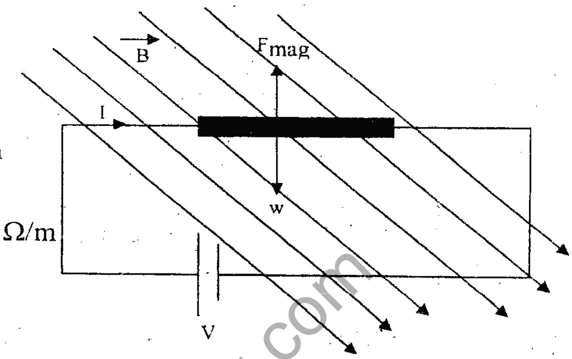
14.22 SOLVED NUMERICALS OF BOOK:

PROBLEM # 14.1:

A horizontal straight wire 5cm long weighing $1.2gm^{-1}$ is placed perpendicular to a uniform horizontal field of 0.6 Weber m^{-2}. If the resistance of the wire is $3.8\ \Omega\ m^{-1}$, calculate the potential difference to be applied between the ends of the wire to make I just self supporting.



Data:

L = 5 cm = 0.05m

Linear density of wire = 1.2 g/m

B = 0.6 Weber/m^2

Resistance Per unit length = 3.8 Ω/m

$\theta = 90^0$

V= ?

Solution:

Mass of 1m long wire = 1.2g

Mass of 0.05m long wire = 1.2 x 0.05

m = 0.06g

OR $m = 6x10^{-5}kg$

Resistance of 1m long wire = 3.8Ω

Resistance of 0.05m long wire = 3.8 x 0.05

R = 0.19Ω

Wire will remain self supported, if and only if F_{mag} = weight of wire

$$BIL\ Sin\theta = mg$$

$$\frac{BVL\ Sin\theta}{R} = mg$$

$$V = \frac{mgR}{BL\ Sin\theta}$$

$$V = \frac{6x10^{-5}x9.8x0.19}{0.6\ x0.05x\ Sin90^0}$$

$$\boxed{V = 3.72\ x\ 10^{-3}\ V}$$

PROBLEM # 14.2:

A cathode ray tube is set up horizontally with its axis N-S and surrounded by a magnetic shield. If the voltage across the tube is 900 Volts, the distance from electron gun to the screen is 10cm and vertical component of earth's field is 0.45×10^{-4} Weber-m^{-2} calculate by how much the spot on the screen will move when the magnetic shield is removed.

Charge to Mass Ratio of Electron

$$\left[\text{Given } \frac{e}{m} = 1.8 \times 10^{11} \text{C kg}^{-1}\right]$$

Data:

$V = 900V$

$b = 10cm = 0.1m$

$B = 0.45 \times 10^{-4}$ Weber/m^2

$\frac{e}{m} = 1.8 \times 10^{11}$ c/kg

$a = ?$

Solution:

$$\frac{e}{m} = \frac{2V}{B^2 r^2}$$

$$1.8 \times 10^{11} = \frac{2 \times 900}{(0.45 \times 10^{-4})^2\, r^2}$$

$$r^2 = \frac{1800}{(0.45 \times 10^{-4})^2\, 1.8 \times 10^{11}}$$

$$r^2 = 4.94$$

$$r = 2.22m$$

$$r = \frac{b^2}{2a}$$

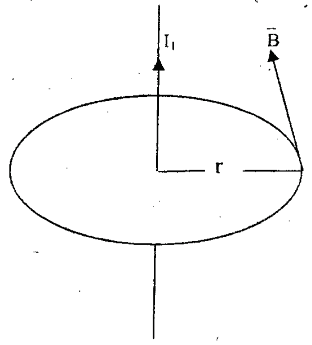
$$a = \frac{b^2}{2r}$$

$$a = \frac{(0.1)^2}{2 \times 2.22}$$

$$\boxed{a = 2.25 \times 10^{-3} m}$$

PROBLEM # 14.3:

What is the flux density at a distance of 0.1m in air from a long straight conductor carrying a current of 6.5 ampere? Hence calculate the force per meter on a similar parallel conductor at a distance of 0.1m from the first and carrying a current of 3 amperes. Will the wire attract or repel each other If the direction of current in two wire is opposite to each other. Explain how the expression of force between two such conductors is used to define ampere.



Data: **(i)** $B = ?$

$r = 0.1m$

$I_1 = 6.5A$

(ii) $F_{12} = ?$

$I_2 = 3A$

$\theta = 90^0$

$L = 1m$

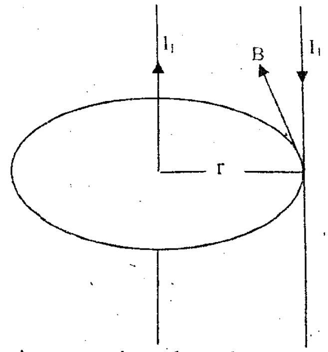
(iii) Type of force = ?

(iv) Definition of one ampere = ?

(i) $B = \frac{\mu_0 I_1}{2\pi r}$

$$B = \frac{{}^{2}\cancel{4}\pi \times 10^{-7} \times 6.5}{\cancel{2}\pi \times 0.1}$$

$$\boxed{B = 13 \times 10^{-6}\ \text{weber/m}^2}$$



(ii) $F_{12} = BI_2\, L\, \text{Sin}\theta$

$F_{12} = 13 \times 10^{-6} \times 3\text{x}1 \times \text{Sin}90^0$

$\boxed{F_{12} = 39\text{x}10^{-6}\ \text{N}}$

(iii) As the direction of current in both wire is opposite, therefore, wires will repel each other.

(iv) $F_{12} = BI_2\, L\, \text{Sin}\theta$

$$F_{12} = \frac{\mu_0 I_1}{2\pi r} I_2\, L\, \text{Sin}\theta$$

$$I_1\, I_2 = \frac{F_{12} \times 2\pi r}{\mu_0\ \text{Sin}\theta}$$

$$I_1\, I_2 = \frac{2 \times 10^{-7} \times 2\pi \times 1}{4\pi \times 10^{-7} \times \text{Sin}90^{\circ}}$$

$I_1\, I_2 = 1$

If a current carrying wire is placed perpendicularly in a magnetic field of another similar parallel wire at a distance of 1m in air and if its unit length acted upon by a force of 2×10^{-7} newton, then current passing through each wire is said to be of one ampere.

PROBLEM # 14.4:

A straight metal rod 50cm long can slide with negligible friction on parallel conducting rails. It moves at right angle to a magnetic field 0.72 Weber m^{-2}. The rails are joined to a battery of emf 3Volts and a fixed series resistance of 1.6Ω. Find the force required to hold the rod at rest.

Data:

$L = 50\text{cm} = 0.5\text{m}$
$\theta = 90^0$
$B = 0.72\ \text{Weber/m}^2$
$V = 3V$
$R = 1.6\Omega$
$F = ?$

Solution:

The rod will remain rest, when

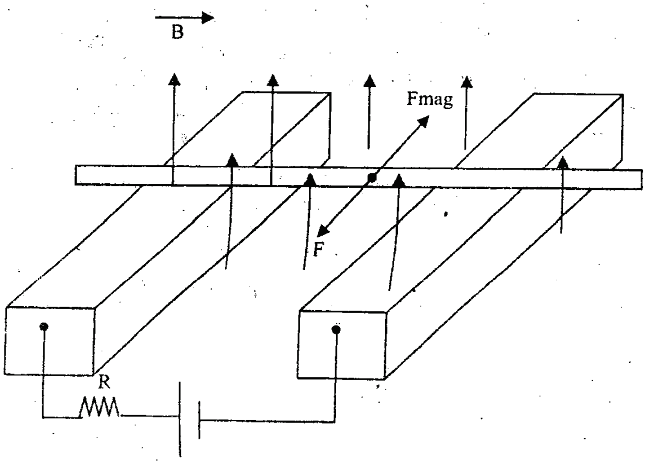
$F = F_{mag}$

$F = BIL\ Sin\theta$

$$F = \frac{BVL\ Sin\theta}{R}$$

$$F = \frac{0.72 \times 3 \times 0.5 \times \text{Sin } 90^{\circ}}{1.6}$$

$\boxed{F = 0.675\ \text{N}}$



PROBLEM # 14.5:

It is required to produce inside a toroid a field of 2×10^{-3} Weber $-m^{-2}$. The toroid has a radius of 15cm and 300 turns. Find the current required for this purpose. If toroid is wound on an iron core of permeability 300 times the permeability of free space, what increase in B will occur for the same current?

Data:

(i) $B = 2 \times 10^{-3}$ Weber/m^2

$r = 15cm = 0.15\,m$

$N = 300$ turns

$I = ?$

(ii) $\mu_r = 300\mu_0$

$B' = ?$

Solution:

(i) $B = \dfrac{\mu_0 NI}{2\pi r}$

$$2\times10^{-3} = \frac{{}^{2}\cancel{4}\pi \times 10^{-7} \times 300\,I}{\cancel{2}\pi \times 0.15}$$

$$2 \times 10^{-3} = 4 \times 10^{-4}\, I$$

$$\boxed{I = 5A}$$

(ii) $B' = \dfrac{\mu_r NI}{2\pi r}$

$$B' = 300\frac{\mu_0 NI}{2\pi r}$$

$$\boxed{B' = 300\,B}$$

PROBLEM # 14.6:

A proton is accelerated by a potential of 6×10^5 Volts. It then enters in uniform field $B = 0.3$ Weber $-m^{-2}$ in a direction making an angle of 45^0 with the magnetic field, what will be the radius of the circular path?

Data:

$e = +1.6\times10^{-19}\,c$

$m = +1.67\times10^{-27}\,kg$

$V = 6\times10^{-5}\,V$

$B = 0.3$ Weber/m^2

$\theta = 45^0$

$r = ?$

Solution:

$$F_{mag} = F_c$$

$$evB\,Sin\theta = \frac{mv_y^{\,2}}{r}$$

$$e\cancel{v}B\,S\cancel{in}\theta = \frac{mv^2 Sin^2\theta}{r}$$

$$r = \frac{mv\,Sin\theta}{eB} \longrightarrow (1)$$

Determination of velocity:-

$$v = \sqrt{\frac{2eV}{m}}$$

$$v = \sqrt{\frac{2\times1.6\times10^{-19} \times 6\times10^5}{1.67 \times 10^{-27}}}$$

$$v = 1.072 \times 10^7\ m/s$$

$$eq(1) \Rightarrow\ r = \frac{1.67 \times 10^{-27} \times 1.07 \times 10^7 \times Sin\,45^0}{1.6\times10^{-19} \times 0.3}$$

$$\boxed{r = 0.26\ m}$$

Self Test# (1):

Q.1 A proton accelerated through 1000 volts is projected normal to a 0.25 tesla magnetic field. Calculate the following:

(i) The kinetic energy of the proton on entering the magnetic field.

(ii) The radius of the circular path of the proton.

(Mass of proton = $m_p = 1.67 \times 10^{-27}$ Kg) **(2005)**

Ans. **[$r = 1.827 \times 10^{-2}$ m = 0.01827 m]**

Q.2 How fast must a proton of mass 1.67×10^{-27} kg be moving if it is to follow a circular path of radius 2cm in a magnetic field of 0.7 Tesla.

(Mass of proton = $M_P = 1.67 \times 10^{-27}$ kg) **(2004)**

Ans. **[$V = 1.3413 \times 10^6$ m/Sec.]**

Q.3 An electron is accelerated by the potential difference of 1000 volts. It then enters into a uniform magnetic field of induction B = 2.5 weber/m^2 at an angle of 45^0 with the direction of the field; find the radius of the path described by the electron.

($e = -1.6 \times 10^{-19}$C, mass of electron $= 9.1 \times 10^{-31}$Kg) **(2001)**

Ans. **[$V_2 = 1.87 \times 18$m/s, $r = 3 \times 10^{-5}$m]**

Q.4 Calculate the speed of electron entering perpendicularly in a uniform magnetic field of 5 w/m^2 which moves along a circle of radius 1.8×10^{-8}m in the field.

$\left(\frac{e}{m} = 1.76 \times 10^{11} \text{C/Kg.}\right)$ **(2002 P.E)**

Ans. **[V = 1.5841 m/s]**

PROBLEM # 14.7:

Two parallel metal plates separated by 5cm of air have a potential difference of 220 Volts. A magnetic field $B = 5 \times 10^{-3}$ Weber –m^{-2} is also produced perpendicular to electric field. A beam of electrons travels undeflected through crossed electric and magnetic fields. Find the speed of electrons.

Data:

d = 5cm = 0.05m

V = 220V

B = 5×10^{-3} Weber/m^2

v = ?

Solution:

$$v = \frac{E}{B} \quad \text{——— (1)}$$

but $E = \frac{V}{d}$

$$eq(1) \Rightarrow v = \frac{V}{dB}$$

$$v = \frac{220}{0.05 \times 5 \times 10^{-3}}$$

$$\boxed{v = 8.8 \times 10^5 \text{ m/s}}$$

PROBLEM # 14.8:

A coil of 50 turns wound a rectangular ivory frame 2cm x 4cm is pivoted to rotate in magnetic field of 0.2 Weber -m^{-2}. The face of the coil is parallel to the field. How much torque acts over the coil when a current of 0.5 amp passes through it? What will be the torque when the coil is rotated by 60^0 from its initial position?

Data:

N = 50 turns

A = 2cm x 4cm =8cm^2

A = 8×10^{-4} m^2

B = 0.2 Weber/m^2

I = 0.5 A

(i) $\alpha = 0^0$ (ii) $\alpha = 60^0$

$\tau = ?$ $\tau = ?$

Solution:

$\tau = BIAN \cos\alpha$

(i) $\tau = 0.2 \times 0.5 \times 8 \times 10^{-4} \times 50 \times \cos 0^0$

$\boxed{\tau = 0.004 \text{ Nm}}$

(ii) $\tau = 0.2 \times 0.5 \times 8 \times 10^{-4} \times 50 \times \cos 60^0$

$\boxed{\tau = 0.002 \text{ Nm}}$

Self Test# (2):

Q. A coil of 50 turns is wound on a ivory frame 3cm x 6cm which rotates in a magnetic field of induction B=2 weber/m^2.What will be the torque acting on it if a current of 5 amp passes through it and the place of coil makes an angle of 45^0 with the field. **(2003 P.E)**

Ans. [$\tau = 0.64$ Nm.]

PROBLEM # 14.9:

A cube 100cm of each side is placed in a uniform magnetic field of flux density 0.2 Weber –m^{-2} as shown in the diagram, wires A, C and D move in the directions indicated, each at the rate of 50cm -s^{-1} Determine the induced emf in each wire.

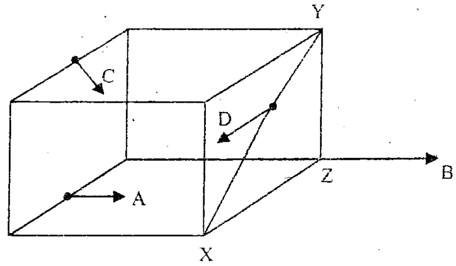
Date:

L = 100 cm = 1m
B = 0.2 weber /m^2
V = 50 cm/s = 0.5 m/s

(a) $\theta = 0^0$
$V_A = ?$

(b) $\theta = 45^0$
$V_c = ?$

(c) $\theta = 45^0$
$V_D = ?$



Solution:

$V = vBL \sin\theta$

(a) $V_A = 0.5 \times 0.2 \times 1 \times \sin 0^0$

$\boxed{V_A = 0}$

(b) $V_c = 0.5 \times 0.2 \times 1 \times \sin 45^0$

$V_c = 0.01 \times 0.707$

$\boxed{V_c = 0.0707 \text{ Volt}}$

(c) Determination of length of diagonal xy

$(xy)^2 = (xz)^2 + (yz)^2$

$(xy)^2 = 1^2 + 1^2$

$xy = \sqrt{2} \text{ m}$

$V_D = 0.5 \times 0.2 \times \sqrt{2} \times \sin 45^0$

$\boxed{V_D = 0.1V}$

PROBLEM # 14.10:

What is the mutual inductance of a pair of coils if a current change of 6 ampere in one coil causes the flux in the second coil of 2000 turns to change by 12×10^{-4} Weber?

Data:

$M = ?$

$\Delta I_p = 6A$

$\Delta\Phi = 12 \times 10^{-4}$ Weber

$N = 2000$ turns

Solution: $M = \dfrac{N\Delta\phi}{\Delta I_p}$

$M = \dfrac{2000 \times 12 \times 10^{-4}}{6}$

$M = 0.4$ henry

OR $\boxed{M = 400 \text{ mh}}$

Self Test# (3):

Q.1 What will be the mutual inductance of two coils when the change of a current of 3 amperes in one coil produces the change of flux of 6×10^{-4} Weber in the second coil having 2000 turns. **(2001)**

Ans. [m = 400mh]

Q.2 A pair of adjacent coils has a mutual inductance of 850mH. If the current in the primary coil changes from zero (0) to 20 Amp. in 0.1 sec. What is the change in the magnetic flux in the secondary coil of 800 turns. **(2009)**

Ans. [0.02125 Weber]

PROBLEM # 14.11:

An emf of 45 mV is induced in a coil of 500 turns. When the current in a neighbouring coil changes from 10 amperes to 4 amperes in 0.2 seconds.

(a) what is the mutual inductance of the coils ?

(b) What is the rate of change of flux in the second coil?

Data:

$E_s = 45\text{ mV} = 45 \times 10^{-3}\text{V}$

$N_s = 500$ turns

$\Delta I_p = 6$ A

$\Delta t = 0.2$ sec

(a) $M = ?$

(b) $\frac{\Delta\varphi}{\Delta t} = ?$

Solution:

(a) $E_s = \frac{M\Delta I_P}{\Delta t}$

$45\text{x}10^{-3} = \frac{M\text{x}6}{0.2}$

$M = \frac{45\text{x}10^{-3}\text{x}0.2}{6}$

$\boxed{M = 1.5\text{ mh}}$

(b) $E_s = \frac{N_s\Delta\varphi}{\Delta t}$

$\frac{\Delta\varphi}{\Delta t} = \frac{E_s}{N_s}$

$\frac{\Delta\varphi}{\Delta t} = \frac{45\text{x}10^{-3}}{500}$

$\boxed{\frac{\Delta\varphi}{\Delta t} = 9\text{x}10^{-5}\text{ Weber/sec}}$

Self Test# (4):

Q. An e.m.f. of 45 mille volts is induced in a coil of 500 turns, when the current in a neighbouring coil changes from 10 amperes to 14 amperes in 0.2 seconds.
(i) What is the mutual inductance of the coils? (2002 P.E)
(ii) What is the rate of change of flux?

PROBLEM # 14.12:

An iron core solenoid with 400 turns has a cross section area of 4.0cm^2 .Current of 2 amp passing through it produces B= 0.5 Weber-m^{-2}. How large an emf is induced in it. If the current is turned off in 0.1 second? What is the self inductance of solenoid.

Data:

$N = 400$ turns

$\Delta A = 4\text{ cm}^2 = 4 \times 10^{-4}\text{ m}^2$

$\Delta I = 2\text{A}$

$B = 0.5\text{ Weber/m}^2$

$\Delta t = 0.1$ sec

(a) $E = ?$

(b) $L = ?$

Solution:

(a) $\Delta\Phi = B\Delta A$

$E = \frac{N\Delta\varphi}{\Delta t}$

$E = \frac{NB\Delta A}{\Delta t}$

$E = \frac{400 \text{ x } 0.5 \text{ x } 4\text{x}10^{-4}}{0.1}$

$\boxed{E = 0.8\text{V}}$

(b) $L = \frac{N\Delta\phi}{\Delta I}$

$L = \frac{NB\Delta A}{\Delta t}$

$L = \frac{400\text{ x}0.5\text{x}4\text{x}10^{-4}}{2}$

$L = 0.04$ Henry

OR $\boxed{L = 40\text{ mh}}$

PROBLEM # 14.13:

The current in a coil of 325 turns is changed from zero to 6.32 amp. thereby producing a flux of 8.46×10^{-4} Weber. What is the self inductance of the coil?

Data:

$N = 325$ turns

$\Delta I = 6.32 - 0 = 6.32A$

$\Delta \Phi = 8.46 \times 10^{-4}$ Weber

$L = ?$

Solution:

$$L = \frac{N\Delta\phi}{\Delta I}$$

$$L = \frac{325 \times 8.46 \times 10^{-4}}{6.32}$$

$L = 0.0435$ Henry

OR $\boxed{L = 43.5 \text{ mh}}$

Self Test# (5):

Q. The current in coil of 500 turns is changed from zero to 5.43A, there by producing a magnetic flux of 8.52×10^{-4} webers. What is the self inductance of coil.

Ans. **[$L = 7.845 \times 10^{-2}$ Henry]** *OR* **[$L = 78.45$ mH]**

PROBLEM # 14.14:

A 100 turns coil in a generator has an area of $500 cm^2$ rotates in a field $B = 0.06$ Weber-m^{-2} How fast must the coil be rotated in order to generate maximum Voltage of 150V?

Data:

$N = 100$ turns

$A = 500 cm^2 = 0.05 m^2$

$B = 0.06$ Weber/m^2

$V_o = 150$ V

$\omega = ?$

Solution:

$V_o = ABN\omega$

$$\omega = \frac{V_o}{ABN}$$

$$\omega = \frac{150}{0.05 \times 0.06 \times 100}$$

$\boxed{\omega = 500 \text{ rad/sec}}$

In revolution per second

$1 \text{ rev} = 2\pi \text{ rad}$

$$\omega = \frac{500}{2\pi}$$

$\boxed{\omega = 79.6 \text{ rev/sec}}$

In revolution per minute

$\omega = 79.6 \times 60$

$\boxed{\omega = 4777 \text{ rev/min}}$

PROBLEM # 14.15

A step down transformer at the end of a transmission line reduces the Voltage from 2400V to 1200V. The power out put is 9.0 KW and overall efficiency of the transformer is 95%. The primary winding has 400 turns. How many turns have the secondary coil what is the power input? What is the current in each of the coils?

Data:

$V_p = 2400V$

$V_s = 1200V$

$P_{output} = 9KW = 9000W$

$E = 95\%$

$N_p = 400$ turns

(a) $N_s = ?$

(b) $P_{input} = ?$

(c) $I_p = ?$

$I_s = ?$

Solution:

(a)

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{1200}{2400} = \frac{N_s}{400}$$

$$\frac{1}{2} = \frac{N_s}{400}$$

$$\boxed{N_s = 200 \text{ turns}}$$

$$E = \frac{\text{output}}{\text{input}} \times 100$$

$$95 = \frac{9000}{P_{input}} \times 100$$

$$P_{input} = \frac{900000}{95}$$

$$\boxed{P_{input} = 9473.7W}$$

$$P_{input} = V_p I_p$$

$$\boxed{9473.7 = 2400 I_p}$$

$$\boxed{I_p = 3.94A}$$

$$P_{output} = V_s I_s$$

$$9000 = 1200 I_s$$

$$\boxed{I_s = 7.5A}$$

Self Test# (6):

Q.1 A step-down transformer reduces 1100 volt to 220 volt. The power output is 12.5 KW and the over all efficiency of transformer is 90%. The primary winding has 1000 turns. How many turns does the secondary have? What is the power input? What is the current in each coil?

Ans. $\boxed{N_S = 200 \text{ Turns}}$ $\boxed{P_P = P_{input} = 13.89 \text{ KW}}$

$\boxed{I_P = 12.63 \text{ Amp.}}$ $\boxed{I_S = 56.81 \text{ Amp.}}$

Q.2 A step-down transformer having 4000 turns in primary is used to convert 4400 volts to 220 volts. The efficiency of the transformer is 90% and 9 KW output is required. Determine the input power, the number of turns in the secondary coil and the current in the primary and secondary coils.

Ans. $N_S = 200$ Turns $\quad P_P = P_{input} = 10^4 w = 10KW$

$I_P = 2.27$ Amp. $\quad I_S = 40.91$ Amp.

PROBLEM # 14.16:

The overall efficiency of a transformer is 90%. The transformer is rated for an output of 12.5 KW. The primary Voltage is 1100 V and the ratio of primary to secondary turns is 5:1.The iron losses at full load are 700 watts. The primary coil has a resistance of 1.82 ohms.

(a) How much power is lost because of the resistance of the primary coil?

(b) What is the resistance of the secondary coil?

Data:

$E = 90\%$

$P_{output} = 12.5 \text{ KW} = 12500 \text{ W}$

$V_p = 1100 \text{ V}$

$\frac{N_p}{N_s} = \frac{5}{1}$

$P(loss)_t = 700 \text{ W}$

$R_p = 1.82\ \Omega$

(a) $P(loss)_p = ?$

(b) $R_p = ?$

Solution:

(a)

$P(loss)_p = I_p^2 R_p$ ——— (1)

$P_{input} = V_p I_p$ ——— (2)

$$E = \frac{Poutput}{Pinput} \times 100$$

$$90 = \frac{12500}{Pinput} \times 100$$

$P_{input} = 13888.9 \text{W}$

eq(2) $\Rightarrow 13.888.9 = 1100\, I_p$

$I_p = 12.62$ A

eq(1) $\Rightarrow P_{(loss)p} = (12.62)^2 \times 1.82$

$P_{(loss)p} = 290$ **W**

(b)

$P_{(loss)T} = P_{(loss)p} + P_{(loss)s}$

$700 = 290 + P_{(loss)s}$

$P_{(loss)s} = 410$ W

$P_{(loss)s} = I_s^2 R_s$

$$R_s = \frac{P_{(loss)s}}{I_s^2} \quad \text{——— (3)}$$

$P_{output} = V_s I_s$ ——— (4)

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\frac{V_s}{1100} = \frac{1}{5}$$

$V_s = 220\text{V}$

eq(4) $\Rightarrow 12500 = 220 I_s$

$I_s = 56.8A$

$$\text{eq(3)} \Rightarrow R_s = \frac{410}{(56.8)^2}$$

$R_s = 0.127\Omega$

14.23 SOLVED NUMERICALS OF PAPERS:

Q.1 An alternating current generator operating at 50Hz has coil of 200 turns, while the coil has an area 120cm². Calculate the magnetic field intensity to applied to rotate the coil to produce the maximum voltage of 240 volts. **(2011)**

Data:

$f = 50$ Hz
$N = 200$ turns
$A = 120cm^2 = 120 \times 10^{-4} m^2$
$= 1.2 \times 10^{-2} m^2$
$V_o = 240$ volt
$B = ?$

Solution:

$V_o = N\omega AB \sin\theta$
For maximum emf
$\theta = 90°$ and $\omega = 2\pi f$
$V_o = N(2\pi f)AB \sin 90°$
$V_o = 2\pi f NAB \times 1$

$$B = \frac{V_o}{2\pi fNA}$$

$$B = \frac{240}{2 \times 3.1415 \times 50 \times 200 \times 1.2 \times 10^{-2}}$$

$$B = \frac{240}{753.96}$$

B = 0.3183 web/m²

Self Test:

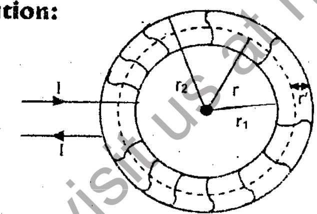
An alternating generator operates at 79Hz. The area of the coil is 500cm². Calculate the number of turns in the coil when a magnetic field of induction 0.06 web/m² produces maximum potential difference of 149Volts. **(2013)**

Q.2 The inner and outer diameter of the toroid are 22cm abd 26cm. If a current of 5.0 amp is passed which produces 0.025T flux density inside core, find the approximate length of the wire wound on the toriod ($\mu_o = 4\pi \times 10^{-7}$ Web/ amp m). **(2011)**

Data:

Inner diameter = d_1 = 22cm
Outer diameter = d_2 = 26cm
Current = I = 5 amp.
Flux density = B = 0.025T
$\mu_o = 4\pi \times 10^{-7}$ web/amp m
Length of wire = L = ?

Solution:



Inner radius = $r_1 = \frac{d_1}{2} = \frac{22}{2}$

$r_1 = 11$cm

Outer radius = $r_2 = \frac{d_2}{2} = \frac{26}{2}$

$r_1 = 13$cm

There fore

$$r = \frac{r_1 + r_2}{2}$$

$$r = \frac{11+3}{2} = \frac{24}{2}$$

$$r = 12cm = \frac{12}{100} m$$

r = 0.12cm
As for toroid

$$B = \frac{\mu_o NI}{2\pi r}$$

$$N = \frac{B.2\pi r}{\mu_o I}$$

$$N = \frac{0.025 \times 2\pi \times 0.12}{4\pi \times 10^{-7} \times 5}$$

$$N = \frac{3 \times 10^{-3}}{10 \times 10^{-7}}$$

$$N = \frac{3 \times 10^{-3}}{10^{-6}}$$

N = 3000 turn
Now radius of core of solenoid
$r' = r - r_1 = r_2 - r$
$r = 12 - 11$
$r = 1$cm Or $r' = 10^{-2}$m
Now for length of wire
$L = N \times 2\pi r'$
$L = 3000 \times 2 \times 3.1415 \times 10^{-2}$
L = 188.49m = 188.5m

Q.3 Find the current required to produce a field of induction $B = 2.512 \times 10^{-3}$ tesla in a 50cm long solenoid having 4000 turns of wire ($\mu_o = 4\pi \times 10^{-7}$ wb/A-m) **(2012)**

Data:

$B = 2.512 \times 10^{-3}$ T

$L = 50\text{cm} = \frac{50}{100}\text{m} = 0.5\text{m}$

$N = 4000$ turns $= 4 \times 10^3$ turns

$\mu_o = 4\pi \times 10^{-7}$ web/A-m

$I = ?$

Solution:

For Solenoid

$B = \mu_o n I$

But

$n = \frac{N}{L}$

$\therefore \quad B = \mu_o \frac{N}{L} I$

$I = \frac{BL}{\mu_o N}$

$I = \frac{2.512 \times 10^{-3} \times 0.5}{4\pi \times 10^{-7} \times 4 \times 10^3}$

$= \frac{1.256 \times 10^{-3}}{5.0264 \times 10^{-3}}$

$\boxed{I = 0.2498\text{A} = 0.25\text{A}}$

Q.4 An aeroplane flying in a region where the vertical component of earths magnetic field is 3.2×10^{-4} Tesla. If the wing span of the plane is 50m and its velocity is 360 km/hours. Find the induced e.m.f between the tips of the wings of the aeroplane. **(2007)**

Data: Length of wing span = L = 50m

Velocity of plane = $v = 360$ km/h $= \frac{360 \times 1000}{3600}$ m/sec. $= 10^2$ m/sec

Magnetic field $= B = 3.2 \times 10^{-4}$ T

E.M.F = V = ?

Solution:

As we know that

$V = vBL\sin\theta$

Where $\theta = 90°$

$\therefore \quad V = 10^2 \times 3.2 \times 10^{-4} \times 50 \sin(90°)$

$V = 3.2 \times 10^{-2} \times 50 \times 1$

$\boxed{V = 1.6 \text{ Volt}}$

Self Test (1)

Q.1 A long solenoid is wound with 35 turns in 10cm, and carries a current of 10 Amp. Find the magnetic field in it ($\mu_o = 4\pi \times 10^{-7}$ w/Am) **(2006)**

Ans. **[$B = 4.4 \times 10^{-3}$ web/m^2]**

Self Test (2)

Q.2 A long solenoid is wound with 10 turns per cm and carries a current of 10 amperes. Find the magnetic flux density in it.($\mu_0 = 4\pi \times 10^{-7}$weber/Am).

Ans. **[$B = 2.5 \times 10^{-3}$ T]**