ENEE 381 Problem Set #1
9/10/02 - due 9/17/02

(1)(380 Review) The current density in a certain region is

\[ J = 0.1e^{-10t} \hat{r}/r \]

in spherical coordinates. At \( t=1\mu s \) how much current is crossing the surface \( r=5 \)?

(2) (380 review) A current density \( J = 5\hat{j} \) A/m² exists wherever \(|z| < 2\) m. (a) Find \( H \) for \(|z| < 2 \) and \(|z| > 2 \). Find the magnetic vector potential \( A \) for \(|z| < 2 \) if \( A = 0 \) at the origin.

(3) A circular coil of 100 turns of radius 50mm, total resistance 1 ohm, and no self inductance is rotated about a vertical diameter with uniform angular velocity 100 rad/s in a horizontal magnetic flux of 0.2 Tesla. Calculate the average power needed to keep the coil in motion.

The mean power required to keep the coil in motion is

\[ W = n^2 \pi^2 a^4 b^2 \omega^2 /(2R) \]

What is the ohmic power dissipated in the coil?

(4) A small magnetic needle, which is free to turn slowly in a horizontal plane, is placed at the center of the coil in question (3). Calculate the angle with respect to \( B \) at which it reaches equilibrium.

Show that it will set at an angle \( \phi \) to \( B \) where

\[ \cot \phi = 4R/(\pi n^2 \mu_o \omega a) \]

(5) A charged particle starts from rest at the origin of coordinates in a region where there is a uniform electric field \( E \) parallel to the \( x \)-axis, and a uniform magnetic flux density \( B \) parallel to the \( z \)-axis. Show that the coordinates of the particle at a time \( t \) later will be

\[ x = (E/\omega B)(1 - \cos(\omega t)), \]
\[ y = (E/\omega B)(\omega t - \sin \omega t), \]
\[ z = 0, \]

where \( \omega = eB/m \). \( (E = |E|, B = |B|) \) (This path is called a cycloid.)

(6) Electrons are liberated with zero velocity from the negative plate of a parallel plate capacitor, to which is applied a magnetic flux density \( B \) parallel to the plates. Prove that these electrons will not reach the positive plate if the plate separation \( d \) is greater than \( 2mE/eB^2 \), where \( E = |E| \) is the field between the plates.

(7) A plane circular disk of radius \( a \) rotates at a speed of \( 2\pi f \) rad/s about an axis through the center of the disk perpendicular to the plane of the disk. There is a uniform magnetic flux \( B \) parallel to the axis of rotation. Prove that the \( emf \) between the center of the disk and its rim is of magnitude \( V = fB\pi a^2 \). \( (B = |B|) \)