ENEE 381 Problem Set #1

9/10/02 - due 9/17/02

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

$$\mathbf{J} = 0.1e^{-10^6 t}\hat{\mathbf{r}}/r$$

in spherical coordinates. At t=1μs how much current is crossing the surface r=5?

(2) (380 review) A current density $\mathbf{J} = 5\hat{\mathbf{j}}$A/m^2 exists wherever $|z| < 2$m. (a) Find $\mathbf{H}$ for $|z| < 2$ and $|z| > 2$. Find the magnetic vector potential $\mathbf{A}$ for $|z| < 2$ if $\mathbf{A} = 0$ 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 $\mathbf{B}$ at which it reaches equilibrium.

Show that it will set at an angle ϕ to B where

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

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

$$x = (\frac{E}{\omega B})(1 - \cos(\omega t),$$

$$y = (\frac{E}{\omega B})(\omega t - \sin \omega t),$$

$$z = 0,$$

where $\omega = eB/m$. ($E = |\mathbf{E}|$, $B = |\mathbf{B}|$)(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 $\mathbf{B}$ 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 $E = |\mathbf{E}|$ 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 $\mathbf{B}$ parallel to the axis of rotation. Prove that the emf between the center of the disk and its rim is of magnitude $V = fB\pi a^2$. ($B = |\mathbf{B}|$.)

Documents/Classes/381102.tex