TOPIC 1 Alternating Current and Its Characteristics

SQ 17.1.1 What is alternating current?

Definition
Alternating current means a sinusoidally varying current which can be represented by time dependent sine or cosine functions.

SQ 17.1.2 Write the equations of alternating voltage and current.

Formulas
$V = V_0 \sin \omega t$
$I = I_0 \sin \omega t$
Here V_0 and I_0 are the maximum or peak values and ω is the angular frequency.

SQ 17.1.3 When is a periodically varying quantity termed alternating?

Definition
A periodically varying current or voltage is termed alternating if every cycle occupies one time period and has two symmetrical half cycles, one positive and the other negative.

SQ 17.1.4 What reverses after every half cycle in AC?

Answer
In the case of current the direction of current reverses after every half cycle, and in the case of voltage the polarity of potential difference reverses after every half cycle.

SQ 17.1.5 What is the second condition for a quantity to be alternating?

Condition
The amplitude or peak value of current or voltage, that is the maximum value on both the positive and negative sides, must remain constant in all cycles.

SQ 17.1.6 Where do changes occur most rapidly and most slowly in an AC waveform?

Answer
Changes occur most rapidly at the zero or crossover points and most slowly at the peak.

SQ 17.1.7 Define waveform and cycle.

Waveform
The path traced by an alternating quantity plotted as a function of time.

Cycle
One complete set of positive and negative values of an alternating quantity is called a cycle.

SQ 17.1.8 Define time period and frequency of AC.

Time Period
The time taken to complete one cycle of an alternating quantity, measured in seconds.

Frequency
The number of cycles that occur in one second, measured in hertz, with

$f = \dfrac{1}{T}$

SQ 17.1.9 Define the average value of an AC waveform.

Definition
The average value of AC is obtained by averaging all instantaneous values over one half cycle.

SQ 17.1.10 Why is the average of a full AC cycle zero?

Reason
The positive half-cycle and the negative half-cycle are mirror images of each other, so they cancel each other. Therefore the average over a full cycle is zero.

SQ 17.1.11 Write the average values of alternating current and voltage.

Formulas
$I_{av} = 0.637\, I_0$
$V_{av} = 0.637\, V_0$

SQ 17.1.12 Where is the average value of AC used?

Answer
The average value is used in situations involving rectification. When an AC signal passes through a rectifier the output is a pulsating DC signal, and the average of this pulsating DC is what matters for many applications.

SQ 17.1.13 Define instantaneous value and write its equations.

Definition
The value of an AC quantity at any instant of time is known as its instantaneous value.

Formulas
$V = V_0 \sin(2\pi f t)$
$I = I_0 \sin(2\pi f t)$

SQ 17.1.14 Define peak or maximum value.

Definition
It is the highest value that an AC waveform reaches during one cycle. It is the topmost point on the positive half-cycle or the bottommost point on the negative half-cycle.

SQ 17.1.15 Define peak to peak value.

Definition
This is the total distance from the positive peak to the negative peak of the waveform.

Formula
$V_{p-p} = 2V_0$

SQ 17.1.16 What do rms values represent?

Answer
The rms values represent the direct current or voltage values that will produce the same heating effect, or power dissipation, as the alternating current or voltage.

SQ 17.1.17 **Define the rms value of alternating current and write its formula.**

Definition
It is the value of a constant current that produces the same power in a resistor as the alternating current.
Formula
$I_{rms} = \frac{I_0}{\sqrt{2}} = 0.707\, I_0$

SQ 17.1.18 **Define the rms value of alternating voltage and write its formula.**

Definition
It is the value of a constant voltage that produces the same power in a resistor as the alternating voltage.
Formula
$V_{rms} = \frac{V_0}{\sqrt{2}} = 0.707\, V_0$

SQ 17.1.19 **Why do high voltage power lines crackle and hiss?**

Reason
The hissing sound is primarily caused by corona discharge, where the air surrounding the conductor becomes ionized due to a strong electric field.
Result
This ionization creates a discharge producing a visible glow, radio noise and audible hissing, particularly when the voltage exceeds the breakdown strength of the air.

TOPIC 2 Relation Between Mean Power and Maximum Power

SQ 17.2.1 **What is a resistive load?**

Definition
A resistive load is one that does not store energy, unlike a capacitor or inductor, and simply dissipates energy as heat.

SQ 17.2.2 **Define instantaneous power in an AC circuit.**

Definition
The instantaneous power is the power at any given moment in time.
Formula
$P = VI$
Here V and I are the instantaneous voltage and current.

SQ 17.2.3 **When does the maximum or peak power occur?**

Answer
The maximum power occurs when the current and voltage are at their peak values I_0 and V_0.
Formula
$P_{max} = I_0^2 R$

SQ 17.2.4 **Define mean power and write its formula.**

Definition
The mean power is the average power over one complete cycle of the AC waveform.
Formula
$P_{mean} = I_{rms}^2 R$

SQ 17.2.5 **Prove that the mean power is half the maximum power.**

Derivation
Since
$I_0 = \sqrt{2}\, I_{rms}$
therefore
$P_{max} = (\sqrt{2} I_{rms})^2 R = 2 I_{rms}^2 R.$
Since
$I_{rms}^2 R = P_{mean}$
Result
$P_{mean} = \frac{P_{max}}{2}$

SQ 17.2.6 **Why is the mean power half the maximum power?**

Reason
The instantaneous power in an AC circuit varies over time. While it reaches a maximum at certain points in the cycle, it spends significant time at zero or lower values, resulting in an average power that is half the peak value.

SQ 17.2.7 **An alternating voltage of 220 V is supplied across a 50 Ω resistor. Find the maximum power.**

Solution
$P_{max} = \frac{V_{rms}^2}{R} = \frac{(220)^2}{50}$
Result
$P_{max} = 968\,\text{W}$

SQ 17.2.8 **For the above circuit, find the mean power.**

Solution
$P_{mean} = \frac{P_{max}}{2} = \frac{968}{2}$
Result
$P_{mean} = 484\,\text{W}$

TOPIC 3 Phase of A.C.

SQ 17.3.1 **Define the phase of an alternating quantity.**

Definition
The angle θ which specifies the instantaneous value of the alternating voltage or current is called the phase.

SQ 17.3.2 **Write the phases of the key points of an AC cycle.**

Answer
The phases of the successive points of one cycle are 0
$\frac{\pi}{2}$
π
$\frac{3\pi}{2}$ and 2π. Thus each point of an AC cycle corresponds to a phase.

SQ 17.3.3 **Define initial phase.**

Definition
The value of the phase angle θ at
$t = 0$
is called the initial phase of the AC quantity.

SQ 17.3.4 When is the current said to be leading the voltage?

Answer

If at
$t = 0$
the voltage is zero but the current is positive, then the current had its zero value earlier by an angle ϕ than the voltage. The current is then said to be leading the voltage.

Equation

$I = I_0 \sin(\theta + \phi)$

SQ 17.3.5 When is the current said to be lagging the voltage?

Answer

If at
$t = 0$
the voltage is zero but the current has some negative value, the current reaches its zero value later by an angle ϕ. The current is then said to be lagging behind the voltage.

Equation

$I = I_0 \sin(\theta - \phi)$

SQ 17.3.6 What is the phase difference?

Definition

The angle ϕ between the initial phases of the voltage and the current is called the phase difference between them.

SQ 17.3.7 How is a vector diagram used to represent AC quantities?

Answer

A vector represents the peak or rms value of the current, taken as the reference quantity, and another represents the voltage. Both vectors rotate in an anticlockwise direction with the angular frequency.

TOPIC 4 AC Circuits

SQ 17.4.1 What is the basic circuit element in a DC circuit?

Answer

The basic circuit element in a DC circuit is a resistor R, which controls the current or voltage, and the relation between them is given by Ohm's law
$V = IR$

SQ 17.4.2 Name the three basic circuit elements in an AC circuit.

Answer

The basic circuit elements in an AC circuit are the resistor R, the inductor L and the capacitor C. These elements control the current and voltage through the circuit.

TOPIC 5 AC Through a Resistor

SQ 17.5.1 Write the current through a resistor connected to an AC source.

Derivation

Since
$I = \frac{V}{R}$
and
$V = V_0 \sin \omega t$

therefore

Formula

$I = I_0 \sin \omega t \quad \text{where} \quad I_0 = \frac{V_0}{R}$

SQ 17.5.2 What is the phase relationship in a purely resistive AC circuit?

Answer

Both voltage and current pass their minimum and maximum values at the same time, so their instantaneous values are said to be in phase with each other.

SQ 17.5.3 Why are the V and I vectors drawn parallel for a resistor?

Reason

The V and I vectors are drawn parallel because there is no phase difference between them in a purely resistive circuit.

SQ 17.5.4 What is the opposition to AC presented by a resistor?

Answer

The opposition to AC which the circuit presents is the resistance, given by
$R = \frac{V}{I}$

SQ 17.5.5 Why is the power dissipation of AC not the same as DC of the same maximum value?

Reason

The alternating current is at its maximum value only for an instant during each half-cycle, so its power dissipation is not the same as that produced by a direct current of the same maximum value.

SQ 17.5.6 Write the expressions for instantaneous power dissipated in a resistor.

Formulas

$P = VI$
$P = I^2 R$
$P = \frac{V^2}{R}$

SQ 17.5.7 Write the average power dissipated in a resistive AC circuit.

Derivation

Since
$\langle I^2 \rangle = \frac{I_0^2}{2} = I_{rms}^2$

therefore

Formulas

$\langle P \rangle = I_{rms}^2 R$
$\langle P \rangle = I_{rms} V_{rms}$

SQ 17.5.8 When does the power equation P = VI hold good?

Answer

The equation for power holds good only when V and I are in phase.

SQ 17.5.9 **A 1 kW heating element is connected to 250 V AC. Find the current taken.**

Solution

$I = \frac{P}{V} = \frac{1000}{250}$

Result

$I = 4\,\text{A}$

SQ 17.5.10 **For the above heating element, find its hot resistance.**

Solution

$R = \frac{V}{I} = \frac{250}{4}$

Result

$R = 62.5\,\Omega$

TOPIC 6 AC Through Inductor

SQ 17.6.1 **Define an inductor.**

Definition

An inductor, also called a coil or choke, is a passive two terminal electrical component having a large value of self-inductance and negligible resistance, that stores energy in a magnetic field when electric current flows through it.

SQ 17.6.2 **What is the purpose of an inductor in a circuit?**

Answer

The inductor is used to slow down current surges or spikes by temporarily storing energy in an electromagnetic field and then releasing it back into the circuit.

SQ 17.6.3 **Derive the voltage across an inductor carrying alternating current.**

Derivation

The changing current sets up a back emf of magnitude

$V = L\frac{\Delta I}{\Delta t}$

Putting

$I = I_0 \sin \omega t$

gives

$V = LI_0\omega \cos \omega t$

Result

$V = V_0 \cos \omega t \qquad \text{where} \qquad V_0 = \omega L I_0$

SQ 17.6.4 **What is the phase relationship in a purely inductive circuit?**

Answer

In an inductor the voltage leads the current by 90° or $\frac{\pi}{2}$ radian.

SQ 17.6.5 **Define inductive reactance and write its formula.**

Definition

The resistance offered by an inductor is called inductive reactance.

Formula

$X_L = \frac{V_{rms}}{I_{rms}} = \omega L = 2\pi f L$

Its unit is the ohm.

SQ 17.6.6 **On what does inductive reactance depend?**

Answer

Inductive reactance is directly proportional to both the frequency of the current and the inductance L of the inductor.

SQ 17.6.7 **Why does an inductor allow DC but block AC?**

Reason

In the case of DC the frequency is zero, so

$X_L = 0$

In the case of a large AC frequency, X_L is also large.

Conclusion

An inductor allows DC but blocks AC.

SQ 17.6.8 **Why is the average power dissipated in a pure inductor zero?**

Reason

The inductor does not consume power; it stores energy in the magnetic field and returns it to the source during demagnetisation. This behaviour is due to the 90° phase difference between voltage and current.

Result

The instantaneous power is non-zero but the average power per cycle is zero.

SQ 17.6.9 **Why is an inductor useful for controlling AC?**

Answer

Since the inductor does not consume energy, it is used for controlling AC without consuming energy.

SQ 17.6.10 **A 400 mH coil carries 6 mA rms at 1 kHz. Find its inductive reactance.**

Solution

$X_L = 2\pi f L = 2 \times 3.14 \times 1000 \times 400 \times 10^{-3}$

Result

$X_L = 2512\,\Omega$

SQ 17.6.11 **For the above coil, find the rms voltage across it.**

Solution

$V_{rms} = I_{rms} X_L = 6 \times 10^{-3} \times 2512$

Result

$V_{rms} = 15\,\text{V}$

TOPIC 7 Choke

SQ 17.7.1 **Define a choke.**

Definition

A choke is a coil of thick copper wire wound closely in a large number of turns over a soft iron laminated core.

SQ 17.7.2 **How is a choke modelled?**

Answer

A choke is often modelled as a series RL-circuit, consisting of a resistor with a very small value of resistance in series with an inductor of quite large inductance.

SQ 17.7.3 Why is the inductance of a choke coil very high?

Reason

The inductance of the choke coil is very high due to the high permeability of the iron core on which the choke coil is wound.

SQ 17.7.4 Why is almost no power dissipated by a choke coil?

Reason

As the resistance of a choke coil is negligibly small, the power factor of the choke coil is almost zero, and the phase difference between current and voltage is nearly 90°.

Result

Practically no power is dissipated as heat by a choke coil.

SQ 17.7.5 How is a choke used with different frequencies?

Answer

A choke is used to block high frequency AC while allowing DC and low frequency AC to pass.

SQ 17.7.6 Give the applications of choke coils in electronic circuits.

Applications

Choke coils filter out high frequency AC noise from electronic circuits, ensuring a cleaner DC output.

They are essential in switch-mode power supplies, helping to regulate voltage and filter out switching noise.

They prevent unwanted radio frequency signals from leaking out of circuits.

SQ 17.7.7 How is a choke used in a fluorescent light?

Answer

Chokes in fluorescent lights generate transient voltages across the tube, making it conducive to the breakdown voltage of the gas inside.

SQ 17.7.8 How do choke coils protect insulation?

Answer

Choke coils can limit the rate of current changes in circuits, preventing damage to insulation from sudden surges.

TOPIC 8 AC Through a Capacitor

SQ 17.8.1 Why does a capacitor not allow direct current to pass?

Reason

A capacitor does not allow direct current to pass through it because of the presence of an insulating medium between its plates.

SQ 17.8.2 Why can alternating current pass through a capacitor?

Reason

When an alternating voltage is applied, the capacitor is charged in one direction and then in the other as the voltage reverses. Electrons move to and fro around the circuit connecting the plates, thus constituting alternating current.

SQ 17.8.3 Why is a capacitor called a reactive component?

Reason

Unlike a resistor, a capacitor behaves differently in AC and DC circuits, because a capacitor can store energy in the form of an electric field, whereas a resistor cannot store electrical energy in any form.

SQ 17.8.4 Derive the current through a capacitor connected to an AC source.

Derivation

Since

$q = CV = CV_0 \sin \omega t$

and

$I = \dfrac{\Delta q}{\Delta t}$

therefore

$I = \omega C V_0 \cos \omega t$

Result

$I = I_0 \sin\left(\omega t + \dfrac{\pi}{2}\right) \qquad \text{where} \qquad I_0 = \omega C V_0$

SQ 17.8.5 What is the phase relationship in a purely capacitive circuit?

Answer

In a capacitor the current leads the voltage by 90° or $\dfrac{\pi}{2}$ radian.

SQ 17.8.6 Define capacitive reactance and write its formula.

Definition

The opposition offered by a capacitor to alternating current is called capacitive reactance.

Formula

$X_C = \dfrac{V_{rms}}{I_{rms}} = \dfrac{1}{\omega C} = \dfrac{1}{2\pi f C}$

Its unit is the ohm.

SQ 17.8.7 How does frequency affect capacitive reactance?

Answer

For low frequencies the capacitor has a large reactance and the current is small, whereas at high frequencies the reactance is small and the current through the same capacitor is large.

SQ 17.8.8 Who is known as the father of alternating currents?

Answer

Nikola Tesla, born in 1856 in Austria-Hungary, pioneered the generation, transmission and use of alternating current, which can be transmitted over much greater distances than direct current.

TOPIC 9 Impedance

SQ 17.9.1 Define impedance.

Definition

In AC circuits the opposition to current flow is called impedance, denoted by Z. The combined effect of resistance and reactances in such circuits is known as impedance.

SQ 17.9.2 **What is reactance?**

Definition

Reactance is the opposition to current flow due to capacitors, that is capacitive reactance, and inductors, that is inductive reactance.

SQ 17.9.3 **Write the formula and unit of impedance.**

Formula

$Z = \frac{V_{rms}}{I_{rms}}$

SI Unit

The SI unit of impedance is the ohm.

SQ 17.9.4 **What does a pure resistive circuit have?**

Answer

A pure resistive circuit has only resistance R and no reactance.

SQ 17.9.5 **An AC circuit has a peak voltage of 200 V and peak current of 10 A. Find its impedance.**

Solution

The rms values are
$V_{rms} = 141.4\,\text{V}$
and
$I_{rms} = 7.07\,\text{A}$

Calculation

$Z = \frac{141.4}{7.07}$

Result

$Z = 20\,\Omega$

TOPIC 10 AC Through RC-Series Circuit

SQ 17.10.1 **Why is the same current used for R and C in a series circuit?**

Reason

As R and C are connected in series, the same current flows through each of them.

SQ 17.10.2 **Write the potential differences across R and C in an RC-series circuit.**

Formulas

$V_R = I_{rms} R$

$V_C = I_{rms} X_C = \frac{I_{rms}}{\omega C}$

The voltage V_R is in phase with the current, while V_C lags behind the current by $\frac{\pi}{2}$.

SQ 17.10.3 **Derive the applied voltage in an RC-series circuit.**

Derivation

The applied voltage is the vector resultant of V_R and V_C.

Result

$V_{rms} = \sqrt{V_R^2 + V_C^2} = I_{rms}\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$

SQ 17.10.4 **Write the impedance of an RC-series circuit.**

Formula

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

SQ 17.10.5 **What is an impedance diagram?**

Definition

The resistance R is represented by a horizontal line in the direction of the current, and the reactance X_C by a line lagging the R-line by 90°. The impedance Z is obtained by the vector summation of resistance and reactance.

SQ 17.10.6 **Write the phase angle of an RC-series circuit.**

Formula

$\theta = \tan^{-1}\left(\frac{X_C}{R}\right) = \tan^{-1}\left(\frac{1}{2\pi f C R}\right)$

SQ 17.10.7 **Where is power consumed in an RC-series circuit?**

Answer

The power consumed is primarily due to the resistor, as the capacitor only stores energy and does not dissipate it.

Formula

$P = I^2 R = VI\cos\theta$

SQ 17.10.8 **A 5 kΩ resistor and 5 μF capacitor are in series across 50 Hz AC. Find the phase angle.**

Solution

$\theta = \tan^{-1}\left(\frac{1}{2\pi f C R}\right) = \tan^{-1}\left(\frac{1}{2 \times 3.14 \times 50 \times 5 \times 10^{-6} \times 5000}\right)$

Result

$\theta = 32.5^\circ$

TOPIC 11 AC Through RL-Series Circuit

SQ 17.11.1 **Write the impedance of an RL-series circuit.**

Formula

$Z = \sqrt{R^2 + (\omega L)^2} = \sqrt{R^2 + X_L^2}$

SQ 17.11.2 **Write the phase angle of an RL-series circuit.**

Formula

$\theta = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{2\pi f L}{R}\right)$

SQ 17.11.3 **Write the power consumed in an RL-series circuit.**

Formula

$P = VI\cos\theta$
Here θ is the phase angle between voltage and current.

SQ 17.11.4 **Define power factor.**

Definition

The factor $\cos\theta$ in the expression
$P = VI\cos\theta$
is known as the power factor.

SQ 17.11.5 What is inverter efficiency?

Definition

When we convert DC power into AC power, we have to account for a quantity known as inverter efficiency, which is usually 85% to 90%.

Formula

$P_{ac} = (\text{Inverter efficiency}) \times P_{dc}$

TOPIC 12 Rectification

SQ 17.12.1 Define rectification.

Definition

Rectification is the process of converting alternating current into direct current.

SQ 17.12.2 Why can a diode be used for rectification?

Reason

A diode allows a large current to flow when forward biased, however the current through a reverse biased diode is practically zero. It is due to this property that a diode can be used for rectification.

SQ 17.12.3 Name the two types of rectification.

Types

Half-wave rectification and full-wave rectification.

SQ 17.12.4 Where is rectification commonly used?

Answer

Rectification is commonly used in electronic devices that require a stable DC power source, such as computers and smartphones, as most household and commercial power is AC.

SQ 17.12.5 Explain the working of a half-wave rectifier.

Working

During the positive half-cycle the diode is forward biased, so it offers a very low resistance and current flows through the load resistance.
During the negative half-cycle the diode becomes reverse biased and offers a very high resistance, so practically no current flows.

SQ 17.12.6 What is the nature of the output of a half-wave rectifier?

Answer

The current across the load flows in only one direction, which means it is direct current. However, this current flows in pulses.

SQ 17.12.7 Define full-wave rectification.

Definition

Rectification during which both halves of the alternating input voltage are converted into unidirectional current through a resistance is called full-wave rectification.

SQ 17.12.8 How is full-wave rectification achieved?

Answer

Full-wave rectification is achieved by a bridge rectifier, in which four individual rectifying diodes are connected in a closed loop bridge configuration.

Arrangement

The four diodes are arranged in series pairs, with only two diodes conducting current during each half-cycle.

SQ 17.12.9 How does a capacitor smooth the rectified output?

Answer

The smoothing capacitor converts the full-wave rippled output of the rectifier into a more smooth DC output voltage, because the capacitor acts like a storage device.

SQ 17.12.10 What determines the maximum ripple voltage in a full-wave bridge rectifier?

Answer

The maximum ripple voltage is not determined by the value of the smoothing capacitor, but by the frequency and the load current.

Formula

$V_{ripple} = \frac{I_{DC}}{2fC}$

SQ 17.12.11 What is the ripple frequency of a full-wave rectifier?

Answer

The ripple frequency is twice that of the input frequency, that is
$f_{ripple} = 2f$

SQ 17.12.12 Why do cell phones store DC and not AC?

Answer

Cell phone batteries store DC because it is easier to store DC than AC, and DC is also safer. The electric grid provides AC only, so the AC is converted to DC using a rectifier before charging.

TOPIC 13 Self-Induction

SQ 17.13.1 Define self-induction.

Definition

When the current through a coil changes, the magnetic flux through the coil also changes, which finally induces an emf in the coil itself. This phenomenon is called self-induction.

SQ 17.13.2 Write the relation defining self-inductance.

Formula

$N\phi = LI$

Here L is the constant of proportionality called the self-inductance of the coil.

SQ 17.13.3 On what factors does self-inductance depend?

Factors

The number of turns of the coil.
The area of cross-section of the coil.
The core material, since winding the coil around a ferromagnetic iron core increases the magnetic flux and hence the inductance significantly.

SQ 17.13.4 **Write the emf induced in a coil by self-induction.**

Formula

$\varepsilon_L = -L\dfrac{\Delta I}{\Delta t}$

SQ 17.13.5 **What does the minus sign in the self-induction equation indicate?**

Answer

The minus sign indicates that the induced emf opposes the applied voltage.

SQ 17.13.6 **Define one henry.**

Definition

If the emf induced in a coil is $1\,\mathrm{V}$ when the current flowing through it changes at the rate of $1\,\mathrm{A\,s^{-1}}$, the coil has a self-inductance of 1 henry.

Unit

The SI unit of self-inductance is $\mathrm{V\,s\,A^{-1}}$.

SQ 17.13.7 **Write the energy stored in an inductor.**

Formula

$U_m = \dfrac{1}{2}LI^2$

SQ 17.13.8 **Why can the energy stored in an inductor never be negative?**

Reason

Energy is stored in the magnetic field and is proportional to the square of the current. The inductor stores energy while absorbing power and returns it when delivering power, so the net energy transfer can never be negative.

SQ 17.13.9 **Write the energy density inside a solenoid.**

Formula

$\dfrac{U_m}{\text{volume}} = \dfrac{B^2}{2\mu_0}$

SQ 17.13.10 **Write the self-inductance of a solenoid.**

Formula

$L = \mu_0 n^2 A l$

Here n is the number of turns per unit length, A is the area of cross-section and l is the length of the solenoid.

TOPIC 14 Mutual Induction

SQ 17.14.1 **Define mutual induction.**

Definition

The phenomenon in which a changing current in one coil induces an emf in another coil is called mutual induction.

SQ 17.14.2 **Describe the arrangement used to demonstrate mutual induction.**

Arrangement

One coil connected with a battery through a switch and a rheostat is called the primary coil, and the other one connected to a galvanometer is called the secondary coil.

SQ 17.14.3 **Explain how an emf is induced in the secondary coil.**

Explanation

If the current in the primary is changed by varying the resistance of the rheostat, the magnetic flux in the surrounding region changes.

Result

Since the secondary coil is in the magnetic field of the primary, the changing flux also links with the secondary, causing an induced emf.

SQ 17.14.4 **Write the relation defining mutual inductance.**

Formula

$N_s\phi_s = MI_p$

$M = \dfrac{N_s\phi_s}{I_p}$

Here M is the mutual inductance of the two coils.

SQ 17.14.5 **Write the emf induced in the secondary coil.**

Formula

$\varepsilon_s = -M\dfrac{\Delta I_p}{\Delta t}$

SQ 17.14.6 **On what factors does mutual inductance depend?**

Factors

The number of turns of both the primary and secondary coils.
The area of cross-section of the two coils.
The magnetic permeability of the medium between the coils.
The nature of the material on which the coils are wound.
The distance and orientation between the two coils.