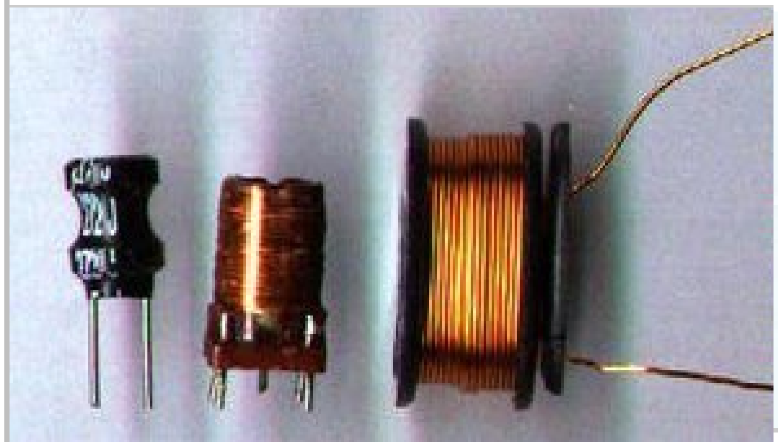
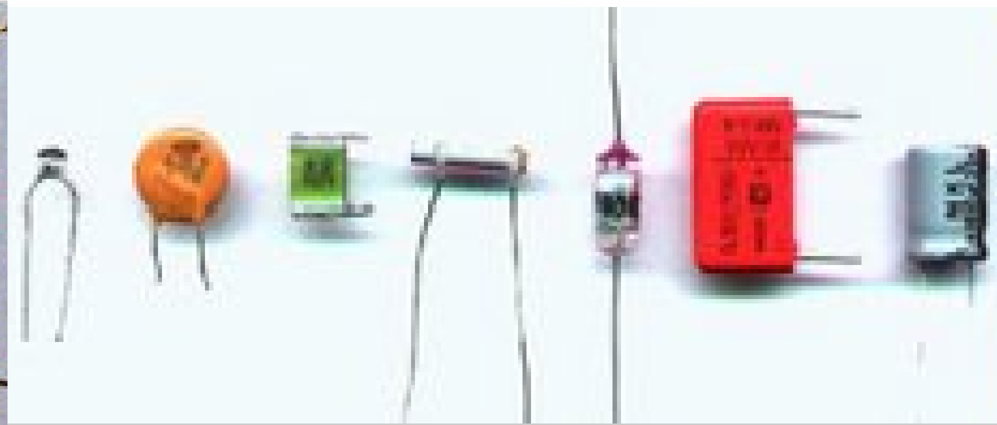
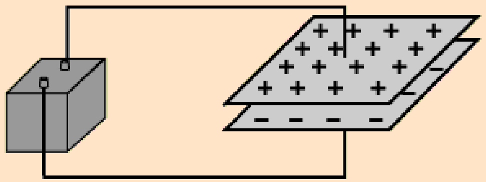
Capcitors and Inductors

Capacitors



A battery will transport charge from one plate to the other until the voltage produced by the charge buildup is equal to the battery voltage.

Capacitance is typified by a parallel plate arrangement and is defined in terms of charge storage:

$$C = \frac{Q}{V}$$

$$\text{Unit} = \frac{\text{coulomb}}{\text{volt}} = \text{Farad}$$

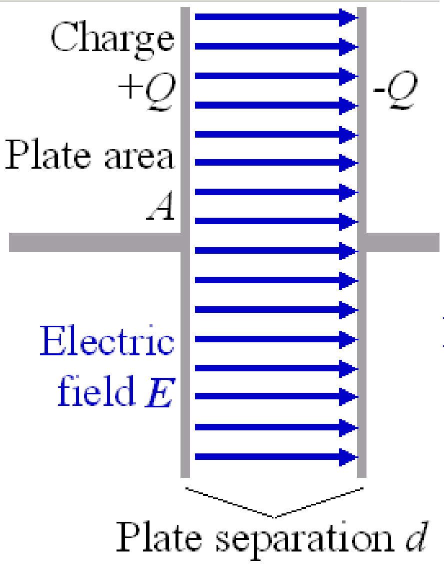
where

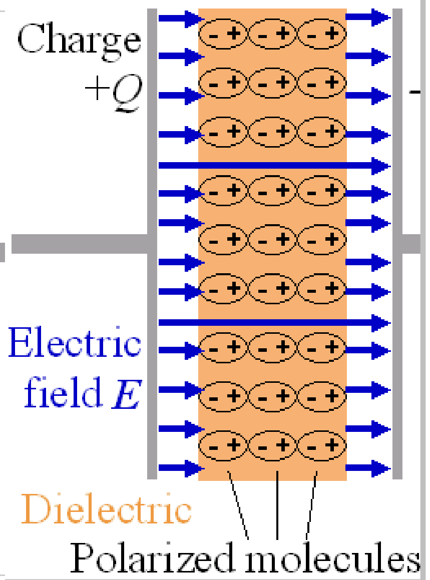
- Q = magnitude of charge stored on each plate.
- V = voltage applied to the plates.

3 factors that determine capacitance

1. dielectric material
2. size of the plate
3. distance between plates

Dielectric constant



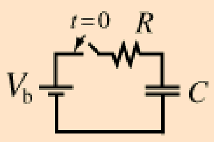


The electrons in the molecules move or rotate the mo
toward the positively charged left plate. This process
creates an opposing electric field that partially annuls

Charging a Capacitor

When a battery is connected to a series resistor and capacitor, the initial current is high as the battery transports charge from one plate of the capacitor to the other. The charging current asymptotically approaches zero as the capacitor becomes charged up to the battery voltage. Charging the capacitor stores energy in the electric field between the capacitor plates. The rate of charging is typically described in terms of a time constant RC.

Universal time constant for RC and RL circuits



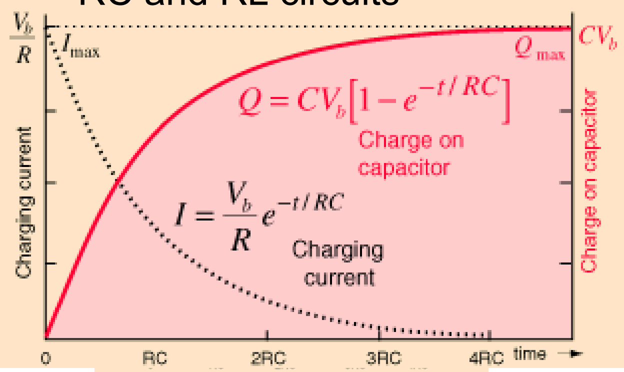
$$V_b = V_R + V_C$$

$$V_b = IR + \frac{Q}{C}$$

As charging progresses,

$$V_b = IR + \frac{Q}{C}$$

current decreases and charge increases.



At $t = 0$
$Q = 0$
$V_C = 0$
$I = \frac{V_b}{R}$

As $t \to \infty$
$Q \to CV_b$
$V_C \to V_b$
$I \to 0$

$$X_C = -\frac{1}{2\pi fC} = -\frac{1}{\omega C}$$

where

$\omega = 2\pi f$, the angular frequency measured in radians per second
X_C = capacitive reactance, measured in ohms
f = frequency of AC in hertz
C = capacitance in farads

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

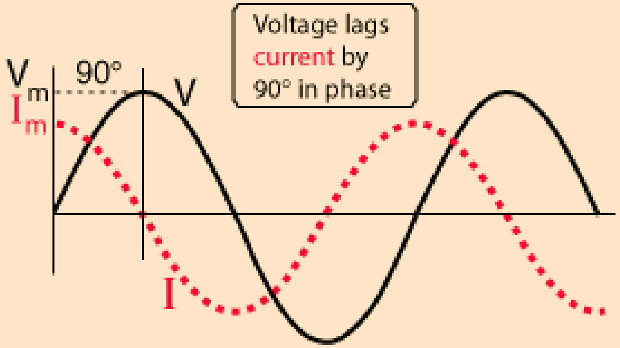
Capacitor AC Response

Impedance

$$I = \frac{V}{X_C}$$

$$X_C = \frac{1}{\omega C}$$

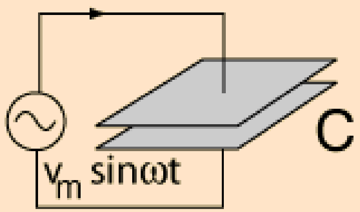
Calculate



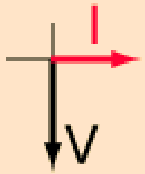
Examine

Inductor

Resistor



$$I = \frac{I_m}{\sqrt{2}}, \; V = \frac{V_m}{\sqrt{2}}$$

Contribution to complex impedance	Phasor diagram
$\frac{-j}{\omega C}$	

Index

Capacitance concepts

Inductance concepts

You know that the voltage across a capacitor lags the current because the current must flow to build up the charge, and the voltage is proportional to that charge which is built up on the capacitor plates.

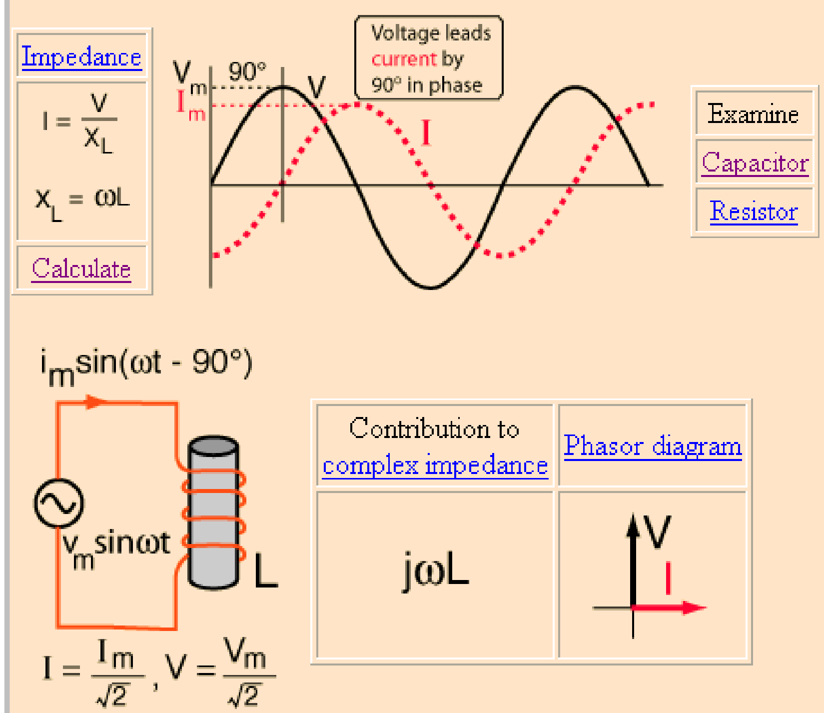
Time Constant	Charging	Discharging
1	63.2V	36.8
2	86.5V	13.5
3	95 V	5
4	98 V	2
5	99.3V	.7(1)

63.2% of 100V

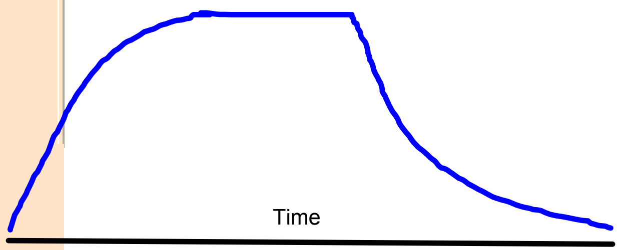
http://www.kpsec.freeuk.com/capacit.htm

http://www.kpsec.freeuk.com/imped.htm

Inductor AC Response



Transient Response L circuit



Current rise	Steady state	Current Decay
10V	6.32V	3.68V

You know that the voltage across an inductor leads the current because the Lenz' law behavior resists the buildup of the current, and it takes a finite time for an imposed voltage to force the buildup of current to its maximum.

p.146 1-13

Ohm's Law for AC

DC	AC
Resistance, $\mathbf{R} = \dfrac{\mathbf{V}}{\mathbf{I}}$	Impedance, $\mathbf{Z} = \dfrac{\mathbf{V}}{\mathbf{I}}$

V = voltage in volts (V)
I = current in amps (A)
Z = impedance in ohms (Ω)

R = resistance in ohms (Ω)

Transformers

Turns Ratio primary secondary

volts and amp are inversely proportional

Power $P=IE$

3 types of loss

Copper the wires

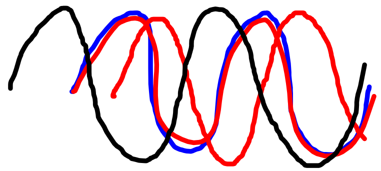
Eddy whirlpool

Hysteresis molecular friction

RCL Circuits

1. R only $P = EI$

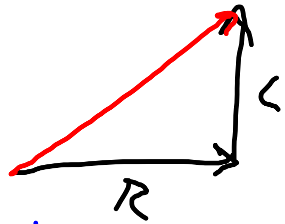
   In Phase



2. L only

   I lags V by 90°

   not in phase



3. RL I lags < 90°

   R_T = vector sum of R + L

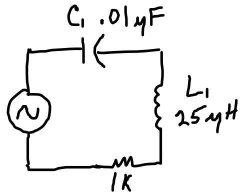
4. C only I leads V by 90°

5. RC I leads V by < 90°

6. $X_C = X_L$ Resonance f_0

   (Tuned Circuit)

RCL circuits



What happens to E_R?

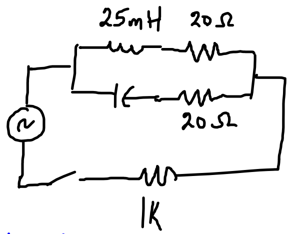
$$f_0 = \frac{.159}{\sqrt{LC}}$$

Series

At Resonance	E_R Up	$E_L + E_C$ Cancel
Above	E_R Down	E_L Up
Below	E_R Down	E_C Up

Text 176

Parallel



Z is high at Resonance I is low

Above R	X_L high	X_C low
	I_L low	I_C high
	E_{R1} low	E_{R2} high
Below R	X_L low	X_C high
	I_L high	I_C low
	E_{R1} high	E_{R2} low