PROBLEMS CH # 14

PRO.# 14.1 Find the value of the magnetic field that will cause a maximum force of 7.0×10^{-3} N on a 20.0 cm straight wire carrying a current of 10.0 A.

#SOLUTION # **Data**

Magnetic Force $= F = 7.0\times10^{-3}\,N$

current $= I = 10.0A$

Length of wire $= L = 20.0\,cm = 0.2\,m$

Magnetic Field $= B = ?$

The maximum magnetic force on a current carrying straight conductor is

$$F = BIL$$

$$\Rightarrow B = \frac{F}{IL} = \frac{7.0\times10^{-3}}{10.0\times0.2}$$

$$B = 3.5\times10^{-3}\,T$$

PRO. # 14.2 How fast must a proton move in a magnetic field of 2.50×10^{-3} T such that the magnetic force is equal to its weight?

#SOLUTION # **Data**

mass of proton $= m = 1.67\times10^{-27}\,kg$

charge on proton $= q = 1.6\times10^{-19}\,C$

Magnetic field $= B = 2.50\times10^{-3}\,T$

$g = 9.8\,m\,s^{-2}$

velocity of proton $= v = ?$

Since magnetic force on proton is equal to its weight. Therefore

$F_m = W$

$qVB = mg$

$\Rightarrow V = \dfrac{mg}{qB} = \dfrac{1.67\times10^{-27}\times 9.8}{1.6\times10^{-19}\times 2.50\times10^{-3}}$

$V = 4.09\times10^{-5}\,ms^{-1}$

PRO.# 14.3 A velocity selector has a magnetic field of 0.30T. If a perpendicular electric field of 10,000 Vm^{-1} is applied. What will be the speed of the particle?

#SOLUTION # -: Data :-

Magnetic Field $= B = 0.3\,T$

Electric Field $= E = 10{,}000\,Vm^{-1}$

Velocity of the particle $= V = ?$

According to velocity selector method

$V = \dfrac{E}{B} = \dfrac{10{,}000}{0.3} = 3.33\times10^{4}\,ms^{-1}$

PRO. # 14.4 A coil of $0.1m\times0.1m$ and of 200 turns carrying a current of 1mA is placed in a uniform magnetic field of 0.1T. Calculate the maximum torque that acts on the coil.

#SOLUTION # -: Data :-

Area of the coil $= A = 0.1m\times0.1m$
$= 0.01m^2$

Number of turns $= N = 200$

Current $= I = 1mA = 1\times10^{-3}A$

magnetic field = $B = 0.1\,T$

Max. Torque $= \tau = ?$

The deflecting torque on a current carrying coil is given as

$$\tau = NIAB\cos\alpha$$

For max. torque $\alpha = 0$ and $\cos 0 = 1$

$$\therefore \quad \tau_{max} = NIAB$$

$$= 200 \times 1 \times 10^{-3} \times .01 \times 0.1$$

$$= 2.0 \times 10^{-4}\ Nm$$

PRO # 14.5

A power line 10.0 m high carries a current 200A. Find the magnetic field of the wire at the ground.

 # SOLUTION # :- DATA :-

Current $= I = 200\,A$

Distance of wire from ground $= r = 10.0\,m$

Magnetic field $= B = ?$

permeability $= \mu_o = 4\pi \times 10^{-7}\ wb\,A^{-1}m^{-1}$

According to Ampere's Law

$$B \times 2\pi r = \mu_o I$$

$$\Rightarrow B = \frac{\mu_o I}{2\pi r} = \frac{4\pi \times 10^{-7} \times 200}{2\pi \times 10}$$

$$= 4 \times 10^{-6}\ T$$

$$= 4\ \mu T$$

PRO # 14.6

You are asked to design a solenoid that will give a magnetic field of 0.10T, yet the current must not exceed 10.0A. Find the number of turns per unit length that the solenoid should have.

#SOLUTION # Data

magnetic field = $B = 0.10T$

Current = $I = 10.0A$

permeability = $\mu_o = 4\pi \times 10^{-7}\ wb\ A^{-1} m^{-1}$

Number of turns per unit length = $n = ?$

$\because \quad B = \mu_o n I$

$$\Rightarrow \quad n = \frac{B}{\mu_o I} = \frac{0.10}{4\pi \times 10^{-7} \times 10}$$

$$n = 7.96 \times 10^{3}$$

PROB # 14.7

what current should pass through a Solenoid that is 0.5m long with 10,000 turns of Copper wire so that it will have a magnetic field of 0.4T?

#SOLUTION # -: Data :-

Length of Solenoid = $l = 0.5m$

Number of turns = $N = 10,000$

Magnetic Field = $B = 0.4T$

Current = $I = ?$

The magnetic field B inside a solenoid is

$B = \mu_o n I$

$$\Rightarrow B = \mu_o \frac{N}{l} I$$

$$\text{or } I = \frac{Bl}{\mu_o N} = \frac{0.4 \times 0.5}{4\pi \times 10^{-7} \times 10000}$$

$$I = 15.92\ A$$

$$I \simeq 16A$$

PROB # 14.8

A galvanometer having an internal resistance $R_g = 15.0\,\Omega$ gives full scale deflection with current $I_g = 20.0\ mA$. It is to be converted in to an ammeter of range $10.0A$. Find the value of shunt resistance.

#SOLUTION # - Data:-

Resistance of galvanometer $= R_g = 15.0\,\Omega$

Current through galvanometer $= I_g = 20.0\ mA$
$= 20.0 \times 10^{-3} A$

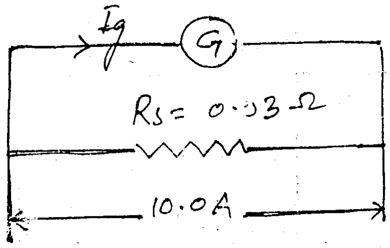
Range of Ammeter $= I = 10.0A$

Value of shunt resistance $= R_s = ?$

$$\because R_s = \frac{I_g}{I - I_g} \times R_g$$

$$= \frac{20.0 \times 10^{-3}}{10 - 20.0 \times 10^{-3}} \times 15$$

$$= 0.030\,\Omega$$



PROB # 14.9

The resistance of a galvanometer is 50.0 Ω and reads full scale deflection with a current of 2.0 mA. Show by diagram how to convert this galvanometer into voltmeter reading 200 V full scale.

#SOLUTION # -: Data :-

Resistance of galvanometer = R_g = 50.0 Ω

Full scale deflection current = I_g = 2.0 mA $= 2.0 \times 10^{-3}$ A

Voltage to be measured = V = 200 Volts

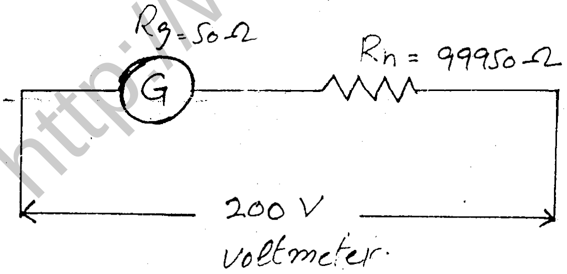
Series high resistance = R_h = ?

$$R_h = \frac{V}{I_g} - R_g$$

$$= \frac{200}{2 \times 10^{-3}} - 50$$

$$= 100000 - 50 = 99950\ \Omega$$

$$= 99.95\ k\Omega$$



PROB # 14.10

The resistance of the galvanometer coil is 10.0 Ω and reads full scale deflection with a current of 1 mA. What should be the values of resistances R_1, R_2 and R_3 to this galvanometer into a multirange ammeter of 100, 10.0 and 1.0 A As shown in fig.

SOLUTION # -: DATA:-

Resistance of galvanometer $= R_g = 10.0\,\Omega$

Full scale deflection current $= I = 1\,mA$

$= 1.0 \times 10^{-3} A$

currents to be measured $= I_1 = 100\,A$

$I_2 = 10.0\,A$

$I_3 = 1.0\,A$

Shunt Resistances - $R_1 = ?,\ R_2 = ?,\ R_3 = ?$

$$R_1 = \frac{I_g}{I_1 - I_g} \times R_g$$

$$R_1 = \frac{1.0 \times 10^{-3} \times 10}{100 - 1.0 \times 10^{-3}} = .0001\,\Omega$$

$$R_2 = \frac{I_g}{I_2 - I_g} \times R_g$$

$$R_2 = \frac{1.0 \times 10^{-3}}{10 - 1.0 \times 10^{-3}} \times 10 = .001\,\Omega$$

$$R_3 = \frac{I_g}{I_3 - I_g} \times R_g$$

$$R_3 = \frac{1.0 \times 10^{-3}}{1.0 - 1.0 \times 10^{-3}} \times 10 = .01\,\Omega$$