General Physics 204, Section … Monday, Mar 2, 2015

Quiz #5

Name:

1) CLASS(2)

Joseph Henry releases a loop with resistance R, length L, width W, and weight mg in a magnetic field. There is no magnetic field at the area $y < 0$ and at $y > 0$ the magnetic field is B, as shown in fig. 1. There are three intervals which Joseph separates, (i) the whole loop is inside magnetic field; (ii) loop is partially inside magnetic field; (iii) the whole loop is under x-axis. Find current direction and magnetic force direction during these intervals. **[3 pts]**

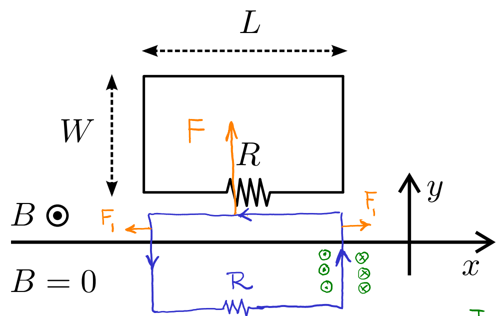


Figure 1: A loop falling down.

Φ_B is scalar.

(i) $\Phi_B = BLW$, const. in time $\rightarrow \varepsilon = -\frac{d\Phi_B}{dt} = 0 \rightarrow I = 0, \vec{F} = 0$.

(ii) Φ_B is decreasing from BLW to zero, in the direction $\odot$. By direction we mean polarization $(\pm)$, not vector direction.

Lenz's law: Induced current must produce magnetic flux in the direction $\odot$ inside the loop to oppose decreasing.

So I must be CCW.

There are three pieces of current inside region with $B \neq 0$.

The net force will be upward $(+\hat{y})$, slowing down the falling.

(iii) $\Phi_B = 0$, const. in time $\rightarrow \varepsilon = -\frac{d\Phi_B}{dt} = 0 \rightarrow I = 0, \vec{F} = 0$.

2) CLASS(2)

Heinrich Lenz puts a wire on the table, carrying a current I. He then takes two copper rings and moves them as shown in fig. 2. Show the direction of induced currents on these rings. Explain your answer briefly. **[4 pts]**

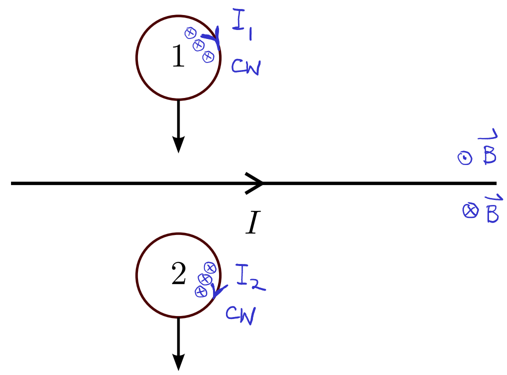


Figure 2: A wire and two copper rings.

1: Φ_B is increasing $\odot$. So the induced current must oppose to change, and make $\otimes$ flux.

2: Φ_B is decreasing $\otimes$. So the induced current must oppose to chage in flux, and make $\otimes$ flux.

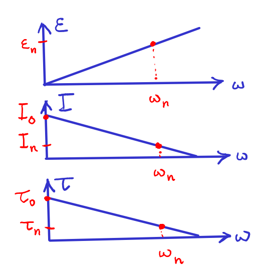
3) CLASS(2)

Oliver Heaviside operates a motor by $V = 120$ V. He measures the starting up current to be $I_0 = 12$ A. When the motor reaches its normal angular speed, $\omega_n = 600$ rpm, it draws a current $I_n = 2.0$ A.

a) Find the resistance of the armature coil. **[1 pt]**

b) Find the back emf at normal speed. **[2 pts]**

c) Find the back emf, current, and torque as a function of angular speed ω. **[2 pts]**



a) $I = \frac{V - \varepsilon}{R}$, when $\omega = 0, \varepsilon = 0 \rightarrow I_0 = \frac{V}{R} \rightarrow R = 10\,\Omega$.

b) $\varepsilon_n = V - RI_n \rightarrow \varepsilon_n = 120^V - 10^\Omega \cdot 2.0^A = 100\,V$.

c) $\varepsilon = K\omega$ where K is a const. $(K = NBA)$. $\varepsilon_n = K\omega_n \rightarrow K = \frac{100^V}{600\,\text{rpm}} = \frac{1}{6}\frac{V}{\text{rpm}}$.

$\varepsilon/_V = \frac{1}{6}\,\omega/_{\text{rpm}}$. $I/_A = \frac{V - \varepsilon}{R} = 12 - \frac{\omega/_{\text{rpm}}}{60}$.

input electric Power is $VI = \underbrace{\varepsilon I}_{\text{mech}} + \underbrace{RI^2}_{\text{heat}}$, 100% efficiency: $\varepsilon I = \tau\omega \rightarrow \tau = 2 - \frac{\omega}{360}\frac{W}{\text{rpm}}$.