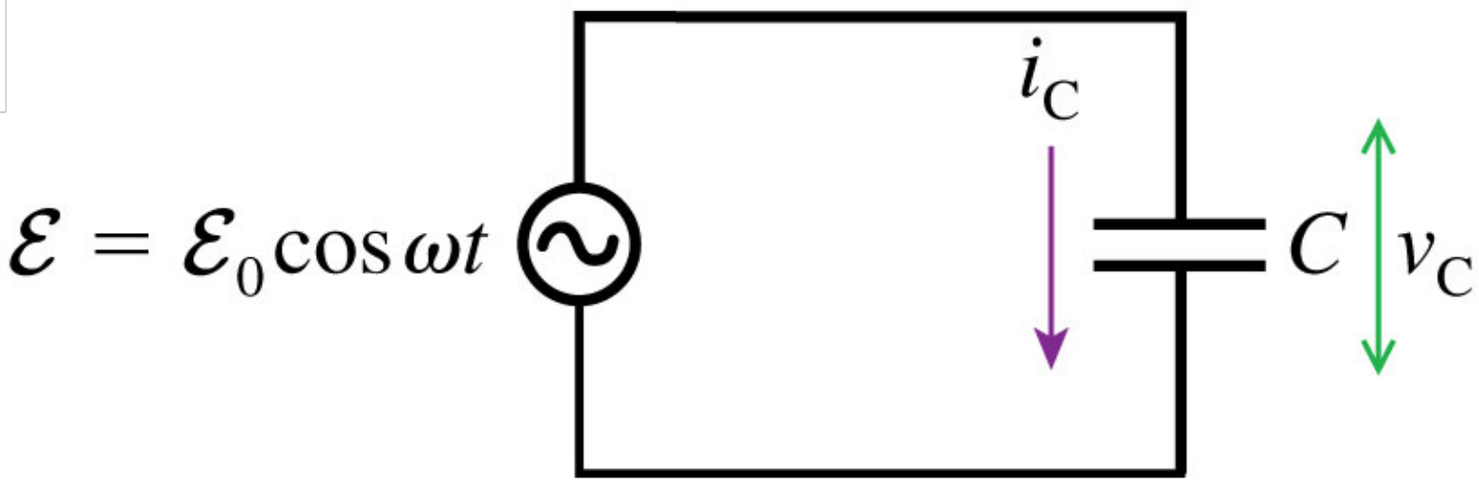
$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

$I_C = \omega C V_C$ (Max current in the circuit)

What about the frequency of the source



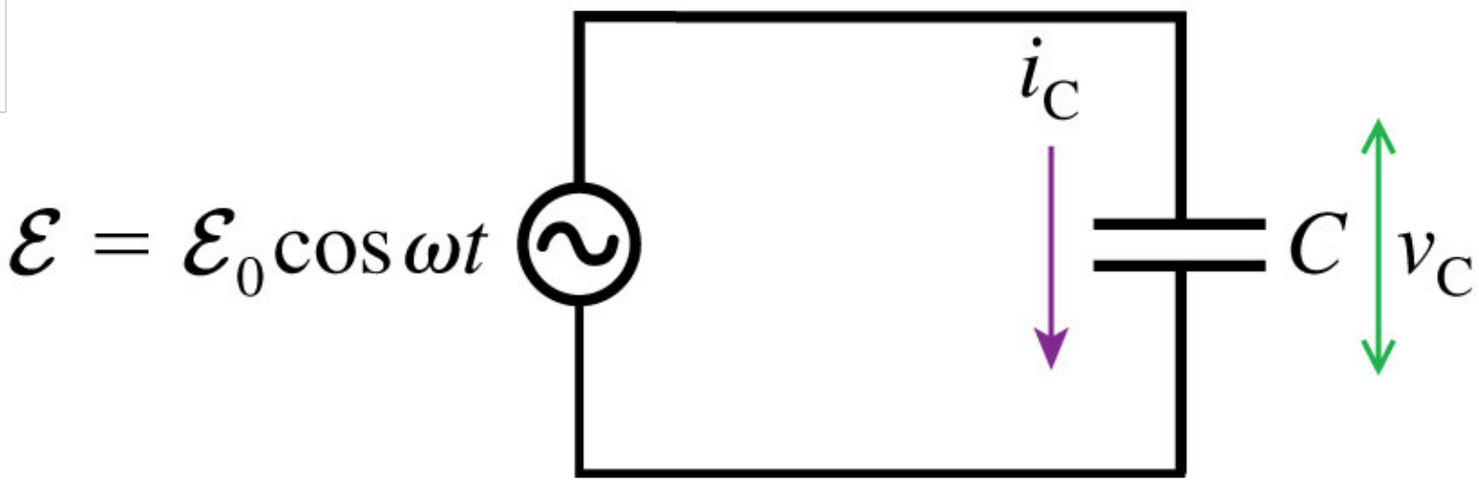
If the frequency of the source is high will the max current in the circuit be high or low?

$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

$$I_C = \omega C V_C \quad \text{(Max current in the circuit)}$$

$$X_C = \frac{1}{\omega C} \quad \text{(Capacitive Reactance)}$$

What about the frequency of the source



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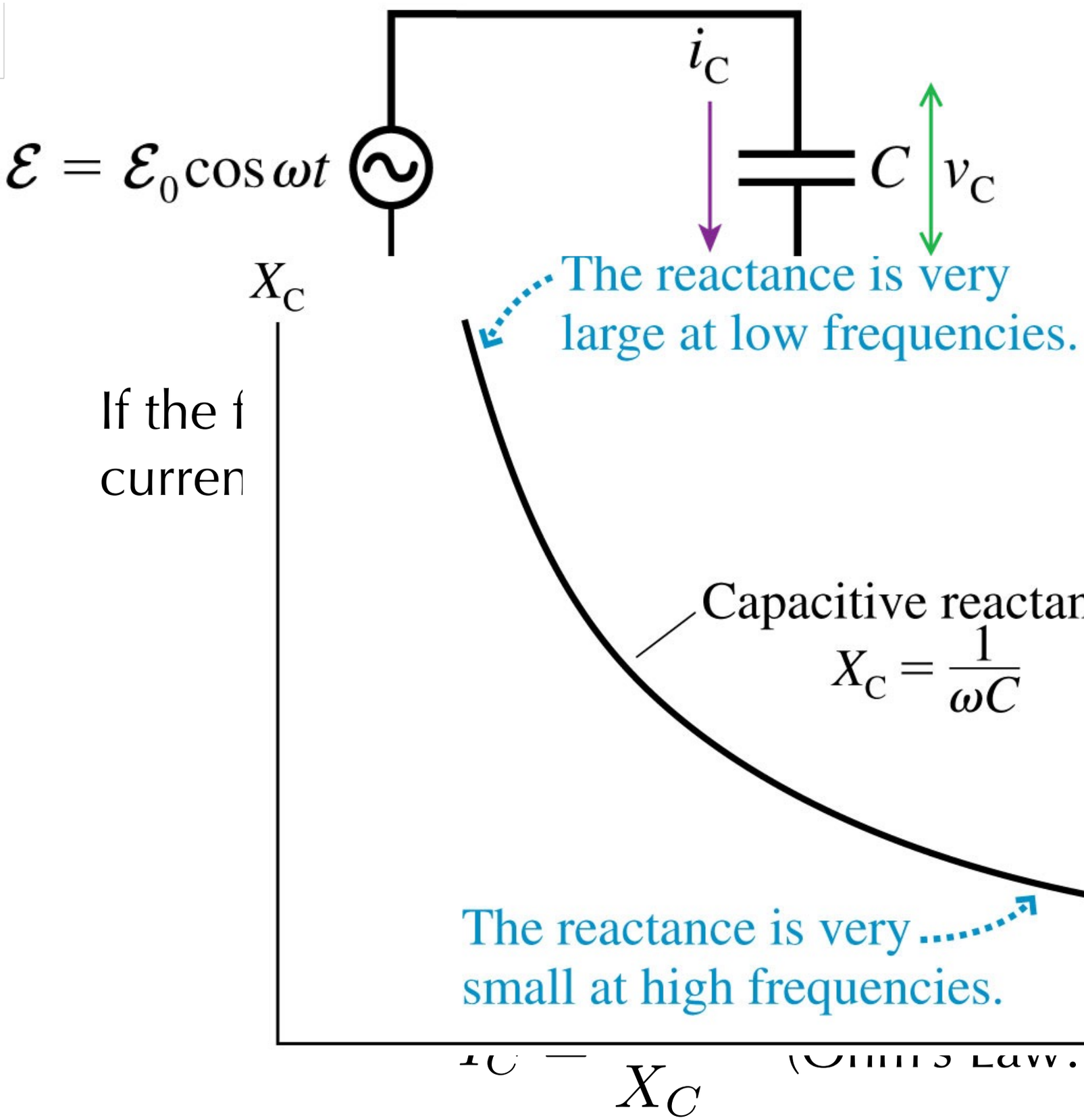
$$i_C = \omega C V_C \cos\left(\omega t + \frac{\pi}{2}\right)$$

$$I_C = \omega C V_C \quad \text{(Max current in the circuit)}$$

$$X_C = \frac{1}{\omega C} \quad \text{(Capacitive Reactance)}$$

$$I_C = \frac{V_C}{X_C} \quad \text{(Ohm's Law…kind of)}$$

What about the frequency of the source



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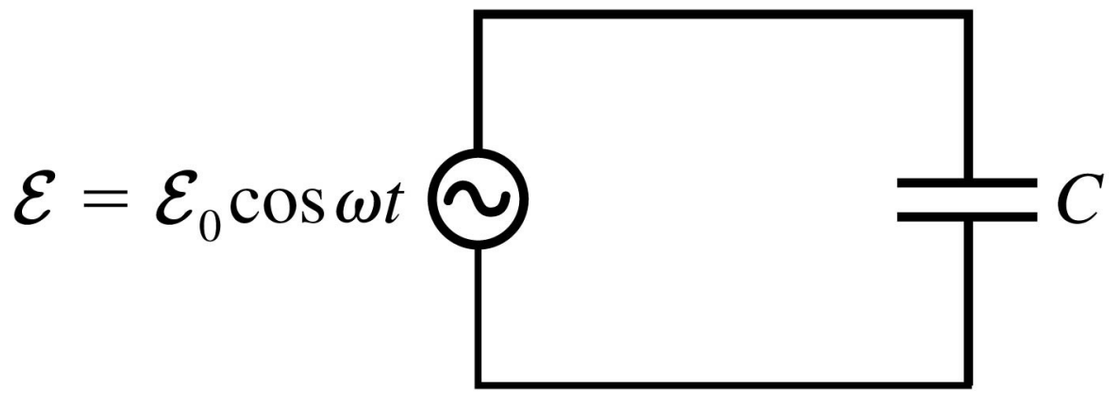
Quiz Question

If the value of the capacitance is doubled, the capacitive reactance

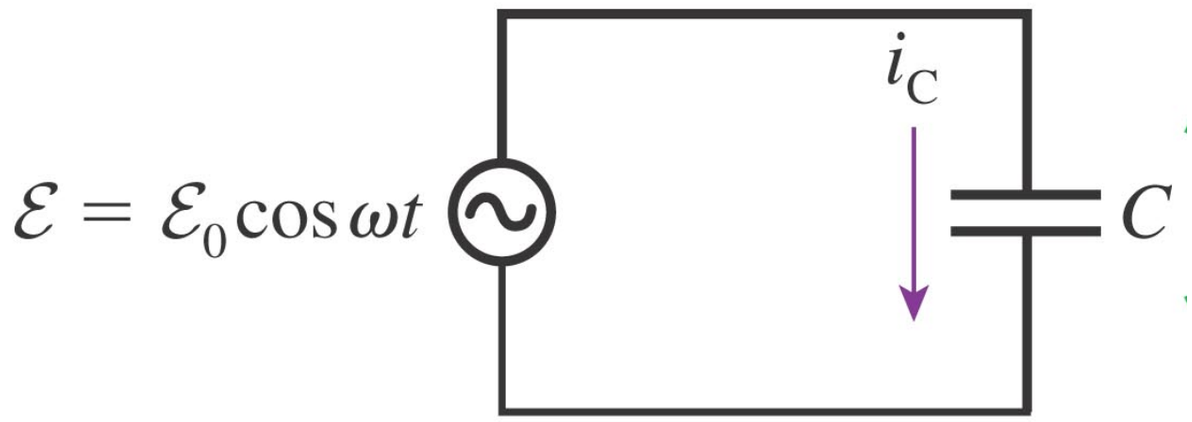
A. Is quartered.
B. Is halved.
C. Is doubled.
D. Is quadrupled.
E. Can't tell without knowing ω.



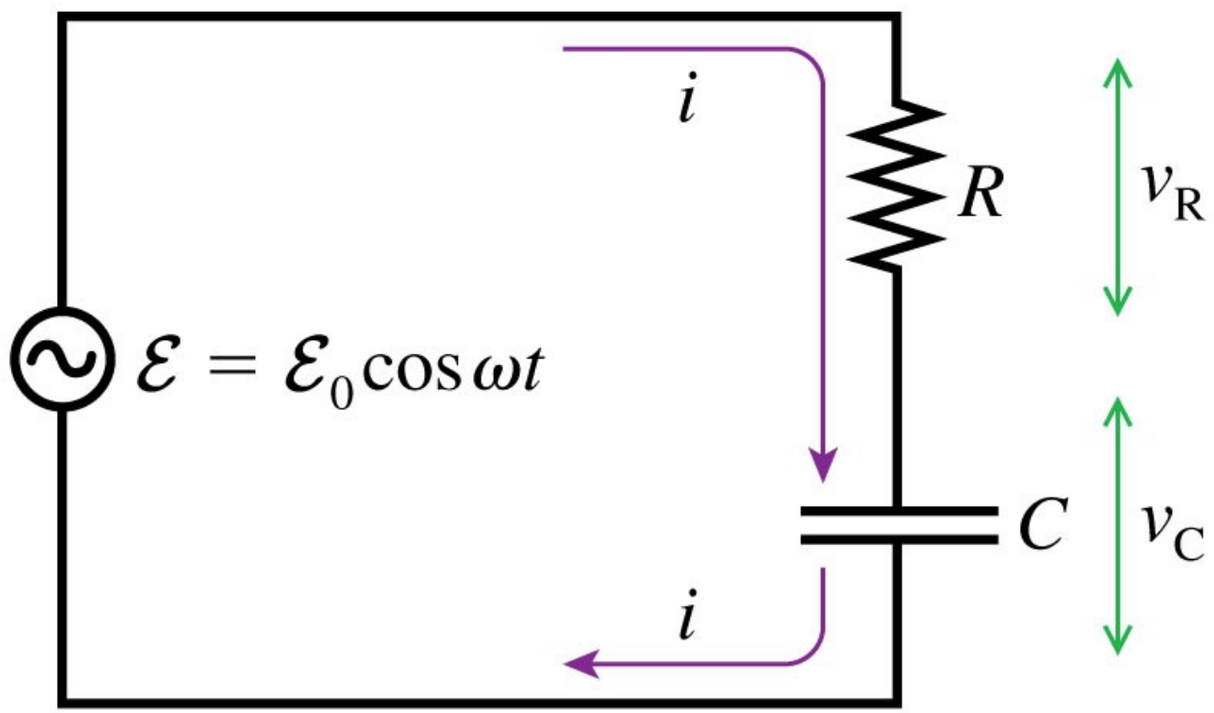
Quiz Question

If the value of the capacitance is doubled, the peak current

A. Is quartered.
B. Is doubled.
C. Is halved.
D. Is quadrupled.
E. Can't tell without knowing C.

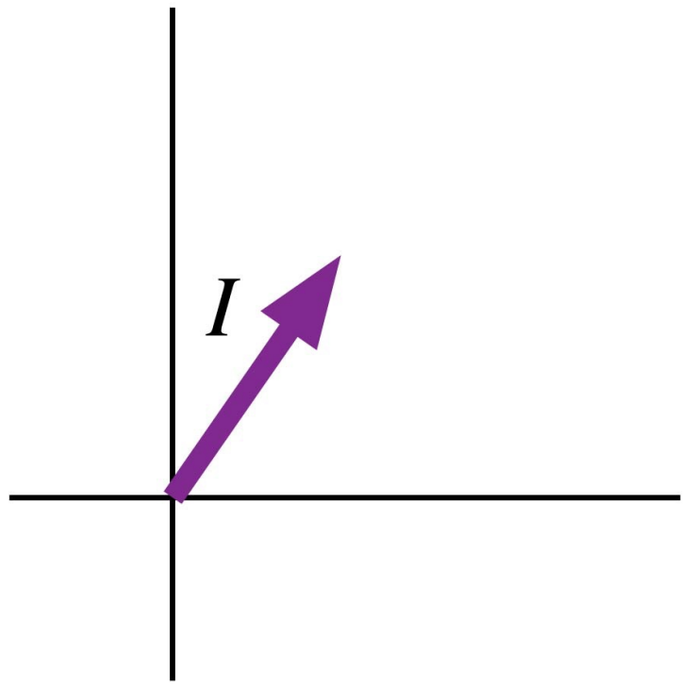


AC RC circuit



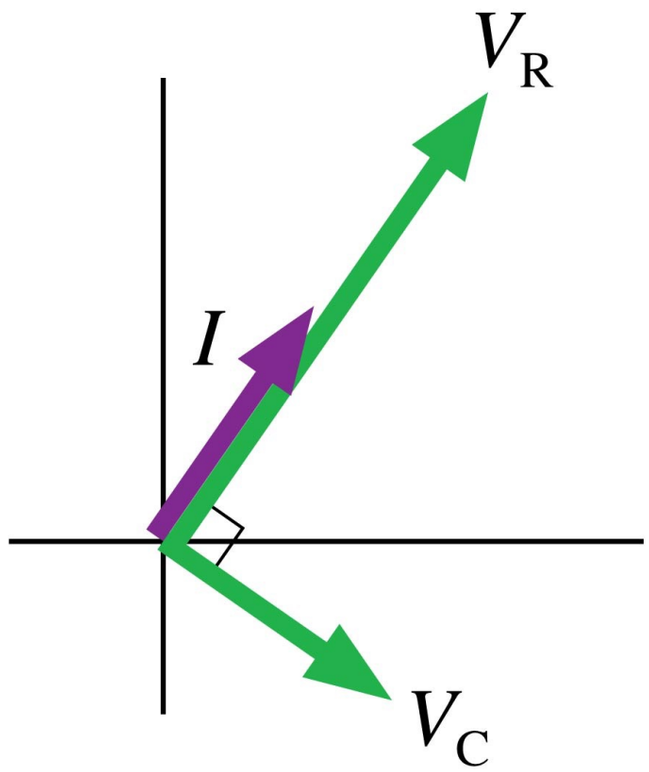
If the source frequency is high(low), will the peak voltage across the resistor (capacitor) be high or low?

Phasor Diagram



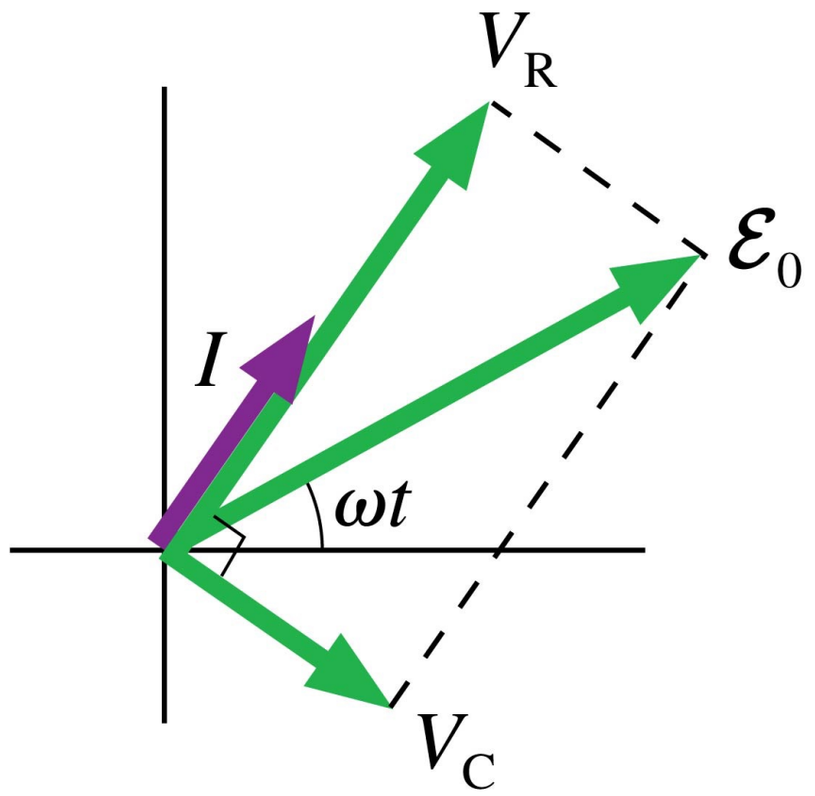
Draw the resistor voltage phasor and the capacitor voltage phasor

Phasor Diagram



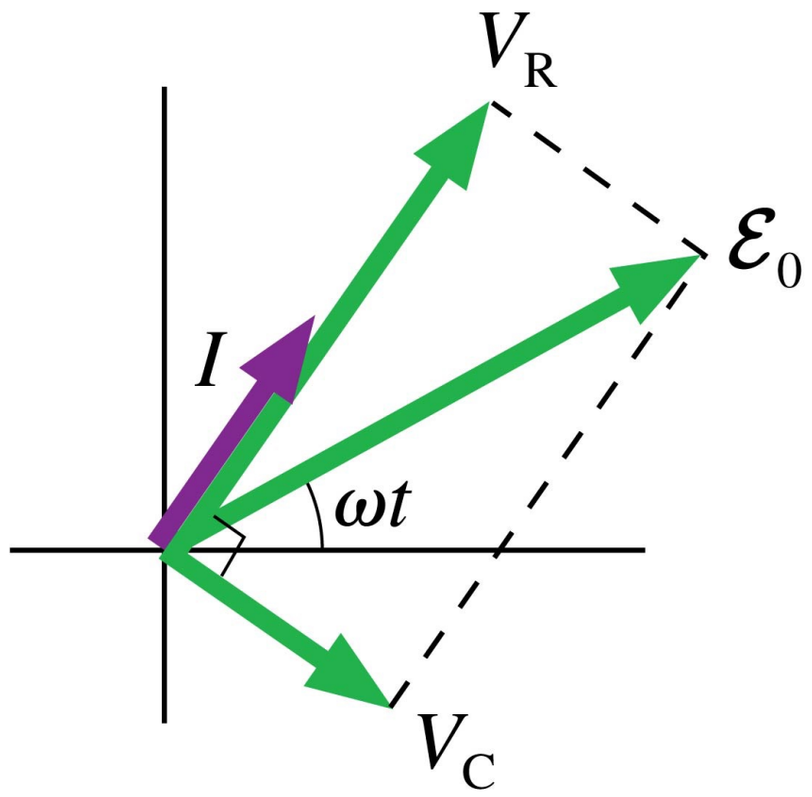
Draw the resistor voltage phasor and the capacitor voltage phasor

Phasor Diagram



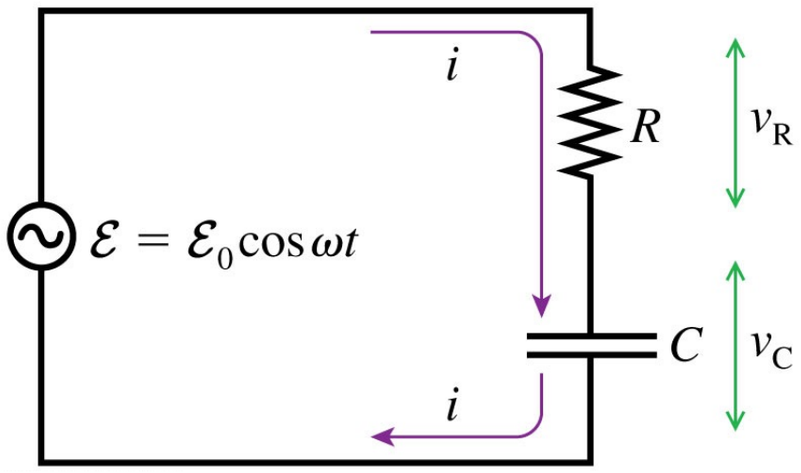
Draw the resistor voltage phasor and the capacitor voltage phasor

Phasor Diagram



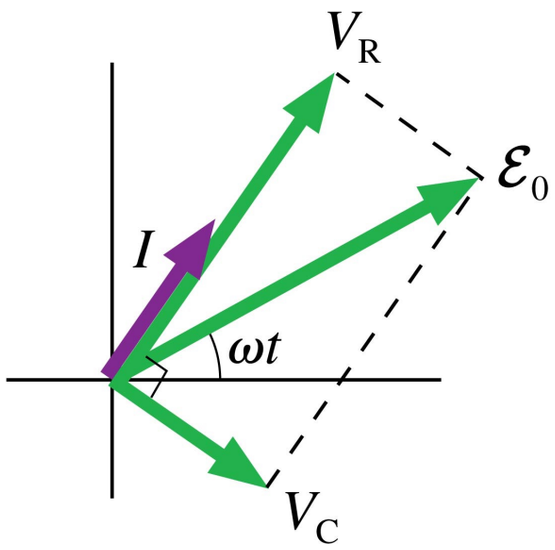
Draw the resistor voltage phasor and the capacitor voltage phasor

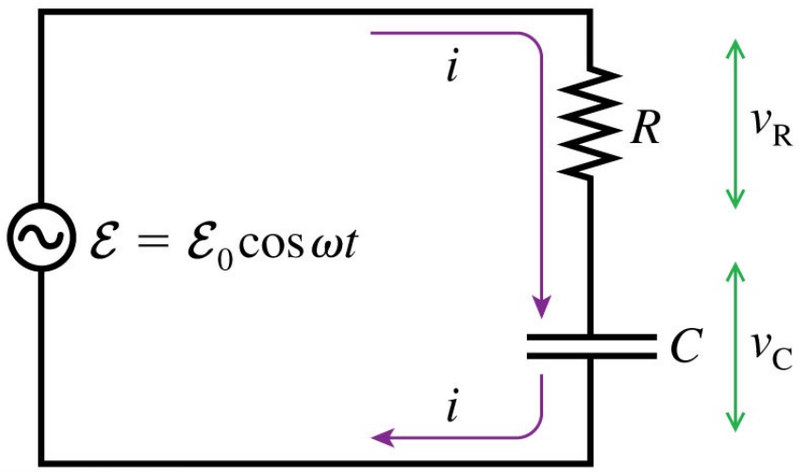
$$\mathcal{E}_0^2 = V_R^2 + V_C^2$$



$$\mathcal{E}_0^2 = V_R^2 + V_C^2$$

-
- Fill in the details and solve for I
-



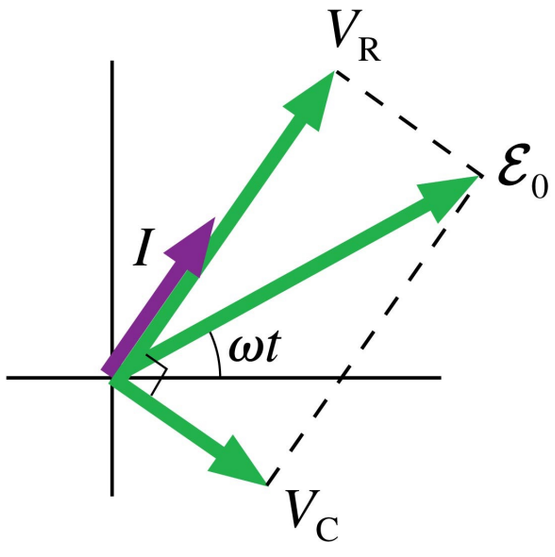


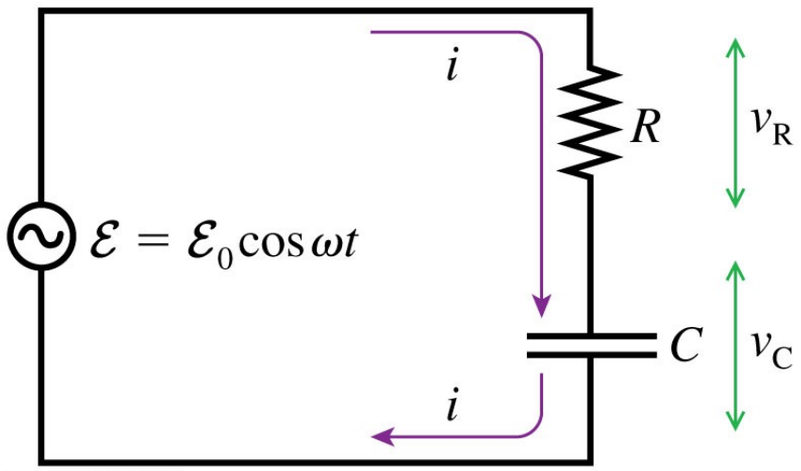
$$\mathcal{E}_0^2 = V_R^2 + V_C^2$$

-
- Fill in the details and solve for I
-

$$\mathcal{E}_0^2 = V_R^2 + V_C^2 = (IR)^2 + (IX_C)^2 = (R^2 + X_C^2)I^2$$

$$= (R^2 + 1/\omega^2 C^2)I^2$$



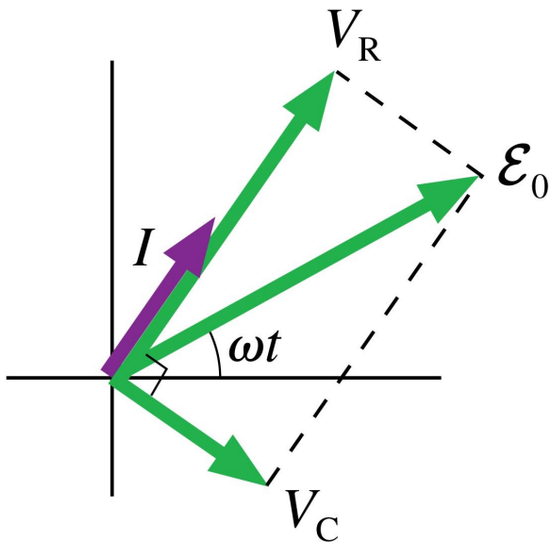


$$\mathcal{E}_0^2 = V_R^2 + V_C^2$$

-
- Fill in the details and solve for I
-

$$\mathcal{E}_0^2 = V_R^2 + V_C^2 = (IR)^2 + (IX_C)^2 = (R^2 + X_C^2)I^2$$

$$= (R^2 + 1/\omega^2 C^2)I^2$$

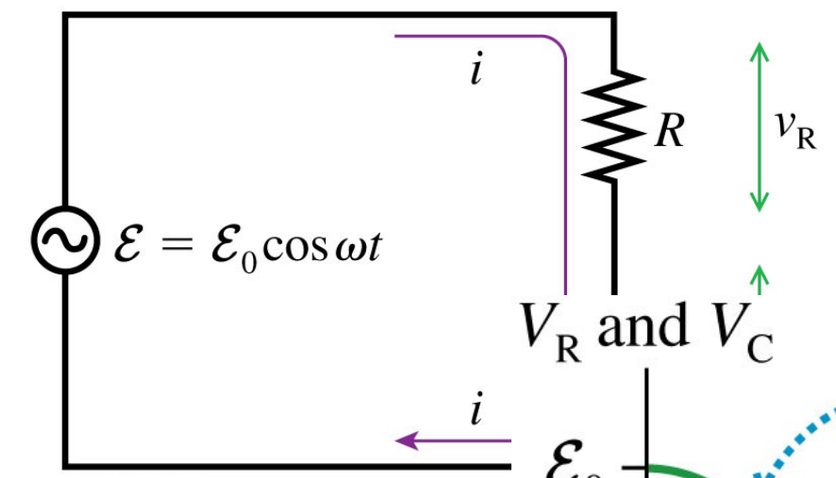


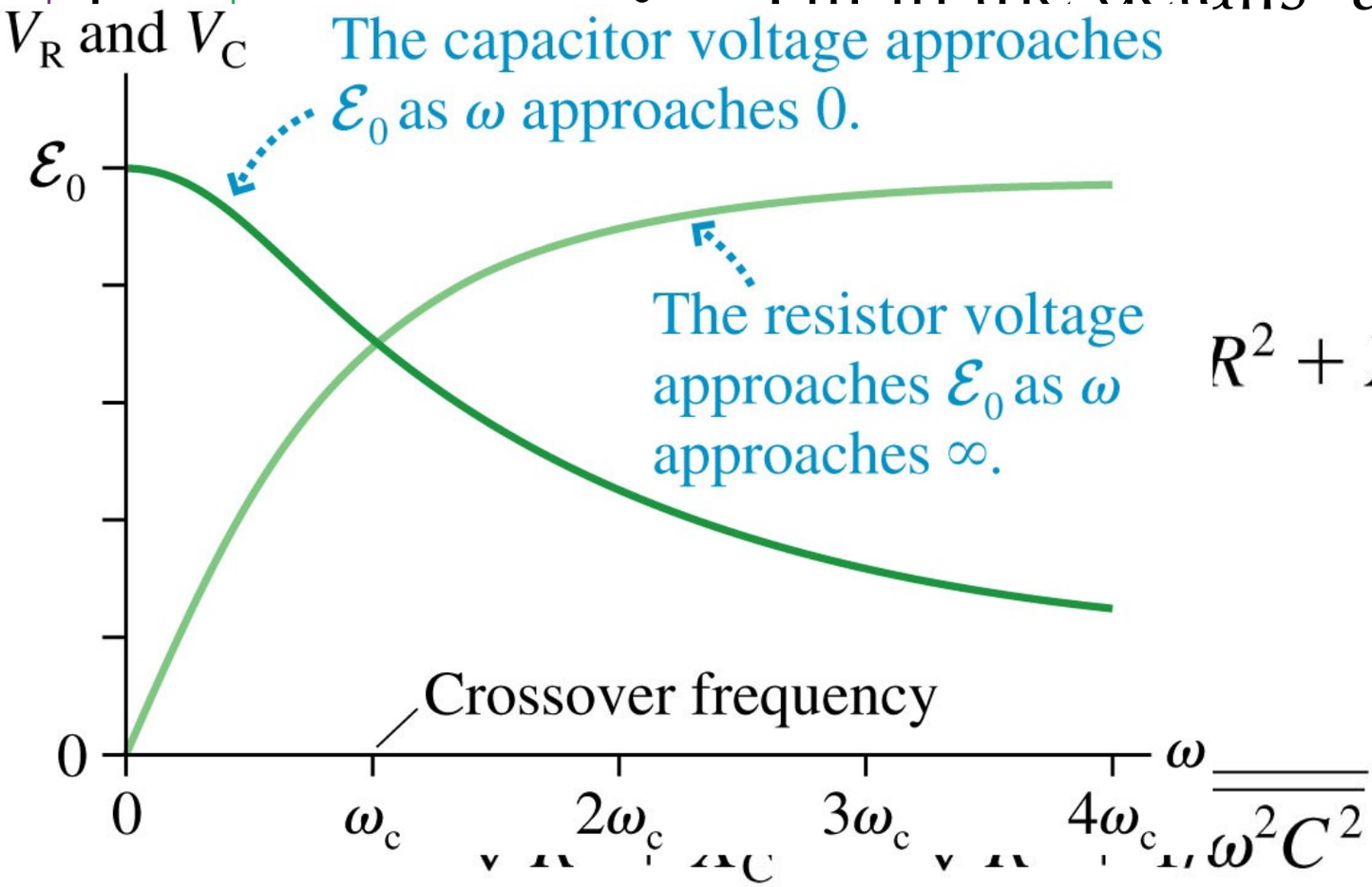
$$V_R = IR = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + X_C^2}} = \frac{\mathcal{E}_0 R}{\sqrt{R^2 + 1/\omega^2 C^2}}$$

$$V_C = IX_C = \frac{\mathcal{E}_0 X_C}{\sqrt{R^2 + X_C^2}} = \frac{\mathcal{E}_0 / \omega C}{\sqrt{R^2 + 1/\omega^2 C^2}}$$

$$\mathcal{E}_0^2 = V_R^2 + V_C^2$$

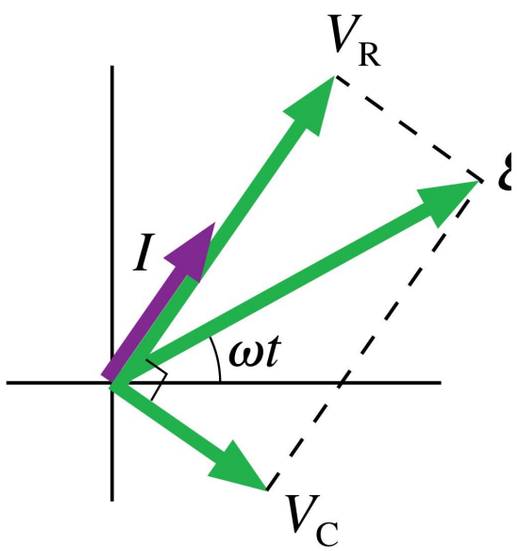
-
- Fill in the details and solve for I





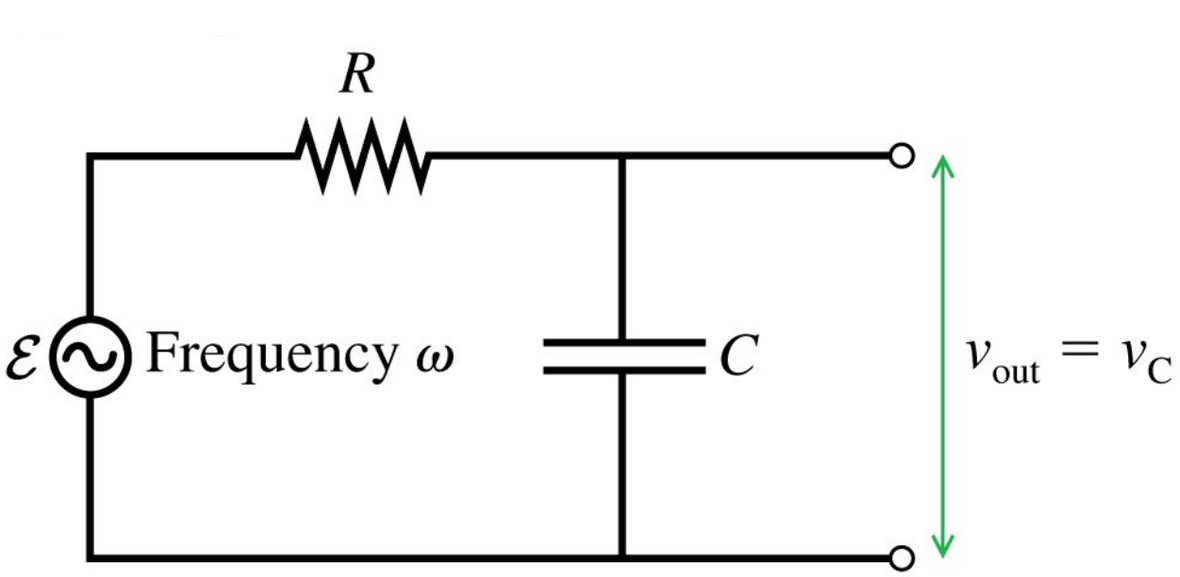
$$\omega_c = \frac{1}{RC}$$

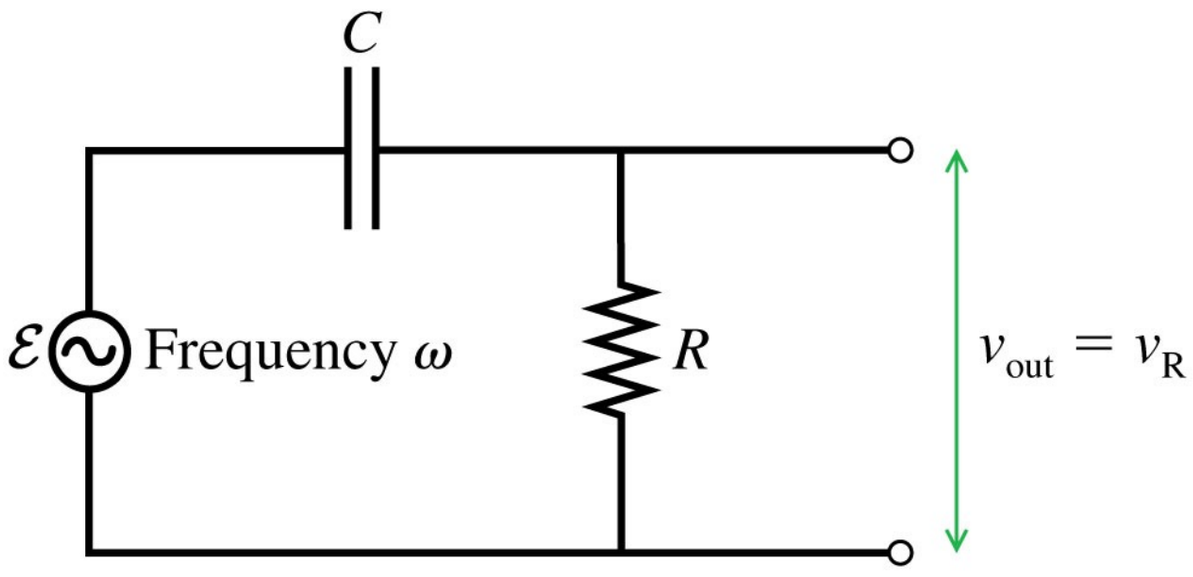
$$R^2 + X_C^2)I^2$$



$$V_C = IX_C = \frac{\mathcal{E}_0 X_C}{\sqrt{R^2 + X_C^2}} = \frac{\mathcal{E}_0 / \omega C}{\sqrt{R^2 + 1/\omega^2 C^2}}$$

Filters





Which circuit will transmit high frequency signals through?