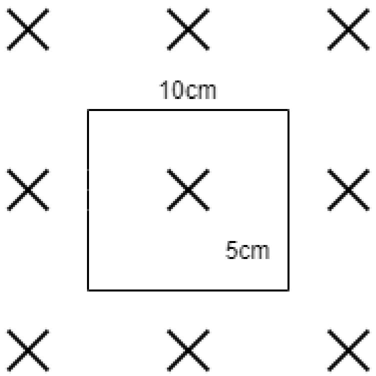
TUTORIAL 6

Q1) Consider a single turn rectangle loop placed in a uniform magnetic field as shown in figure. The plane of the loop is perpendicular & the resistance of loop is 0.4 ohm. Magnetic field = ¼ $sin\omega t$, ω = 100π rad/sec. then power output of loop is?



Sol.

$$V_{emf} = \frac{-d\emptyset}{dt}$$

$$\emptyset = \iint \vec{B}.\vec{d}s$$

$$\emptyset = BAcos\theta$$

$$\theta = 0$$

$$\emptyset = BAcos\theta = \frac{1}{4}sin\omega t\ (50\ \times\ 10^{-4})$$

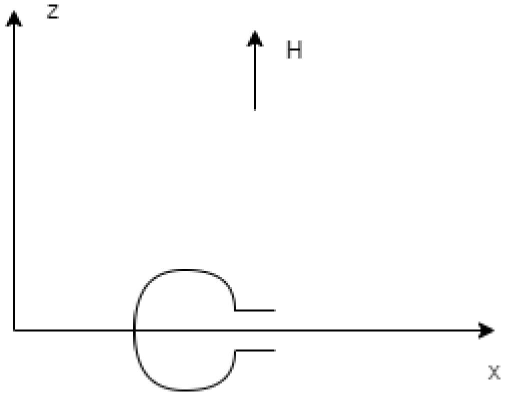
$$V_{emf} = \frac{-d\emptyset}{dt} = \frac{-100\pi}{4} \times 50 \times 10^{-4}cos\omega t$$

$$V_{emf} = \ -0.39cos\omega t$$

$$P = \frac{{V_{rms}}^2}{R} = \frac{1}{2}\frac{{V_m}^2}{R} = \frac{1}{2}\frac{(0.39)^2}{0.4}$$

$$P = 0.1925\ W$$

Q2) A Circular turn of 1 m revolves at 60 rpm about its diameter as shown in fig. Then the peak value of induced emf is? $(H = 10^7\ \hat{a}_z)$



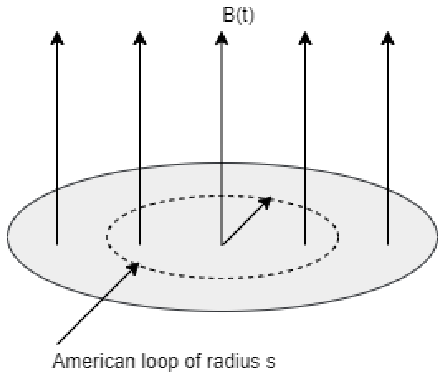
Sol.

$$60rpm = 60 \times \frac{2\pi}{60} r/sec$$

$$V_{emf} = \frac{-d(BAcos\theta)}{dt} = \omega BAsin\theta$$

⇨ Peak value = $BA\omega = \frac{4\pi\times10^{-7}\times10^{7}\times\pi\times60\times2\pi}{60} = 248.05$

Q3) A uniform magnetic field B(t), pointing straight up, fills the shaded circular region of Fig. if B is changing with time, what is the induced electric field?



Sol.

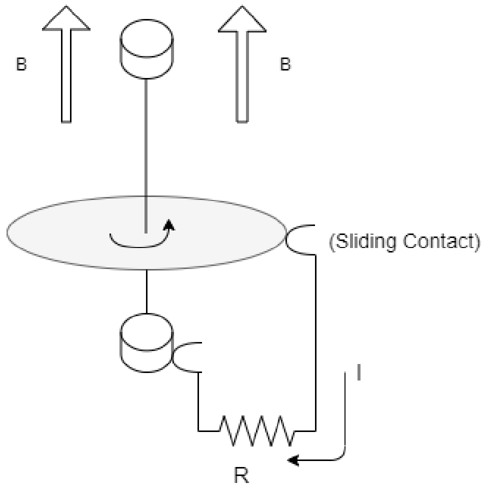
$$\oint E.dl = E(2\pi s) = \frac{-d\varphi}{dt} = \frac{-d}{dt}(\pi s^2 B(t)) = -\pi s^2 \frac{dB}{dt}$$

Therefore,

$$E = \frac{-s}{2}\frac{dB}{dt}\hat{\emptyset}$$

If B is increasing, E runs clockwise, as viewed from above.

Q4) A metal disk of radius a rotates with angular velocity ω about a vertical axis, through a uniform field B, pointing up. A circuit is made by connecting one end of a resistor to the axle and the other end to a sliding contact, which touches the outer edge of the disk. Find the current in the resistor?



Sol. The speed of a pointer on the disk at a distance s from the axis is $v = \omega s$, so the force per unit charge is $f_{mag} = v \times B = \omega s B \hat{s}$. The emf is therefore

$\varepsilon = \int_0^a f_{mag}\, ds = \omega B \int_0^a s ds = \frac{\omega B a^2}{2}$ and the current is $I = \frac{\varepsilon}{R} = \frac{\omega B a^2}{2R}$

Q5) An all-metal aeroplane drives down vertically at 300km/s at a place where the horizontal component of the earth's field is 0.4 oersted. If the wing span is 30m, what will be the resulting potential difference between the tips?

Sol. Vertical distance = 300km/s = 3 x 10^5 m/s

Distance between wing tips = 30m

Area swept by the wing span in one sec. $\frac{dA}{dt} = 3 \times 10^5 \times \frac{30m^2}{s} = 9 \times \frac{10^6 m^2}{s}$

Now using Faraday's law of induction the potential difference between the wing tips is given by-

$$\xi = \frac{-d\varphi_B}{dt} = \frac{-d(\vec{B}.\vec{A})}{dt} = \frac{-d(HA)}{dt} = -H\frac{dA}{dt}$$

Where –ve sign shows the direction of the induced emf.

Now oersted (Gauss) = $10^{-4} weber/m^2$

$$\xi = 3.6 \times 10^2 = 360 Volts$$

Q6) A vertical disc of diameter 20 cm makes 100 revolutions per second about a horizontal axis passing through its centre. A uniform magnetic field of 100 gauss acts perpendicular to the plane of the disc. Calculate the potential difference between its centre and rim in volts?

Sol.

B =100 gauss = 10^{-2}Wb/m^2

r = 10 cm = 0.1 m

Area swept out by disc in one sec

$\frac{dA}{dt} = \pi r^2 \times no\ of\ revolution\ per\ second$

= $\pi \times (0.1)^2 \times 10$

= 3.14 x 0.1 x 0.1 x 100 = 3.14

The magnetic flux linked with the disc is given by $\varphi = BA$

By Faraday's law, the induced emf is given by

$\xi = -\frac{d\varphi_B}{dt} = -\frac{d(BA)}{dt} = -B\frac{dA}{dt} = 10^{-2} \times 3.14 = 0.0314$ Volt