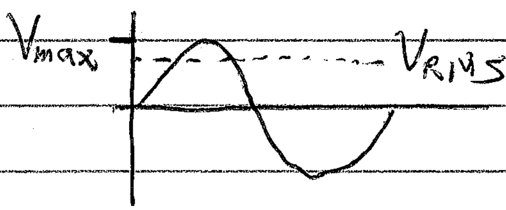
(1) Phys 1402 2015-10-20 Lec 16

Exam 2 Thu 10/29

Covers Magnetism Chap 19
EM Induction 20
AC Circuits 21

AC Voltages oscillate



$$V_{RMS} = \frac{V_{max}}{\sqrt{2}}$$

$$V_{RMS} = (70.7\%)\ V_{max}$$

RMS is most like the "standard deviation".

$$V(t) = V_{max} \sin(2\pi f t).$$

f = frequency in hertz (Hz)

$T = \frac{1}{f}$ = period in seconds (s)

Ex: US outlets:

$V_{RMS} = 120\ V$ $f = 60\ Hz$

Resistors in AC

In DC: $V = IR$

In AC: $V(t) = I(t)\, R$

$$\boxed{V_{RMS} = I_{RMS}\, R}$$

f is shared by V and I

In DC $P = VI$

In AC $P(t) = V(t)\, I(t)$

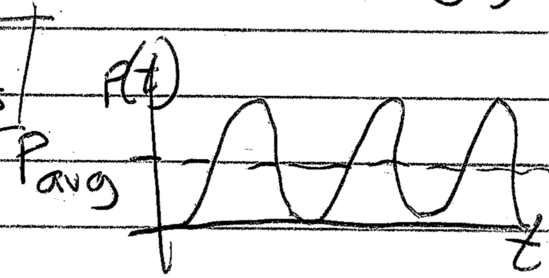
$$= \left(V_{RMS}\sqrt{2}\right)\sin(2\pi f t)\left(I_{rms}\sqrt{2}\right)\sin(2\pi f t)$$

$$P(t) = 2\, V_{rms} I_{rms} \sin^2(2\pi f t)$$

$$\sin^2(\theta) = \frac{1}{2}\left(1 - \cos(2\theta)\right)$$

$$P(t) = V_{rms} I_{rms}\left(1 - \cos\left(2\pi(2f)t\right)\right)$$

$$\boxed{\text{Average}\left[P(t)\right] = V_{RMS} I_{RMS}}$$



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Ex: ~~100 W~~ 60 W Light bulb

120 V RMS voltage

$$P = IV$$

$$(60\ W) = I\ (120\ V) \Rightarrow I = 0.5\ A$$

RMS current is 0.5 A.

$$V = IR$$

$$(120\ V) = (0.5\ A)(R) \Rightarrow R = 240\ \Omega$$

$$P = VI = (IR)I = I^2 R$$

This is the *ONLY* power used in AC.

Inductors (L)

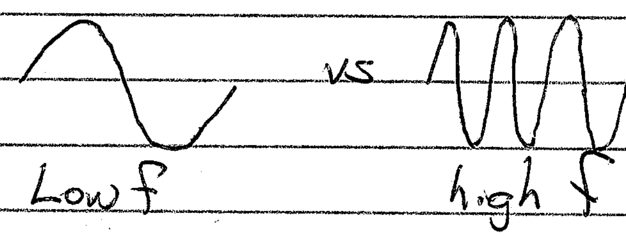
In DC: Inductor is a wire.
Low R → high current

Inductors oppose change in current and B.

In AC, I varies continually.
The inductor responds by opposing w/ voltage.

$V_L \propto I$ because $I(t) = I_{max} \sin(2\pi f t)$
bigger I_{max} → steeper graph

$V_L \propto f$



$$V_{L,rms} = \underbrace{(2\pi f L)} I_{rms}$$

X_L Reactance
Z_L Impedance (generic term)

Impedance is like resistance for AC.

$V_{RMS} = Z\, I_{RMS}$ AC Ohm's Law

$P_{L,avg} = 0$ Inductor doesn't use energy.

Capacitors (C)

In DC, capacitor has an insulator

$R = \text{high} \Rightarrow$ No current

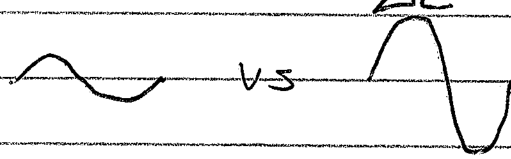
Capacitors take time to charge.
Changing the voltage is difficult.

In AC, V is changing continually.
The faster V changes, the more current must flow to charge & discharge the capacitor.

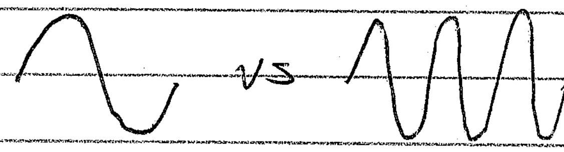
$$Q = CV$$

$$I = \frac{\Delta Q}{\Delta t} = C\,\frac{\Delta V}{\Delta t}$$

$I \propto V_{max}$



$I \propto f$



$$I_{rms} = (2\pi f C)\, V_{rms}$$

$$V_{rms} = \underbrace{\left(\frac{1}{2\pi f C}\right)}_{X_C} I_{rms}$$

X_C Capacitive Reactance

Z_C Impedance

$V_{RMS} = I_{rms} Z$

Resistor $Z = R$ $P = I_{Rms}^2 R$

Inductor $Z = 2\pi f L$ $P = 0$

Capacitor $Z = \frac{1}{2\pi f C}$ $P = 0$

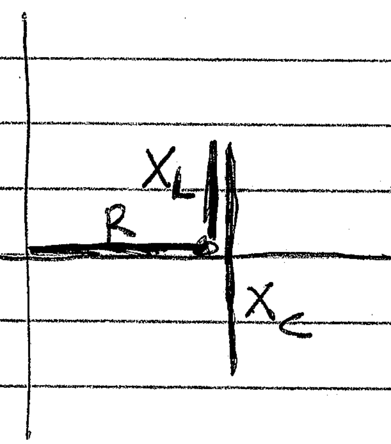
Series RLC Circuit

Impedances add like vectors.

Z_R in $+X$

Z_L in $+Y$

Z_C in $-Y$



	x	y
R	R	
L		$X_L = 2\pi f L$
C		$-X_C = -(1/(2\pi f C))$
Tot	R	$X_L - X_C$

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