Name: ____________________

GTID: ____________________

ECE 3025: Electromagnetics

TEST 2 (Fall 2005)

- Please read all instructions before continuing with the test.
- This is a **closed** notes, **closed** book, **closed** calculator, **closed** friend, **open** mind test. You should only have writing instruments on your desk when you take this test. If I find anything on your desk (excluding the test itself, writing instruments, and life-or-death medication) I will turn you in for an honor code violation. I am serious.
- Show all work. (It helps me give partial credit.) Work all problems in the spaces below the problem statement. If you need more room, use the back of the page. DO NOT use or attach extra sheets of paper for work.
- Work intelligently – read through the exam and do the easiest problems first. Save the hard ones for last.
- All necessary mathematical formulas are included either in the problem statements or the last few pages of this test.
- You have 50 minutes to complete this examination. When I announce a "last call" for examination papers, I will leave the room in 5 minutes. The fact that I do not have your examination in my possession will not stop me.
- I will not grade your examination if you fail to 1) put your name and GTID number in the upper left-hand blanks on this page or 2) sign the blank below acknowledging the terms of this test and the honor code policy.
- Have a nice day!

Pledge Signature: ____

I acknowledge the above terms for taking this examination. I have neither given nor received unauthorized help on this test. I have followed the Georgia Tech honor code in preparing and submitting the test.

(1) **Short Answer Section** (**20 points**)

(a) __________ (1) __________ (2) __________ (3) __________ (4)
List 4 ways to describe charge distributions in space. Each answer should have different units.

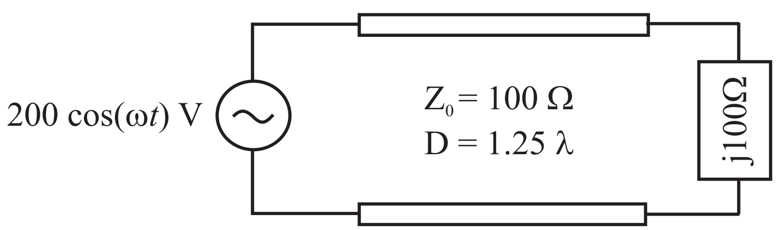
(b) __________
In the linear scale, VSWR can never drop below a value of *Answer*.

(c) __________
Electric field *Answer* start on positive charges and end on negative charges.

(d) __________ (1) __________ (2)
What are the two units often used for reporting attenuation constant values, α, on a lossy transmission line?

(e) __________ (1) __________ (2)
If a lossless Z_0 transmission line were connected to a purely resistive load and had a VSWR of 3 (linear scale), what are the two possible values for the load resistance in terms of Z_0?

(2) **Sinusoidal Transmission Lines:** Below is an ideal 200 volt sinusoidal source connected to a pure inductor via a 1.25λ transmission line. Write the phasor-form solutions for $\tilde{v}(z)$ and $\tilde{i}(z)$. What is the VSWR for this line? (**30 points**)



(3) **Transmission Line Solutions:** Below are sets of possibly invalid transmission line solutions for voltage and current. If the solution pair is valid, simply write "valid". If not, explain why the solution pair is impossible for a linear transmission line in terms of basic *physical* properties (i.e. intrinsic impedance, pulse shape, attenuation, velocity of propagation, etc.) No credit will be given for purely mathematical answers. (**20 points**)

(a)

$$\begin{aligned} v(z,t) &= 100\cos(2\pi ft - z) + 50\sin(2\pi ft + z) \\ i(z,t) &= 5\cos(2\pi ft - z) - 5\sin(2\pi ft + z) \end{aligned}$$

(b)

$$\begin{aligned} \tilde{v}(z) &= 200\exp\left(-j80z\right) \\ \tilde{i}(z) &= (5-3j)\exp\left(-j80z\right) \end{aligned}$$

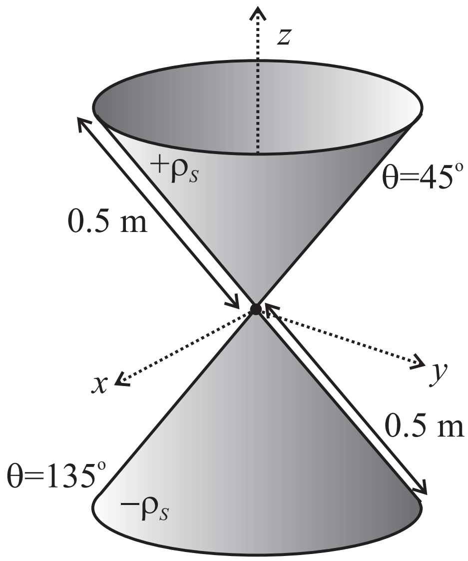
(c)

$$\begin{aligned} \tilde{v}(z) &= 77\exp\left(-[7+5j]z\right) + 55\exp\left(-[7-5j]z\right) \\ \tilde{i}(z) &= \frac{77}{Z_0}\exp\left(-[7+5j]z\right) - \frac{55}{Z_0}\exp\left(-[7-5j]z\right) \end{aligned}$$

(d)

$$\begin{aligned} v(z,t) &= 75\exp\left(-[t-z]^2\right) + 75\exp\left(-[t+\frac{z}{2}]^2\right) \\ i(z,t) &= \exp\left(-[t-z]^2\right) - \exp\left(-[t+\frac{z}{2}]^2\right) \end{aligned}$$

(4) **Conical Charge Dipole:** A biconical surface of charge is defined by the regions $\theta = 45°$, $\theta = 135°$, and $r < 0.5$m. The upper cone has a positive, uniform surface charge density of $+\rho_S$ and the lower cone has a negative, uniform surface charge density of $-\rho_S$. Derive an expression for calculating the electrostatic field $\vec{E}$ for point on the xy plane due to this charge distribution. *Simplify as much as possible* without evaluating the final integral(s). (**30 points**)



Formula Sheet

$\lambda f = v_p$ $\quad \omega = 2\pi f$ $\quad \beta = \frac{2\pi}{\lambda}$ $\quad$ Reflection: $\Gamma_{L,G} = \frac{Z_{L,G} - Z_0}{Z_{L,G} + Z_0}$ $\quad$ Transmission: $1 + \Gamma_{L,G}$

Phasor Transform: $A\cos(2\pi ft + \phi) \longrightarrow A\exp(j\phi)$

Reverse Transform: $\tilde{x} \longrightarrow \text{Real}\left\{\tilde{x}\exp(j2\pi ft)\right\}$

$$v(z,t) = V^+ f\left(t - \tfrac{z}{v_p}\right) + V^- g\left(t + \tfrac{z}{v_p}\right) \qquad \tilde{v}(z) = V^+\exp(-\gamma z) + V^-\exp(+\gamma z)$$

$$i(z,t) = \tfrac{V^+}{Z_0} f\left(t - \tfrac{z}{v_p}\right) - \tfrac{V^-}{Z_0} g\left(t + \tfrac{z}{v_p}\right) \qquad \tilde{i}(z) = \tfrac{V^+}{Z_0}\exp(-\gamma z) - \tfrac{V^-}{Z_0}\exp(+\gamma z)$$

$$\gamma = \alpha + j\beta = \sqrt{(R + j\omega L)(G + j\omega C)} \qquad Z_{in} = Z_0 \frac{Z_L + jZ_0\tan\beta D}{Z_0 + jZ_L\tan\beta D}$$

$$VSWR = \frac{V_{\text{max}}}{V_{\text{min}}} = \frac{1 + |\Gamma_L|}{1 - |\Gamma_L|}$$

$\vec{F} = Q\vec{E}$ $\quad$ Point Charge at the Origin: $\vec{E}(\vec{r}) = \frac{Q}{4\pi\epsilon r^2}\hat{r}$

Charge Distributions: $$\vec{E}(\vec{r}) = \int\limits_L \frac{\rho_L(\vec{r}')(\vec{r} - \vec{r}')dL}{4\pi\epsilon||\vec{r} - \vec{r}'||^3} = \iint\limits_S \frac{\rho_S(\vec{r}')(\vec{r} - \vec{r}')dS}{4\pi\epsilon||\vec{r} - \vec{r}'||^3} = \iiint\limits_V \frac{\rho_V(\vec{r}')(\vec{r} - \vec{r}')dV}{4\pi\epsilon||\vec{r} - \vec{r}'||^3}$$