BONUS SESSION

LC Oscillation

ALTERNATING CURRENT L-5

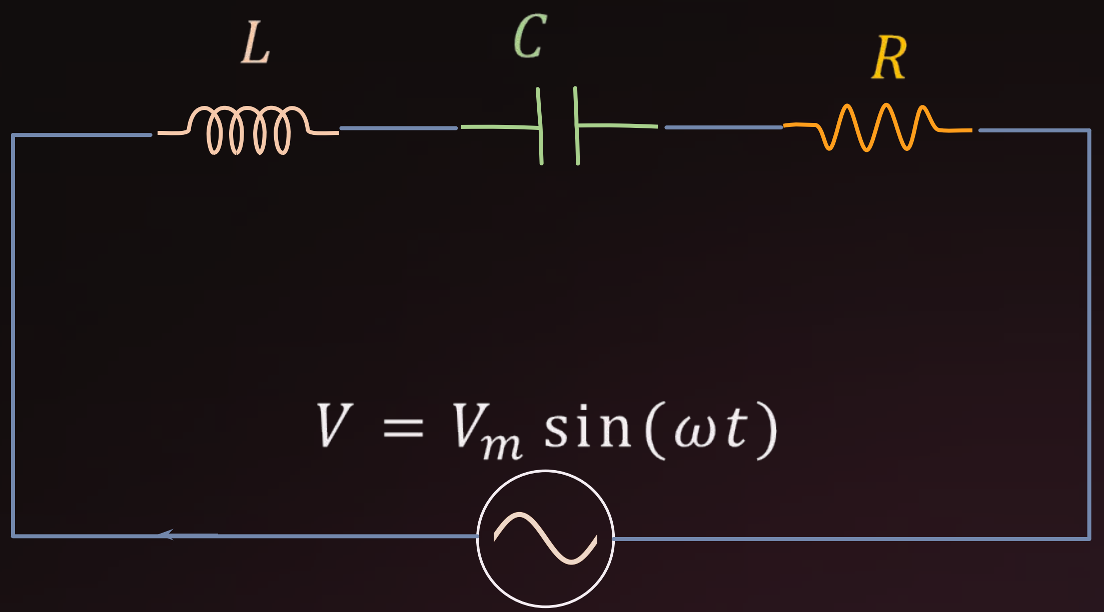
GRADE 12 PHYSICS

MRINAL SIR

https://t.me/neetaakashdigital

CONTENTS

RESONANCE



$$i_m = \frac{V_m}{\sqrt{R^2 + (X_C - X_L)^2}}$$

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

$$X_L = \omega L$$

If ω is varied, then at a particular frequency (ω_0), $X_C = X_L$

RESONANCE

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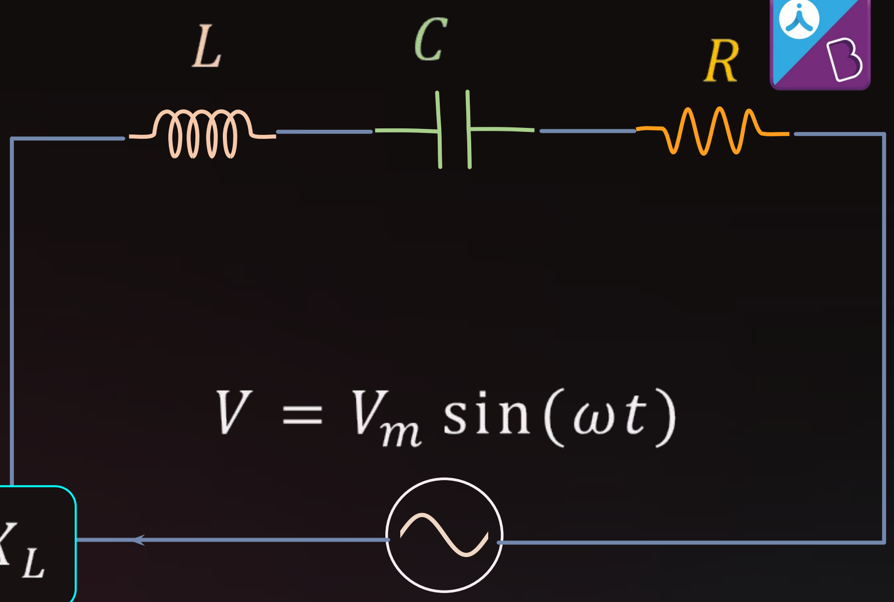


If ω is varied, then at a particular frequency (ω_0), $X_C = X_L$

ω_0 is resonant angular frequency

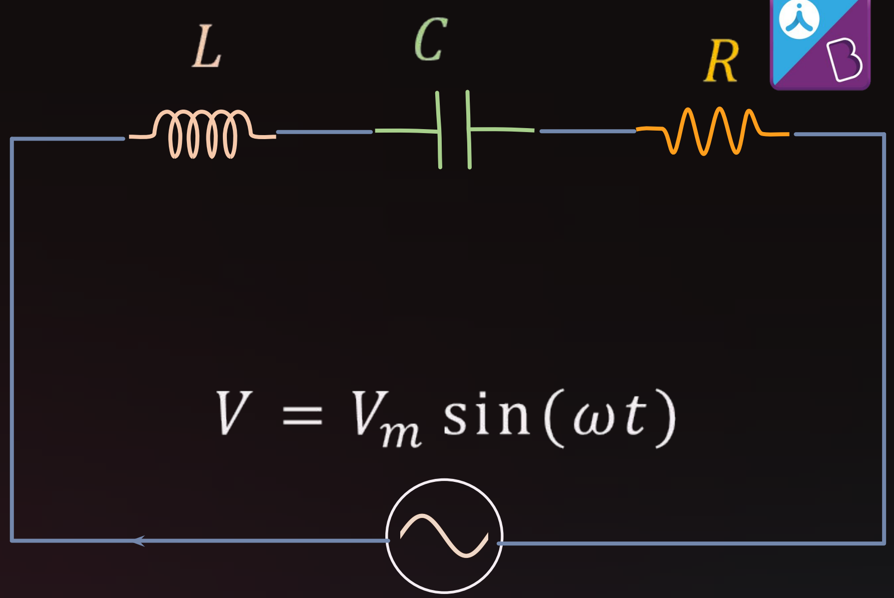
Impedance is minimum $(Z = \sqrt{R^2 + 0^2} = R)$
and purely resistive circuit

Current is maximum $(i_m = V_m/R)$

RESONANCE

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

$$X_L = \omega L$$



RESONANCE

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

$$X_L = \omega L$$

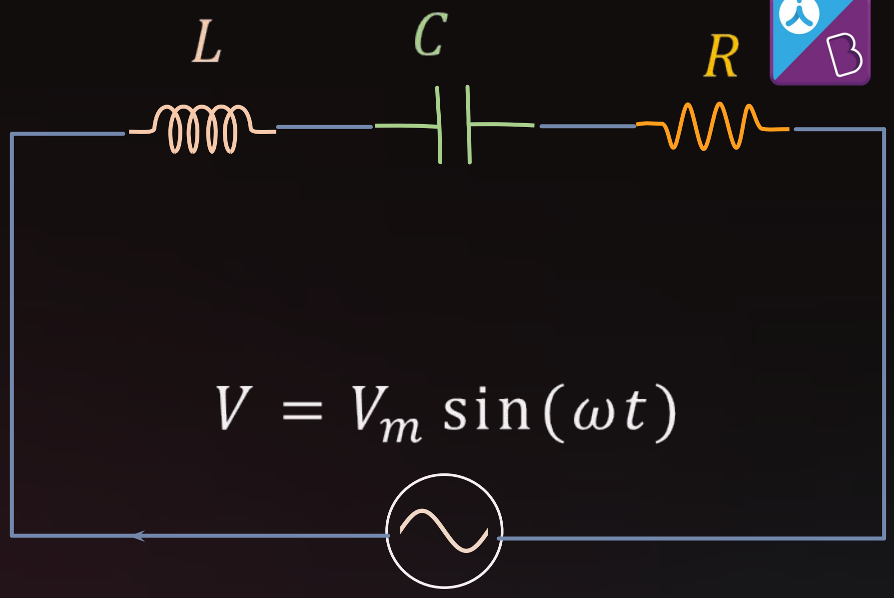
For resonance condition, $X_C = X_L$

$$\frac{1}{\omega_0 C} = \omega_0 L$$

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

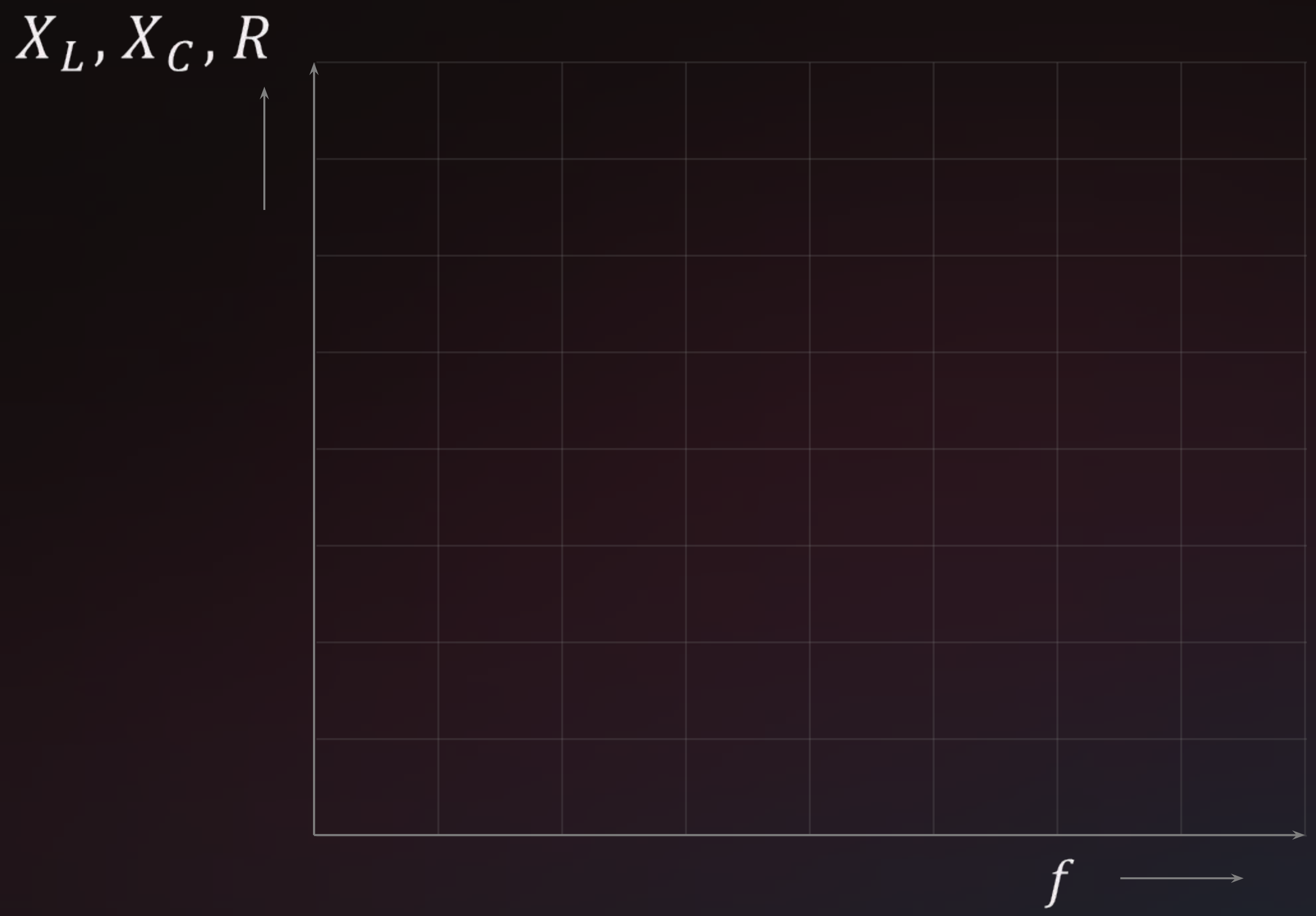
$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

Resonant frequency



RESONANCE

Graphical representation

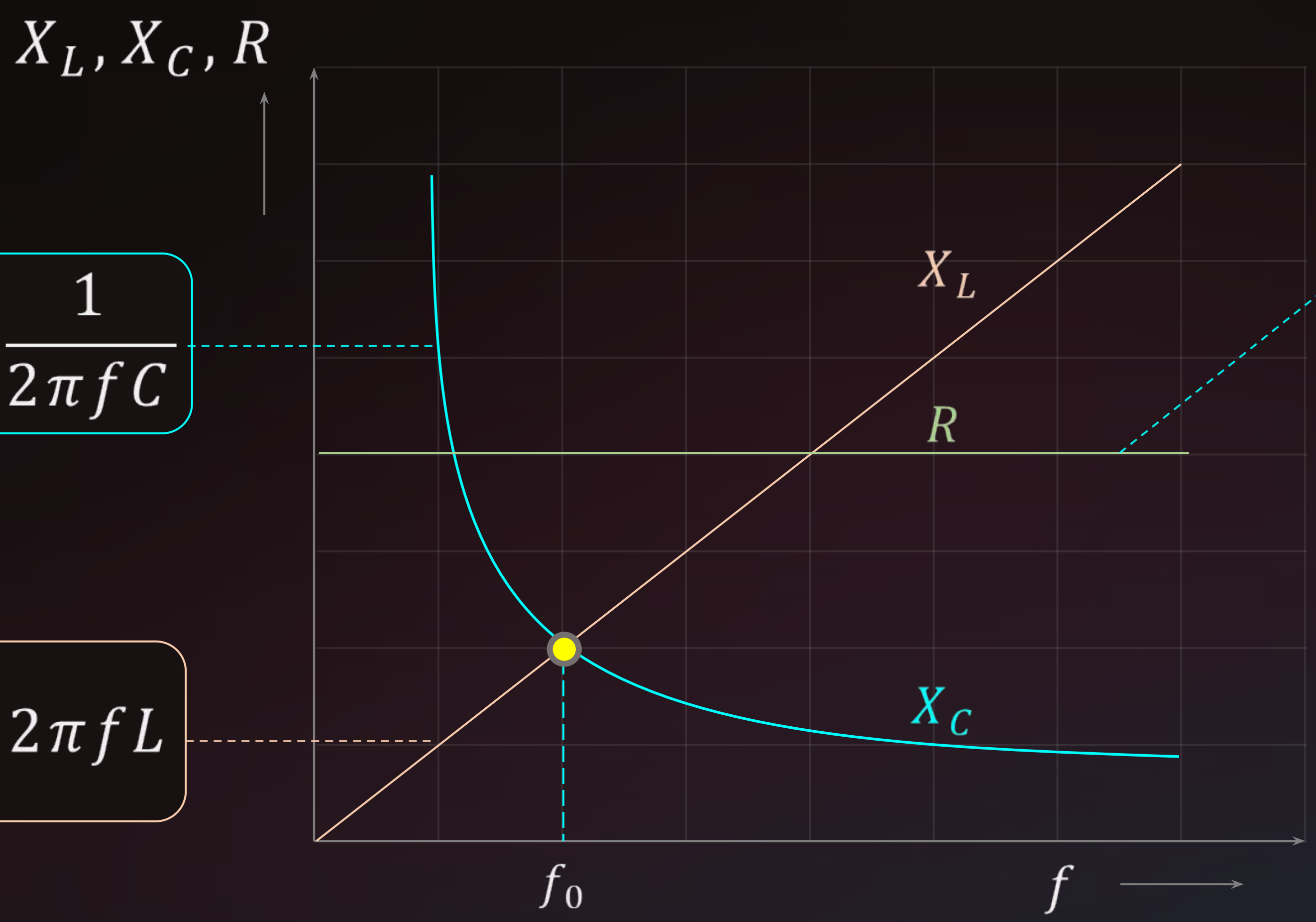


Resonance condition, $X_C = X_L$

RESONANCE Graphical representation

$$X_C = \frac{1}{2\pi f C}$$

$$X_L = 2\pi f L$$



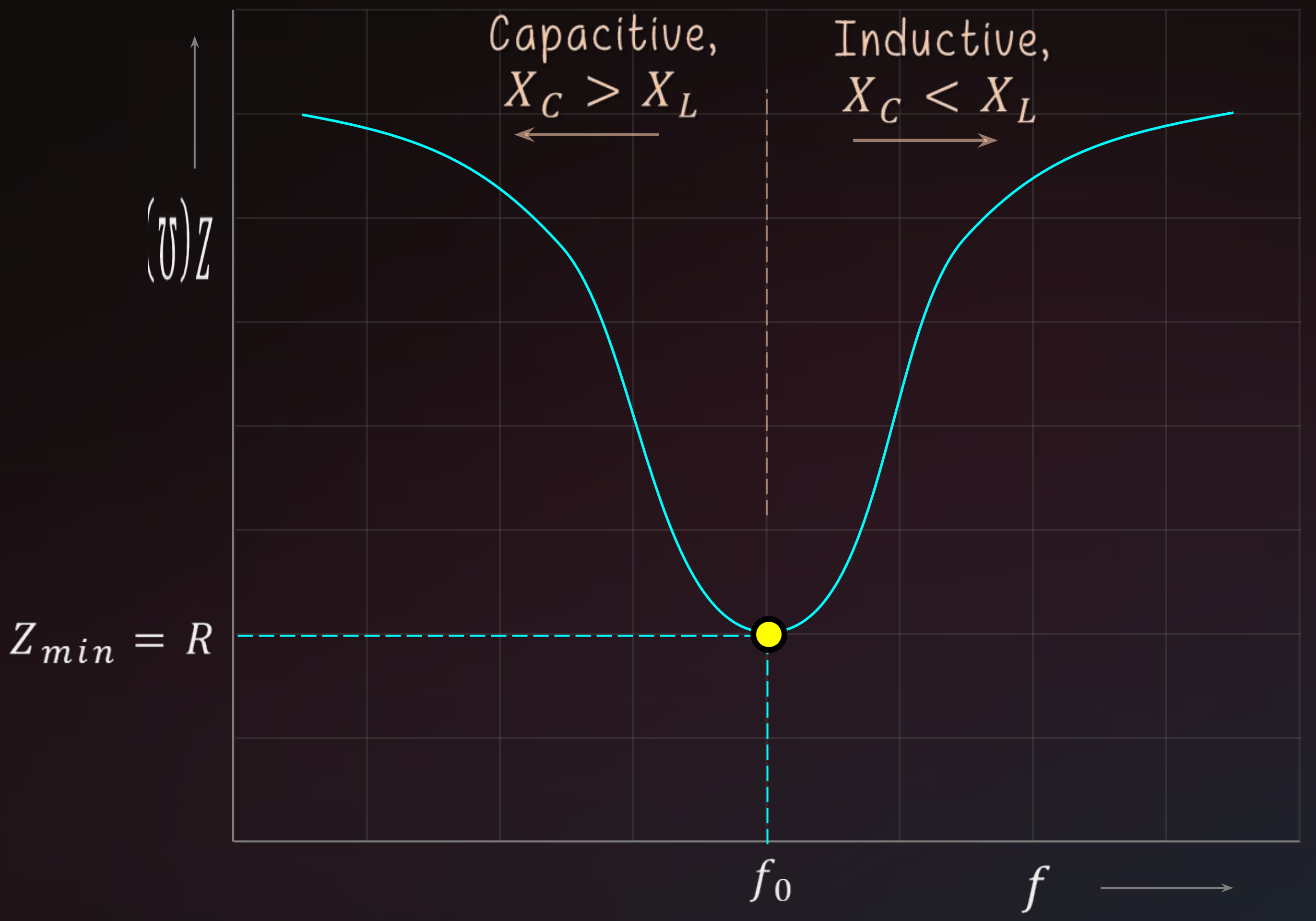
Independent of frequency

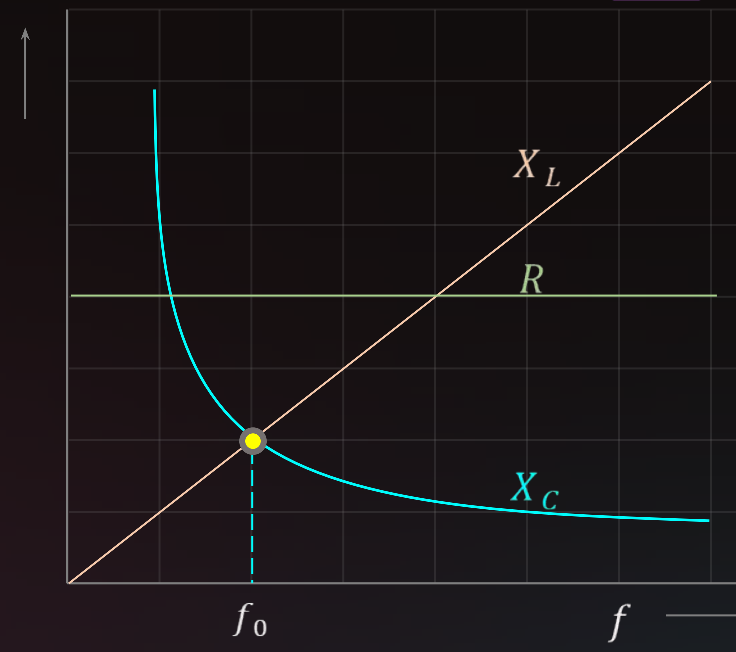
Resonance condition, $X_C = X_L$

RESONANCE

Graphical representation

$$Z = \sqrt{R^2 + \left(\frac{1}{2\pi f C} - 2\pi f L\right)^2}$$



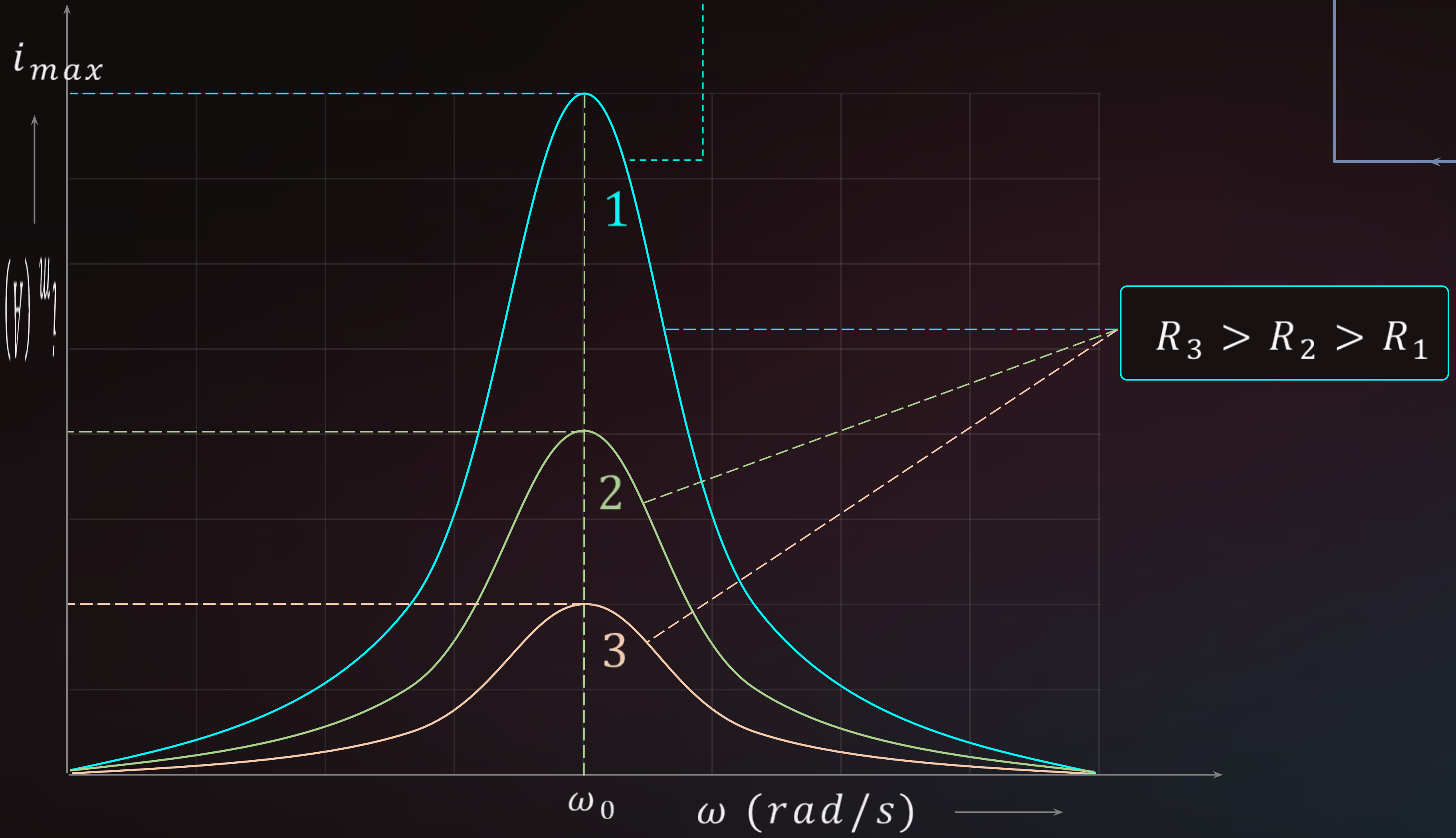


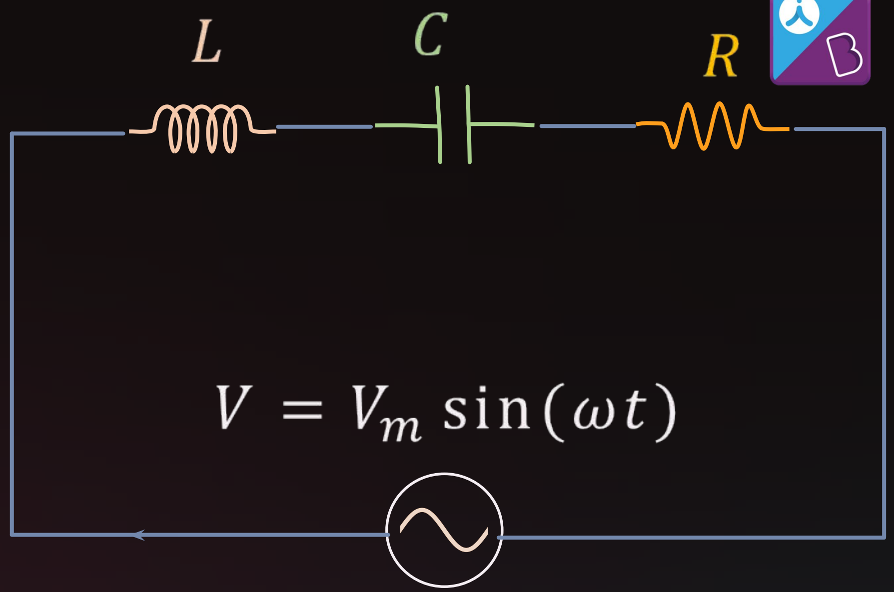
Resonance condition, $X_C = X_L$

RESONANCE

$$Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$$

$$i_m = V_m / Z$$





Question

What is the value of inductance L for which the current is maximum in a series LCR circuit with $C = 10\ \mu F$ and $\omega = 1000\ s^{-1}$?

(a) $1\ mH$

(b) $10\ mH$

(c) $100\ mH$

(d) Cannot be calculated unless R is known

Y

For maximum current in series LCR circuit,

$$X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$$

For maximum current in series LCR circuit,

$$X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$$

$$L = \frac{1}{\omega^2 C} = \frac{1}{(1000)^2 \times 10 \times 10^{-6}}$$

$$L = \frac{1}{10} = 0.1\ H = 100\ mH$$

Answer

What is the value of inductance L for which the current is maximum in a series LCR circuit with $C = 10\ \mu F$ and $\omega = 1000\ s^{-1}$?

a) $1\ mH$

b) $10\ mH$

c) $100\ mH$

d) Cannot be calculated unless R is known

NEET 2007

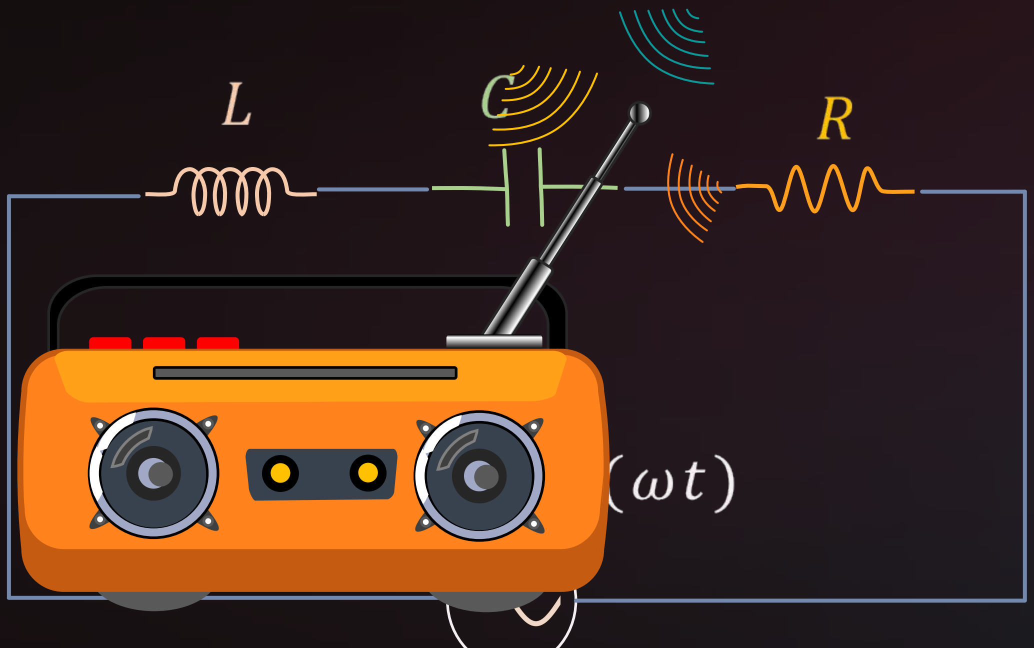
RESONANCE

Radio Tuning

To hear one particular radio station, radio tuning is required.

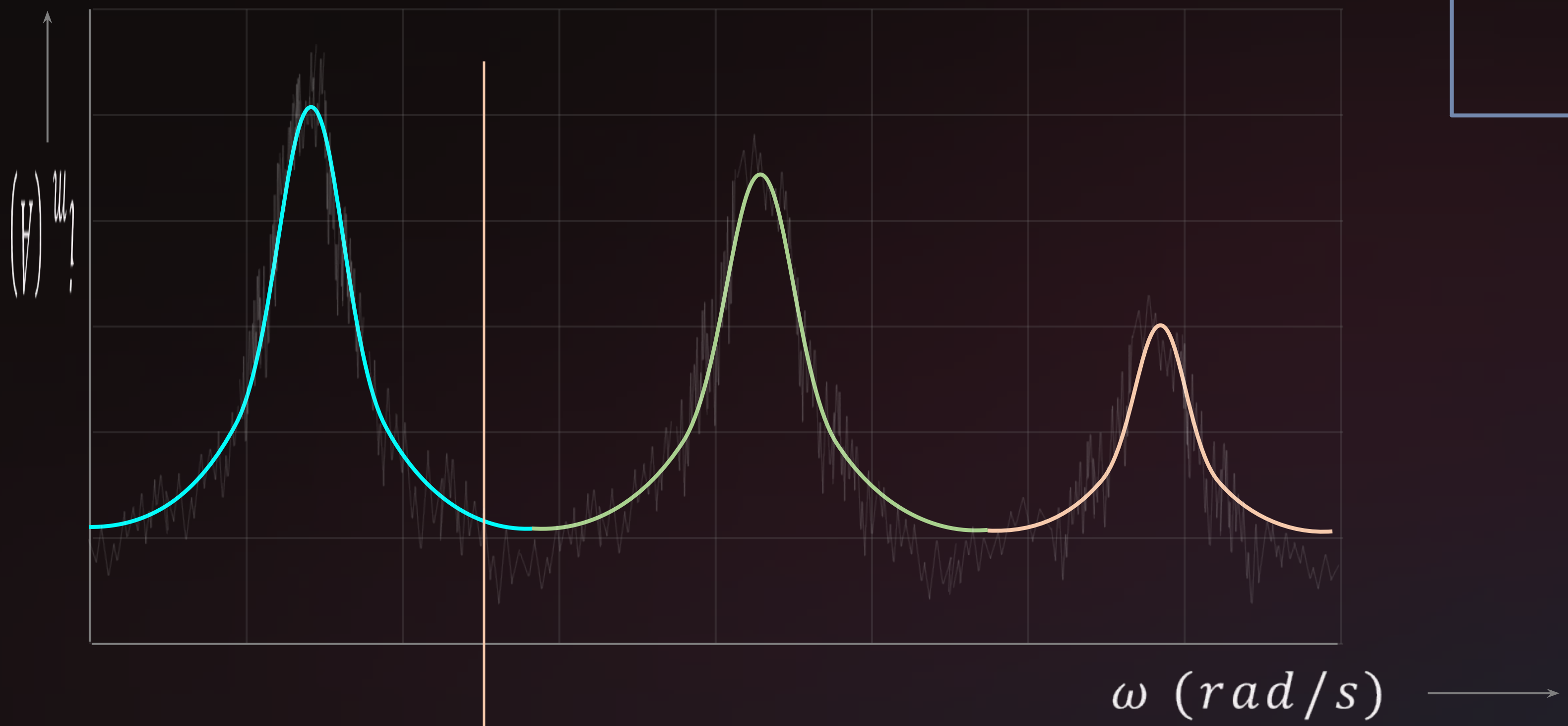
RESONANCE

Radio Tuning

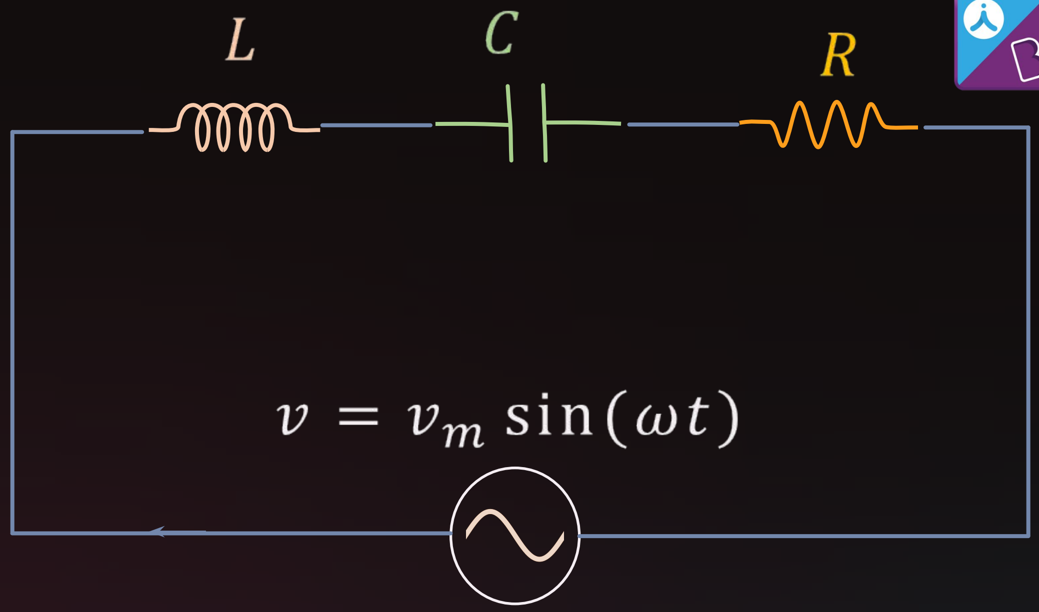


RESONANCE

Radio Tuning



$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

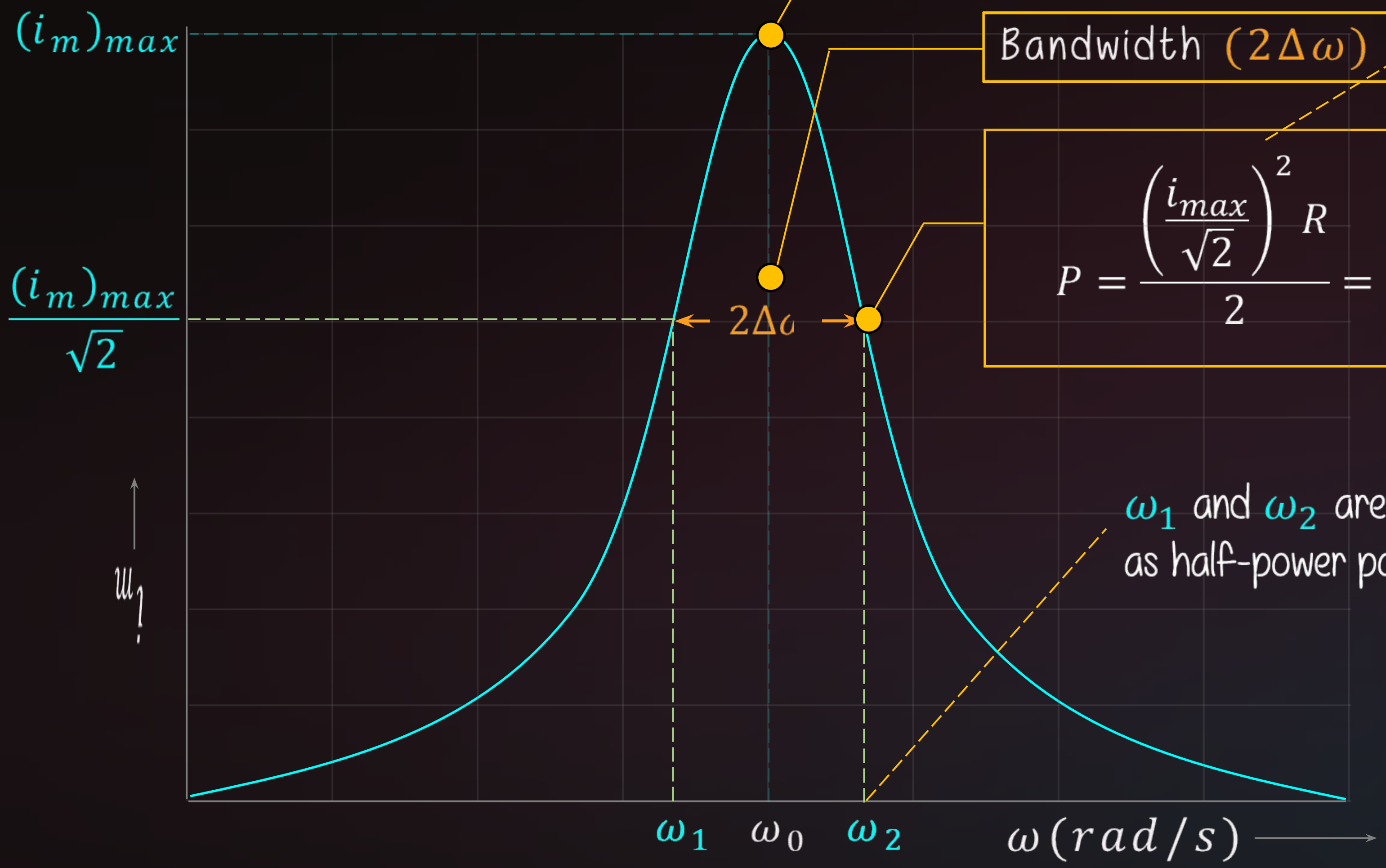


RESONANCE

BANDWIDTH & POWER

RESONANCE: BANDWIDTH & POWER

- The current will be $1/\sqrt{2}$ times the maximum value of current at ω_1 and ω_2.



$P_{max} = (i_{max})^2 R/2$

Bandwidth $(2\Delta\omega)$

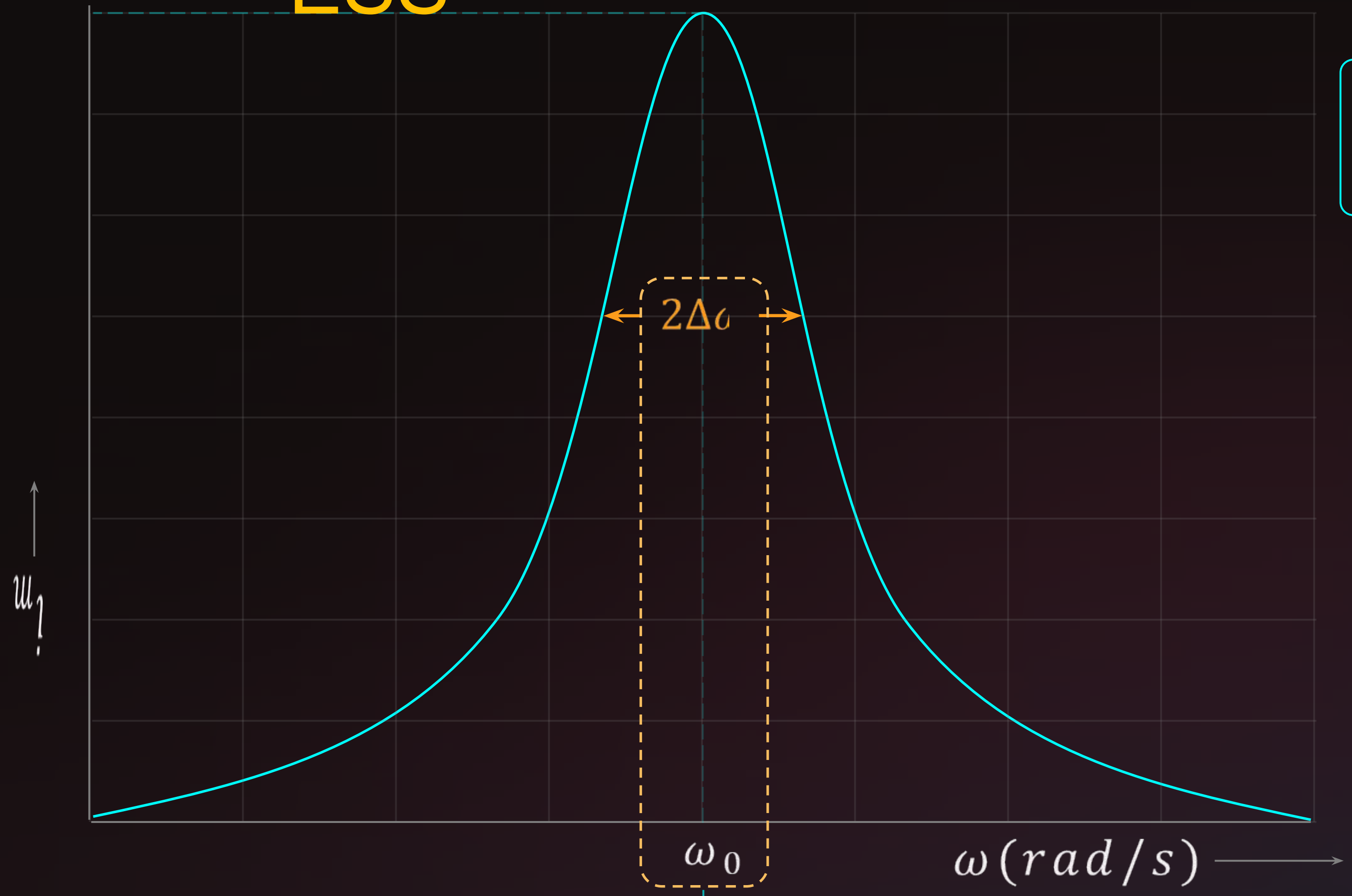
$$P = \frac{\left(\frac{i_{max}}{\sqrt{2}}\right)^2 R}{2} = \frac{P_{max}}{2}$$

At resonance, Power will be maximum

ω_1 and ω_2 are called as half-power points

RESONANCE

SHARPNESS



$$\Delta\omega = \frac{R}{2L}$$

The quantity $(\omega_0/2\Delta\omega)$ is regarded as a measure of sharpness of resonance.

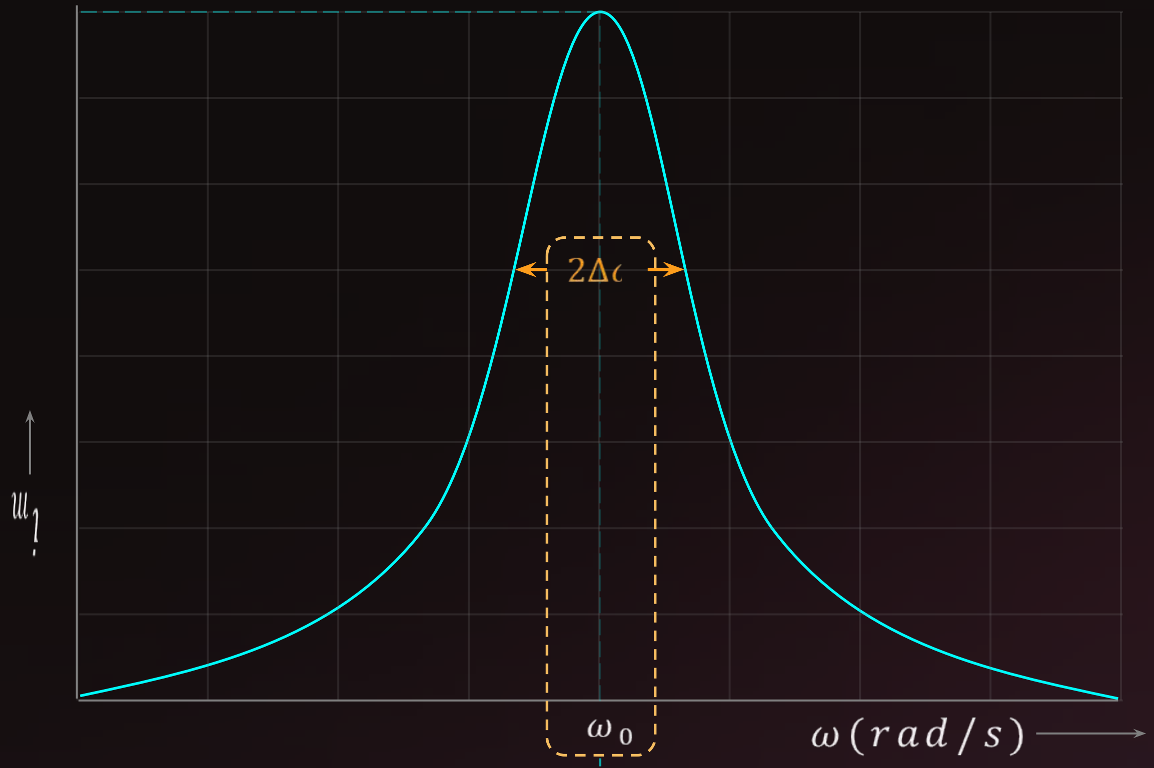
SMALL $\Delta\omega$

GOOD TUNNING

HIGH SHARPNESS

LOW BANDWIDTH

RESONANCE SHARPNESS



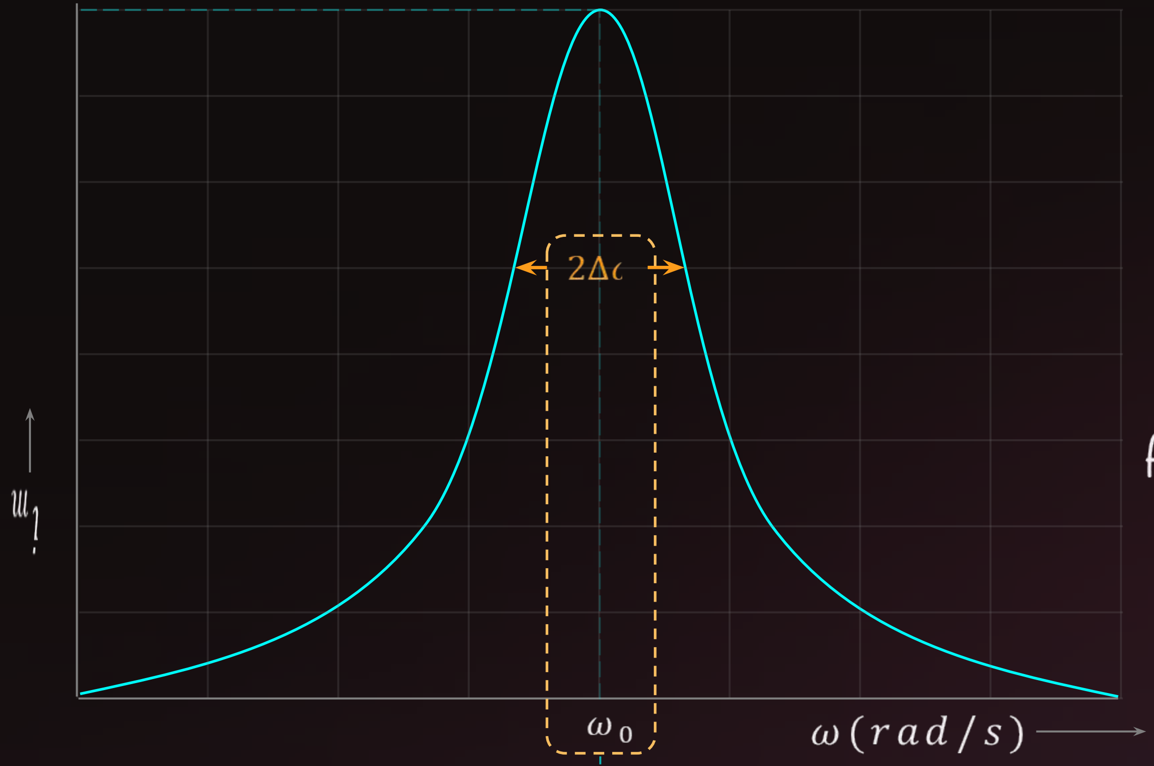
The quantity $(\omega_0/2\Delta\omega)$ is regarded as a measure of sharpness of resonance.

$$\Delta\omega = \frac{R}{2L}$$

Sharpness of resonance $= \dfrac{\omega_0}{2\Delta\omega} = \boxed{\dfrac{\omega_0 L}{R}}$

Quality Factor, Q

RESONANCE SHARPNESS



The quantity $(\omega_0/2\Delta\omega)$ is regarded as a measure of sharpness of resonance.

$$\Delta\omega = \frac{R}{2L}$$

Sharpness of resonance $= \dfrac{\omega_0}{2\Delta\omega} = \dfrac{\omega_0 L}{R}$ → Quality Factor, Q

At resonance, Q can also be defined as

$$Q = \frac{V_L}{V_R} = \frac{V_C}{V_R}$$

$$Q = \frac{i_0\omega_0 L}{i_0 R} = \frac{i_0}{\omega_0 C i_0 R}$$

$$Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 RC} = \frac{1}{R}\sqrt{\frac{L}{C}}$$

RESONANCE

QUALITY FACTOR

$$Q = \frac{\omega_0}{2\Delta\omega}$$

$\left(\because \Delta\omega = \frac{R}{2L}\right)$

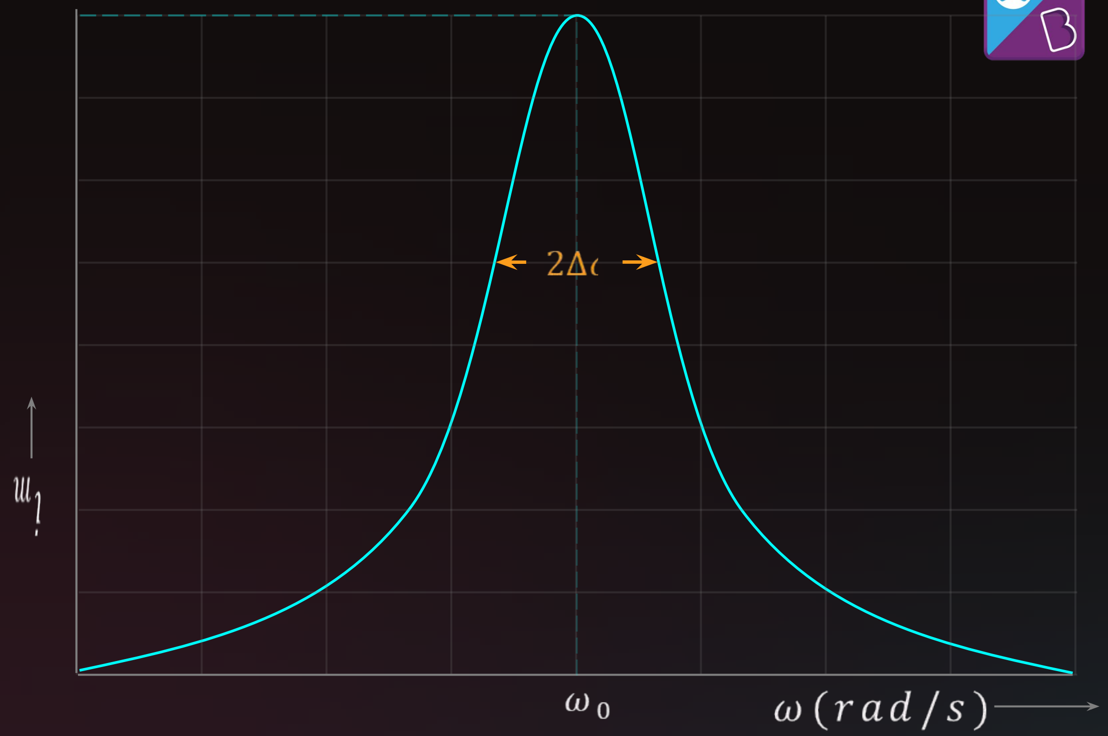
$$Q = \frac{\omega_0 L}{R}$$

$(\because \omega_0^2 = 1/LC)$

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$(\because L = 1/\omega_0^2 C)$

$$Q = \frac{1}{\omega_0 RC}$$



Question

Which of the following combination should be selected for better tuning of an L-C-R circuit used for communication?

a) $R = 25\ \Omega,$ $L = 1.5\ H,$ $C = 45\ \mu F$

b) $R = 20\ \Omega,$ $L = 1.5\ H,$ $C = 35\ \mu F$

c) $R = 25\ \Omega,$ $L = 2.5\ H,$ $C = 45\ \mu F$

d) $R = 15\ \Omega,$ $L = 3.5\ H,$ $C = 30\ \mu F$

Y

For better tuning, the quality factor of the circuit should be high.

a: $R = 25\ \Omega,\ L = 1.5\ H,\ C = 45\ \mu F$

b: $R = 20\ \Omega,\ L = 1.5\ H,\ C = 35\ \mu F$

c: $R = 25\ \Omega,\ L = 2.5\ H,\ C = 45\ \mu F$

d: L should be high.

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

L should be high.

Value of R and C should be minimum

Answer

Which of the following combination should be selected for better tuning of an L-C-R circuit used for communication?

a) $R = 25\ \Omega$, $L = 1.5\ H$, $C = 45\ \mu F$

b) $R = 25\ \Omega$, $L = 1.5\ H$, $C = 35\ \mu F$

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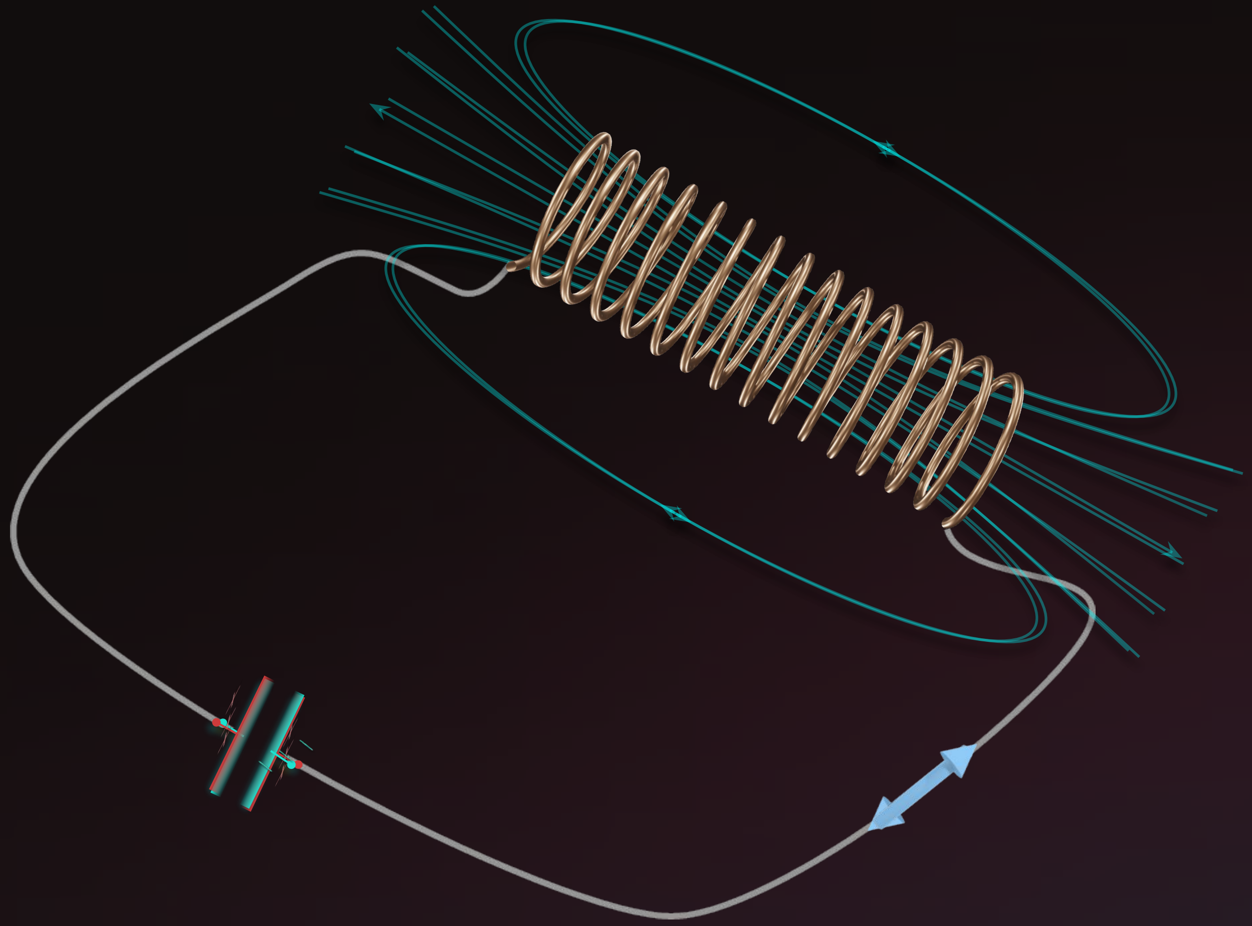
NEET 2016

LC OSCILLATION)



Electric

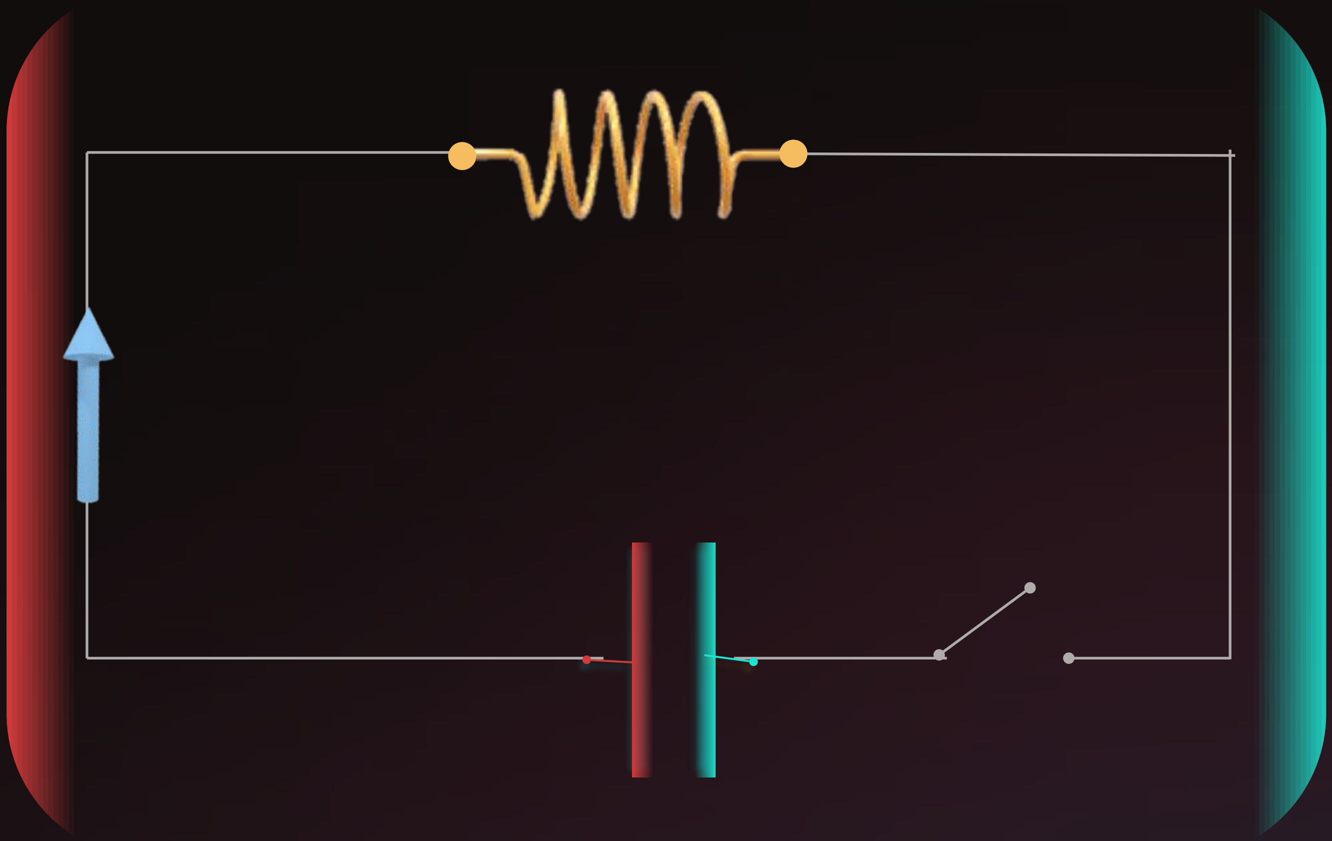
Energy

⇅

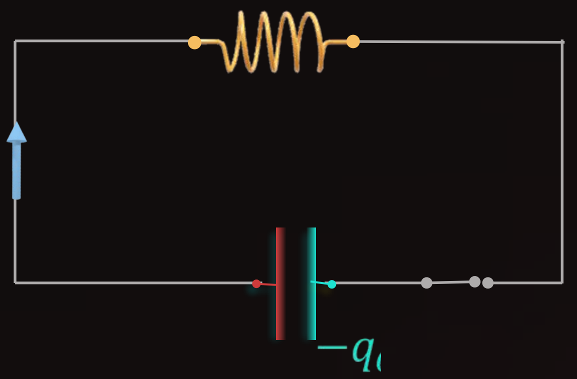
Magnetic

Energy

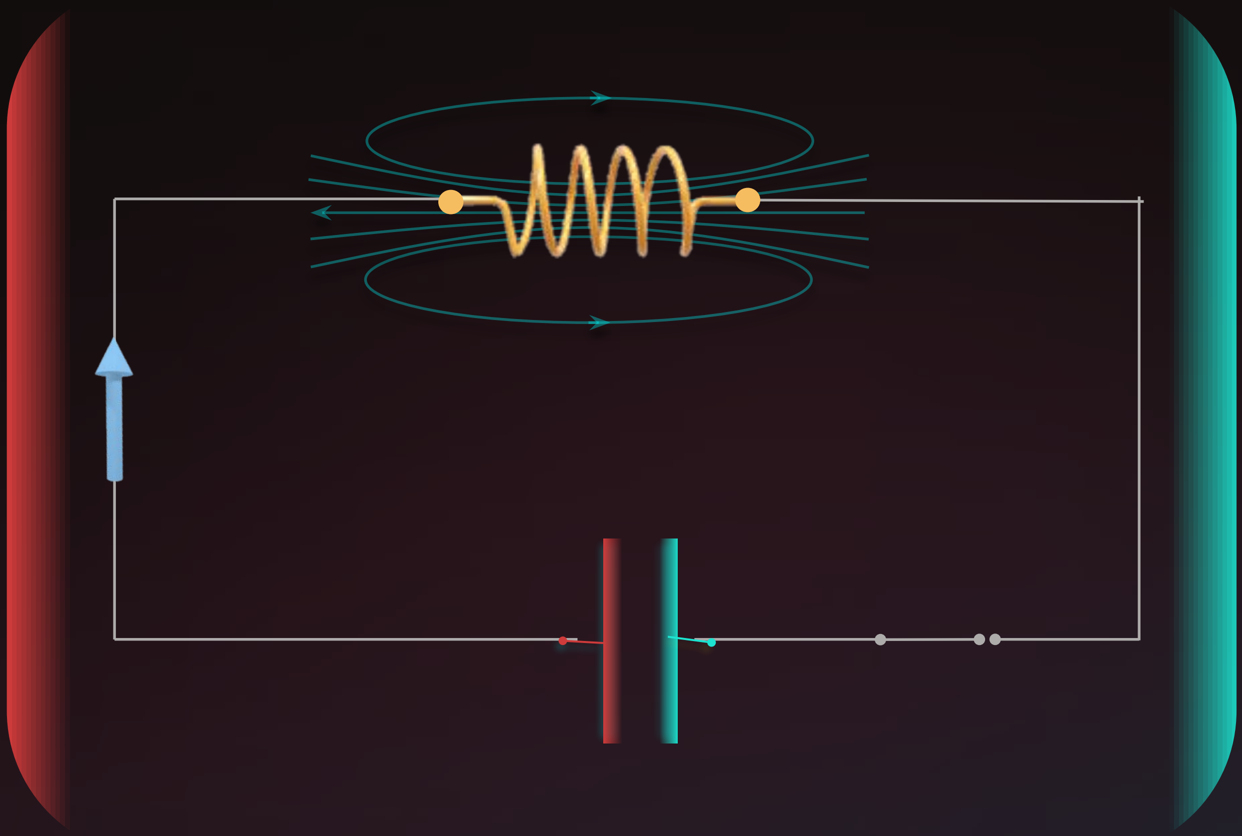
LC OSCILLATION)



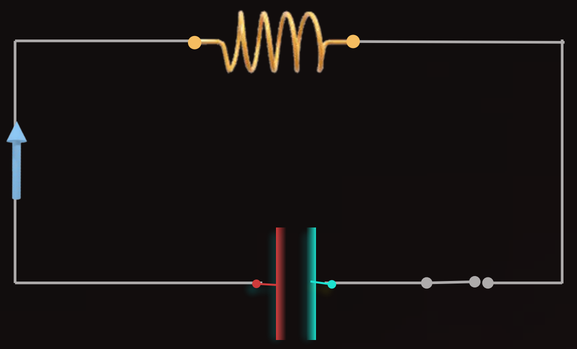
LC OSCILLATION)



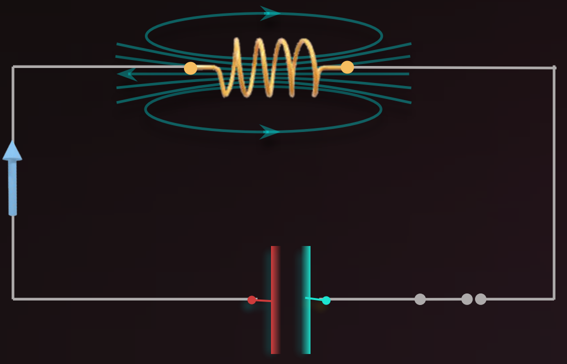
Step 1



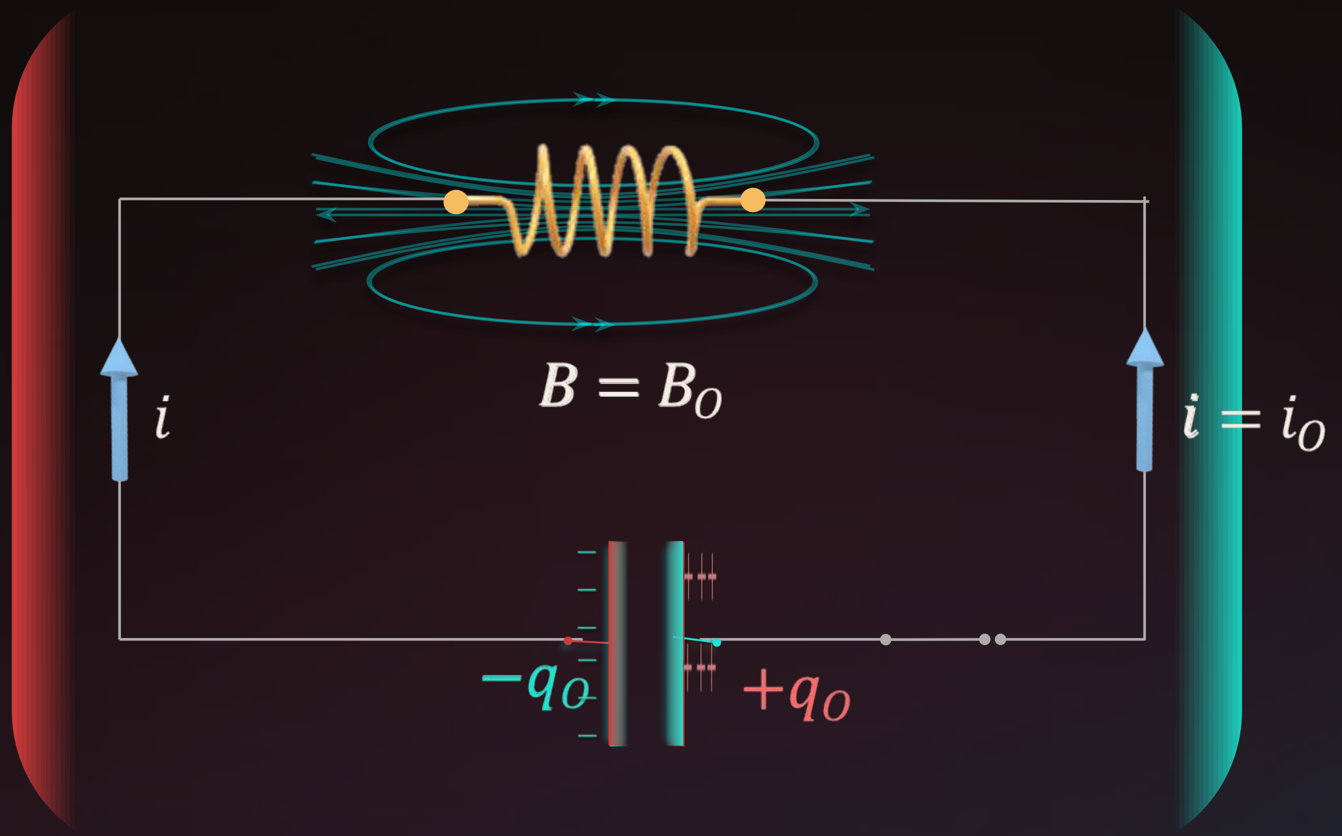
LC OSCILLATION)



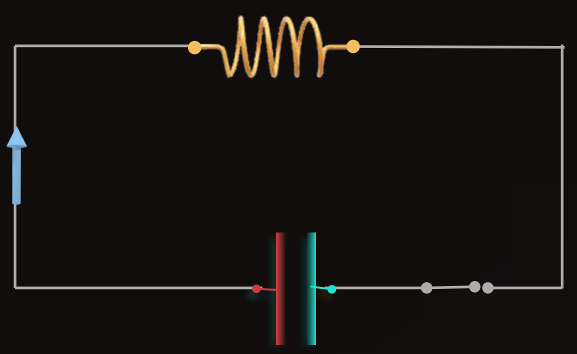
Step 1



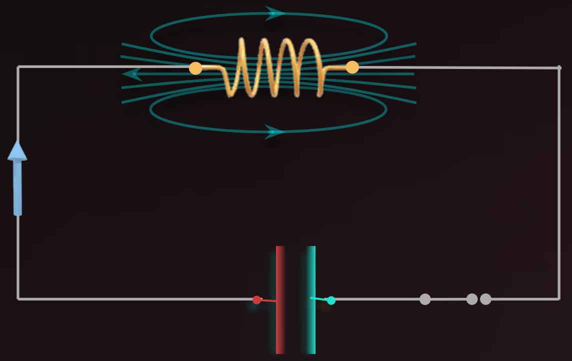
Step 2



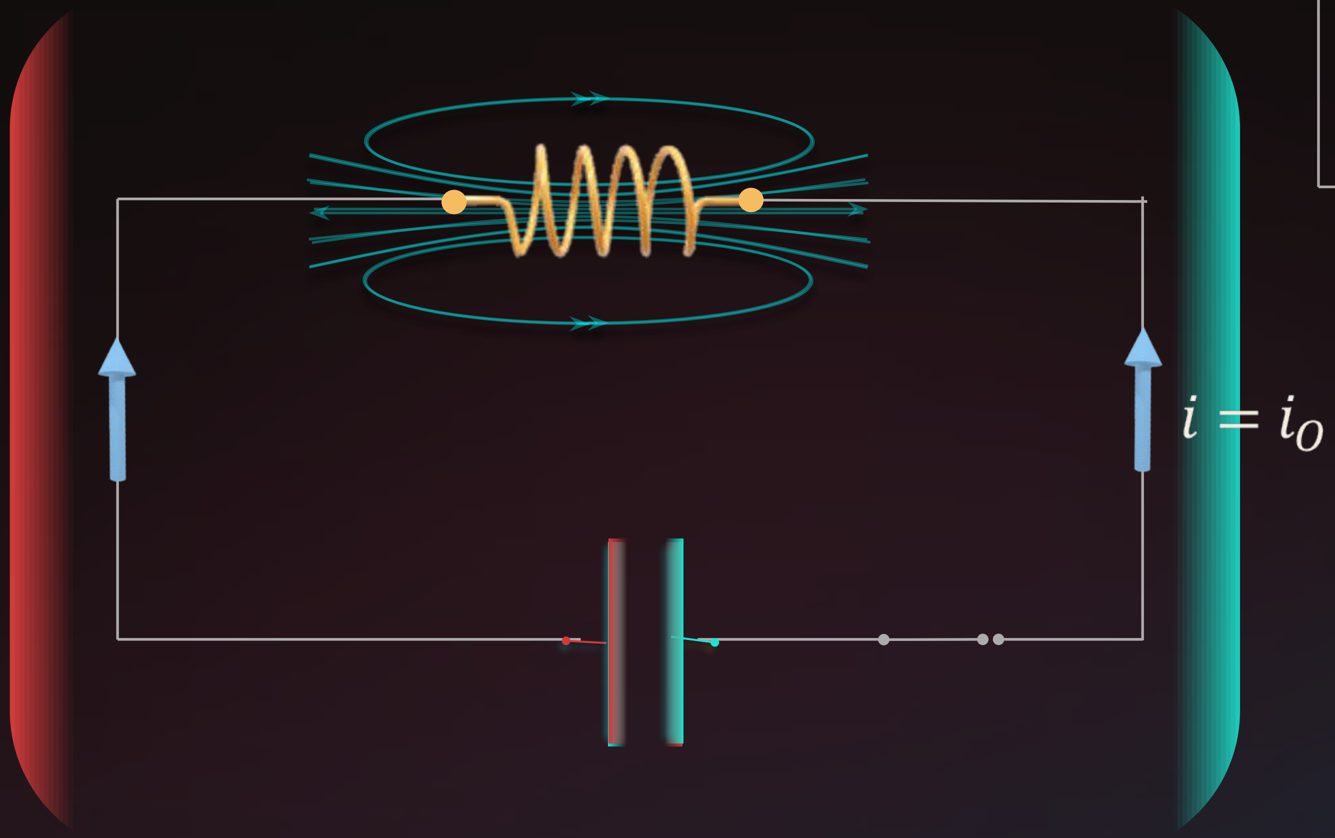
LC OSCILLATION)

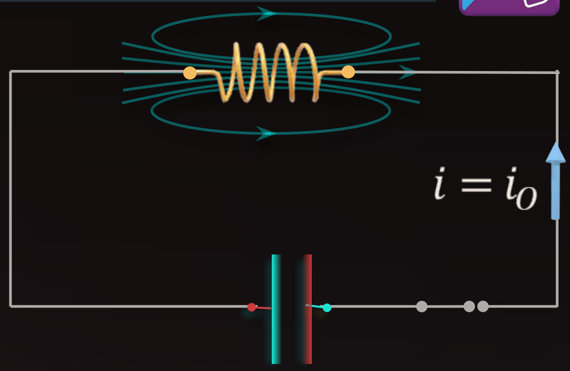


Step 1



Step 2





Step 3

Now the same oscillation and steps will occur

LC OSCILLATION)

Oscillation period

At $t = 0$,

Current, $i = 0$

Charge on capacitor, $q = q_m$

Induced emf across the inductor, $L\dfrac{di}{dt} = 0$

LC OSCILLATION

Oscillation period

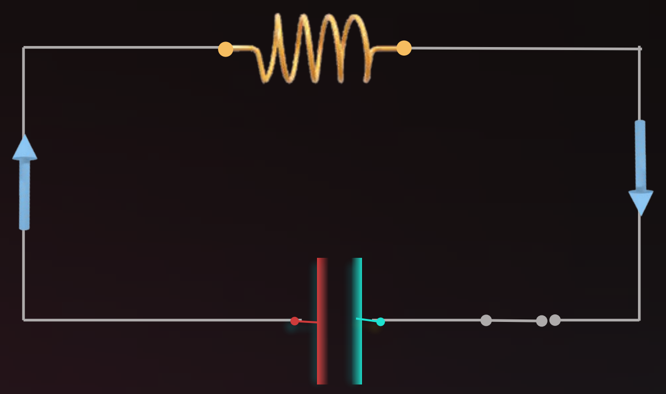
At time, t

Current $= i$

Charge on capacitor $= q$

Potential difference $= \frac{q}{c}$

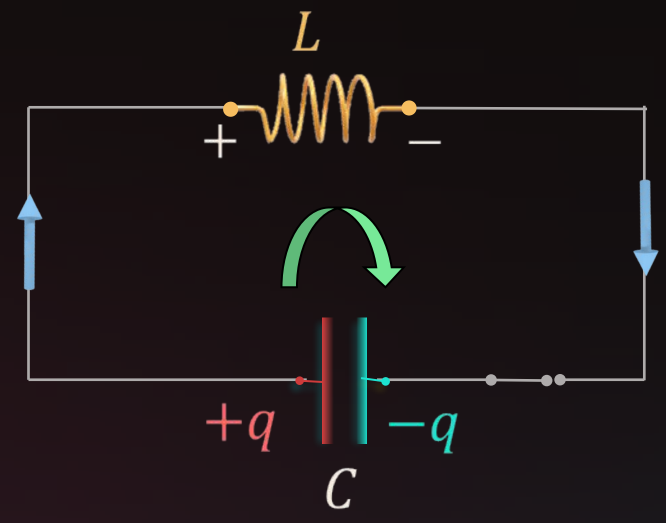
Induced emf across the inductor, $L\frac{di}{dt} = 0$



LC OSCILLATION)

Oscillation period

Applying Kirchhoff's Law

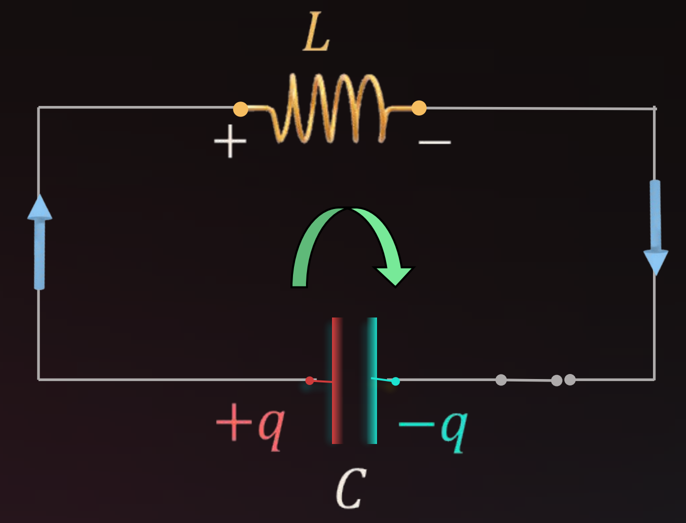


LC OSCILLATION)

Oscillation period

Applying Kirchhoff's Law

$$\frac{q}{C} - L\frac{di}{dt} = 0 \ldots (1) \qquad i = -\frac{dq}{dt}$$



$$\frac{q}{C} - L\frac{d\left(-\frac{dq}{dt}\right)}{dt} = 0 \Rightarrow \frac{q}{LC} + \frac{d^2q}{dt^2} = 0$$

$$\frac{d^2q}{dt^2} + \frac{q}{LC} = 0$$

For a particle in SHM

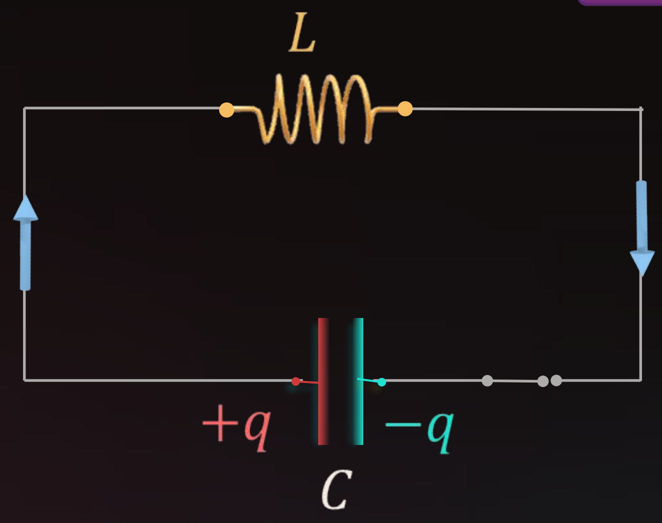
$$\frac{d^2x}{dt^2} + \omega_o^2 x = 0 \ldots (3) \qquad \omega = \sqrt{\frac{k}{m}}$$

$$\omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

LC OSCILLATION

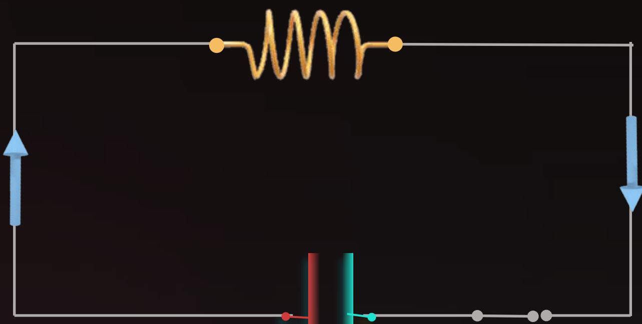
Oscillation period

$$\frac{d^2q}{dt^2} + \frac{q}{LC} = 0 \quad \ldots (2)$$



LC OSCILLATION)

Oscillation period



$$\frac{d^2q}{dt^2} + \frac{q}{LC} = 0 \;...\; (2)$$

For a particle in SHM

$$\frac{d^2x}{dt^2} + \omega_o^2 x = 0 \;...\; (3)$$

$$\omega = \sqrt{\frac{k}{m}}$$

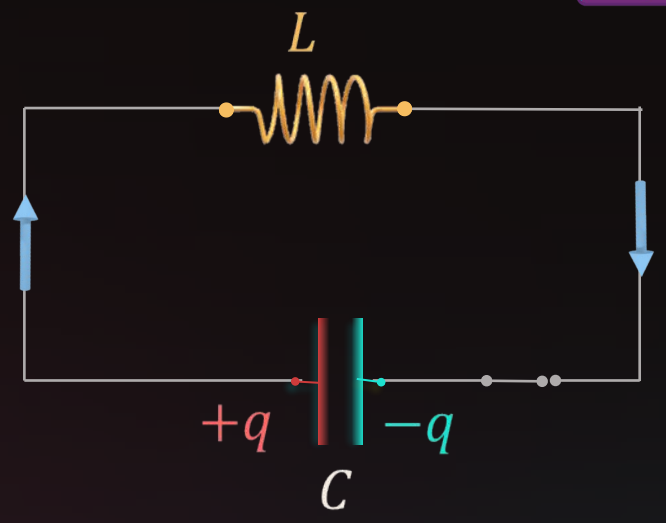
$$\omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

LC OSCILLATION)

Oscillation period

$$\frac{d^2x}{dt^2} + \omega_o^2 x = 0 \; ... (3)$$

$$\omega = \frac{1}{\sqrt{LC}}$$



LC OSCILLATION)

Oscillation period

$$\frac{d^2x}{dt^2} + \omega_o^2 x = 0 \ldots (3)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$x = A\cos(\omega_o t + \phi)$$

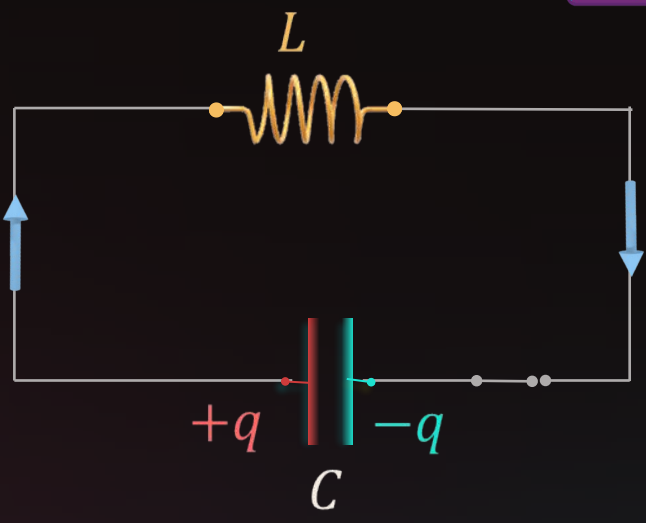
$$q = q_m \cos(\omega_o t + \phi) \ldots (4)$$

At $t = 0, q = q_m$

$$\Rightarrow q_m = q_m \cos(\phi)$$

$$\Rightarrow \cos(\phi) = 1 \Rightarrow \phi = 0$$

$$q = q_m \cos(\omega_o t)$$

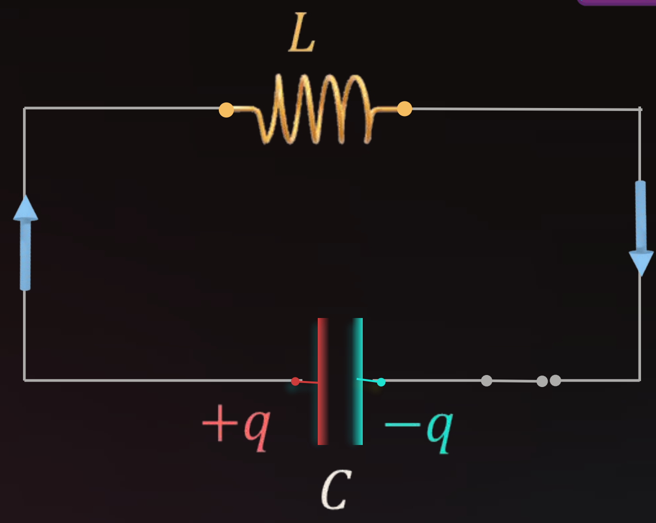


LC OSCILLATION)

Oscillation period

$$q = q_m \cos(\omega_o t) \ldots (5)$$

$$\omega = \frac{1}{\sqrt{LC}}$$



LC OSCILLATION)

Oscillation period

$$q = q_m \cos(\omega_o t) \ldots (5)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

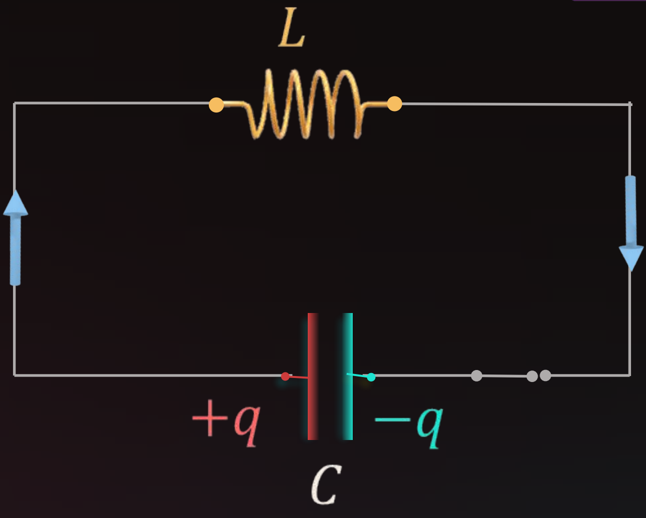
$$\Rightarrow i = -\frac{d}{dt}[q_m \cos(\omega_o t)]$$

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

$$\Rightarrow i = \omega_o q_m \sin(\omega_o t)$$

$$i = i_m \sin(\omega_o t)$$

$$i_m = \omega_o q_m$$



LC OSCILLATION

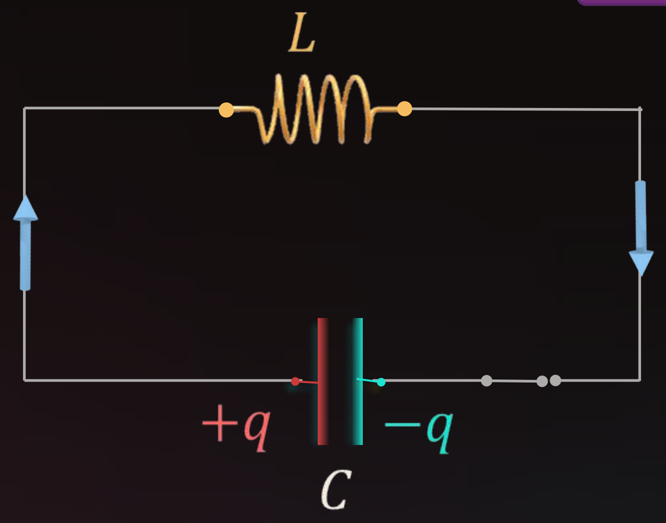
Oscillation period

$$q = q_m \cos(\omega_o t) \ldots (5)$$

$$i = i_m \sin(\omega_o t) \ldots (6)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$i_m = \omega_o q_m$$



LC OSCILLATION

Oscillation period

$$q = q_m \cos(\omega_o t) \ldots (5)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$i_m = \omega_o q_m$$

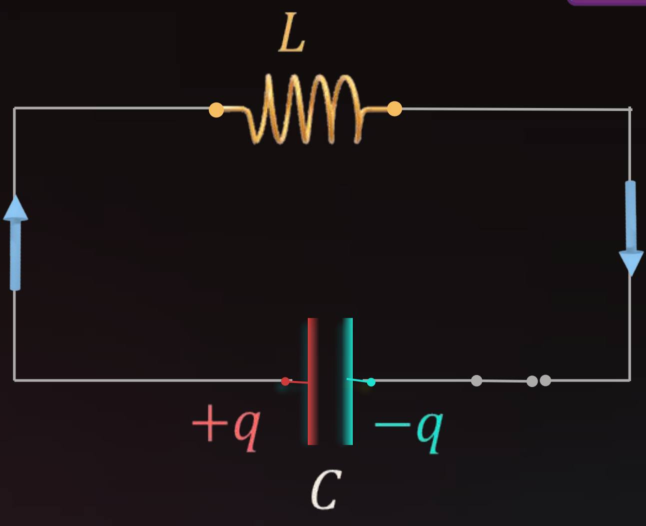
$$i = i_m \sin(\omega_o t) \ldots (6)$$

$$U = \frac{q^2}{2C}, \quad U' = \frac{1}{2}Li^2$$

$$L = \frac{1}{\omega_o^2 C}$$

$$U_{Total} = U + U'$$

$$U_{Total} = \frac{q^2}{2C} + \frac{1}{2}Li^2$$



LC OSCILLATION

Oscillation period

$$q = q_m \cos(\omega_o t) \ldots (5)$$

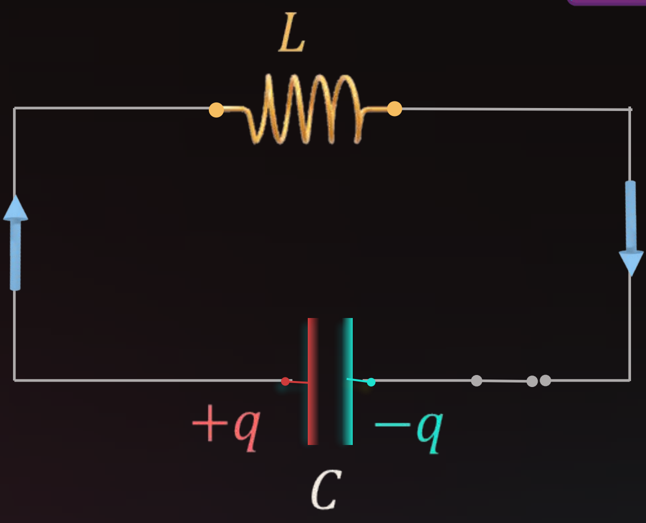
$$i = i_m \sin(\omega_o t) \ldots (6)$$

$$U_{Total} = \frac{q^2}{2C} + \frac{1}{2}Li^2$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$L = \frac{1}{\omega_o^2 C}$$

$$i_m = \omega_o q_m$$



LC OSCILLATION)

Oscillation period

$$q = q_m \cos(\omega_o t) \dots (5)$$

$$\omega = \frac{1}{\sqrt{LC}}$$

$$i_m = \omega_o q_m$$

$$i = i_m \sin(\omega_o t) \dots (6)$$

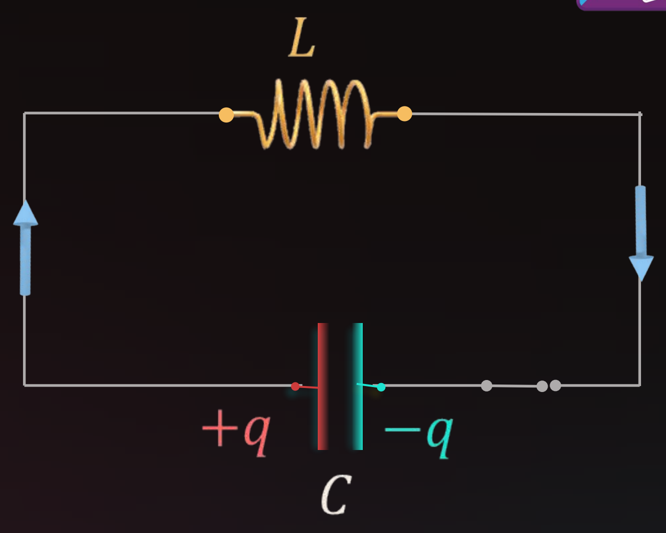
$$L = \frac{1}{\omega_o^2 C}$$

$$U_{Total} = \frac{q^2}{2C} + \frac{1}{2} L i^2$$

$$U_{Total} = \frac{[q_m \cos(\omega_o t)]^2}{2C} + \frac{1}{2}\frac{1}{\omega_o^2 C}[i_m \sin(\omega_o t)]^2$$

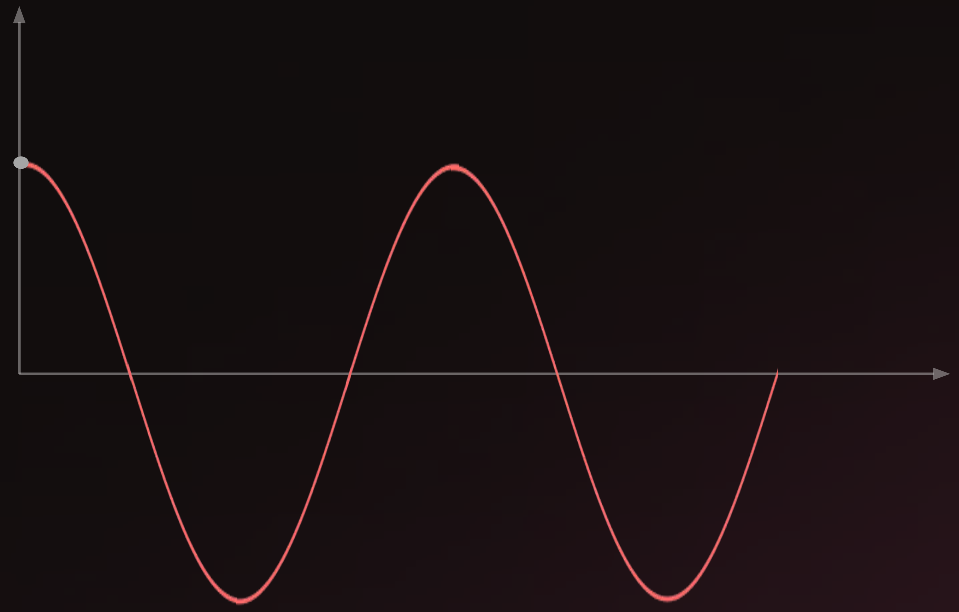
$$U_{Total} = \frac{(q_m)^2}{2C}[(\cos^2 \omega_o t) + (\sin^2 \omega_o t)]$$

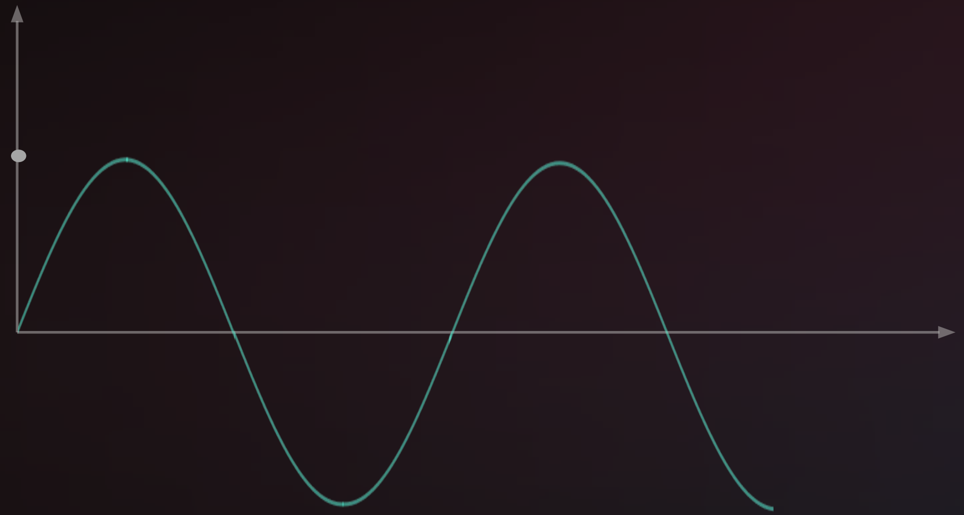
$$U_{Total} = \frac{q_m^2}{2C}$$

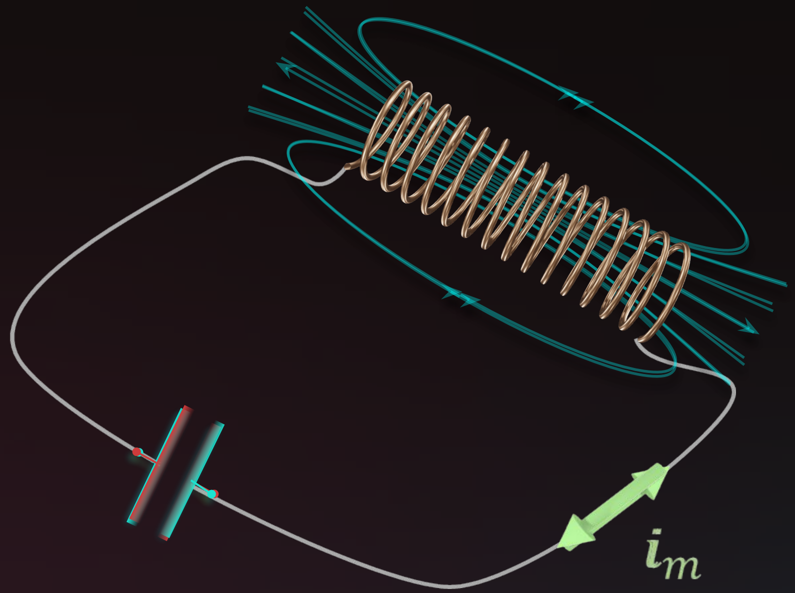


LC OSCILLATION)

GRAPHS







LC OSCILLATION

Energy