CHAPTER 7	PHYSICS ELECTROMAGNETIC INDUCTION

Part three: Subjective Question



Question # 1

Explain Electromagnetic induction ?

Answer:

It is a process in which we place a conductor in changing magnetic field to induce an electromotive force (Usually called as voltage) which further induces electric current. This can be accomplished by either moving a conductor inside a stationary field or by continuously changing field around a fixed conductor.

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Question # 2

Explain induced current ?

Answer:

The current induced in a conducting loop that is exposed to a changing magnetic field is known as induced current.

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Question # 3

State faraday's law in words and write down a mathematical relationship.

Answer:

The emf, ε, produced around a loop of conductor is proportional to the rate of change of the magnetic flux, φ, through the area, A, of the loop. This can be stated mathematically as:

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$$

where $\phi = B \cdot A$ and B is the strength of the magnetic field

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Question # 4

What is the name of phenomenon of generating induced emf ?

Answer:

Electromagnetic Induction

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Question # 5

Which type of voltage source is needed to produce an induced emf ?

Answer:

The induced emf can be produced by changing the flux, the magnetic induction and area enclosed by the coil.

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Question # 6

Which law has explained the significance of faraday's of Electromagnetic induction? Sate that law ?

Answer:

When there is flux change through a coil, an induced emf produced in the coil and if the coil is closed, current flows through it called induced current.

Induced emf is proportional to negative rate of flux change.

$$e\alpha\frac{-\Delta\phi}{\Delta t}$$

$$e=-k\frac{\Delta\phi}{\Delta t}$$

Negative sign indicates that induced current always opposes the cause by which it has been produced.

k is constant.

$$e=-\frac{\Delta\phi}{\Delta t}$$

If the coil has 'N' terms,

$$e=-N\frac{\Delta\phi}{\Delta t}=-N\frac{d\phi}{dt}$$

$$|E|=N\frac{d\phi}{dt}$$

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Question # 7

What is meant by the following symbols used to represent the units:

a) V b) m^2 c) T d)wb

To Which physical quantities are they related ?

Answer:

V is the unit of voltage
m^2 is the unit of area
T(Tesla) is the unit of magnetic field
wb(weber) is the unit of magnetic flux

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Question # 8

List three real-life applications of faraday's law ?

Answer:

There are many application of Faraday's law in daily life, some of these are :

1) Magnetic flow meters and energy meters use faradays law of induction

2) Electrical generators and motors works on the principle as electromagnetic induction.

3) Security check at airports and railway stations.

4) Tape recorders use to record voices or to listen songs works on the principle of electromagnetic induction.

5) ATM cards and swiping machines are also the application of law of electromagnetic induction.

6) Transformers are works on the principle of electromagnetic production, which are used in different electrical and electronics appliances.

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Question # 9

A copper bar 30cm long is perpendicular to a field of 0.80 wb/m^2 and moves at right angles to the field at a speed of 0.50m/s. determine the emf induced in the bar.

Solution:

Length of copper bar = L = 30cm = 30/100 m = 0.30 m

Magnetic Field = B = 0.80 wb/m^2

Speed = v = 0.50 m/s

emf = Length of bar $\times$ Flux density $\times$ Speed

$\varepsilon = L \times v \times B$ = 0.30 $\times$ 0.80 $\times$ 0.50 = 0.12 Volts

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Question # 10

A single circular loop with a radius of 22cm is placed in a uniform external magnetic field with a strength of 0.50T so that the plane of the coil is perpendicular to the field. The coil is pulled steadily out of the field in 0.25s. find the average induced emf during this interval.

Solution:

Given

Radius = 22 cm = 0.22m

Magnetic Field = B = 0.50T

Time = t = 0.25s

Induced emf = $\varepsilon = -\frac{d\varphi}{dt} = -\frac{\Delta\varphi}{\Delta t} = ?$

Area of loop = A = $\pi r^2 = 3.141 \times (0.22)^2 = 0.1521\ m^2$

$$\varphi_1 = B \times A = 0.50 \times 0.1521 = 0.076\ Tm^2$$

$$\varphi_2 = 0$$

$$\varphi_1 - \varphi_2 = 0 - 0.076 = -0.076$$

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$$\varepsilon = -\frac{d}{dt}(\varphi_2 - \varphi_1)$$

$$\varepsilon = -\frac{-0.076}{0.25} = 0.304\ V$$

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Question # 11

A coil with 205 turns of wire a total resistance of 23Ω, and a cross sectional area of 0.25m^2 is proportional with its plane perpendicular to the field of a powerful electromagnet. What average current is induced in the coil during the 0.25s that the magnetic field drops from 1.6T to 0.0T ?

Solution:

Given

Number of turns = N = 205

Area = A = 0.25 m^2

Angle $= \theta = 0^o$

Time = t = 0.25s

Resistance = R = 23Ω

Change in Magnetic Field $= \Delta B = B_f - B_i = 0 - 1.6T = 0.16T$

$$\boldsymbol{emf = \varepsilon = -NAcos\theta . \frac{\Delta B}{\Delta t}}$$

$$\varepsilon = -205 \times 0.25 \times cos0 \times \frac{-1.6}{0.25} = 328V$$

$$I = \frac{\varepsilon}{R} = \frac{328}{23} = 14.26\ A$$

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Question # 12

A circular wire loop with a radius of 0.33m is located in an external magnetic field of strength +0.35T that is perpendicular to the plane of the loop. The field strength changes to –0.25T in 1.5s. The plus and minus signs for a magnetic field refer to opposite directions through the coil. Find the magnitude of the average induced emf during this interval.

Solution:

Given

Radius of the loop = R = 0.33m

Change in Magnetic Field $= \Delta B = B_f - B_i = 0.35 - (-0.25) = 0.60T$

Time = t = 1.5 s

Induced emf = $|\varepsilon| = \left|\frac{d\varphi}{dt}\right| = \left|\frac{\Delta\varphi}{\Delta t}\right| = ?$

Area of loop = $A = \pi r^2 = 3.141 \times (0.33)^2 = 0.3422\ m^2$

$$\varphi_1 = B \times A = 0.60 \times 0.3422 = 0.2053\ Tm^2$$

$$\varphi_2 = 0$$

$$\varphi_1 - \varphi_2 = 0.2053 - 0 = 0.2053$$

$$|\varepsilon| = \frac{0.2053}{1.5} = 0.14\ V$$

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Question # 13

A 50-loop circular coil has a radius of 3.0cm. it is oriented so that the field lines of a magnetic field are normal to the area of the coil. Suppose that the magnetic field is varied so that B increases from 0.10T to 0.35T in a time of 2.0milliseconds, find the average induced emf in the coil.

Solution:

Given

Number of turns = N = 50

Radius = 3cm = 0.03m

Angle $= \theta = 0^o$

Time = t = 2millisec = $2 \times 10^{-3} s$

Change in Magnetic Field $= \Delta B = B_f - B_i = 0.35 - 0.10T = 0.25T$

Area = $\pi r^2 = 3.142 \times (0.03)^2 = 2.8278 \times 10^{-3} m^2$

$$\boldsymbol{emf = \varepsilon = -NA cos\theta . \frac{\Delta B}{\Delta t}}$$

$$\varepsilon = -50 \times 2.8278 \times 10^{-3} m^2 \times cos0 \times \frac{0.25}{2 \times 10^{-3}} = -17.67V$$

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Question # 14

Determine the direction of the induced current in a coil using the lenz law.

Answer:

Lenz law states that the direction of the current induced in a conductor by a change in magnetic field is such that the magnetic field created by the induced current opposes the initial changing the magnetic field which produced it.

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Question # 15

A 30.0m length wire moves at 2.0m/s vertically over a strength of magnetic field 1.0T.

a) How much is the EMF induced in it ?
b) If the circuit resistance is 15.0Ω, how much current is in it ?

Solution:

L=30m
v=2m/s
B=1T
Induced emf,

$$e = BvL\sin\theta$$

$$e = 1 \times 2 \times 30\sin 90$$

$$e = 60V$$

(b)

$$R = 15\Omega$$

$$I = \frac{e}{R} = \frac{60}{15} = 4amp$$

Hence, current is 4A.

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Question # 16

A 505-turn circular- loop coil with a diameter of 15.5cm is initially aligned so that its plane is perpendicular to the earth's magnetic field. In 2.77ms the coil is rotated 90.0^0 so that its plane is parallel to earth's magnetic field.

If an average emf of 0.166V is induced in the coil, what is the value of earth's magnetic field ?

Solution:

Given

Number of turns = N = 505

Diameter = D = 15.5cm

Radius = r = $\frac{15.5}{2} = 7.75cm = \frac{7.75}{100}m = 0.0775m$

Change in Angle $= \Delta\theta = \Delta[cos90^o - cos0^o] = 0 - 1 = -1$

Time = t = 2.77 millisec = $2.77 \times 10^{-3}s$

Average emf = $\varepsilon = 0.166T$

Area = $\pi r^2 = 3.142 \times (0.0775)^2 = 1.89 \times 10^{-2}m^2$

Magnetic Field = B = ?

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$$\boldsymbol{emf = \varepsilon = -NA cos\theta . \frac{\Delta B}{\Delta t}}$$

$$\boldsymbol{B = \frac{\Delta t \times \varepsilon}{NA cos\theta}}$$

$$B = \frac{2.77 \times 10^{-3} s \times 0.166}{-505 \times 1.89 \times 10^{-2} m^2 \times -1} = 4.83 \times 10^{-5} T$$

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Question # 17

A circular coil consisting of 256 turns and a cut-off area of 0.0025m^2 is placed inside a uniform magnetic field of strength of 0.25T with a direction perpendicular to the plane of the coil. If the coil is pulled at a constant speed out of the field through 0.72s, calculate the amount of induced electromotive force generated in the coil.

Solution:

Given

Number of turns = N = 256

Area = A = 0.0025 m^2

Angle $= \theta = 0^o$

Time = t = 72s

Change in Magnetic Field $= \Delta B = B_f - B_i = 0.25 - 0 = 0.25$

$$\boldsymbol{emf = \varepsilon = -NA cos\theta . \frac{\Delta B}{\Delta t}}$$

$$\varepsilon = -256 \times 0.0025 \times cos0 \times \frac{0.25}{0.72} = -0.2V$$

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Question # 18

How can we apply lenz's law in motors ?

Answer:

Lenz's law also applies to electric motors. When an EMF is sent through a motor (aka, a current is passed through the armature of a motor) a force is produced that causes the armature to turn.

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Question # 19

A coil with 25turns of wire is wrapped around a hollow tube with an area of 1.8m^2. Each turn has the same area as the tube. A uniform magnetic field is applied at a right angle to the plane of the coil. If the field of increases uniformly from 0.00T in 0.85s, find the magnitude of the induced emf in the coil. If the resistance in the coil is 2.5 Ω find the magnitude of the induced current in the coil. Find the direction of the current in the loop shown in the diagram as the current in the straight wire:

a) increases b) decreases

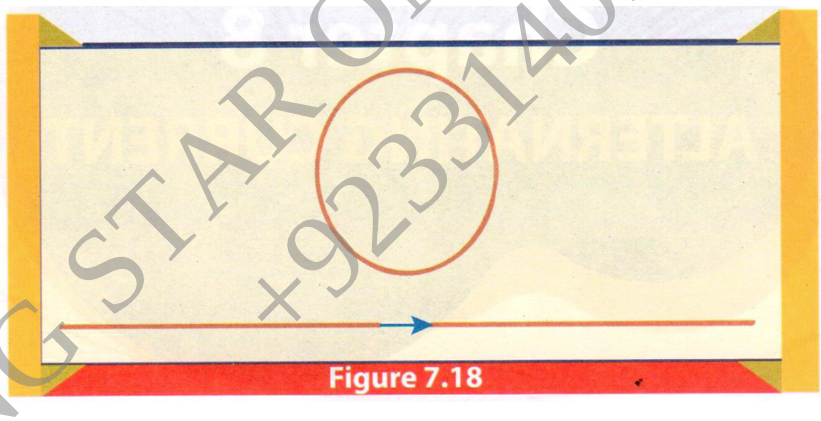


Figure 7.18

Solution:

Given

Number of turns = N = 25

Area = A = 1.8m^2

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Angle $= \theta = 0^o$

Time = t = 0.85s

Resistance = R = 2.5Ω

Induced Current = I = ?

Change in Magnetic Field $= \Delta B = B_f - B_i = 0.55 - 0 = 0.55$

$$\boldsymbol{emf = \varepsilon = -NA cos\theta . \frac{\Delta B}{\Delta t}}$$

$$\varepsilon = -25 \times 1.8 \times cos0 \times \frac{0.55}{0.85} = -29V$$

$$I = \frac{\varepsilon}{R} = -\frac{29}{2.5} = -11.6 \; or \; -12V$$

(a) Clockwise Direction
(b) Anticlockwise Direction

Explanation:

Due to the straight current carrying wire and given direction of current, magnetic flux through the loop is in out of the page. When current start to increase, the flux through the coil also start to increase, to oppose this change in flux a current will be induced in **clockwise direction** in the loop.

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Question # 20

The magnet in the figure below induces an emf in the coils as the magnet moves towards the right or the left. Find the directions of the induced currents through the resistors when the magnet is moving :-

a) Toward the right b) towards the left

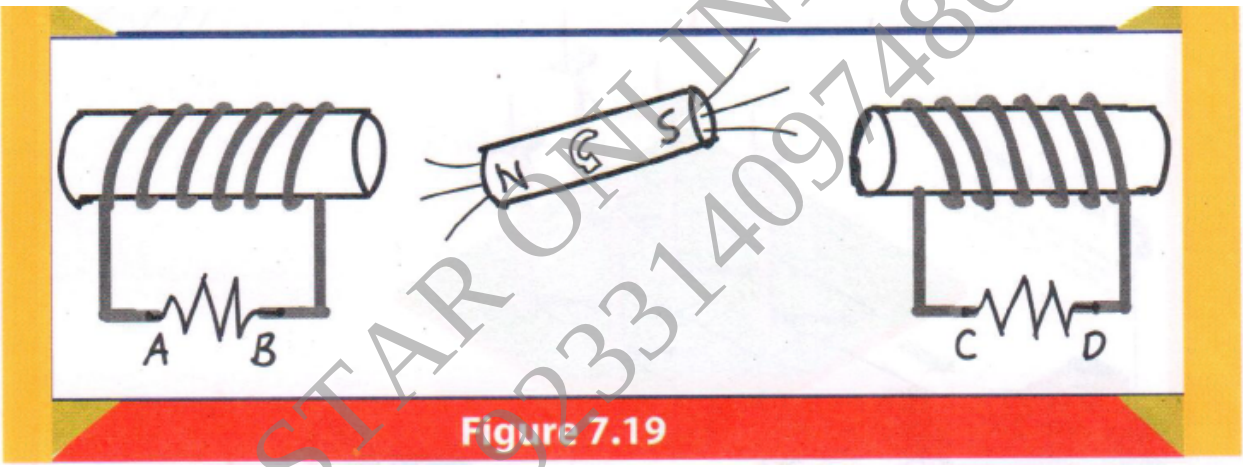


Figure 7.19

Answer:

(a) When magnet is move toward left, the flux linked to the coil increased. Thus according to Lenz's law, the current flows in the coil in such a direction which opposes the increased flux linked with the coil. Thus current flows from B to A.

(b) Here the south pole of the magnet moves toward coil, the face of the coil facing south-pole should repel the south pole of the magnet. For this current should flow from D to C.

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