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Physics Midterm 3

1a) Lorentz Force

$$\vec{F} = q(\vec{v} \times \vec{B})$$

Force is along x axis and velocity is ↑ y axis
$\longleftarrow$

$$\vec{F} = F(-\hat{\imath})$$

$$\vec{v} = v(\hat{\jmath})$$

Since,

$$-\hat{\imath} = \hat{\jmath} \times (-\hat{k})$$

the direction of the B field is

$\boxed{\text{into the plane of the paper}}$

1b) $\vec{F} = F(-\hat{k})$

$\vec{v} = v(-\hat{\jmath})$

and because $-\hat{k} = -\hat{\jmath} \times (-\hat{\imath})$

we know that the direction of the

$\boxed{\text{B field is to the left side or more specifically along the left side.}}$

1c) $\vec{F} = F(\hat{\jmath})$

$\vec{v} = v(-\hat{\imath})$

$$\hat{\jmath} = -\hat{\imath} \times (\hat{k})$$

$\boxed{\text{the direction of the B field is out of the page}}$

2a) $qE = qvB\sin\theta$

where $\theta = 90°$ and $\therefore \theta = 1$ we can therefore assume

$qE = qvB$

and set $E = vB$

So, $\boxed{v = \frac{E}{B}}$

2b) if the electric field is constant

$E = \frac{\Delta V}{\Delta x}$ and $\Delta V = E(\Delta x)$

since

$E = vB$

$\Delta V = (vB)\Delta x$ and $\Delta V = B(\Delta x)v$

here since v is the drift velocity from the eqn $V_d = \frac{I}{nq_e A}$

we can therefore substitute V_d into ΔV in the following manner

$$\Delta V = \frac{B(\Delta x)I}{nq_e A}$$

$$\Delta V = \frac{(1.33T)(2\times10^{-2}m)(10A)}{\left(\frac{2\times10^{28}}{m^3}\right)(1.6\times10^{-19}C)((1.0\times10^{-3})^2)}$$

$$\boxed{\Delta V = 8.31\times10^{-5}\ V}$$

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(3) $\tau = iBA$ $\quad i = 1.05\times10^{4}$ A

$B = 2.35$ T

$A = \pi r^2$

$$A = \pi(0.65\times10^{-15})^2 = 1.33\times10^{-30}\ m^2$$

$$\tau = (1.05\times10^{4}\,A)(2.35\,T)(1.33\times10^{-30}\,m^2)$$

$$\boxed{\tau = 3.28\times10^{-26}\ N\cdot m}$$

3 Chapter 12: Sarces of Magnetic Fields

1a) number of turns per length $n = 500$
current inside a solenoid $I = 0.3A$

$$B = \mu_0 n I$$
$$= (4\pi\times10^{-7})(500)(0.3\,A)$$
$$\boxed{B = 1.88\times10^{-4}\ T}$$

1b) if we are boosting the μ_0 by a factor of 5000 we can infer this is a scaling problem $\quad \mu = 5000\,\mu_0$

$$B = (5000\times1.88\times10^{-4}\,T)$$
$$\boxed{B = .94\ T}$$

(2a) Based on the digram e field is up, B field is out of the page and v is towards the right

$F_{electrical} + F_{magnetic} = 0$

$F_{electrical} = q\vec{E}$ and $F_{magnetic} = q(\vec{v} \times \vec{B})$

$F_{total} = F_{electrical} + F_{magnetic} = 0$

$q|\vec{E} + \vec{v} \times \vec{B}| = 0$

if $V \times B$ is $\downarrow$ then $\vec{E}$ is opposite

now,

$|F_{total}| = q|E - vB| = 0$

$E = vB$ where $v = \frac{E}{B}$ for $F_{net} = 0$

(2b) Centripetal force $= \frac{mv^2}{r}$

and if we set it equal to the Lorentz force we get

$qvB = \frac{mv^2}{r}$

$r = \frac{mv}{q}$

and $v = \frac{E}{B}$

$r = \frac{m\frac{E}{B}}{qB} = \frac{mE}{qB^2}$

mass of O_2 $\quad m = 16 \cdot$ mass of proton

$$= (16) \times (1.67 \times 10^{-27} Kg)$$

$$= 2.672 \times 10^{-26}$$

now to solve for r we know that,

$q = 1.60 \times 10^{-19} C$ $\qquad r = \frac{mE}{qB^2}$

$E = 10 V/m$ $\qquad r = \frac{(2.672 \times 10^{-26})(10)}{(1.60 \times 10^{-19} C)(0.01)^2}$

$B = 0.01 T$

$$\boxed{\begin{gathered} r = 0.0167 m \\ \text{or} \\ r = 1.67 \text{ cm} \end{gathered}}$$

4 Chapter 13: Electromagnetic Induction

$N = 1$

change in magnitude of the magnetic field

$$\frac{\Delta B}{\Delta t} = \frac{B_0}{T_0}(\sin(2\pi f t))$$

$$e = \frac{d(BA)}{dt}$$

a) induced voltage

when area is constant $\quad e = A\frac{dB}{dt}$

$$\boxed{e = \pi r^2 \times \frac{B_0}{T_0} \sin(2\pi f t)}$$

b) Induced emf at $t=0$; At $t=0$, $\sin(2\pi f t)$

and since $\sin 0 = 0$

the induced emf will be 0 at $t=0$

c) At $t_1 = 0.16$ ms $\quad f = 10^3$ Hz $\quad B_0 = 0.1$ T $\quad r = 0.1$m

$$e = \pi (0.1)^2 \times \frac{0.1}{1ms} \sin(2\pi \times 10^3 \times 0.16 \times 10^{-3} m)$$

$$= \pi \frac{(0.1)^3}{1ms} \sin(0.32\pi)$$

$= \pi \times \frac{(0.1)^3}{1ms} \sin(1.0053)$

$e = \pi \frac{(0.1)^3}{1ms} \times 0.0175 = 0.055 V$

$\boxed{e = 0.055 V}$

d) at t_1 $I = \frac{e}{R} = \frac{0.055}{5 \Omega}$

$\boxed{I = 0.011 A}$

5 Chapter 14 : Inductance

L (inductance) $= 0.50 - H$

emf induced $= 0.150 V$

induced emf across an inductor

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

$\frac{dI}{dt} = \frac{-\mathcal{E}}{L} = -\frac{0.150 V}{0.50 H} = -0.3 A/s$

$\boxed{\frac{dI}{dt} = -0.3 A/s}$

(2) emf of the coil (in terms of self inductance)

$\mathcal{E} = L\frac{dI}{dt}$ L = inductance of coil

dI = change in current

$\mathcal{E}$ = induced emf of the coil dt = change in time

if we rewrite this we get

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

$\therefore$ by solving we get

$dt = \frac{2.00\ mH}{500\ V}(0.100\,A)$

$= \frac{(2.00 \times 10^{-3}\ H)}{500\ V}(0.100\ A)$

$= \boxed{4.00 \times 10^{-7} s}$