Physics 1C — Fall 2015

Midterm # 1

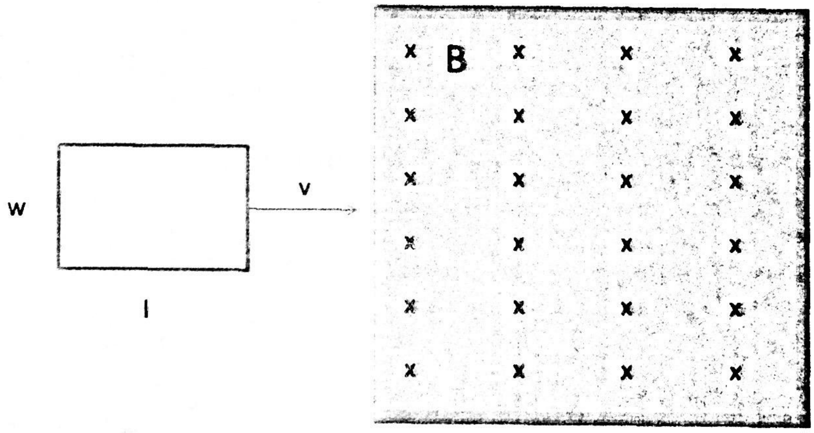
20

1) A rectangular loop of sides $w = 4$ cm and $l = 5$ cm and resistance $R = 10$ Ohm is moved at a constant velocity of $v = 3$ m/s into, through and then out of a uniform $B = 1.25$ T magnetic field as shown in the Figure. The magnetic field region is much wider than the size of the loop.

   a) Find magnitude and direction of the current induced in the circuit as
      - i. the circuit is going into the magnetic field
      - ii. the circuit is totally within the magnetic field but still moving.
      - iii. moving out of the field.

   b) Find magnitude and direction of the magnetic force on the loop as
      - i. the circuit is going into the magnetic field
      - ii. the circuit is totally within the magnetic field but still moving.
      - iii. moving out of the field.

   c) Calculate the total energy dissipated in this motion.



a)

$\mathcal{E} = vBw = (3\,\text{m/s})(1.25\,\text{T})(0.04\,\text{m}) = 0.15\,\text{V}$

$I = \frac{\mathcal{E}}{R} = 0.015\,\text{A}$

i) 0.015 A counterclockwise ↺ 10

ii) No current

iii) 0.015 A clockwise ↻

b) see back of the page

b)

$F = q\vec{v} \times \vec{B} = w I B$ 2

i) $F = 7.5 \times 10^{-4}$ N backward — which direction is backward?

ii) 0 N 2

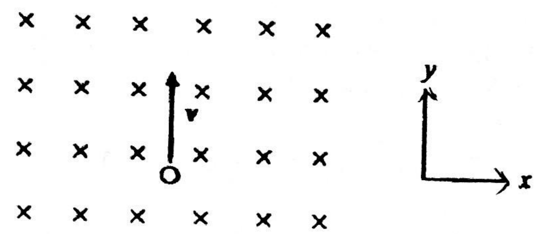
iii) 7.5×10^{-4} N ~~froneward~~ same

c) $P = I^2 R$

$= 2(0.015\text{ A})^2 (10\ \Omega)$ 4

$= 0.0045$ W

30 2) An electron ($q = -1.6 \times 10^{-19}$ C, $m = 9.11 \times 10^{-31}$ kg) with an instantaneous velocity $v = 1.50 \times 10^{6}$ **j** m/s is moving through a region of constant magnetic field directed into the page with $B = -0.25$ **k** Tesla as shown in figure.



a) What are the magnitude and direction of the magnetic force acting on the electron?
b) What is the radius of the electron circular trajectory in this magnetic field?
c) What is the period of the electron circular motion?
d) What is the direction of the electron circular motion (clockwise or anticlockwise) when viewed from above the page?
e) What are the magnitude and direction of the electric field that must be applied if the electron is to move through this region undeflected?

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

$= (-1.6 \times 10^{-19} C)\ \langle 0,\ 1.5 \times 10^{6}\ m/s,\ 0 \rangle \times \langle 0,\ 0,\ -0.25 T \rangle$

$= (-1.6 \times 10^{-19} C \times 1.5 \times 10^{6}\ m/s \times -0.25 T)\ \hat{i}$

$= 6 \times 10^{-14}$ N ✓ in +x direction.

b) $F = m\dfrac{v^2}{R}$ $\qquad \dfrac{1}{R} = \dfrac{F}{mv^2}$

$R = \dfrac{mv^2}{F} = 3.42 \times 10^{-5}$ m ✓

c) $v = R\omega = 2\pi R f$

$T = \dfrac{1}{f} = \dfrac{2\pi R}{v} = 1.43 \times 10^{-10}$ s ✓

d) clockwise ✓

e) see back of the page

e)

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

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

$$-\vec{E} = \vec{v} \times \vec{B}$$

$$= (1.5 \times 10^6 \ \text{m/s})(-0.25 \ \text{T})$$

$$= -375000 \ \frac{N}{C}$$

$$\vec{E} = 375000 \ \frac{N}{C} \ i$$ ✓

30 3) An electric current is uniformly distributed throughout a long, straight wire that has a diameter of $d = 50$ mm. If the current through the wire is $I_1 = 6.0$ A, calculate

a) The magnitude of the magnetic field $r_1 = 20$ mm radially away from the wire center
b) The magnitude of the magnetic field $r_2 = 50$ mm radially away from the wire center
c) What must the current be for this wire to exert an attractive force per unit length of 10^{-3} N/m on another equal wire carrying a current of $I_2 = 10$ A located $r_3 = 100$ mm away from it?

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enclosed}$$

a)

$$B\,(2\pi r_1) = \mu_0 I_1 \frac{r_1^2 \pi}{(\frac{d}{2})^2 \pi} = \frac{4\mu_0 I_1 r_1^2}{d^2}$$

$$B = 3.8 \times 10^{-5}\ T$$

b)

$$B\,(2\pi r_2) = \mu_0 I_1$$

$$B = \frac{\mu_0 I_1}{2\pi r_2} = 2.4 \times 10^{-5}\ T$$

c)

$$F = ILB \Rightarrow \frac{F}{L} = IB$$

$$\frac{F}{L} = 10^{-3}\ \frac{N}{m} = I_2 B = (10A)\,B$$

$$B = 10^{-4}\ T = \frac{I_1 \mu_0}{2\pi r}$$

$$I_1 = \frac{(10^{-4}T)(2\pi)(0.1\,m)}{\mu_0} = 50\,A$$