CHAPTER NO. 14(ELECTROMAGNETISM)

Question 14.1:- Find the value of the magnetic field that will cause a maximum force of 7.0 x 10^{-3} Non a 20.0 cm straight wire carrying a current of 10.0 A.

Solution:- Maximum force = F_{max} = 7.0 x 10^{-3} N

Length of wire = L = 20.0 cm = 0.20 m

Current = I = 10.0 A

Force on a current carrying wire = F = I L B sin α

For maximum force, α = 90° and sin α = 1

F_{max} = I L B

$B = \frac{F_{max}}{I\ L}$ = (7.0 x 10^{-3})/(10.0)(0.20)

B = 3.5 x 10^{-3} T

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

Solution:- Applied magnetic field = B = 2.50 x 10^{-3} T

Charge of proton = q = 1.60 x 10^{-19} C

Mass of proton = m = 1.67 x 10^{-27} kg

According to condition of the question: Magnetic force on proton = Weight of proton

q v B sin θ = m g

Since θ is not given in the question, we will consider it 90° for maximum force on moving proton.

q v B sin 90° = m g

$v = \frac{m\ g}{q\ B} = \frac{1.67\ x\ 10^{-27} x\ 9.8}{1.60\ x\ 10^{-19} x\ 2.50\ x\ 10^{-3}}$

v = 4.09 x 10^{-5} m s^{-1}

Question 14.3:- A velocity selector has a magnetic field of 0.30 T. If a perpendicular electric field of 10,000 V m^{-1} is applied, what will be the speed of the particle that will pass through the selector?

Solution:- Applied magnetic field = B = 0.30 T

Applied electric field = E = 10,000 V m^{-1}

In a velocity selector, only those particles pass through its un-deflected for which maximum magnetic force is equal to electric force.

q v B = q E

v B = E

v = E/B

v = 10,000/0.30

$v = 3.3 \times 10^4$ m s^{-1}

Question 14.4:- A coil of 0.1 m x 0.1 m and of 200 turns carrying a current of 1.0 mA is placed in a uniform magnetic field of 0.1 T. Calculate the maximum torque that acts on the coil.

Solution:- Length of coil = L = 0.1 m

Width of coil = W = 0.1 m

Area of cross section of coil = A = L x W = 0.1 x 0.1 = 0.01 m^2

Current through coil = I = 1.0 mA = 0.001 A

Applied magnetic field = B = 0.1 T

Number of turns of coil = N = 200

The torque applied by magnetic field on a current carrying coil is $\tau = N\,I\,B\,A\cos\alpha$

For maximum torque, angle α must be 0^o.

$\tau_{max} = N\,I\,B\,A$

$\tau_{max} = (200)\,(0.001)\,(0.1)\,(0.01)$

$\tau_{max} = 2 \times 10^{-4}$ N m

Question 14.5:- A power line 10.0 m high carries a current 200 A. Find the magnetic field of the wire at the ground.

Solution:- Height of power line = r = 10.0 m

Current in power line = I = 200 A

According to Ampere's law $\vec{B}.\overrightarrow{\Delta L} = \mu_o I$

$B\,\Delta L\cos\theta = \mu_o\,I$

Consider an Amperian loop in the form of circle of radius r = 10.0 m around the power line.

Since wire is straight, the magnetic field and length element both are along the tangent i.e. $\theta = 0^o$ and $\cos\theta = 1$.

Length of circular Amperian loop of radius r = $\Delta L = 2\,\pi\,r$

$B\,(2\,\pi\,r) = \mu_o\,I$

$B = \frac{\mu_o\,I}{2\,\pi\,r} = \frac{4\,x\,3.14\,x\,10^{-7}\,x\,200}{2\,x\,3.14\,x\,10}$

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

Question 14.6:- You are asked to design a solenoid that will give a magnetic field of 0.10 T, yet the current must not exceed 10.0 A. Find the number of turns per unit length that the solenoid should have.

Solution:- Required magnetic field = B = 0.10 T

Current passing through solenoid = I = 10.0 A

Magnetic field inside the solenoid = $B = \mu_o\,n\,I$

$n = \frac{B}{\mu_o I} = \frac{0.10}{4 \times 3.14 \times 10^{-7} \times 10.0}$

<u>$n = 7.96 \times 10^3$ turns m^{-1}</u>

Question 14.7:- What current should pass through a solenoid that is 0.5 m long with 10,000 turns of copper wire so that it will have a magnetic field of 0.4 T?

Solution:- Length of solenoid = L = 0.5 m

Number of turns of solenoid = N = 10,000

Required magnetic field inside solenoid = B = 0.4 T

$B = \mu_o n I = \mu_o \frac{N}{L} I$

$I = \frac{B L}{\mu_o N} = \frac{0.4 \times 0.5}{4 \times 3.14 \times 10^{-7} \times 10{,}000} = 15.96$ A

<u>I = 16.0 A</u>

Question 14.8:- A galvanometer having an internal resistance R_g = 15.0 Ω gives full scale deflection with current I_g = 20.0 mA. It is to be converted into an ammeter of range 10.0 A. Find the value of shunt resistance R_S.

Solution:- Internal resistance of galvanometer = R_g = 15.0 Ω

Full scale deflection current = I_g = 20.0 mA = 0.020 A

Range of ammeter = I = 10.0 A

$R_S = \frac{I_g R_g}{I - I_g} = \frac{(0.020)(15.0)}{10 - 0.020}$

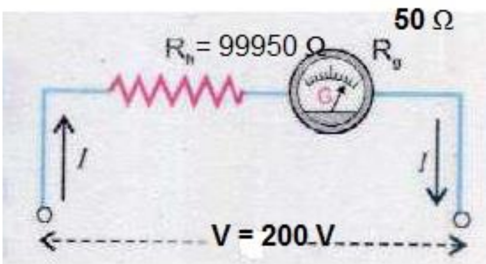
<u>R_S = 0.030 Ω</u>

Question 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 a diagram how to convert this galvanometer into voltmeter reading 200 V full scale.

Solution:- Internal resistance of galvanometer = R_g = 50.0 Ω

Full scale deflection current = I_g = 2.0 mA = 0.002 A

Range of voltmeter = V = 200 V



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

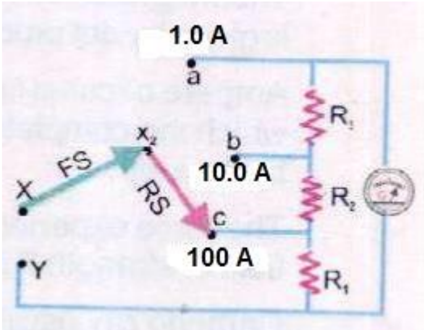
$R_h = \frac{200}{0.002} - 50.0$

<u>R_h = 99,950 Ω</u>

Question 14.10:- The resistance of a galvanometer coil is 10.0 Ω and reads full scale with a current of 1.0 mA. What should be the values of resistances R_1, R_2 and R_3 to convert this galvanometer into multirange ammeter of 100, 10.0 and 1.0 A as shown in the figure.

Solution:- Internal resistance of galvanometer = R_g = 10.0 Ω

Full scale deflection current = I_g = 1.0 mA = 0.001 A



(a) Range of ammeter = I = 100 A

$R_1 = \frac{I_g R_g}{I - I_g} = \frac{(0.001)(10.0)}{100-0.001}$

$R_1 = 0.0001\ \Omega$

(b) Range of ammeter = I = 10.0 A

$R_2 = \frac{I_g R_g}{I - I_g} = \frac{(0.001)(10.0)}{10-0.001}$

$R_2 = 0.001\ \Omega$

(c) Range of ammeter = I = 1.0 A

$R_3 = \frac{I_g R_g}{I - I_g} = \frac{(0.001)(10.0)}{1.0 - 0.001}$

$R_3 = 0.01\ \Omega$