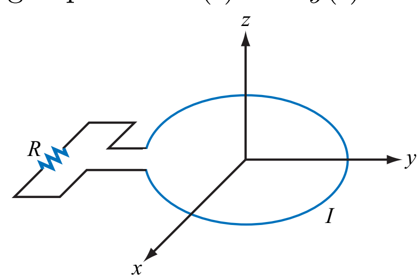
CMPE 330 **Spring 2017** **Problem Set #7**

NOTE: You must show complete work for full credit. Report numerical solutions to two significant figures unless otherwise specified.

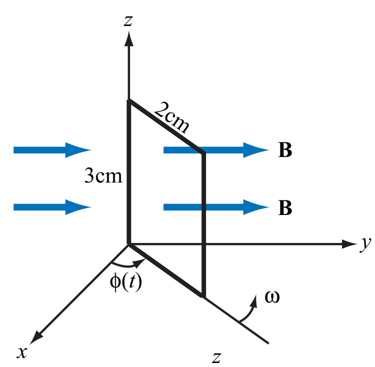
1. A charged particle with charge q and mass m moves in a constant magnetic flux and electric field, $\mathbf{B} = \hat{\mathbf{z}}B$ and $\mathbf{E} = \hat{\mathbf{x}}E$, that are directed respectively in the z- and x-directions. If the initial velocity in the z-direction is zero, show that there is no motion in the z-direction and that the velocities in x- and y-directions, $u_x(t)$ and $u_y(t)$ are equal to

$$u_x(t) = u_{x0}\cos\omega_{\mathrm{L}}t + u_{y0}\sin\omega_{\mathrm{L}}t + \frac{E}{B}\sin\omega_{\mathrm{L}}t,$$
$$u_y(t) = -u_{x0}\sin\omega_{\mathrm{L}}t + u_{x0}\cos\omega_{\mathrm{L}}t + \frac{E}{B}(\cos\omega_{\mathrm{L}}t - 1),$$

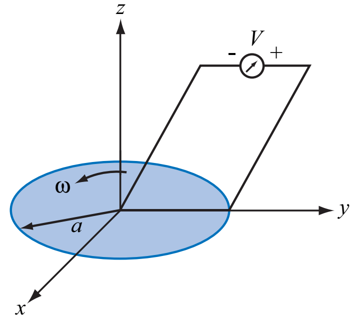
where u_{x0} and u_{y0} are the initial velocities in the x- and y-directions and $\omega_{\mathrm{L}} = qB/m$ is the Larmor frequency. Find the motion of the charged particle $x(t)$ and $y(t)$.



2. The loop in the figure shown to the right [Ulaby and Ravaioli Fig. P6.2] is in the x-y plane and $\mathbf{B} = \hat{\mathbf{z}}B_0\cos\omega t$ with B_0 positive. What is the direction of I ($\hat{\boldsymbol{\phi}}$ or $-\hat{\boldsymbol{\phi}}$) at (a) $t = 0$, (b) $\omega t = \pi/2$, (c) $\omega t = 3\pi/4$. [modified from Ulaby and Ravaioli 6.2, p. 308.]



3. The rectangular conducting loop shown to the right [Ulaby and Ravaioli Fig. P6.7] rotates at 3,000 revolutions per minute in a uniform magnetic flux density given by $\mathbf{B} = \hat{\mathbf{y}}50$ mT. Determine the current induced in the loop if its internal resistance is 1.0 Ω. How accurately must we calculate ωt in order to obtain two significant figures in the final result? [modified from Ulaby and Ravaioli 6.7, p. 309.]



4. The circular disk shown to the right [Ulaby and Ravaioli Fig. P6.13] lies in the x-y plane and rotates with uniform angular velocity ω about the z-axis. The disk is of radius a and is present in a uniform flux density $\mathbf{B} = \hat{\mathbf{z}}B_0$. Obtain an expression for the emf induced at the rim relative to the center of the disk. [Ulaby and Ravaioli 6.13, p. 310.]

5. An electromagnetic wave propagating in seawater has an electric field with a time variation given by $\mathbf{E} = \hat{\mathbf{z}} E_0 \cos \omega t$. If the permittivity of water is $81\epsilon_0$ and its conductivity is 4 S/m, find the ratio of the magnitudes of the conduction current density to the displacement current density at each of the following frequencies: (a) 5 kHz, (b) 1 MHz, (c) 5 GHz, (d) 100 GHz [modified from Ulaby and Ravaioli 6.18, p. 311.]

6. If the current density in a conducting medium is given by

$$\mathbf{J}(x, y, z; t) = (\hat{\mathbf{x}} 2z - \hat{\mathbf{y}} 3y^3 + \hat{\mathbf{z}} x) \cos \omega t$$

   determine the corresponding charge distribution $\rho(x, y, z; t)$. [modified from Ulaby and Ravaioli 6.20, p. 311.]

7. Given an electric field $\mathbf{E} = \hat{\mathbf{x}} E_0 \sin ay \cos(\omega t - kz)$, where E_0, a, ω, and k are constants, find $\mathbf{H}$. [Ulaby and Ravaioli 6.25, p. 311.]