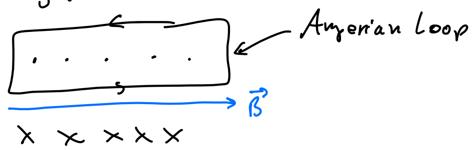
Physics 1C - Discussion 3 Name: Tejas Kantem UID: 305748402

Problem 1. Magnetic field due to a solenoid

A 15.0 cm long solenoid with radius 0.750 cm is closely wound with 600 turns of wire. The current in the solenoid is 8.00 A. Utilize Ampere's law to compute the magnetic field at a point near the center of the solenoid.

negligible field outside solenoid $\Rightarrow$

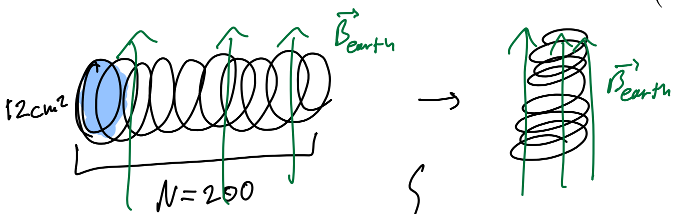


$$\Rightarrow \oint \vec{B}\cdot d\vec{l} \Rightarrow B\cdot L = \mu_0 I$$

$$\Rightarrow \boxed{B = \frac{\mu_0 N I}{L} = \frac{\mu_0 (600)(8.00\ A)}{15.0\ cm} = 0.04\ T}$$

Problem 2. Induced emf in a solenoid due to rotation

In a physics laboratory experiment, a coil with 200 turns enclosing an area of 12 cm^2 is rotated in 0.040 s from a position where its plane is perpendicular to the earth's magnetic field to a position where its plane is parallel to the field. The earth's magnetic field at the lab location is 6.0×10^{-5} T. (a) What is the magnetic flux through each turn of the coil before it is rotated? After it is rotated? (b) What is the average emf induced in the coil?



$\Phi_{disk}(t=0) = 0$

$\Phi_{disk}(t=0.04s) = BA\cos(0) = BA$

$\therefore$ a) $\boxed{\Phi_{before} = 0}$ & $\boxed{\Phi_{after} = B_{earth} A = (6.0\times10^{-5})(0.0012)\,[T\cdot m^2]}$

b) $\mathcal{E}_{instant} = -\frac{d\Phi_B}{dt}$ but $\mathcal{E}_{avg} = \langle \mathcal{E} \rangle = -\frac{\Delta \Phi_B}{\Delta t} = \frac{[\Phi_{disk}(t=0.04) - \Phi_{disk}(t=0)]\cdot N}{0.04}$

$$\Rightarrow \boxed{\langle \mathcal{E} \rangle = \frac{(6.0\times10^{-5})(0.0012)(200)}{0.04}\,[T\cdot m^2/s]}$$

Problem 3. Current induced in a moving loop

A rectangular circuit is moved at a constant velocity of 3.0 m/s, into, through, and then out of a uniform 1.25 T magnetic field, as shown in Fig. 1. The magnetic field region is considerably wider than 50.0 cm. Find the magnitude and direction (clockwise or counterclockwise) of the current induced in the circuit as it is (a) going into the magnetic field; (b) totally within the magnetic field, but still moving; and (c) moving out of the field. (d) Sketch a graph of the current in this circuit as a function of time, including the preceding three cases.

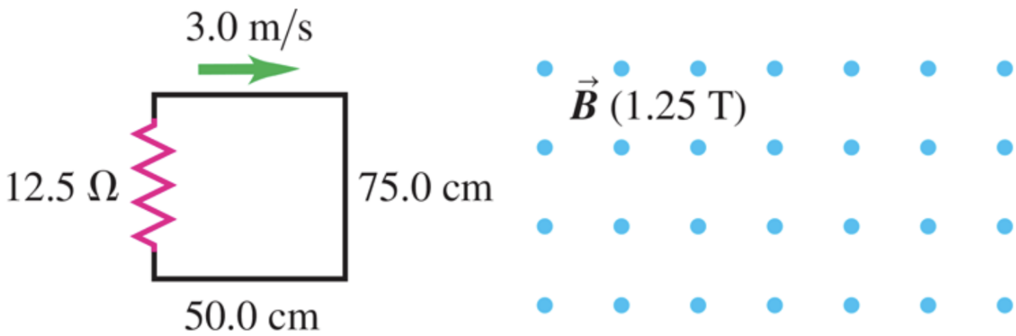


Figure 1: Setup for Problem 3.

$$A = w \cdot L$$

$$\frac{dA}{dt} = \frac{dw}{dt} \cdot L + \underbrace{w \cdot \frac{dL}{dt}}_{0}$$

$$\frac{dA}{dt} = (3\ \text{m/s})(75\ \text{cm})$$

a) $$I = \frac{|\mathcal{E}|}{R} = \frac{\left|\frac{d\Phi_B}{dt}\right|}{R} = \frac{\frac{dA}{dt} \cdot B}{R}$$

$$= \frac{(1.25\,\text{T})(3\,\text{m/s})(.75\,\text{m})}{12.5\,\Omega} \boxed{= 0.225\,\text{A}}$$ $\boxed{\text{clockwise}}$

b) $$I = \frac{|\mathcal{E}|}{R} = \frac{0}{R} \boxed{= 0}$$ no change in $\vec{B}$

c) $I \boxed{= 0.225\,\text{A}}$ $\boxed{\text{counterclockwise}}$ as $\frac{d\Phi_B}{dt}$ is same as (a) but opposite 2nd order effects due to Lenz's Law

Problem 4. Wire loop in a time varying magnetic field

A circular loop of wire with radius 2.00 cm and resistance 0.600 Ω is in a region of a spatially uniform magnetic field **B** that is perpendicular to the plane of the loop. At $t = 0$ the magnetic field has magnitude $B_0 = 3.00$ T. The magnetic field then decreases according to the equation $B(t) = B_0 e^{-t/\tau}$, where $\tau = 0.500$ s. (a) What is the maximum magnitude of the current I induced in the loop? (b) What is the induced current I when $t = 1.50$ s.

$$B(t) = 3e^{-t/0.5} \Rightarrow \mathcal{E}(t) = (3e^{-t/0.5})(0.0004\pi) \Rightarrow I(t) = \frac{|\mathcal{E}(t)|}{0.6}$$

a) graphing the equation for time-varyig current shows, maximum current is:

$$\boxed{I = 0.0063\ [A]}$$

b) We can use the equations above:

$$I(t=1.5) = \frac{|\mathcal{E}(t=1.5)|}{0.6} = \frac{0.0012e^{-3}\pi}{0.6} \boxed{\approx 0.00031282\ [A]}$$