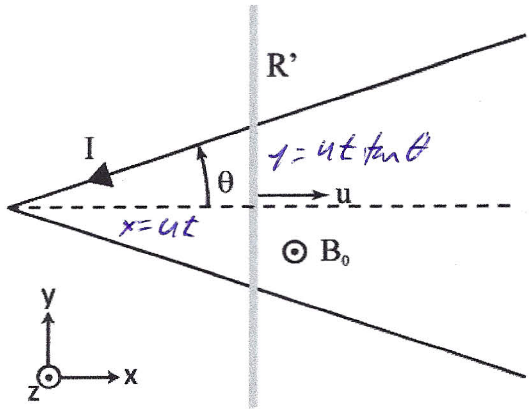
ECE 107 – Electromagnetism Spring 2010 Midterm Exam #3

#1 (10 points) A perfectly conducting V-shaped wire is oriented in the x-y plane as shown. There is a uniform magnetic field $\hat{z}B_0$. A rod with resistance per unit length of R' starts at the apex of the V at t=0, and moves with velocity $\hat{x}u$.

a) Find the magnitude of the EMF voltage |V(t)| along the bar
b) Find the current I as shown in the diagram (include both magnitude and sign).



$Area = xy = u^2 t^2 \tan\theta$

$|V| = B_0 \frac{\partial A}{\partial t} = \boxed{B_0 2u^2 t \tan\theta}$

$R = 2R'y = 2R'ut\tan\theta$

$I = \frac{V}{R} = \frac{B_0 u}{R'}$

sign is negative to oppose B_0

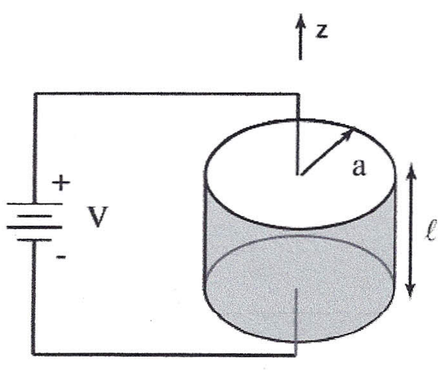
$\boxed{I = -\frac{B_0 u}{R'}}$

#2 (10 points) A wave is propagating in the +z direction, and it is right-hand circularly polarized. At (z,t)=(0,0), the electric field is $\hat{x}E_0$. Find the electric field at

a) (z,t)=$(0,\frac{\pi}{2\omega})$ $\boxed{\hat{y}E_0}$ since $\frac{\pi}{2\omega} = \frac{T}{4}$ → one-quarter period at fixed location
b) (z,t)=$(\frac{\lambda}{4},0)$ $\boxed{-\hat{y}E_0}$ one-quarter wavelength at fixed time

#3 (10 points) A cylinder is made of resistive material, and has perfectly conducting caps at both ends. The cylinder has length ℓ, radius a, and total resistance R. Its axis is oriented along $\hat{z}$. A voltage V is applied across the two caps, as shown.

a) Find the electric field $\vec{E}$ and magnetic field $\vec{H}$ at the surface of the cylinder, r=a.
b) Find the Poynting vector $\vec{S}$ at the surface of the cylinder, r=a.
c) Find $\oint \vec{S}\cdot d\vec{A}$ over the surface of the cylinder.



$\boxed{\vec{E} = -\hat{z}\frac{V}{\ell}}$

$2\pi a H = \frac{V}{R}$

$\boxed{\vec{H} = -\hat{\phi}\frac{V}{2\pi a R}}$

$\boxed{\vec{S} = \vec{E}\times\vec{H} = -\hat{r}\frac{V^2}{2\pi a \ell R}}$

$\boxed{\oint \vec{S}\cdot d\vec{A} = S\cdot 2\pi a \ell = \frac{V^2}{R}}$