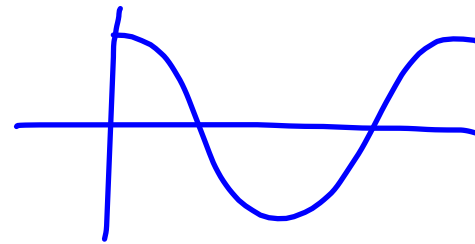


AC Circuits

- Advantage over DC - easy step down of voltage via transformer
- Current direction changes periodically

$$i = I \cos(\omega t)$$

$$\omega = 2\pi f$$



- Circuit symbol for AC power source

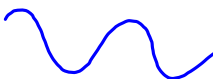


- Have an "Ohm's Law" involving peak I and peak V

① Resistor $i = I \cos(\omega t)$

$$\begin{aligned}v_R &= iR = I \cos(\omega t) R \\ &= IR \cos(\omega t) \\ &= V_R \cos(\omega t)\end{aligned}$$

$$V_R = IR$$


voltage in phase
w current

② Inductor

$$\begin{aligned}v_L &= L \frac{\Delta i}{\Delta t} \rightarrow L \frac{di}{dt} = L \frac{d}{dt} (I \cos(\omega t)) \\ &= -LI \sin(\omega t) \omega \\ &= -LI \omega \sin(\omega t) \\ &= LI \omega \cos\left(\omega t + \frac{\pi}{2}\right) \\ &\equiv V_L \cos\left(\omega t + \frac{\pi}{2}\right)\end{aligned}$$

$$V_L = LI \omega$$

phase leads
current by 90°

$$\rightarrow V_L = I X_L$$

Ohm's Law $X_L \equiv \omega L$ ← Reactance
form.

(AC equivalent
of a resistor)

③ Capacitor

$$v = \frac{q}{C}$$

$$C = \frac{q}{v}$$



$$\frac{dv}{dt} = \frac{1}{C} \frac{dq}{dt}$$

← current

$$= \frac{1}{C} I \cos(\omega t)$$

$$= \frac{I}{C} \cos(\omega t)$$

$$v = \frac{I}{\omega C} \sin(\omega t) \text{ by integration}$$

$$= \frac{I}{\omega C} \cos(\omega t - \frac{\pi}{2})$$

$$= V_c \cos(\omega t - \frac{\pi}{2})$$

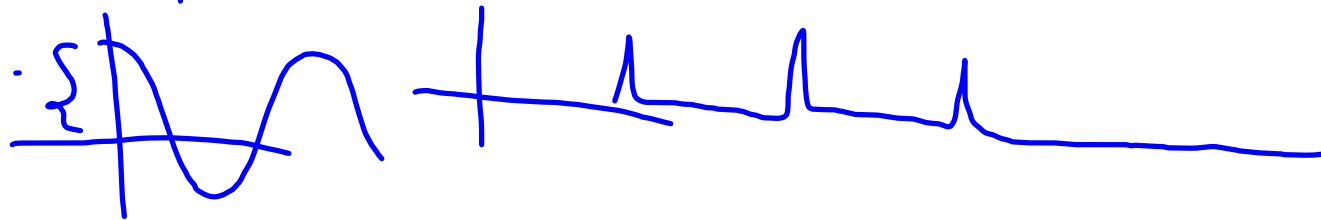
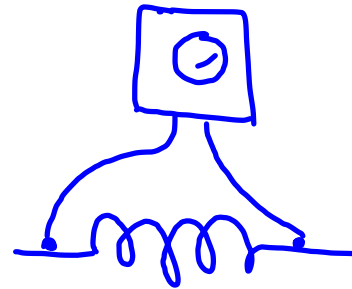
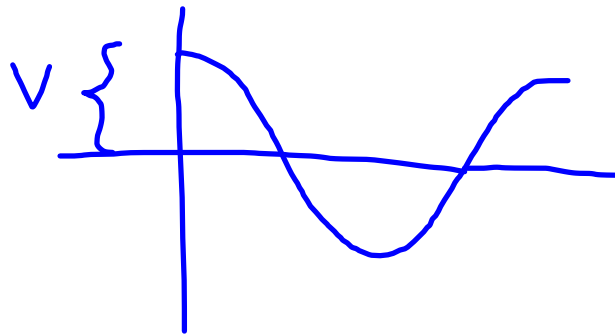
$$V_c = \frac{I}{\omega C}$$

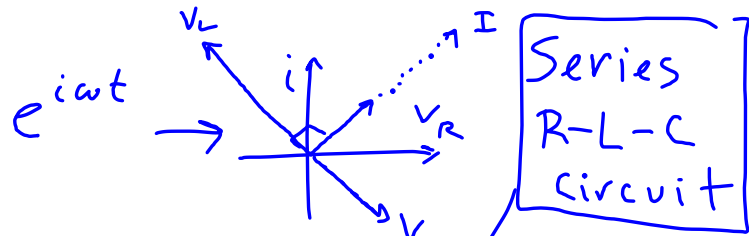
phase lags
by 90°

$$V_c = I X_c$$

$$X_c = \frac{1}{\omega C} \leftarrow \text{reactance of a capacitor}$$

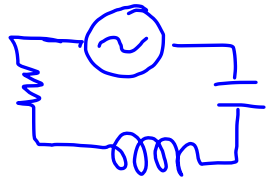
Circuit element	Reactance	"Ohm's Law"	Phase of voltage
resistor	R	$V_R = IR$	in phase with i
inductor	$X_L = \omega L$	$V_L = IX_L$	leads i by 90°
capacitor	$X_C = \frac{1}{\omega C}$	$V_C = IX_C$	lags i by 90°





Series R-L-C circuit

Add vectors in complex plane



$$V_L = IX_L$$

$$V^2 = (V_L - V_C)^2 + V_R^2$$

$$V = \sqrt{(V_L - V_C)^2 + V_R^2}$$

$$= I \sqrt{(X_L - X_C)^2 + R^2}$$

$$\equiv IZ$$

↑
impedance

For AC circuit with at least 2 of the 3 circuit elements, "Ohm's Law" is

$$V = IZ$$

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

V = peak voltage

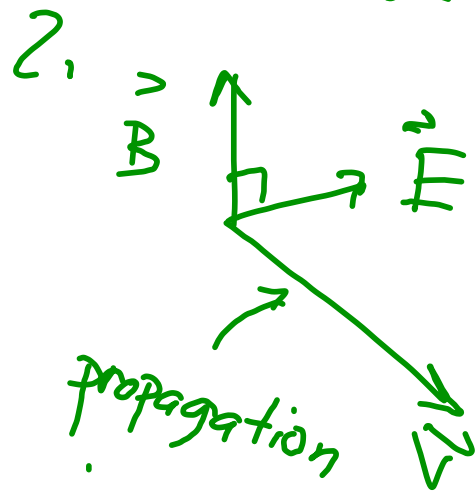
I = peak current

Electromagnetic Waves

1. large spectrum

• visible light is a tiny fraction of spectrum

• We see visible light because it passes thru water



$\vec{E} \times \vec{B}$ points
in direction of
propagation (travel)