

$$m \frac{d^2 \mathbf{x}}{dt^2} + b \frac{d \mathbf{x}}{dt} + k \mathbf{x} = 0$$

The Basics  
of

*Mechanical and Electrical  
Oscillation and Resonance*

$$L \frac{d^2 Q}{dt^2} + R \frac{dQ}{dt} + \frac{1}{C} Q(t) = 0.$$

# Mechanical Resonance Oscillators

# *Mechanical Structures*

Oscillate

or

Resonate

because they have

**Inertial Mass**

and

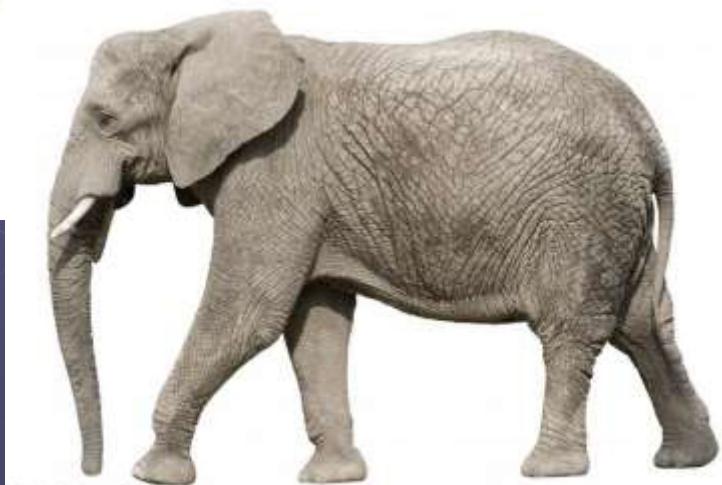
**Elastic Stiffness**

# Mass ( Inertia )

The mass of a material is related to its density and volume.

Mass has 'inertia' =

Mass does not want to move,  
and once moving, doesn't want to stop !



*Mass in Motion contains  
Kinetic Energy*



**Dynamic Energy**

**>> Visible , Moving Energy <<**

# Stiffness ( Elasticity )

The Stiffness of a Material Resists Deformation

**Stiff or Elastic materials do not want to deform and will push or pull to get back to normal**

( Elasticity has limits beyond which permanent deformation occurs )



# *Physical Deformation of Stiff Objects creates Potential ( elastic ) Energy*



## Static Energy

>> Stored , Non ‘visible’ Energy <<

Potential Energy is stored within molecular forces

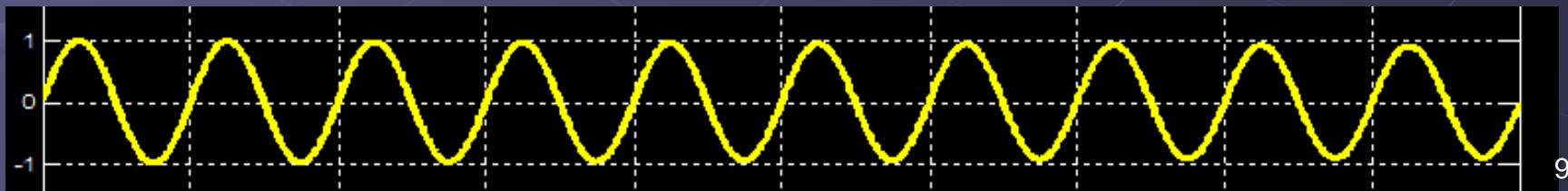
*Kinetic Energy* = Dynamic Moving  
‘visible’ Energy

*Potential Energy* = Static Stored  
Non ‘visible’ Energy

*Oscillation*  
is the  
**sinusoidal periodic**  
( Sine Wave type motion )

>> Exchange of Energy <<

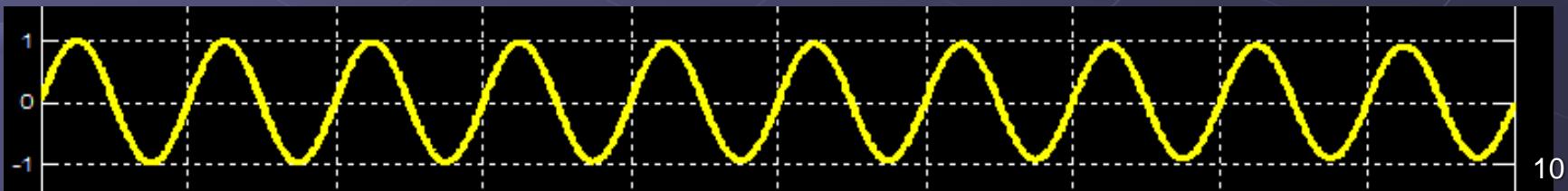
between the  
**Kinetic** and **Potential** Energy States



Mechanical *Resonance*  
is the most efficient  
**>> Rate of Energy Exchange <<**  
( Timing )

Between these two states

*Sometimes called the*  
**Natural Frequency**



# +Potential > +Kinetic > -Potential Energy Exchange



A B C

Spring Max Tension 100% - Potential Energy



A

Mass 0 velocity 0% Energy



Spring UnDeformed 0 % Energy



B

Mass Max Velocity 100% + Kinetic Energy



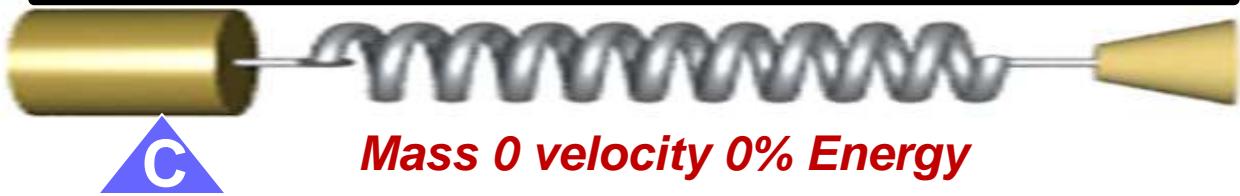
C

Mass 0 velocity 0% Energy

# +Potential > Kinetic > -Potential Energy Exchange



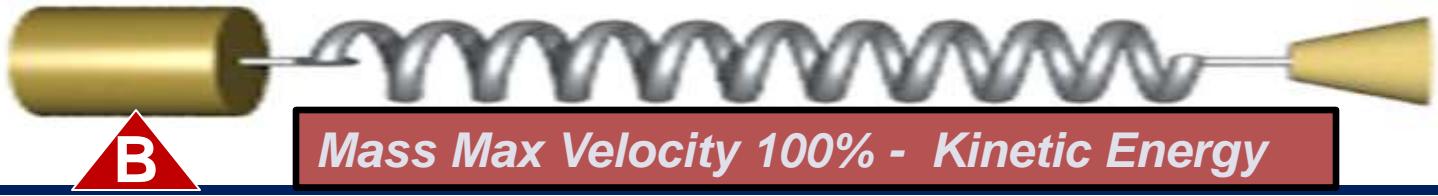
**Spring Max Compression 100% +Potential Energy**



**Mass 0 velocity 0% Energy**

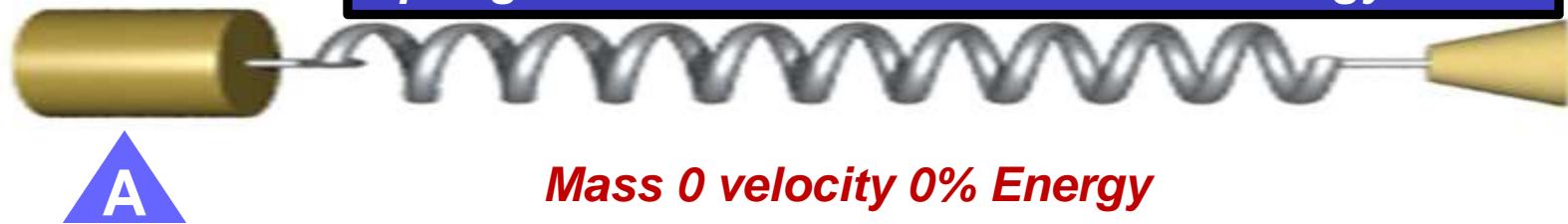


**Spring UnDeformed 0 % Energy**



**Mass Max Velocity 100% - Kinetic Energy**

**Spring Max Tension 100% - Potential Energy**



**Mass 0 velocity 0% Energy**

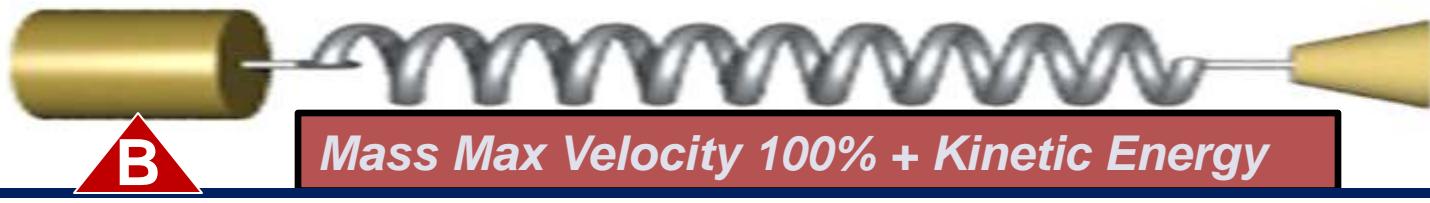
*+Potential > +Kinetic > -Potential* Energy Exchange



*Spring Max Tension 100% - Potential Energy*



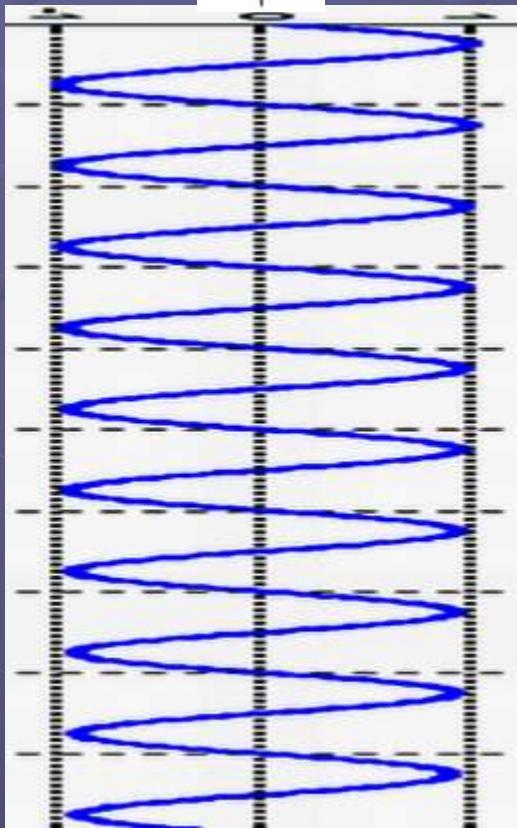
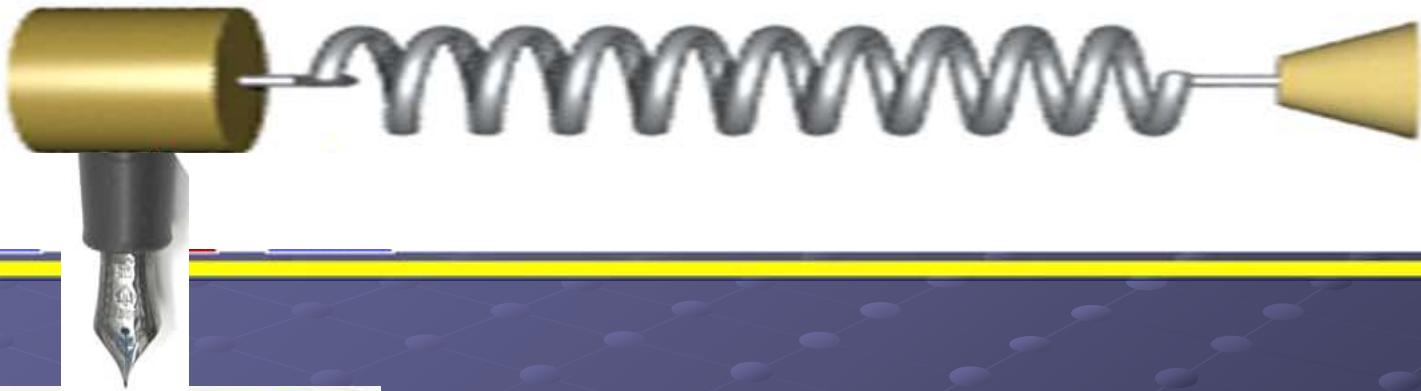
*Spring UnDeformed 0 % Energy*



*Spring Max Compression 100% +Potential Energy*

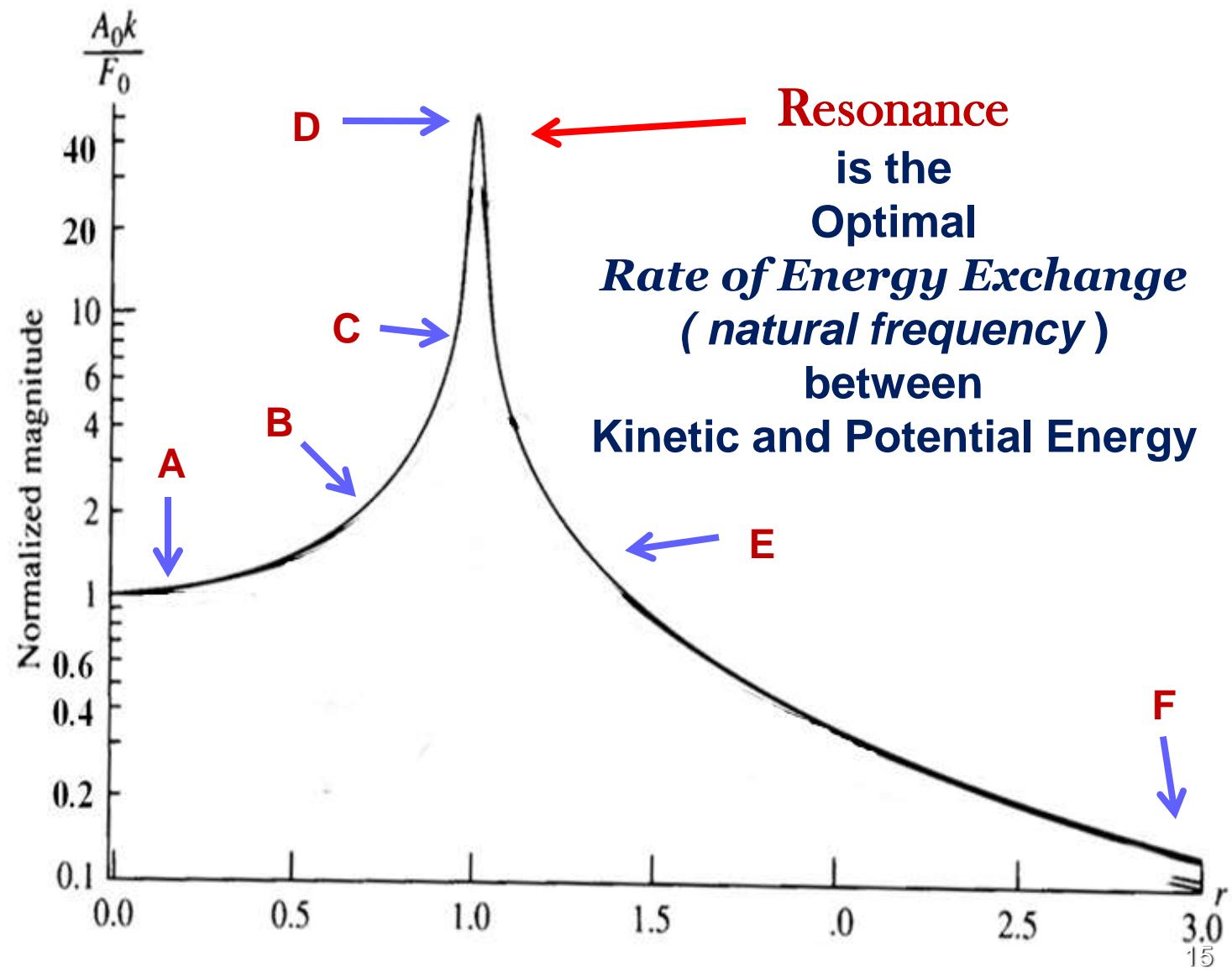


*+Potential > Kinetic > -Potential* Energy Exchange



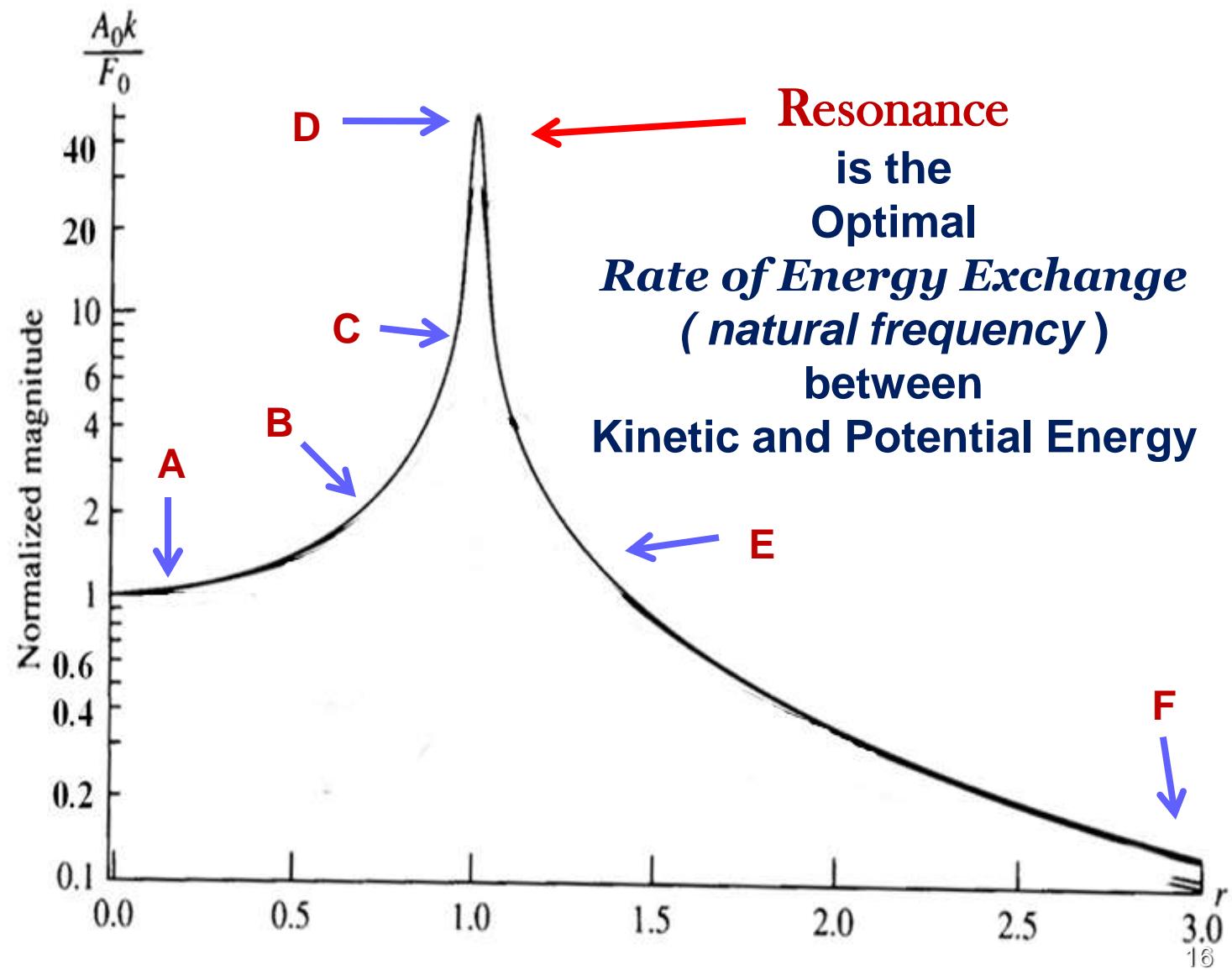
# Resonance of a single degree of freedom system SDOF

Amplitude Displacement Ratio ( Output / Input ) vs Frequency Plot



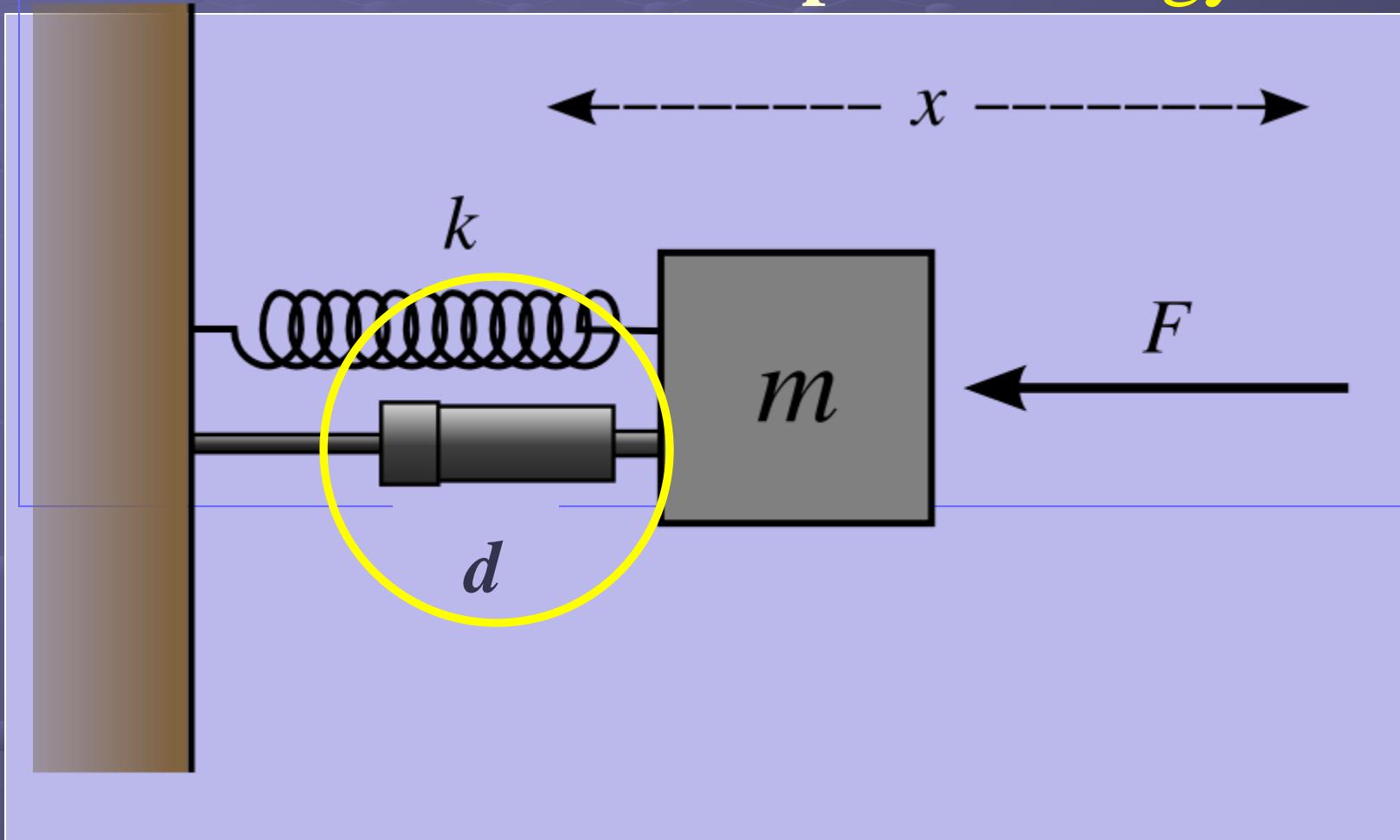
# Resonance of a single degree of freedom system SDOF

Amplitude Displacement Ratio ( Output / Input ) vs Frequency Plot



All real Structures also have **Damping**

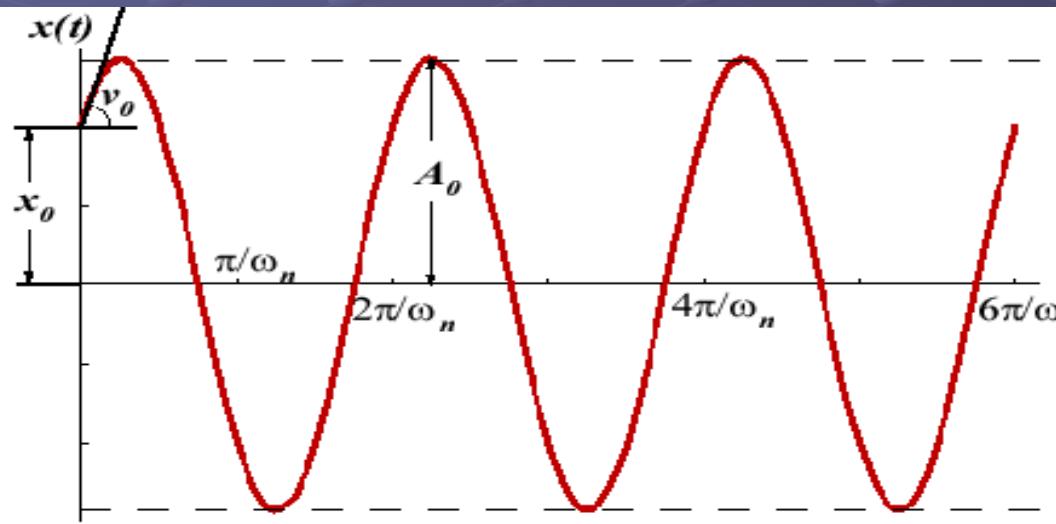
Damping  
consumes or dissipates Energy



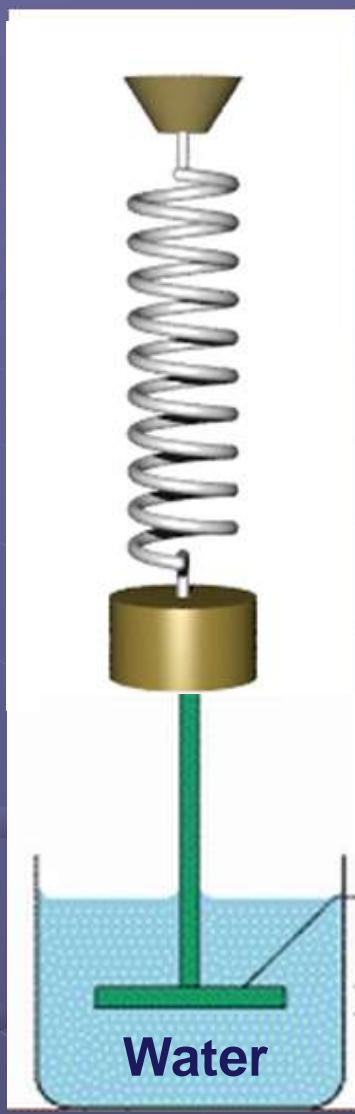
# Resonance of a Single degree of freedom system SDOF



Post Excitation of an Undamped Harmonic Oscillator

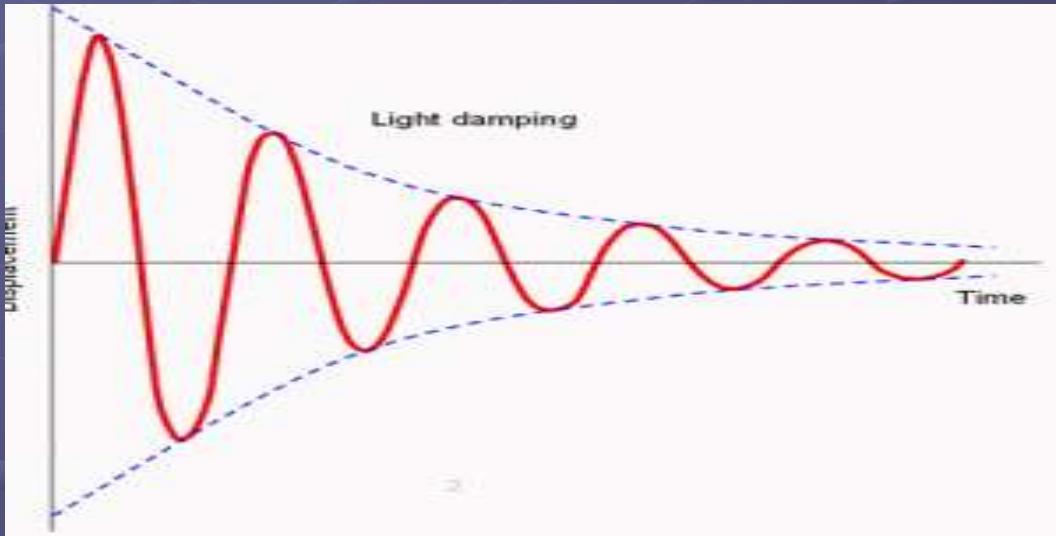


# Resonance of a Single degree of freedom system SDOF

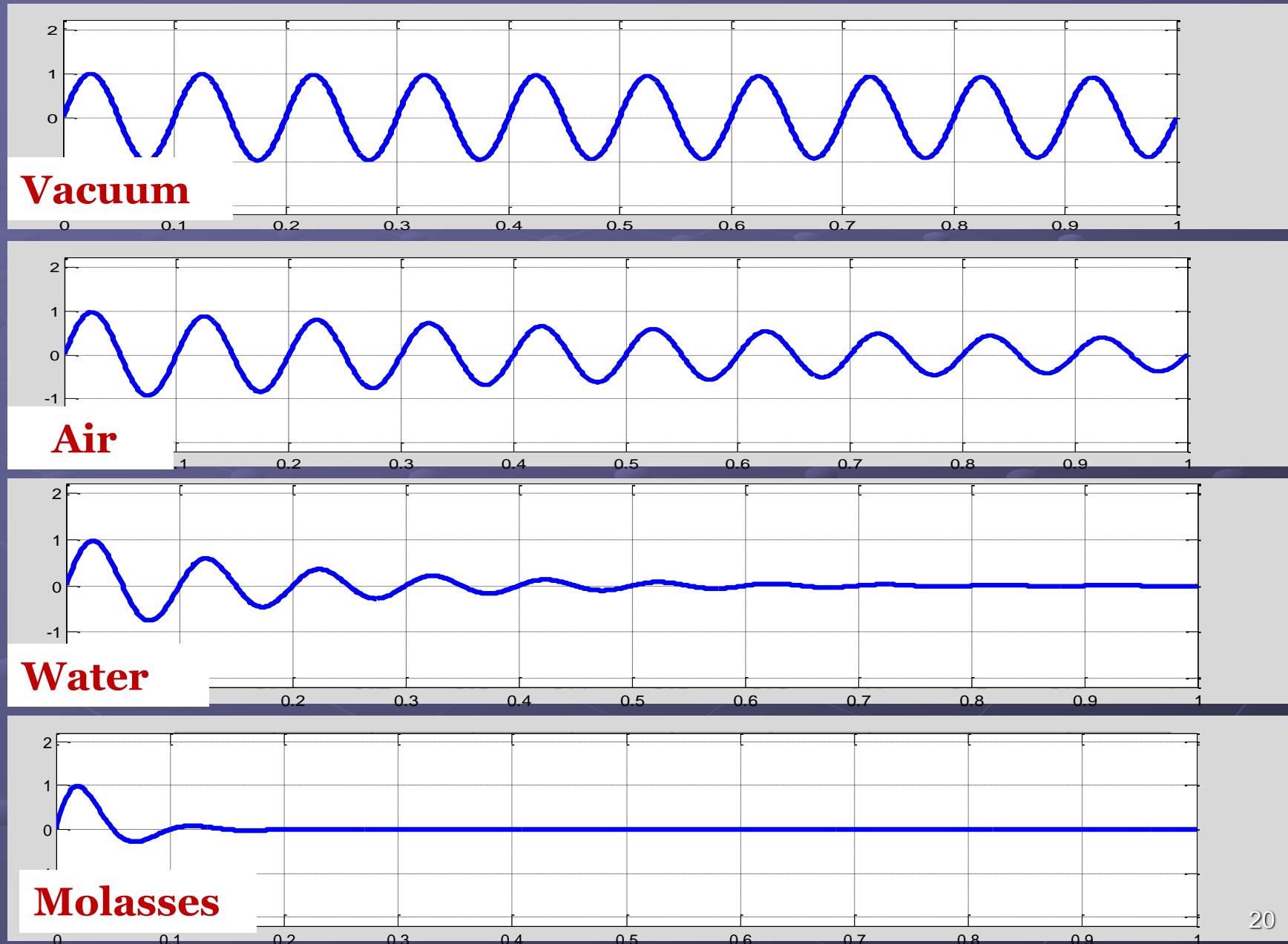


Damping  
consumes or dissipates Energy

Post Excitation of a Damped Harmonic Oscillator



# Lightly and Heavily Damped Sinusoidal Oscillation Decay



# Electrical Resonance Oscillators

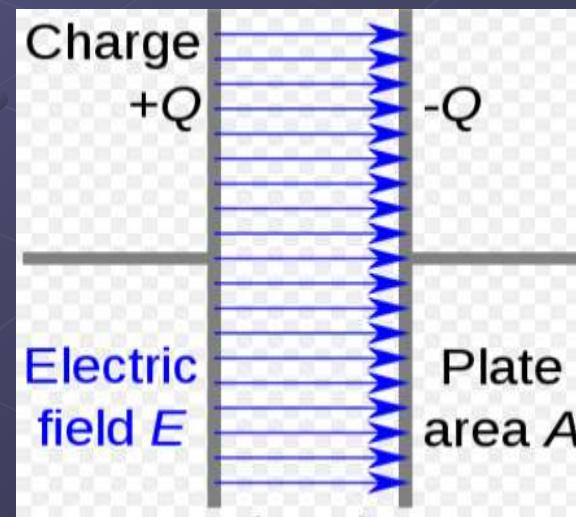
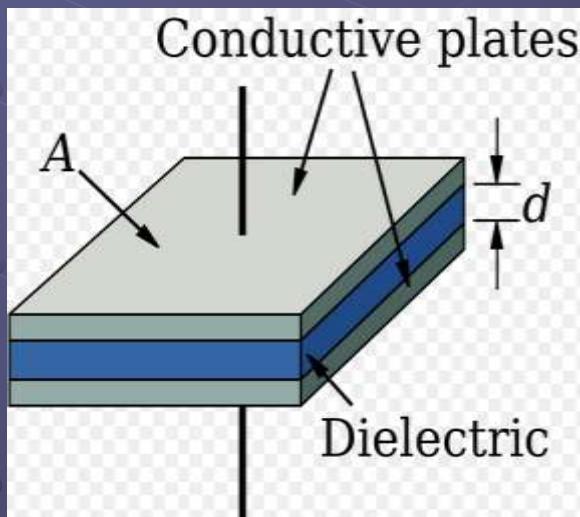
Capacitance  
and  
Inductance

# Capacitor = Static Energy

‘springiness or elasticity’

stores electrical energy in an *Electric Field*  
by the **Static Accumulation of electrons**

*Electrical energy is stored in a non moving Electrostatic Field*

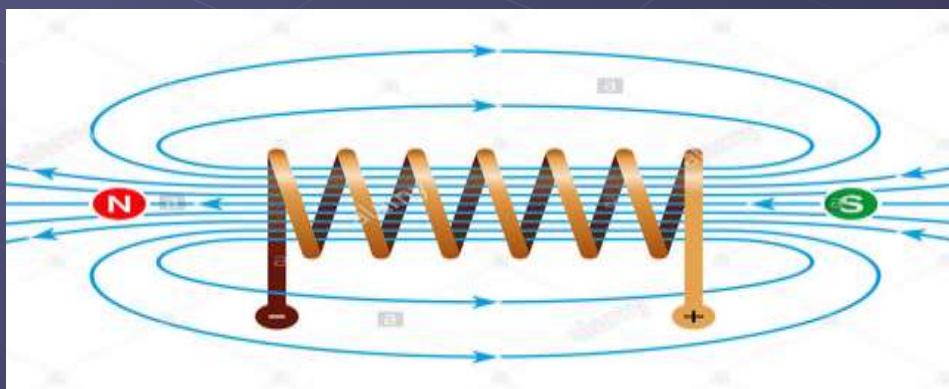


# Inductor = Dynamic Energy

‘an inductor has electrical Inertial properties’

stores energy in a *Magnetic Field*  
by the **Dynamic flow of electrons** through the coil

*The Magnetic Field will continue to maintain the electron flow*



*Dynamic Energy* = Dynamic Moving  
Energy

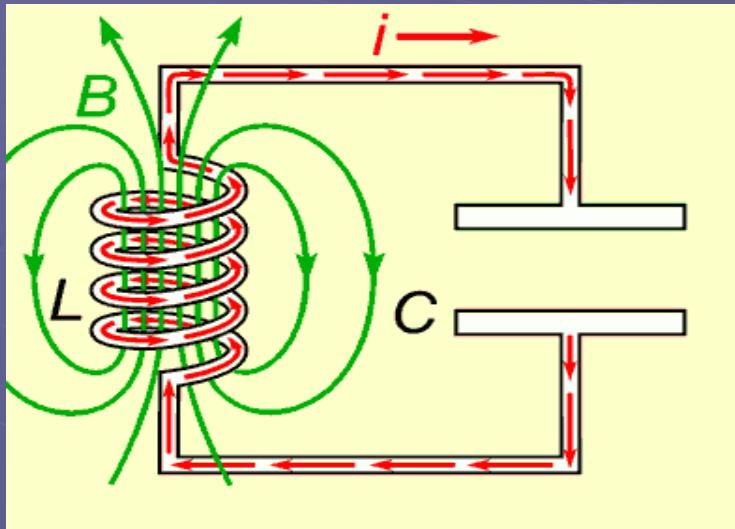
*Static Energy* =

Static Stored  
Energy

# Inductors

*store energy in a magnetic field*

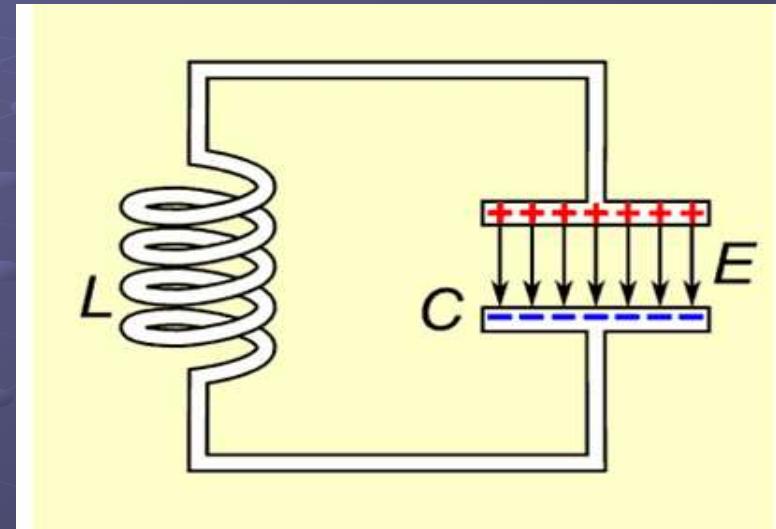
**Dynamic Energy**



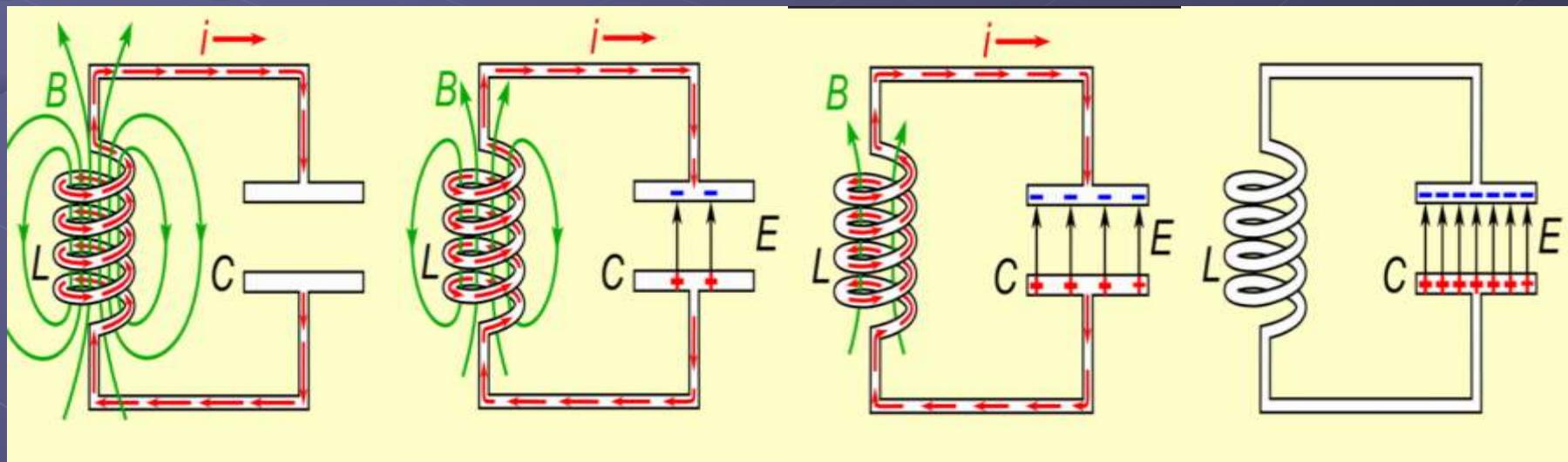
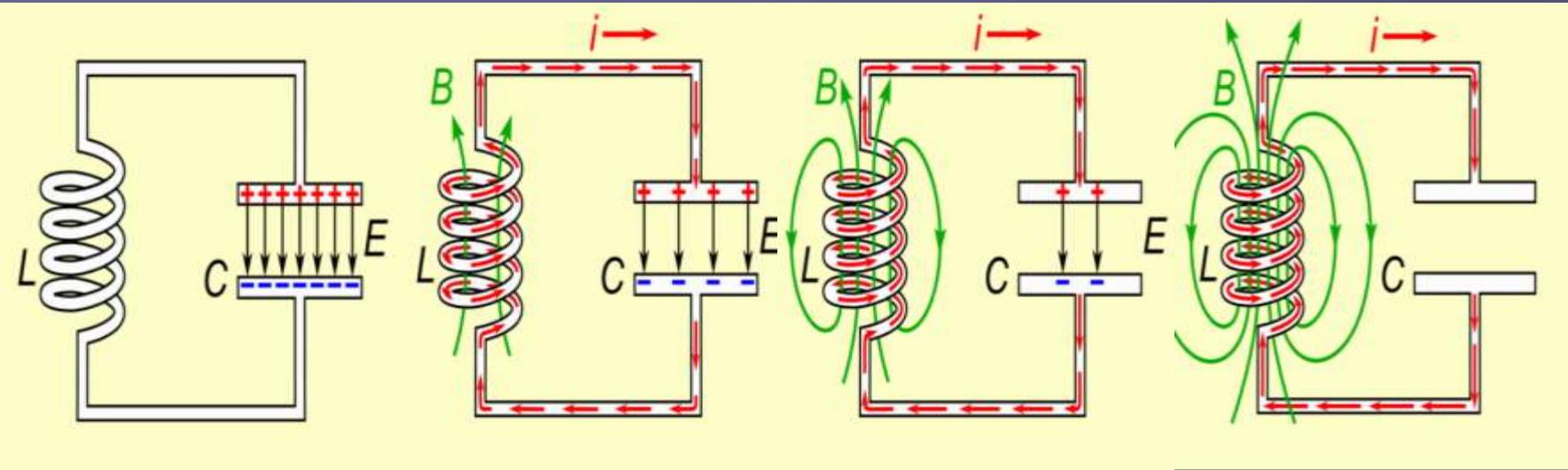
# Capacitors

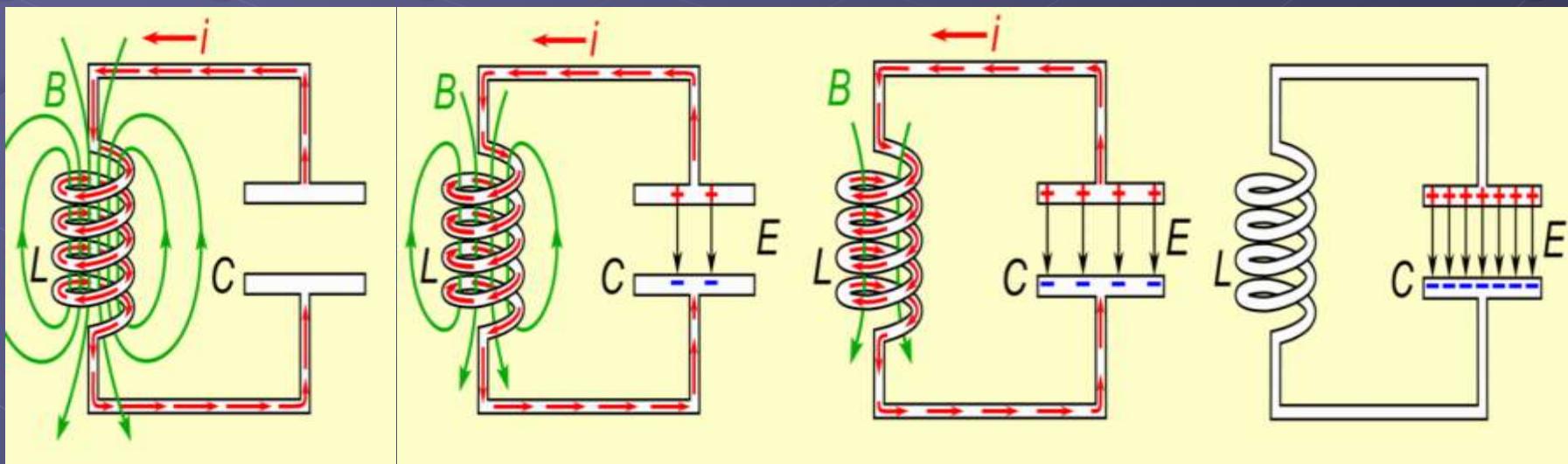
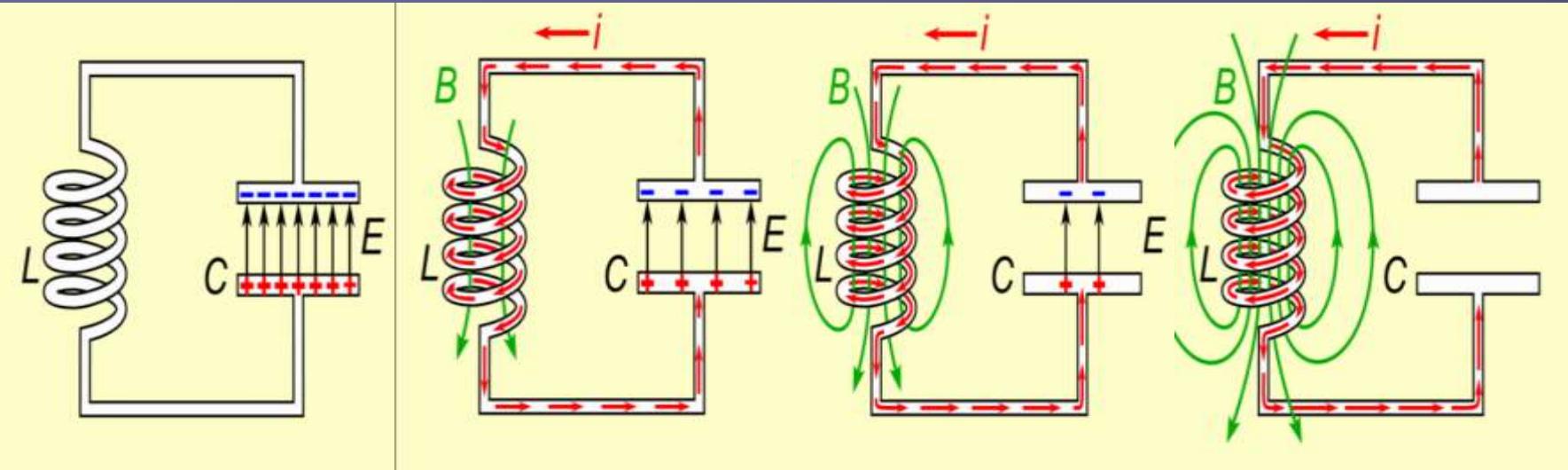
*store energy in a electric field*

**Static Energy**



Capacitors and Inductors  
when connected together  
create an  
**electrical resonant circuit**

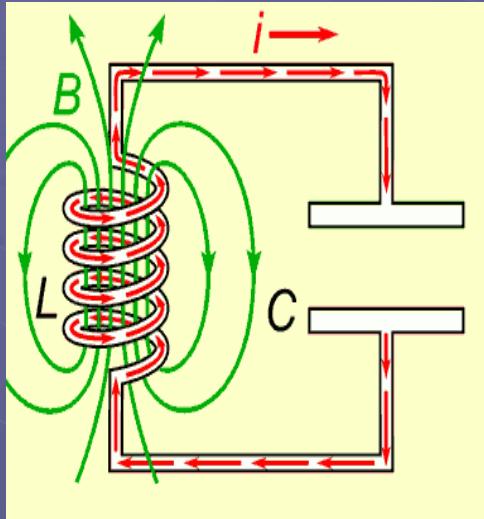




# Inductors

*store energy in a magnetic field*

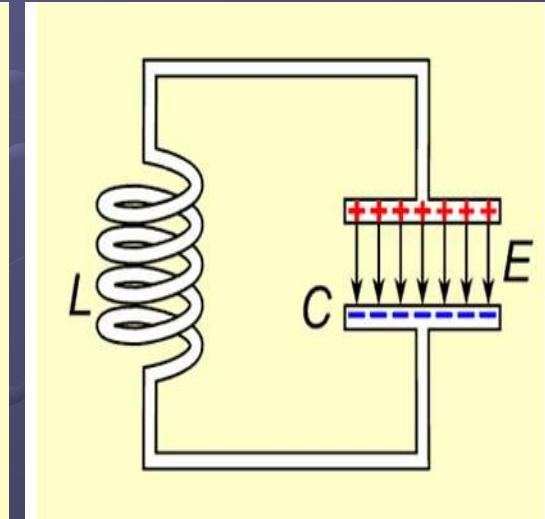
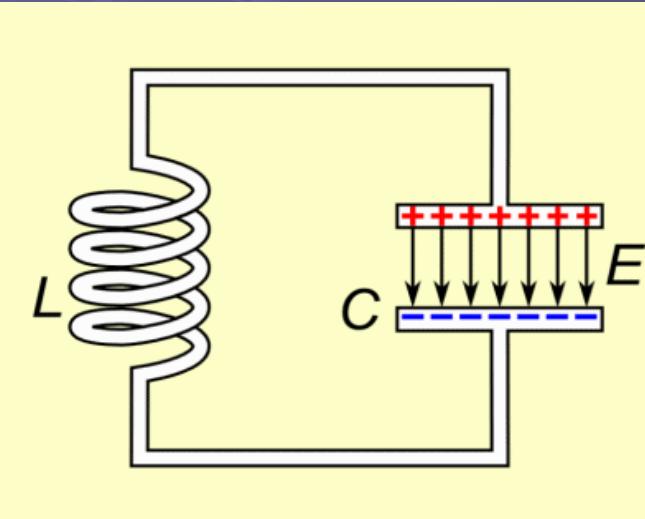
**Dynamic Energy**



# Capacitors

*store energy in an electric field*

**Static Energy**



Capacitors and Inductors  
when connected together  
create an  
**electrical resonant circuit**

# Electrical *Resonance*

is the

most efficient timing

>> *Rate of* <<

*Energy Exchange*

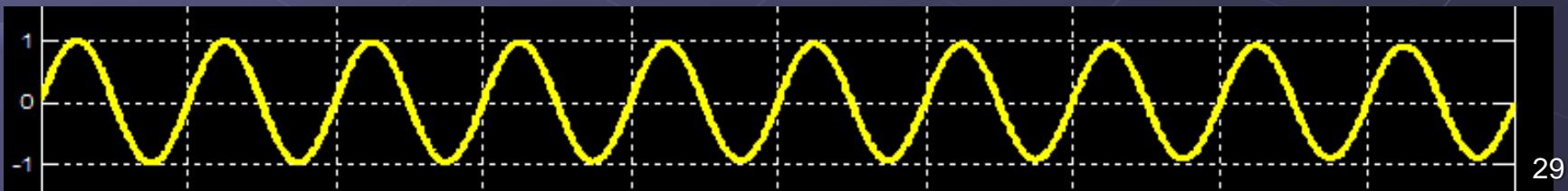
between

**Dynamic**

and

**Stored**

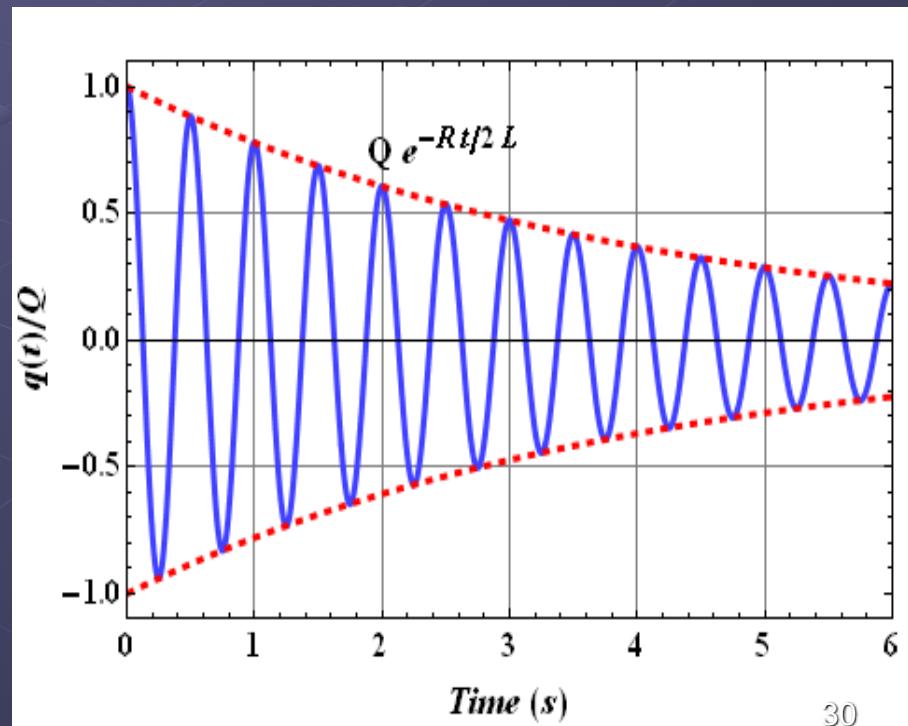
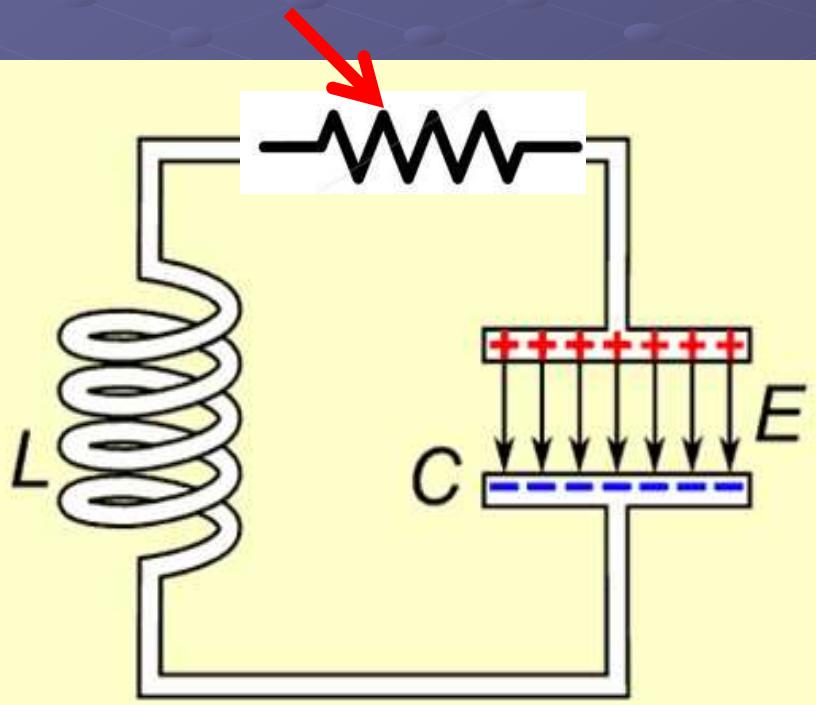
Energy States



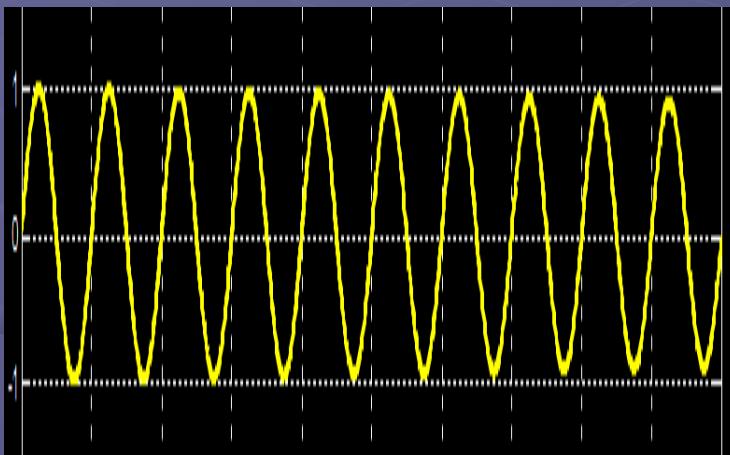
# *in a Real Electrical Circuit*

*There's Always Resistance*

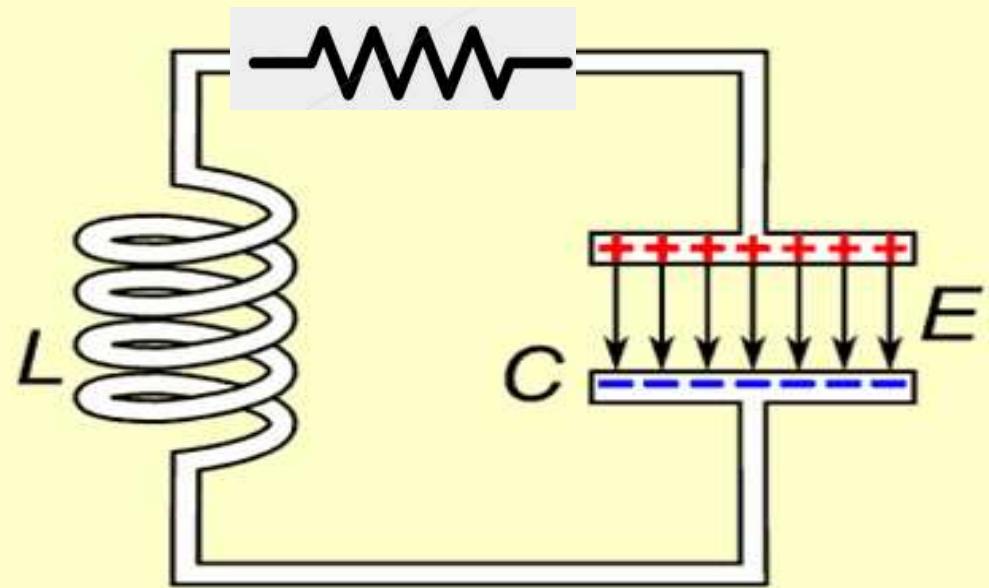
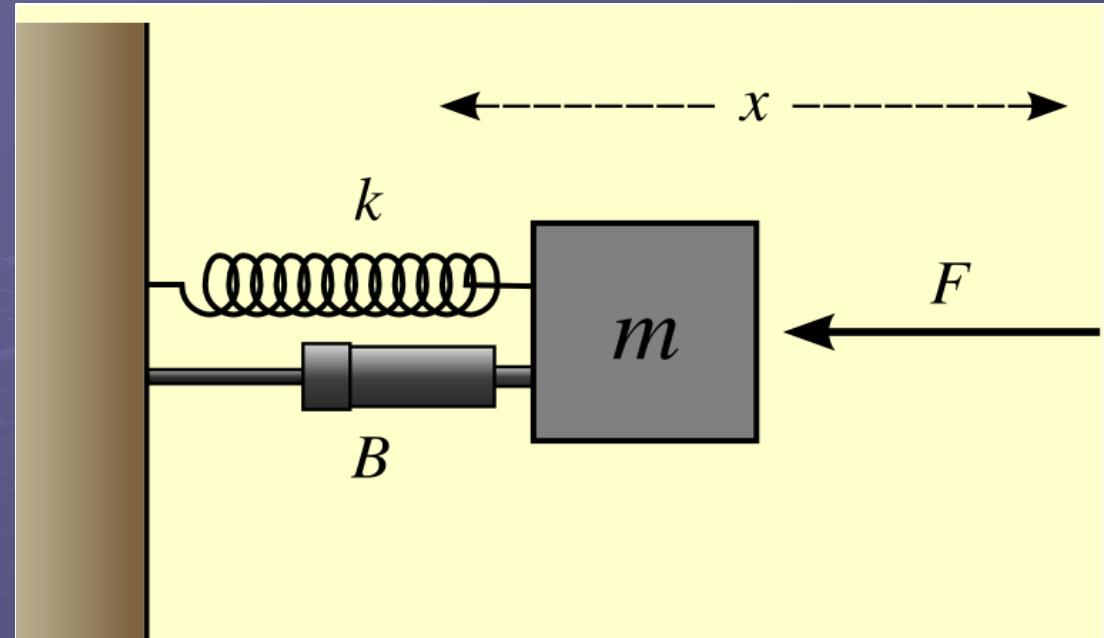
Resistors dissipate energy  
Resistors are therefore Electrical Dampers



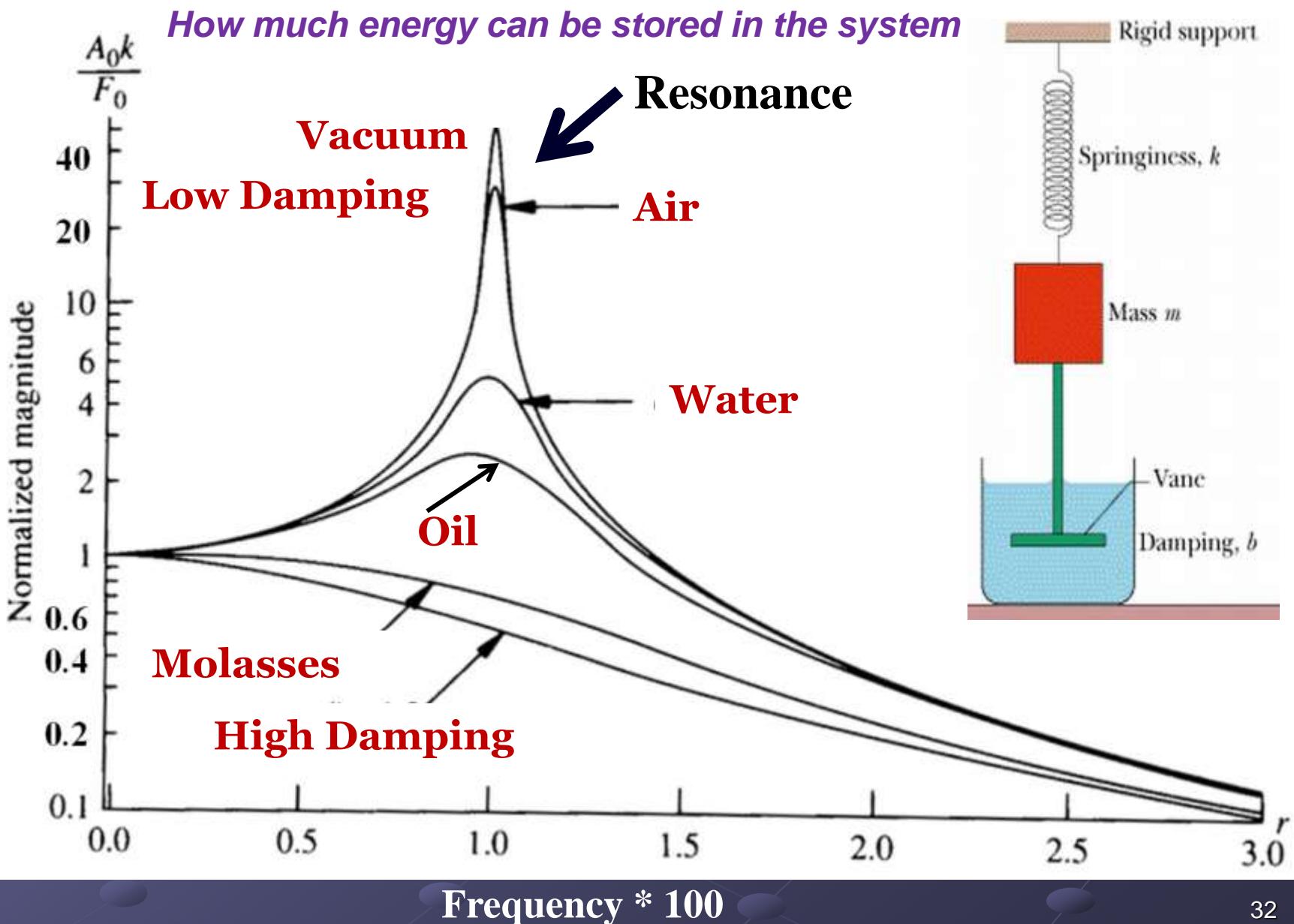
## *Mechanical Resonant Oscillator*



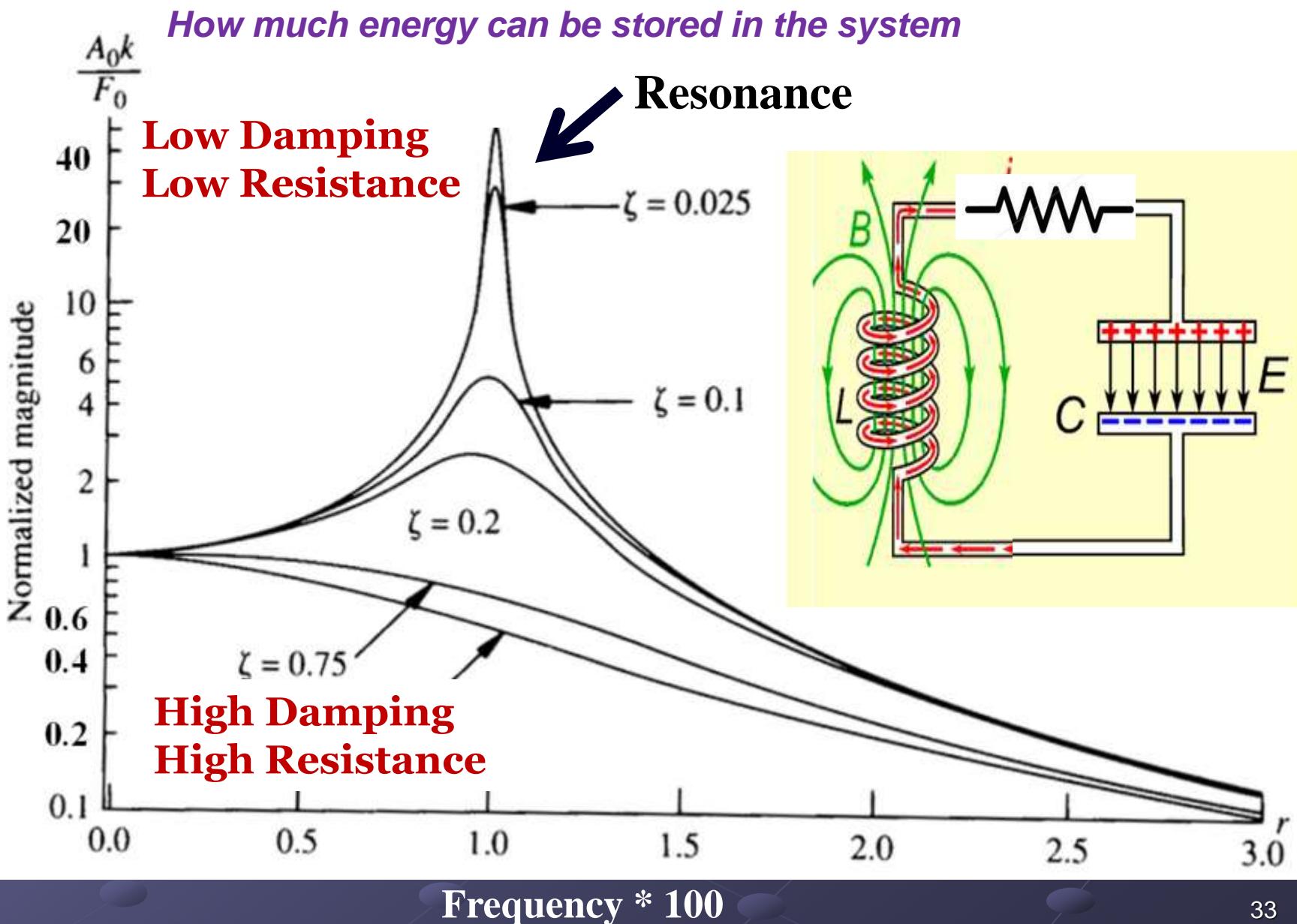
## *Electrical Resonant Oscillator*



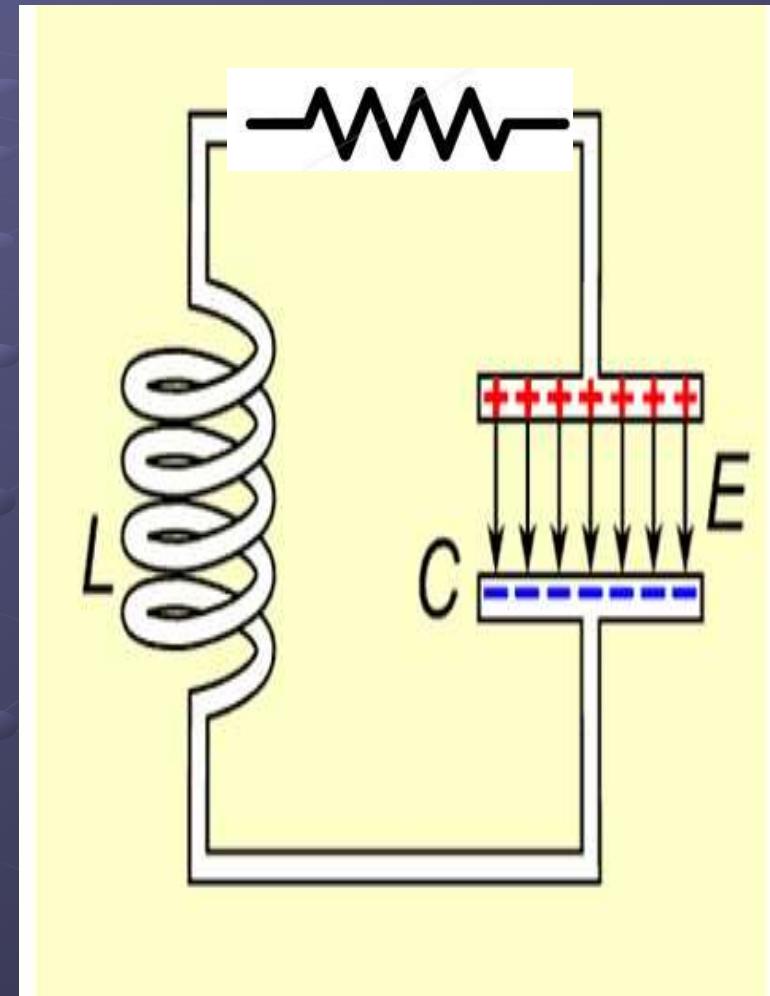
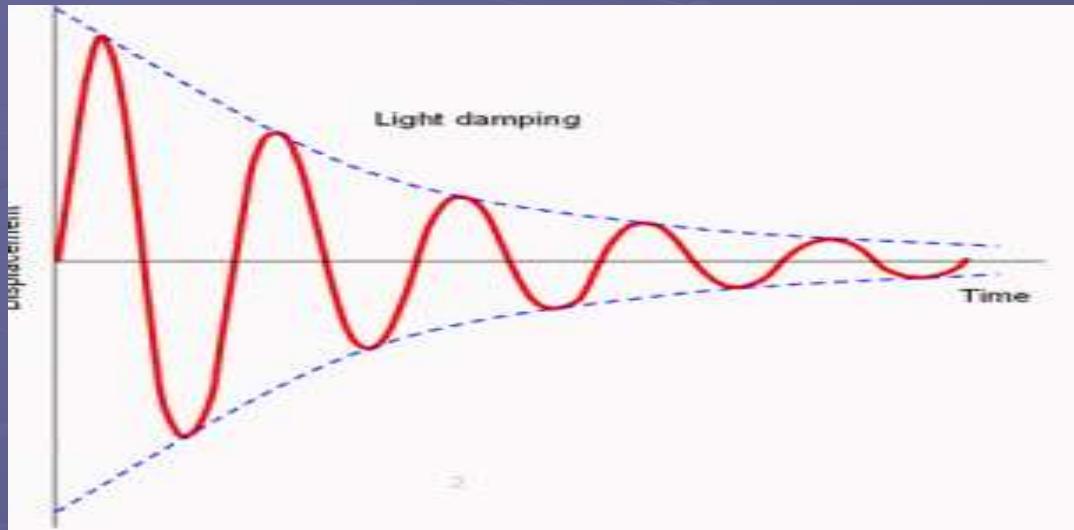
# Damping Effect of Different Materials



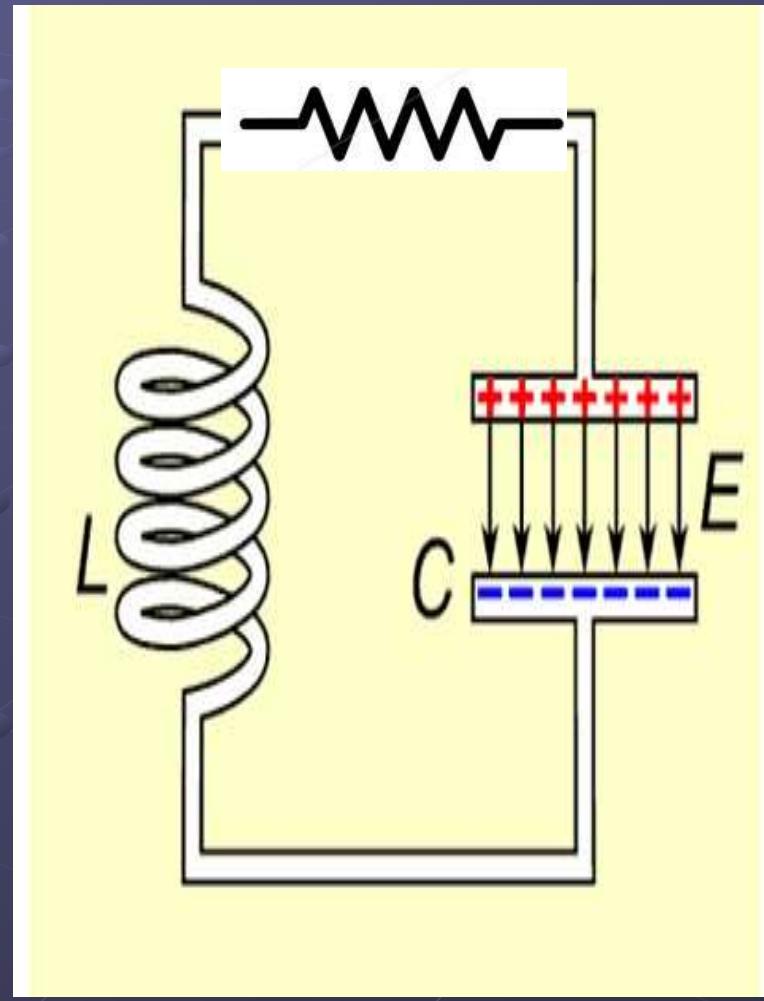
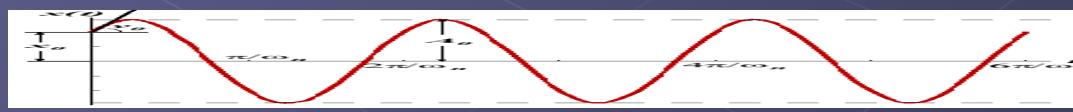
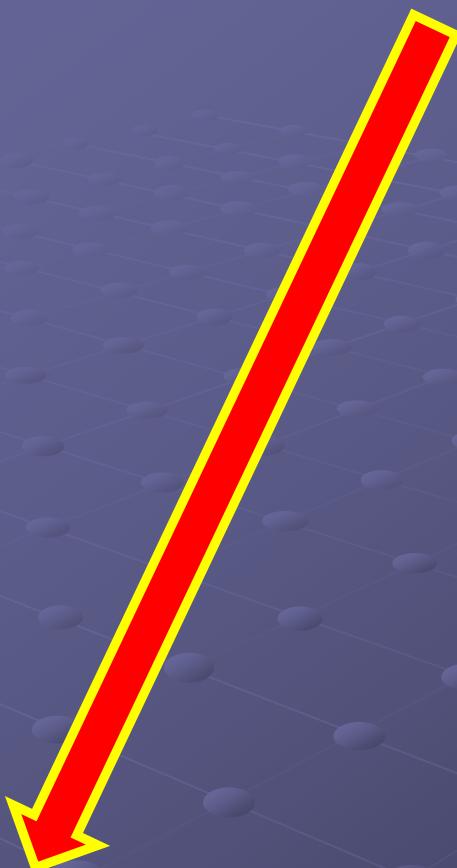
# Electrical Resistance Damping Effect



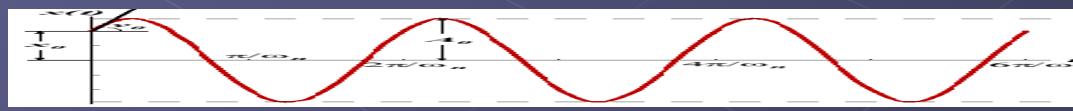
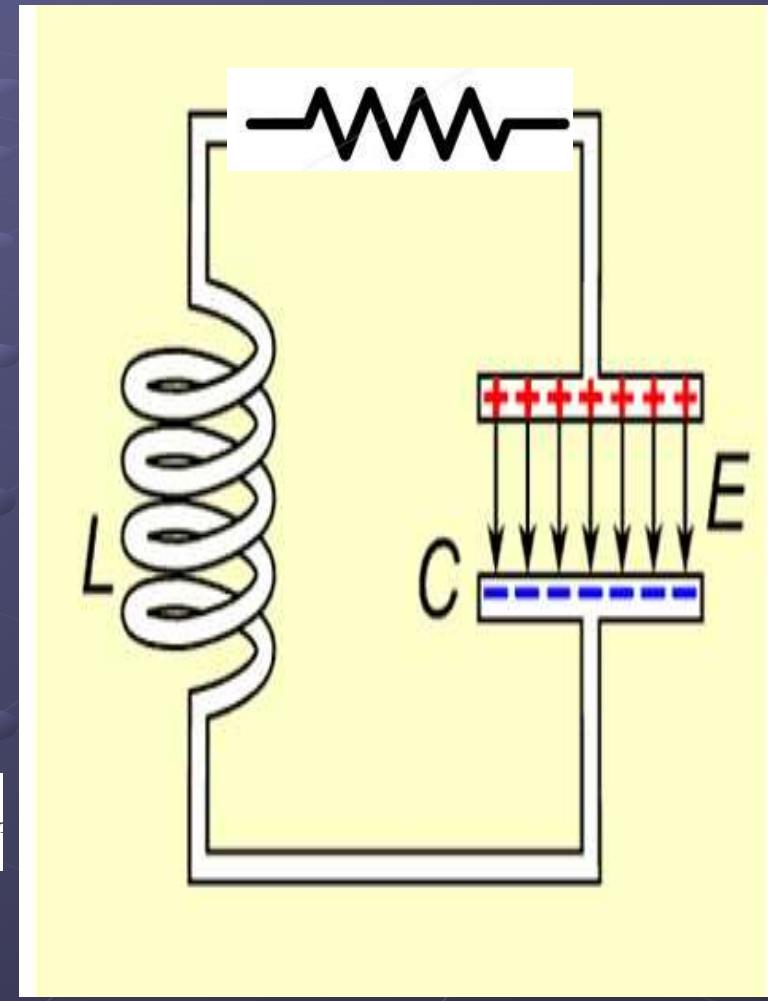
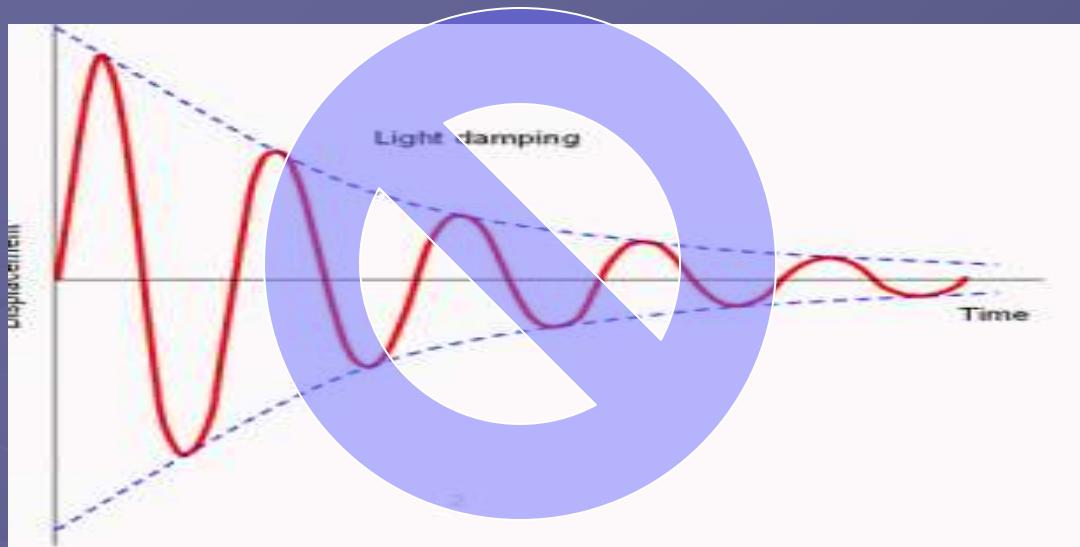
# *Damping causes energy Loss / Dissipation as heat over time*



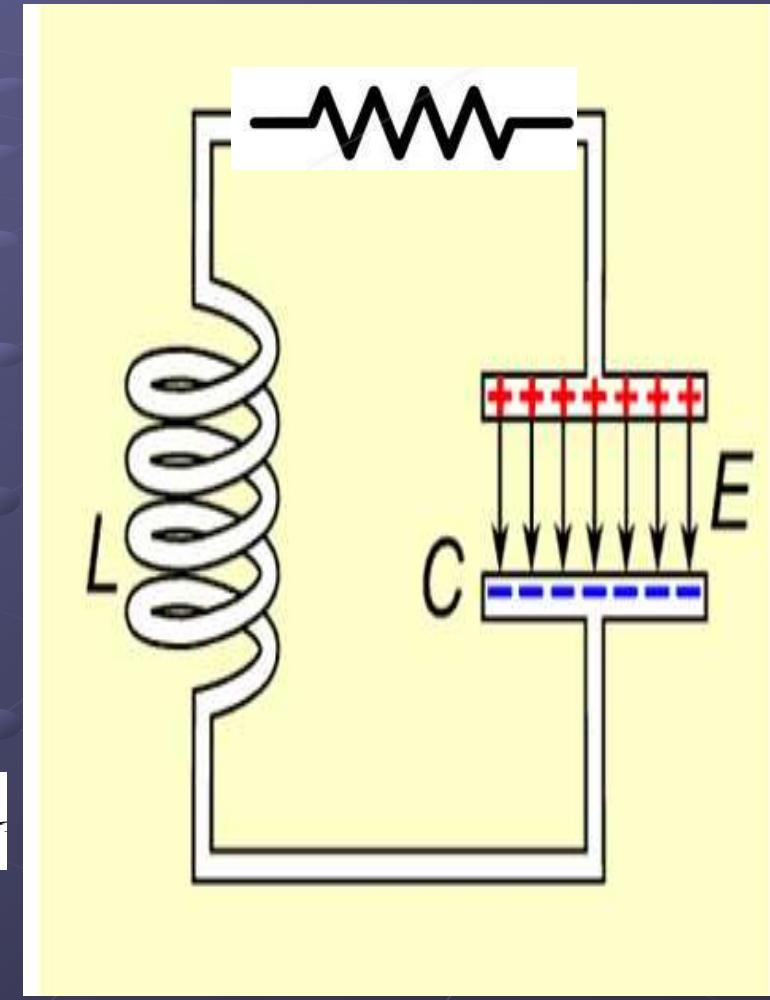
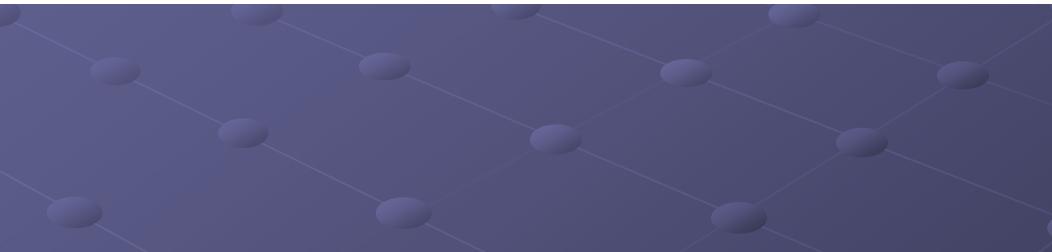
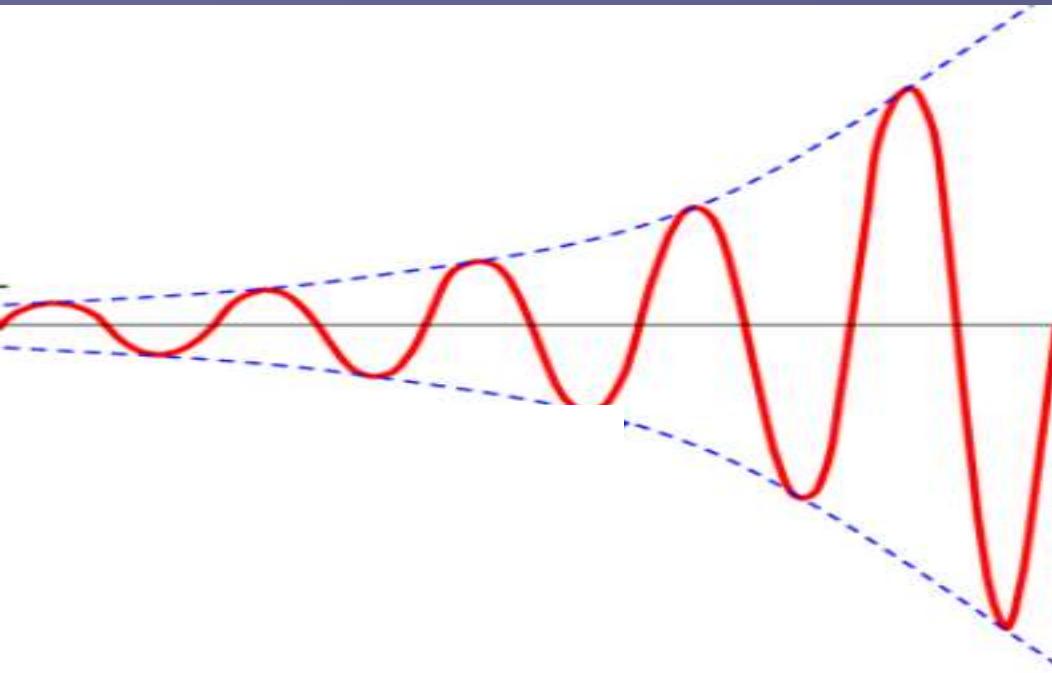
# Add Energy to the System at its Resonant Frequency

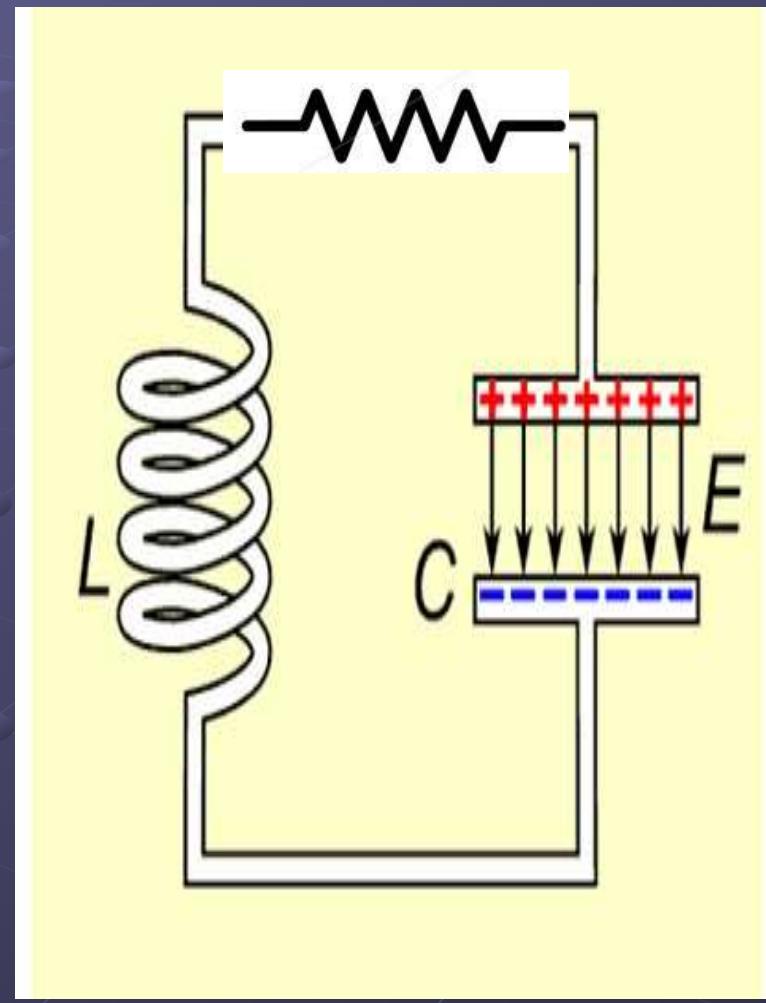
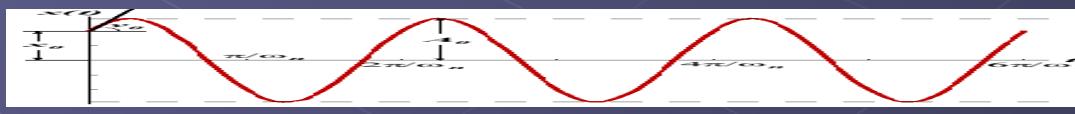
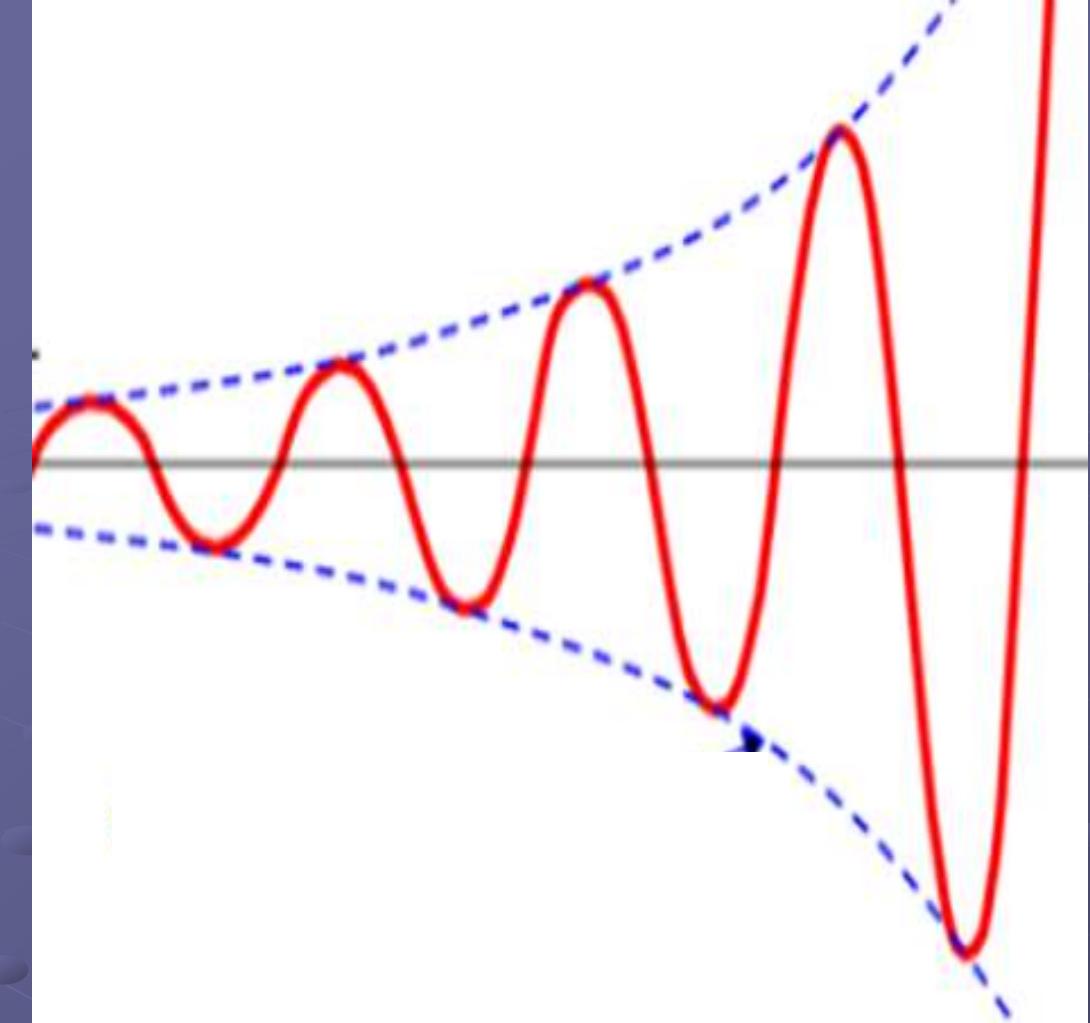


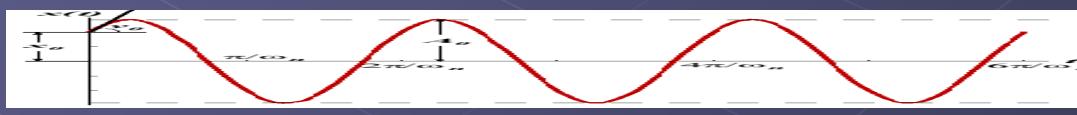
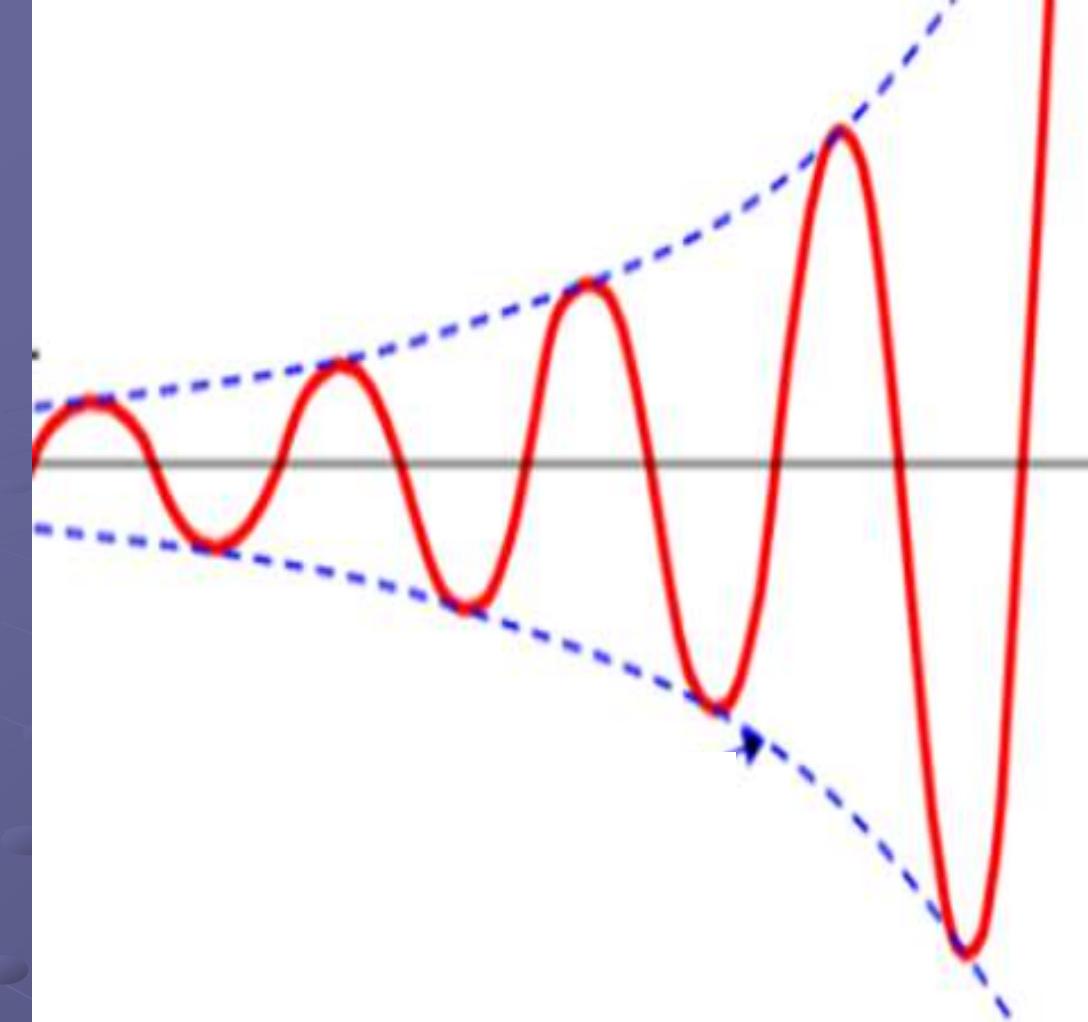
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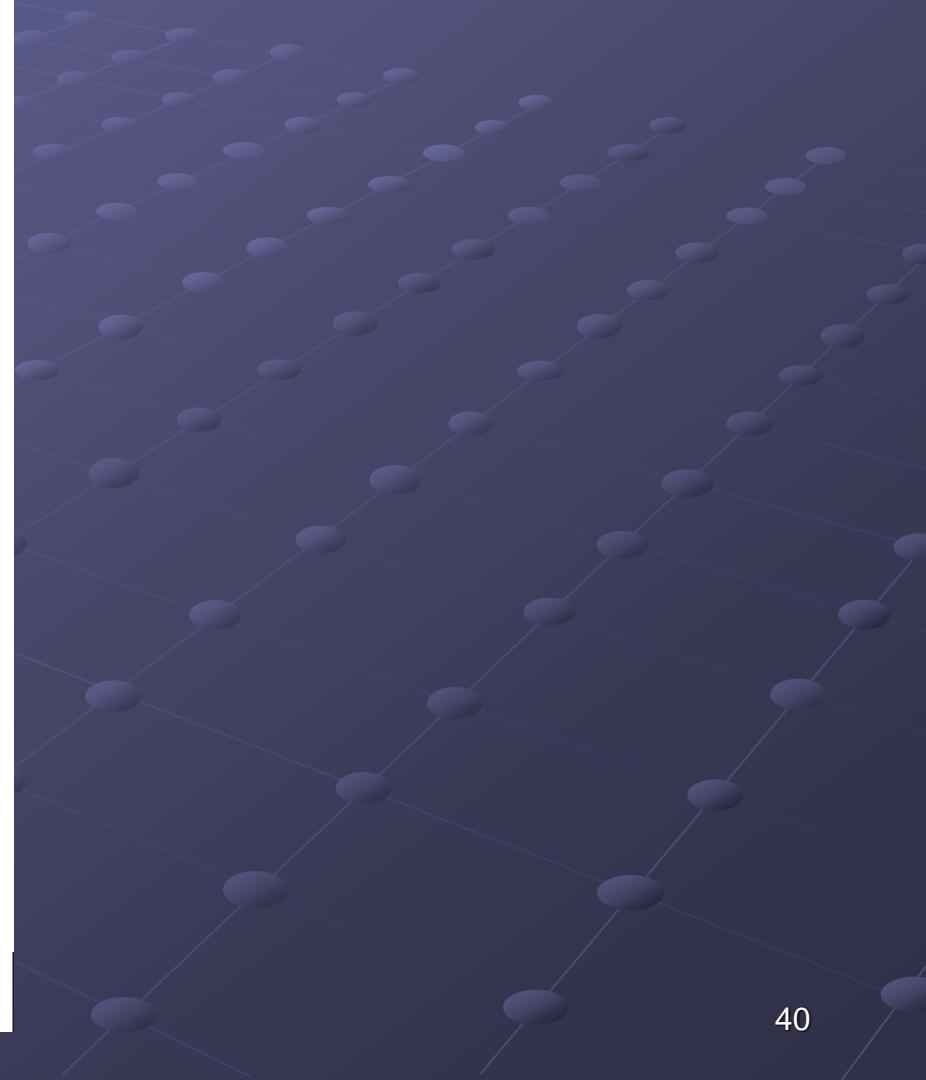
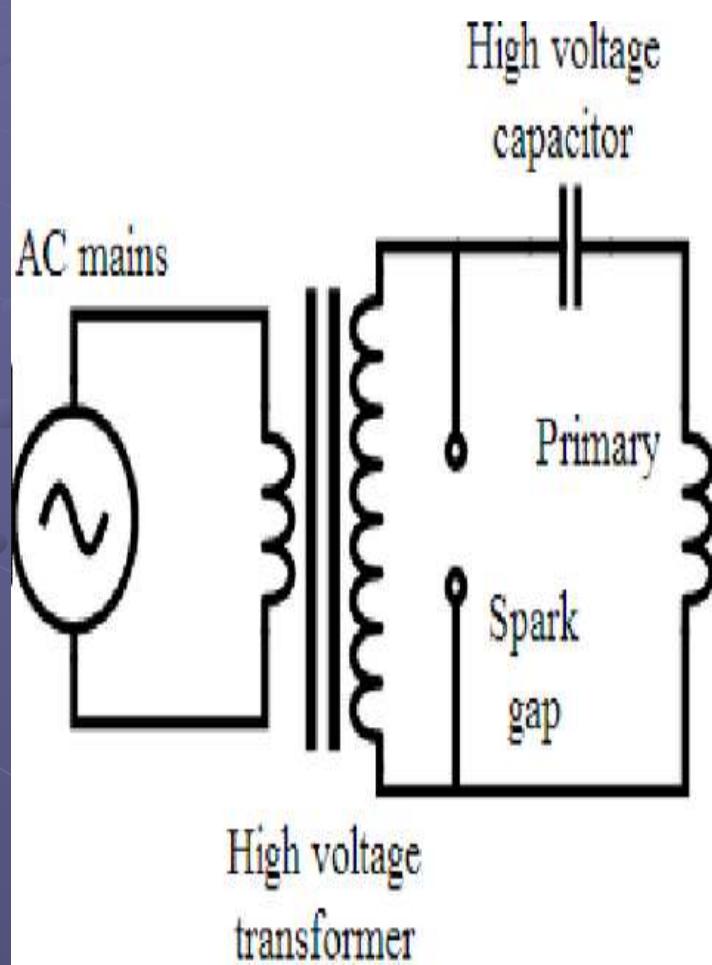
# Add Energy to the System at its Resonant Frequency



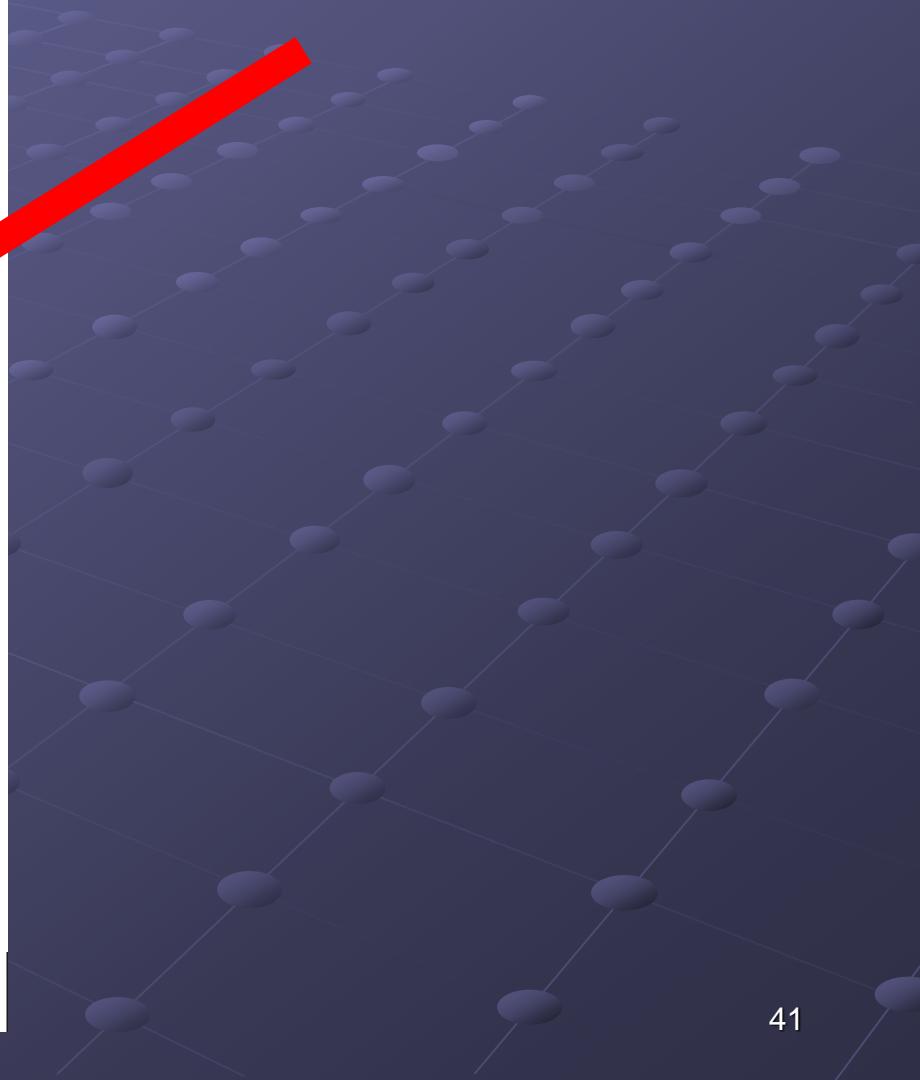
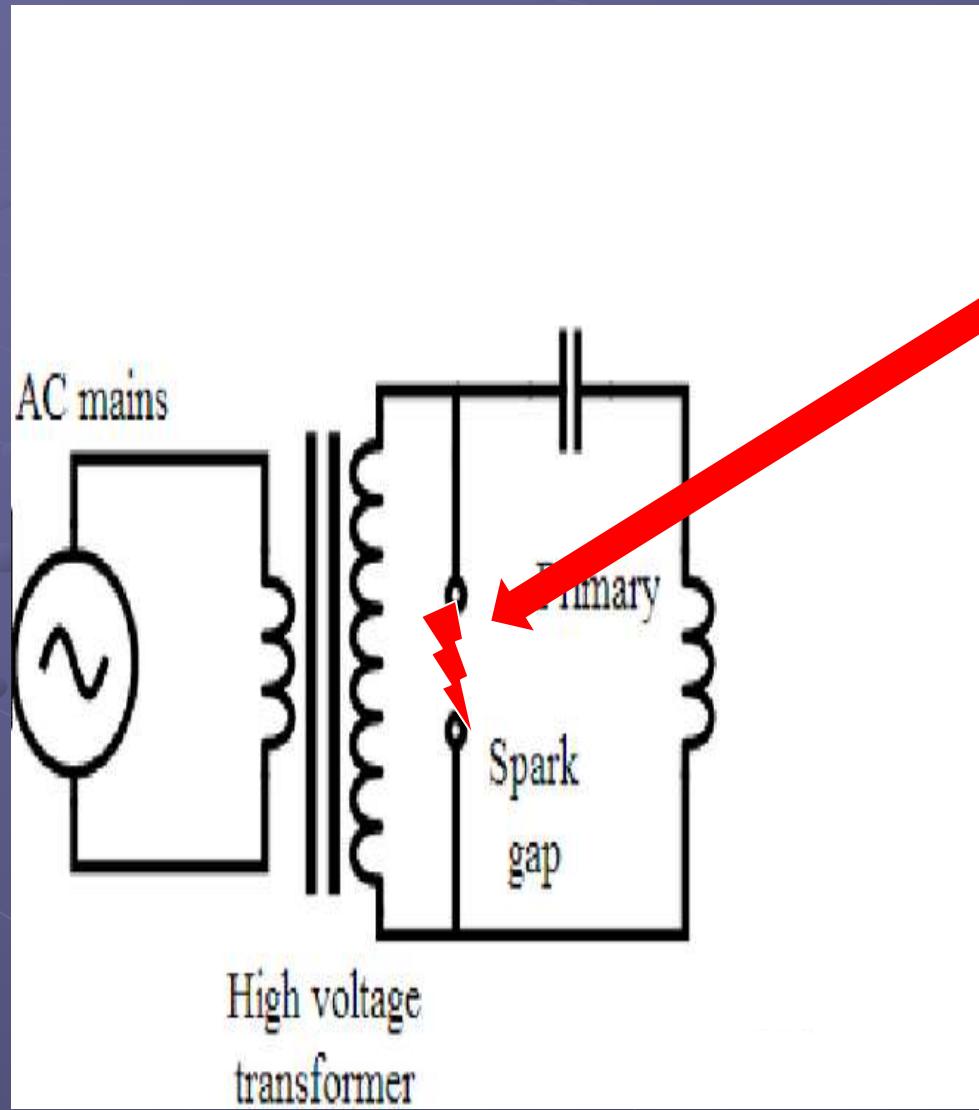




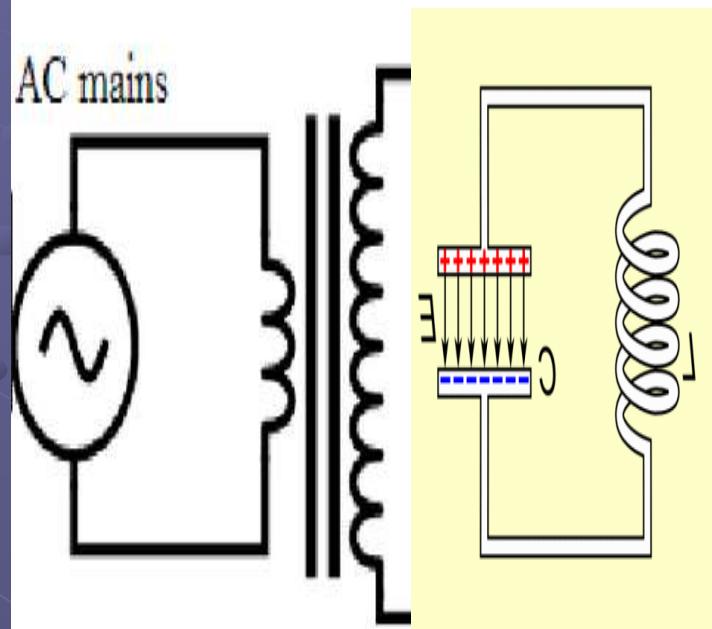
# *Add Energy to the System at its Resonant Frequency*



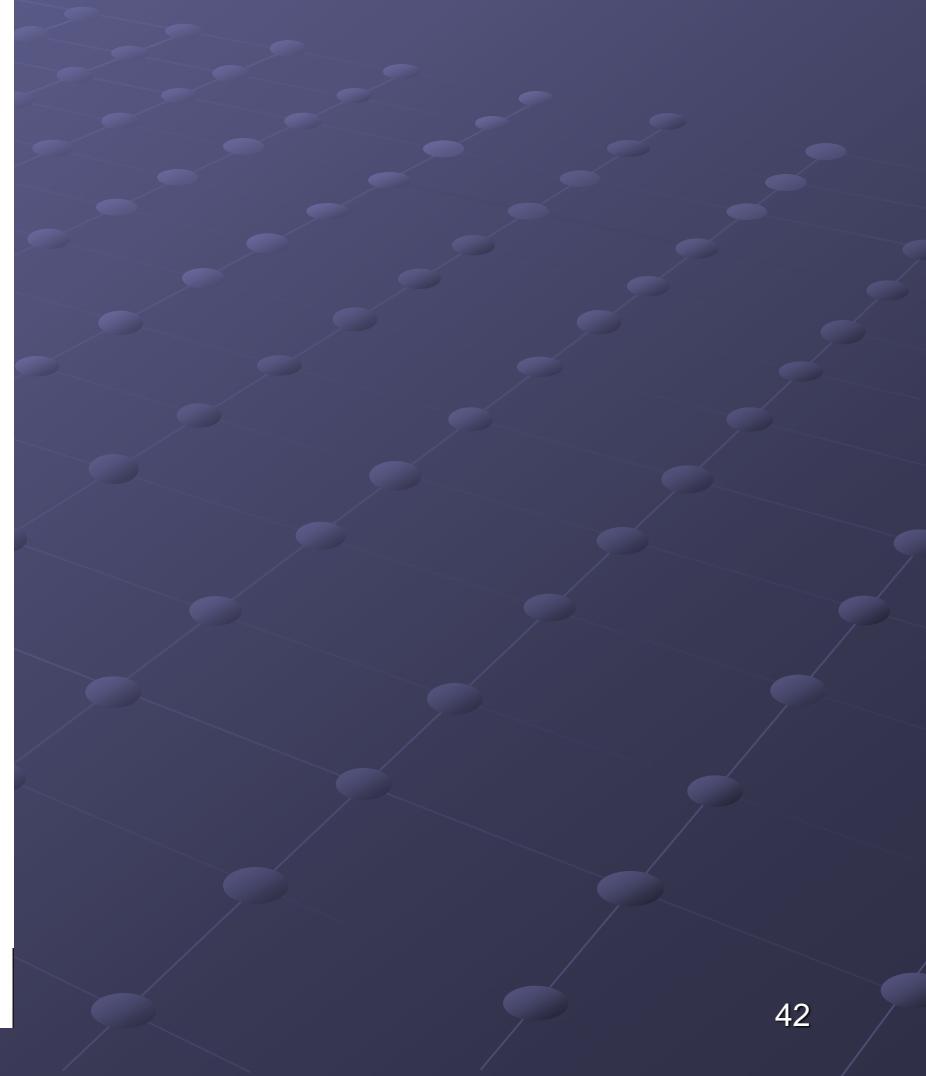
# *Add Energy to the System at its Resonant Frequency*



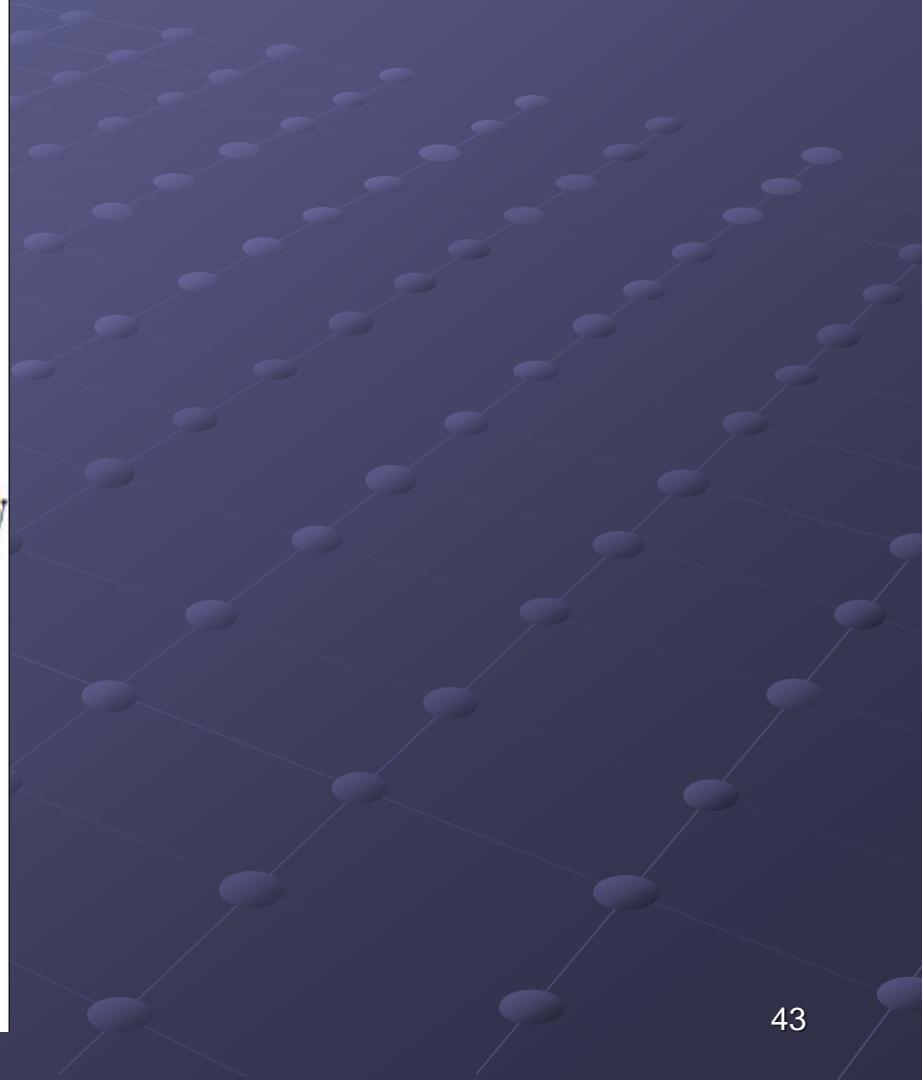
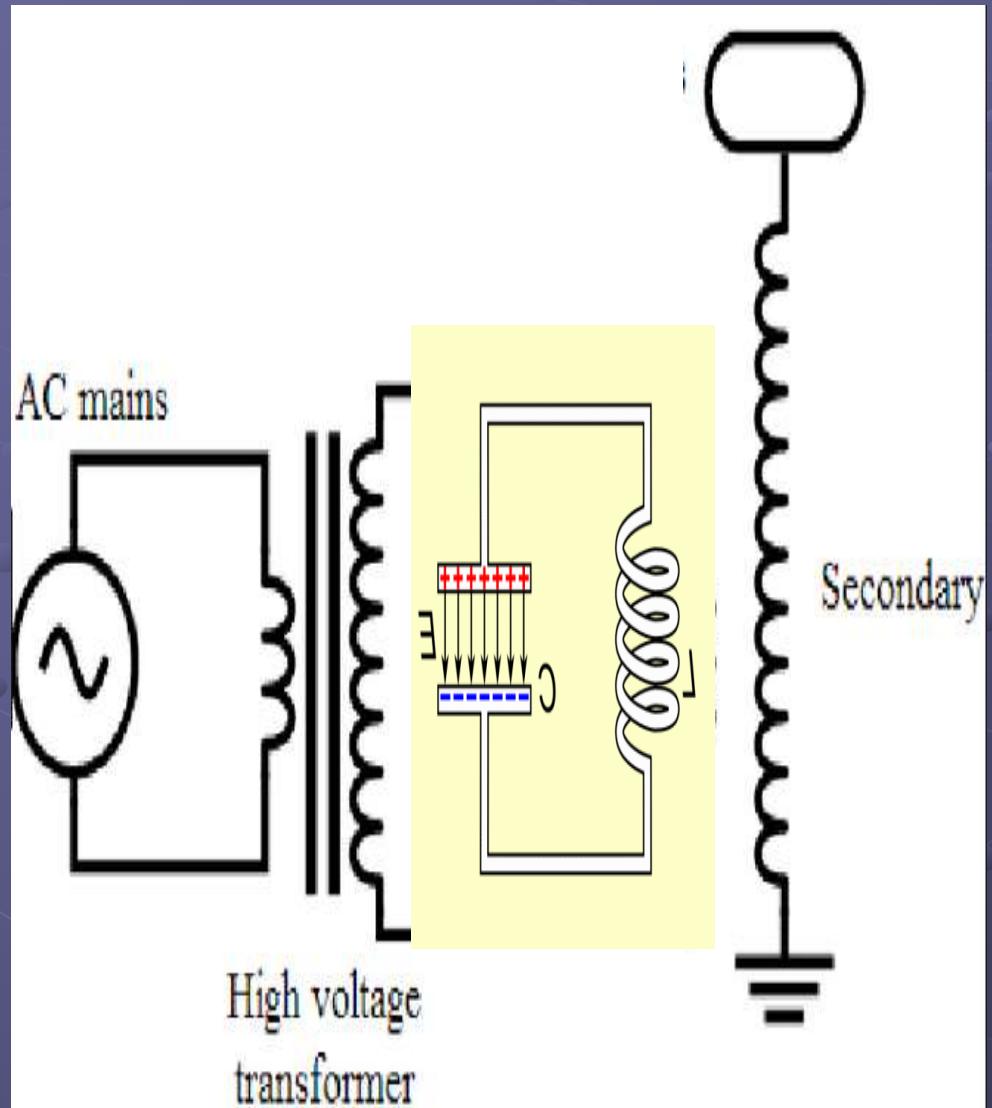
# *Add Energy to the System at its Resonant Frequency*



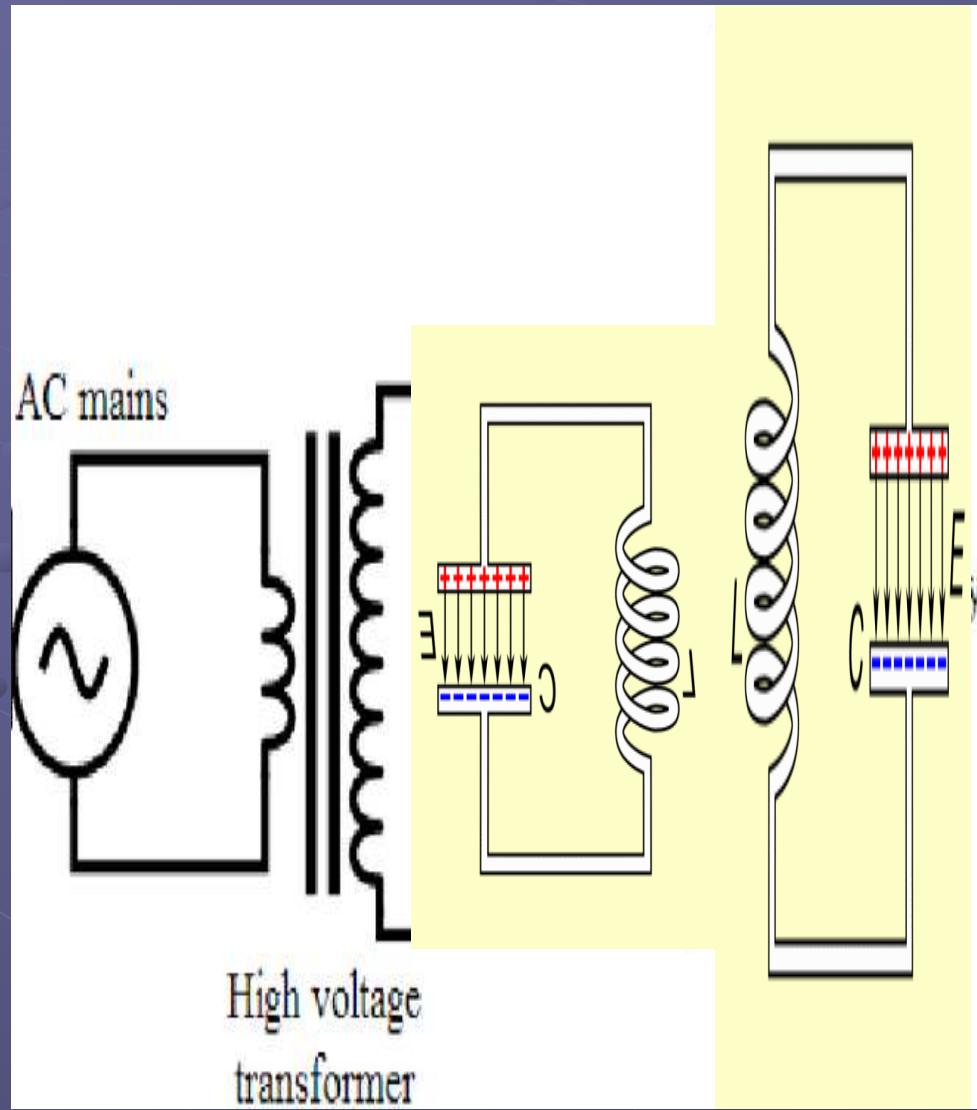
High voltage  
transformer



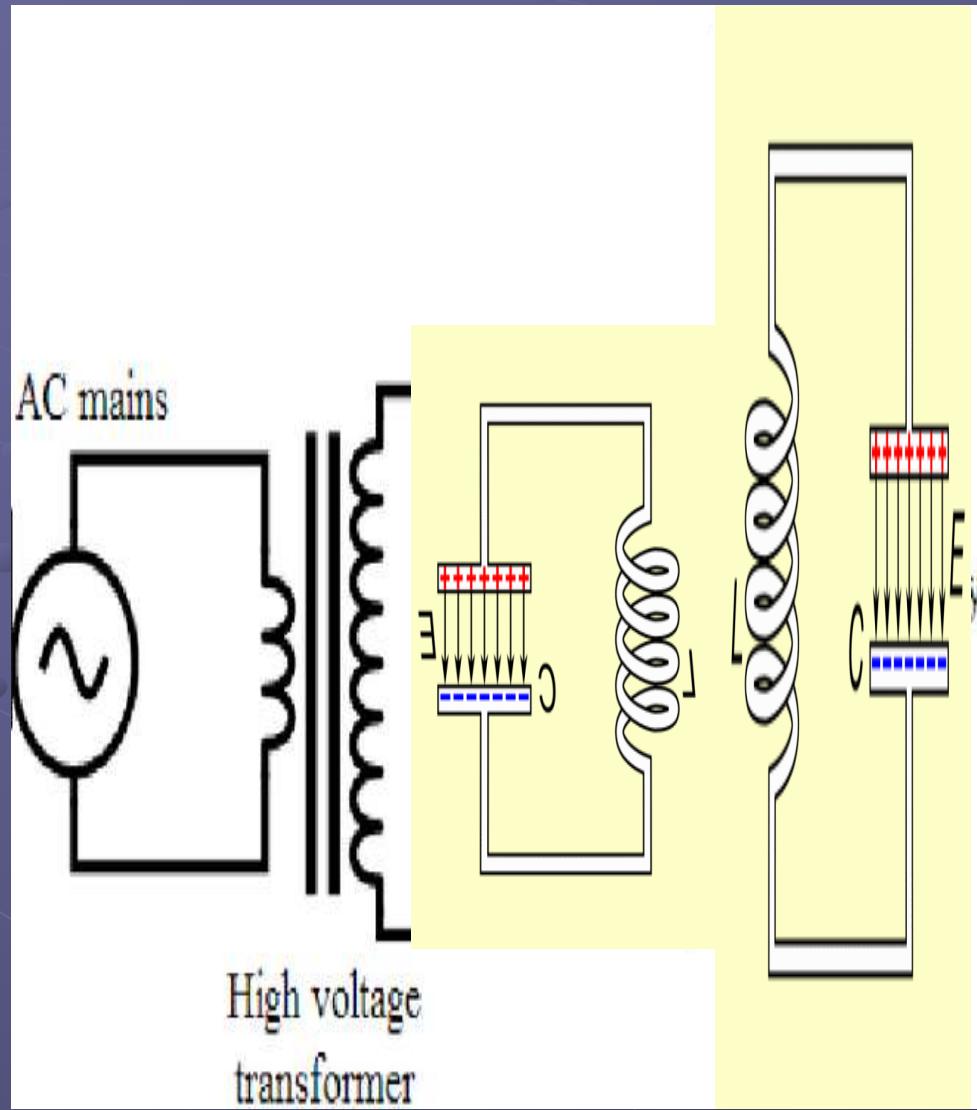
# *Add Energy to the System at its Resonant Frequency*



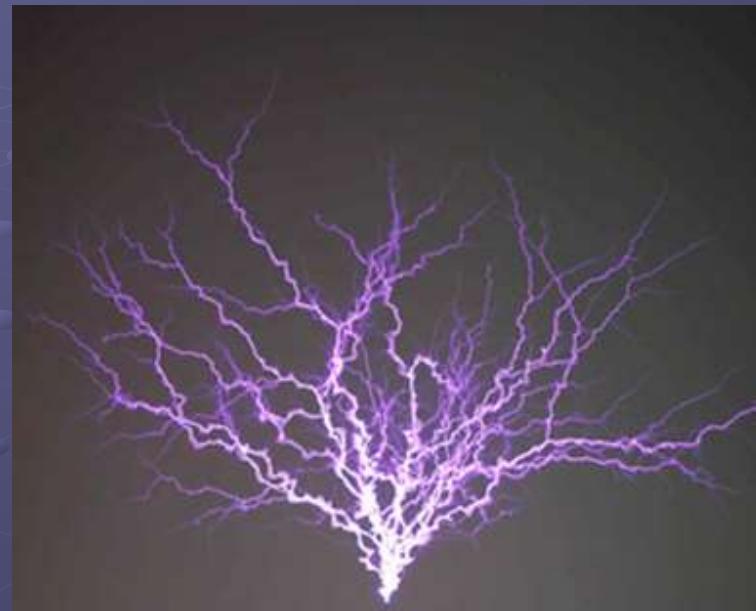
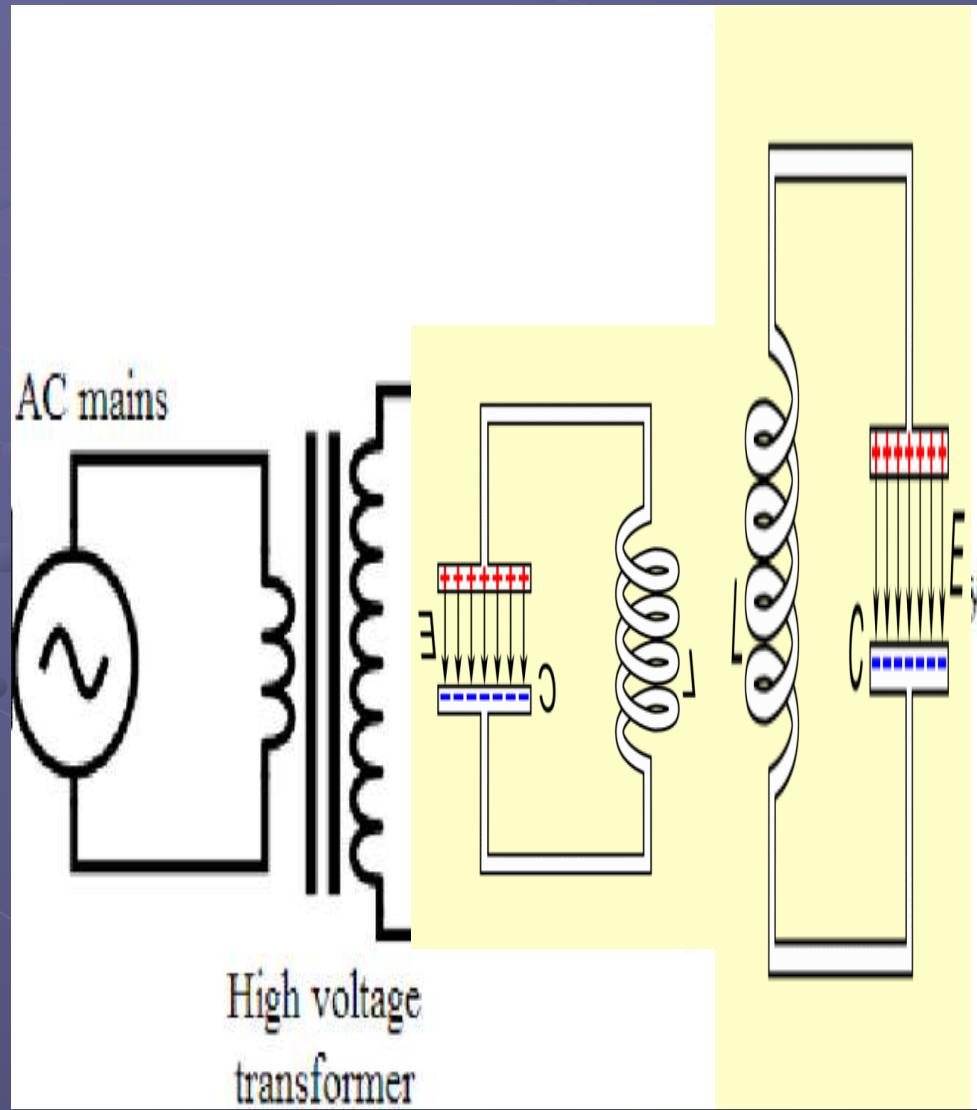
# *Add Energy to the System at its Resonant Frequency*



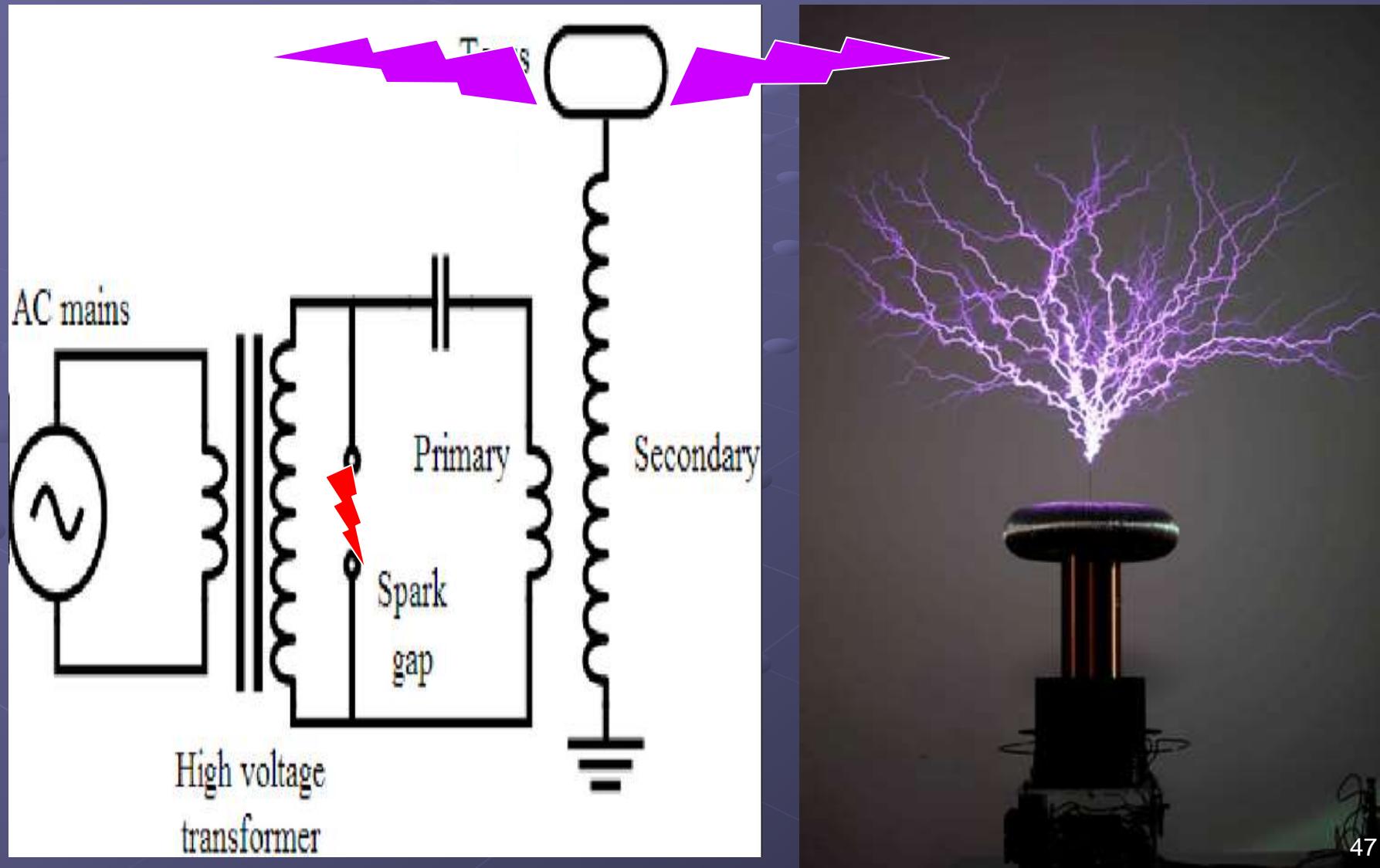
# *Add Energy to the System at its Resonant Frequency*



# *Add Energy to the System at its Resonant Frequency*



# !! Tesla Coil !!



# The End !

