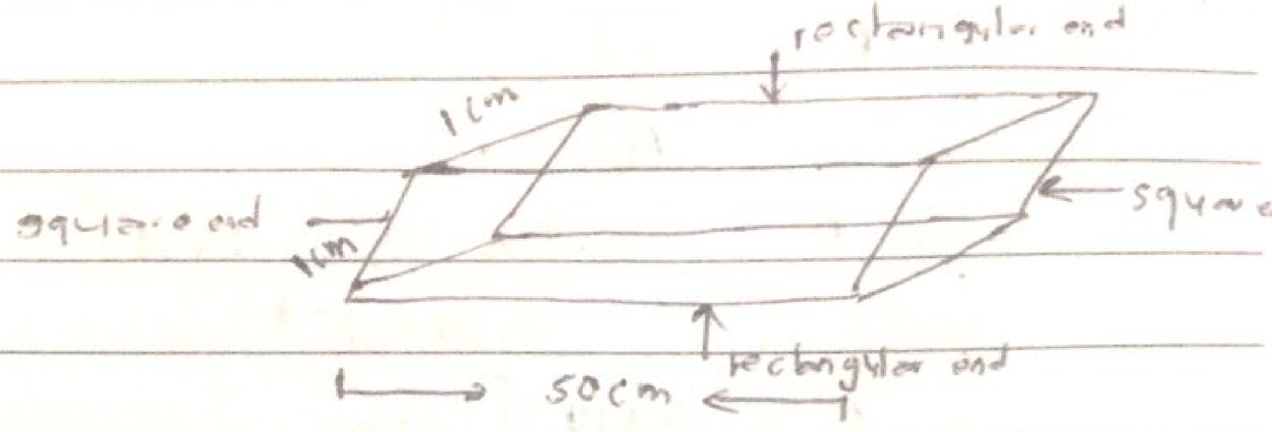
faces? The resistivity of carbon at $20^\circ c$ is 3.5×10^{-5} ohm m

$\Rightarrow$



(i) betn the square ends,

$$\text{length } (l) = 50 \text{ cm}$$

$$\text{Area } (A) = 1 \times 1 \text{ cm}^2.$$

then resistivity $\rho = \frac{RA}{l}$

$$\Rightarrow R = \frac{\rho l}{A}$$

$$\Rightarrow R = \frac{3.5 \times 10^{-5} \times 50 \times 10^{-2}}{1 \times 10^{-4}}$$

$$\Rightarrow R = 0.175 \text{ ohm}$$

(ii) betn the rectangular face

$$\text{length } (l) = 1 \text{ cm}$$

$$\text{Area } (A) = 1 \times 50 \text{ cm}^2$$

then resistivity

$\Rightarrow$ and $\rho = \frac{RA}{l}$

$\Rightarrow R = \frac{\rho l}{A}$

$\Rightarrow R = \frac{3.5 \times 10^{-5} \times 1 \times 10^{-2}}{1 \times 50 \times 10^{-4}}$

$\Rightarrow R = 7 \times 10^{-5}$ ohm

Q3. A current of 1.5 A is passed through a wire of length 1 metere and diameter 2 mm. If the specific resistance is $2.42 \times 10^{-8}\ \Omega m$ Find the potential difference between the ends of the wire in milli-volt.

$\Rightarrow$ Current (I) = 1.5 A

length of wire (l) = 1 m

specific resistance (ρ) = $2.42 \times 10^{-8}\ \Omega\text{-}m$

Diameter of wire (d) = 2mm = 2×10^{-3} m

$\therefore$ Area of cross-section of wire

$A = \frac{\pi d^2}{4}$

$A \Rightarrow \frac{\pi \times (2 \times 10^{-3})^2}{4}$

$$A = \pi \times 10^{-6} \ m^2$$

Now, $\rho = \frac{RA}{l}$

$$\Rightarrow R = \frac{\rho l}{A}$$

$$\Rightarrow R = \frac{2.42 \times 10^{-8} \times 1}{\pi \times 10^{-6}}$$

$$\Rightarrow R = 7.7 \times 10^{-3} \Omega$$

$\therefore$ potential diff^n, $V = IR$

$$= 1.5 \times 7.7 \times 10^{-3}$$

$$= 11.55 \times 10^{-3} V$$

$$\Rightarrow V = 11.55 \ mV$$

Q 4. In Bohr's model of H-atom the electron circulation around the nucleus in a path of radius 5.1×10^{-11} m at a frequency of 6.8×10^{-15} rev/sec. Find the value of B at the centre of orbit.

$\Rightarrow$ Radius of circular path $(r) = 5.1 \times 10^{-11}$ m

frequency of revolution $(f) = 6.8 \times 10^{-15}$ rev/sec

Now, $f = \frac{1}{T}$

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

$$\Rightarrow T = \frac{1}{6.8 \times 10^{-15}} \text{ sec}$$

The current due to electron,

$$I = \frac{\text{charge}}{\text{time}}$$

$$\Rightarrow I = \frac{1.6 \times 10^{-19}}{1/6.8 \times 10^{-15}}$$

∴ B at the centre of orbit

$$B = \frac{\mu_0 I}{2r}$$

$$\Rightarrow B = \frac{4\pi \times 10^{-7} \times 1.6 \times 10^{-19} \times 6.8 \times 10^{-15}}{2 \times 5.1 \times 10^{-11}}$$

$$\Rightarrow B = 1.34 \times 10^{-29} \text{ Tesla}$$

Q5. show that B at the centre of rectangular of length l and width d carrying current I is

$$B = \frac{2\mu_0 I \left[l^2 + d^2 \right]^{1/2}}{\pi l d}$$

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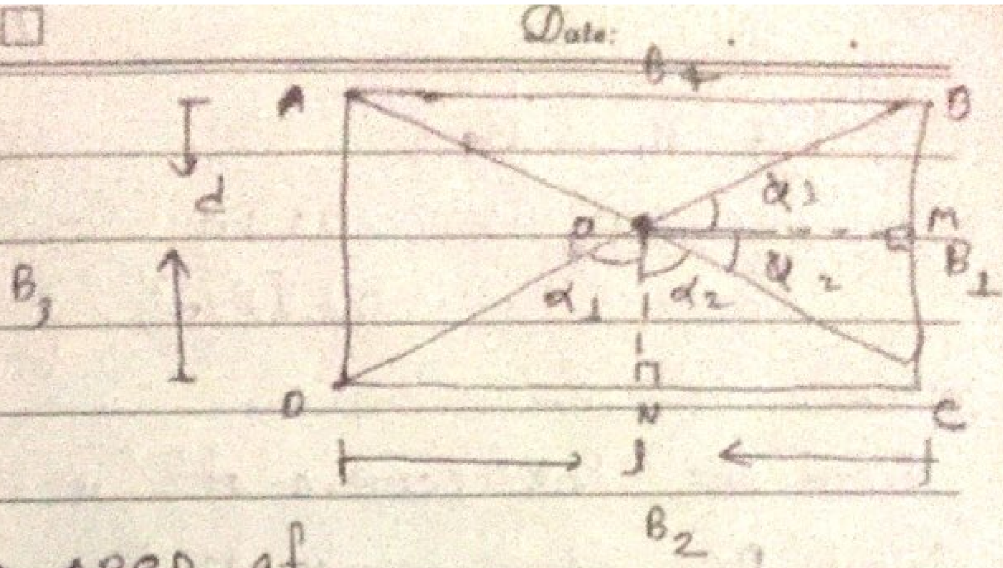


The rectangle ABCD of length l and width d is shown in fig. Let O be the centre of the rectangle. Then due to the width BC, the magnetic field at 'O' at a perpendicular distance $d/2$ is

$$B_1 = \frac{\mu_0 I}{2\pi\, d/2}\left[\sin\phi_1 + \sin\phi_2\right] \quad \text{---} \ (1)$$

but $\sin\phi_1 = \sin\phi_2 = \dfrac{d/2}{\sqrt{(d/2)^2+(l/2)^2}}$

$$\Rightarrow \sin\phi_1 = \sin\phi_2 = \frac{d}{\sqrt{d^2+l^2}} \quad \text{---} \ (2)$$

$$\therefore B_1 = \frac{\mu_0 I}{2\pi l}\,\frac{2d}{\sqrt{d^2+l^2}}$$

$$\Rightarrow B_1 = \frac{\mu_0 I d}{\pi l \sqrt{l^2+d^2}} \quad \text{---} \ (3)$$

but $B_1 = B_3$

$$\therefore B_3 = \frac{\mu_0 I d}{\pi l \sqrt{l^2+d^2}} \quad ---(4)$$

Now,

field at the centre of rectangle due to length DC, at a perpendicular distance on

$$B_2 = \frac{\mu_0 I}{4\pi d/2}\left[\sin\alpha_1 + \sin\alpha_2\right]$$

but $\sin\alpha_1 = \sin\alpha_2 = \dfrac{l/2}{\sqrt{(l/2)^2+(d/2)^2}}$

$$\Rightarrow \sin\alpha_1 = \sin\alpha_2 = \frac{l}{\sqrt{l^2+d^2}}$$

then,

$$B_2 = \frac{\mu_0 I}{2\pi d}\frac{2l}{\sqrt{l^2+d^2}}$$

$$\Rightarrow B_2 = \frac{\mu_0 I l}{\pi d\sqrt{l^2+d^2}} \quad --(5)$$

Also,

$B_2 = B_4 \quad \therefore B_4 = \dfrac{\mu_0 I l}{\pi d\sqrt{l^2+d^2}} \quad -(6)$

$\therefore$ total field at a,

$$B = B_1 + B_2 + B_3 + B_4$$

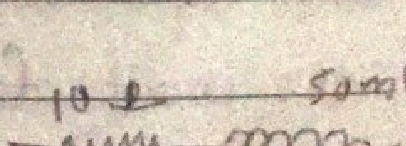
$$\Rightarrow B = \frac{2\mu_0 I l}{\pi d\sqrt{l^2+d^2}} + \frac{2\mu_0 I d}{\pi l\sqrt{l^2+d^2}}$$

$$\Rightarrow B = \frac{2\mu_0 I}{\pi\sqrt{l^2+d^2}}\left[\frac{l}{d} + \frac{d}{l}\right]$$

$$= \frac{2\mu_0 I}{\pi\sqrt{l^2+d^2}}\ \frac{l^2+d^2}{ld}$$

$$B = \frac{2\mu_0 I}{\pi l d}\left[l^2+d^2\right]^{1/2}$$

Q6. A solenoid of inductance 50 mH and resistance 10 Ω is connected to a battery of 6V. Find the time elapsed before the current acquires half of its steady state value.



$\Rightarrow$ The current at any time in the circuit is

$$I = I_0\left[1 - e^{-R/L\, t}\right]$$

It is given that, $I = \frac{1}{2}$ of I_0

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i.e. $\frac{1}{2} I_0 = I_0 [1 - e^{-\frac{R}{L}t}]$

$\Rightarrow \frac{1}{2} = 1 - e^{-R/L\,t}$

$\Rightarrow \frac{1}{2} = e^{-R/L\,t}$

$\Rightarrow 2 = e^{R/L\,t}$

$\Rightarrow \log_e 2 = \frac{R}{L} t$

$\Rightarrow t = \frac{L}{R} \log_e 2$

$\Rightarrow t = \frac{50 \times 10^{-3}}{10} \log_e 2$

$\Rightarrow t = 3.5$ ms

Q7. How many time constants must be we wait for the current in LR circuit to build up to within 0.1% of its equilibrium value?

$\Rightarrow$ we have current in the ckt at any time $I = I_0 [1 - e^{-R/L\,t}]$

but given that

$$I = 0.1\% \text{ of } I_0$$

$$= \frac{0.1}{100} I_0$$

$$I = 0.001 I_0$$

then $0.001 I_0 = I_0 [1 - e^{-R/L t}]$

$\Rightarrow 0.001 = 1 - e^{-R/L t}$

$\Rightarrow e^{-R/L t} = 1 - 0.001$

$\Rightarrow e^{-R/L t} = 0.999$

$\Rightarrow e^{R/L t} = \frac{1}{0.999}$

$\Rightarrow \frac{R}{L} t = \log_e \left(\frac{1}{0.999}\right)$

$\Rightarrow \frac{R}{L} t = 1 \times 10^{-3}$

Q 8. An electric field of 100 V/m is applied to a sample of n-type semi conductor whose Hall coefficient is $-0.0125\ m^3$/colomb. Determine the current density in the sample assuming

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$\mu_n = 0.35\, m^2 V^{-1} s^{-1}$ [mobility]

$\Rightarrow$

Hall coefficient is given by

$$R_H = -\frac{1}{ne}$$

$$\Rightarrow n = -\frac{1}{R_H e}$$

$$\Rightarrow n = \frac{1}{0.0125 \times 1.6 \times 10^{-19}}$$

$$\Rightarrow n = 5 \times 10^{20} / m^3$$

Again,

we have, $\sigma = ne\mu_n$

Also, $\vec{J} = \sigma \vec{E}$

$\therefore \vec{J} = ne\mu_n E$

$$\Rightarrow \vec{J} = 5 \times 10^{20} \times 1.6 \times 10^{-19} \times 0.35 \times 100$$

$$\Rightarrow \vec{J} = 2880\ A/m^2$$

Q9. A copper strip of 2cm wide and 1mm thick is placed in a magnetic field 1.5 T. If a current of 200 A is set up in the strip, calculate.

(i) Hall voltage

(ii) Hall mobility, If the number of electrons per unit volume is $8.4 \times 10^{28} /m^3$ and resisitivity is $1.72 \times 10^{-8}\ \Omega\text{-}m$

⇒ we have,

width of strip (d) = 2cm

$= 2 \times 10^{-2}$ m

thickness (t) = 1 mm = 1×10^{-3} m

magnetic field $(B_Z) = 1.5$ T

current (I) = 200 A

$V_H = ?$

$\mu = ?$

no. of electrons per unit volume $(n) = 8.4 \times 10^{28} /m^3$

resischivity $(\rho) = 1.72 \times 10^{-8}\ \Omega \cdot m$

~~bet~~

we have, $V_H = R_H J_x B_Z d$ --- (x)

and $R_H = -\frac{1}{ne}$

$$J_x = \frac{I}{dt}$$

$$\therefore V_H = -\frac{1}{ne} \frac{I}{dt} B_z d$$

$$\Rightarrow V_H = -\frac{1}{ne} \frac{I}{t} B_z$$

$\therefore$ magnitude,

$$V_H = \frac{1}{ne} \frac{I}{t} B_z$$

$$= \frac{1}{8.4\times10^{28} \times 1.6\times10^{-19}} \frac{200}{1\times10^{-3}} \times 1.5$$

$$\therefore V_H = 2.23 \times 10^{-5} \text{ V}$$

Also,

$$\sigma = ne\mu$$

$$\Rightarrow \mu = \frac{\sigma}{ne}$$

$$\Rightarrow \mu = -R_H \sigma$$

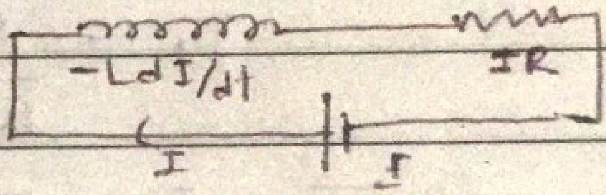
$$\Rightarrow \mu = \frac{-1}{ne} \frac{1}{\rho}$$

$$\Rightarrow \quad \mu = \frac{1}{8.9 \times 10^{28} \times 1.6 \times 10^{-19}} \times \frac{1}{1.72 \times 10^{-8}}$$

$$\Rightarrow \quad \mu = 4.32 \times 10^{-3} \ m^2 V^{-1} s^{-1}$$

Q 10. what is the initial rate of increase of current and final saturation current in LR circuit with $L = 15$ mH, $R = 24\,\Omega$ and emf (E) = 10 V

$\Rightarrow$



The circuit equation is

$$E - L\frac{dI}{dt} = IR$$

$$\Rightarrow \quad L\frac{dI}{dt} = E - IR$$

$$\Rightarrow \quad \frac{dI}{dt} = \frac{E - IR}{L}$$

when $t = 0$, $I = 0$, [initial rate]

$$\frac{dI}{dt} = \frac{E}{L}$$

$$\Rightarrow \frac{dI}{dt} = \frac{10\,V}{15\times10^{-3}} = 666.66\ A/s$$

This is the initial rate of increase of current.

Now for saturation current,

$I = I_0$ (max)

$t = \infty$

$\therefore$ then maximum current is

$$I_0 = \frac{E}{R} \qquad \left[I = I_0 \left[1 - e^{-R/L\, t}\right] \right]$$

$$\Rightarrow I_0 = \frac{10}{24}$$

$$\Rightarrow I_0 = 0.416\ A$$

Q11. A circular loop of wire of 5cm radius carries a current of 100 Amps. What is the energy density of the loop at the centre?

$\Rightarrow$ Radius of loop $(r) = 5\,cm$

$= 5\times10^{-2}\ m$

current $(I) = 100\ A.$

Energy density $U_B = ?$

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but $U_B = \frac{1}{2\mu_0} B^2$

Here, B = magnetic field at the centre of the loop

$\therefore B = \frac{\mu_0 I}{2r}$

$\therefore$ energy density at centre of loop

$U_B = \frac{1}{2\mu_0}\left(\frac{\mu_0 I}{2r}\right)^2$

$= \frac{1}{2\mu_0} \frac{\mu_0^2 I^2}{4r^2}$

$= \frac{\mu_0 I^2}{8r^2}$

$= \frac{4\pi \times 10^{-7} \times (100)^2}{8 \times (5 \times 10^{-2})^2}$

$\therefore U_B = 0.628$

we can also find electric energy density

$U_E = \frac{1}{2} \epsilon_0 E^2$

since $U_B = U_E$

Q 12. Find the magnitude of induced emf in a 200 turns coil with a cross-sectional area of 0.16 m^2, if the ~~magnitud~~ magnetic field through the coil changes from 0.10 wm^{-2} to 0.50 wm^{-2} at the uniform rate over a period 0.02 sec.

⇒ Number of turns (N) = 100

Area of coil (A) = 0.16 m^2

initial magnetic field (B_1) = 0.10 wm^{-2}

Final magnetic field (B_2) = 0.50 wm^{-2}

time (t) = 0.02 sec

∴ Initial flux $\phi_1 = NB_1A$

Final flux $\phi_2 = NB_2A$

magnitude of induced emf = $\frac{\text{change in flux}}{\text{time}}$

$$\Rightarrow e = \frac{NB_2A - NB_1A}{t}$$

$$\Rightarrow e = \frac{NA(B_2 - B_1)}{t}$$

$$\Rightarrow e = \frac{200 \times 0.16\,(0.10 - 0.50)}{0.02}$$

$$\Rightarrow e = 640\,v$$