Please **type** your name and V-number in the sections below **before** you print out the exam!
Identify the section with your name and V-number when Gradescope asks you to do so!

Name: ___________________________________ V-Number: __________________________

Exam 1 – EGRE 310

1. This exam will be graded based on the **completeness** of the answer:
    a. Your discussion of the method and theory(ies) behind the solution to a problem; (use short, succinct sentences and pictures to make your point)
    b. Your visualization of the question and solutions (draw pictures!)
    c. Units are necessary; there is no reason to not have units. You can look them up and perform the necessary conversions;
    d. Your ability, in answering theoretical questions, to recognize and discuss all issues that impact the answer (without me having to be specific about them);
    e. Your ability, when describing graphs, to recognize and show all relevant characteristics;
    f. Neatness, in the sense that the solution is structured well and clearly delineates your process.
2. No collaboration is allowed; if you have any questions, let me know, and if appropriate, I will answer them. I will then email the question and answer to the entire class.

HONOR PLEDGE: "On my honor, I have not received or given help during this exam; I have abided by the spirit and the law of the VCU Honor Code."

Student Signature: ____________________________

Question 1 [15]: In the Maxwell's equations below, what assumptions have we made about the space surrounding $\vec{D}$ and $\vec{H}$?

$$\nabla \cdot \vec{D} = 0$$

$$\nabla \times \vec{H} = \varepsilon \frac{\partial \vec{E}}{\partial t}$$

Question 2 [15]: In the fields represented by the equations below, discuss whether one field is or can be the outcome of the other field. Provide a full (and correct) explanation.

a. $\vec{E} = E_0 \hat{x} \cos(\omega t - kx)$ and $\vec{H} = H_0 \hat{y} \sin(\omega t - kx) + H_0 \hat{z} \cos(\omega t - kx)$

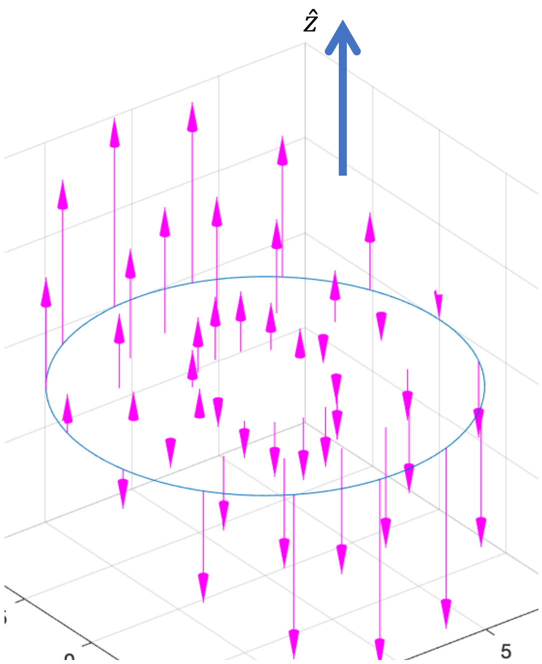
b. $\vec{E} = E_0 \hat{x} \cos(\omega t - ky)$ and $\vec{H} = H_0 \hat{y} \cos(\omega t - kz)$

c. In free space, $\vec{E} = E_0\hat{x}\cos(\omega t - ky)$ and $\vec{H} = \frac{E_0}{377\Omega}\hat{z}\cos(\omega t - ky)$

Question 3 [20]: What is the effect on $\vec{E}$ and $\vec{H}$ when the dielectric material of a material is complex? Where does this complex nature originate and how does that affect the transmission of $\vec{E}$ and $\vec{H}$ through material with a complex dielectric constant? Show and discuss the math!

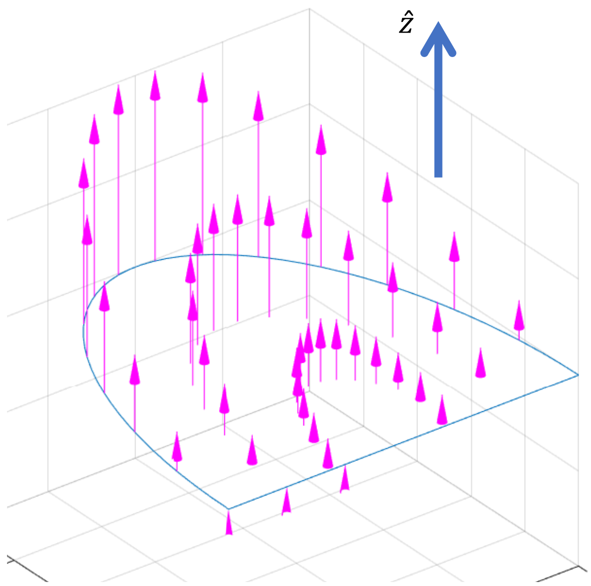
Problem 1 [25]: Find the *emf* at the terminals of a circular loop in the $z = 0$ plane if the loop is subjected to a magnetic field in the z direction that changes with r, φ and time t as:

$$B_z = B_0 r sin\varphi \sin(\omega t)$$



(Note that the figure shows only the variation in space.)

Solve for the emf for the same field but for a half-circle loop:



Problem 2 [25]: A plane wave traveling in the -z direction in a lossless medium ($\varepsilon_r = 3, \mu_r = 1$) has $\vec{E} = 25\cos\left(5 \cdot 10^9 \pi t + \frac{\pi}{3}\right)\hat{x}\ V/m$ at z = 0. Find:

a) $\vec{E}$ at $z = 0.5m,\ t = 3ns$
b) The distance traveled by the wave to have a phase shift of $5°$
c) The distance traveled by the wave to have its amplitude reduced by 30%
d) The expression for $\vec{H}$
e) $\vec{H}$ at $y = 1.5m,\ t = 2ns$
f) The Poynting vector, $\vec{P}$.
g) Describe how your answer would change if you had a lossy medium, $\sigma \neq 0$.

Hint: You will have to calculate $\beta \equiv k$.