Practice Questions for Test 2

ECE 3025: Electromagnetics

Note: Below is a list of all reject test questions I compiled while writing the original test for this class. This document is only meant for practice. The questions on the in-class test ARE NOT as numerous as those contained by this document.

(1) **Short Answer Section**

(a) ____________

If you know the wavelength, λ, and the velocity of propagation, v_p, of sinusoids on a transmission line, what is ω?

(b) ____________

The equivalent impedance, Z_{in}, of a transmission line is equal to the load impedance whenever D is equal to a multiple of [*Answer*] wavlength(s).

(c) ____________

A standing wave on a transmission line is a sign that the load impedance is not [*Answer*] to the intrinsic impedance.

(d) ____________ (1) ____________ (2)

You measure a VSWR of 10 on a lossless transmission line and a minimum voltage envelope of 1 V. The mangitudes of the forward and reflected sinusoidal voltages are [*Answer 1*] and [*Answer 2*], respectively.

(e) ____________

True or False: Lossy transmission lines distort transmitted signals with frequency content since their velocity of propagation and attenuation are frequency dependent.

(f) ____________

True or False: The envelope of a sinusoid is always real-valued.

(g) ____________

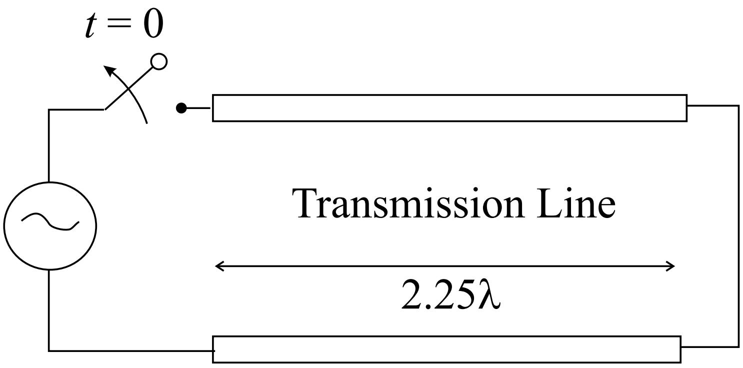
When the dot product of two vectors evaluates to zero, we know that those two vectors are [*Answer*].

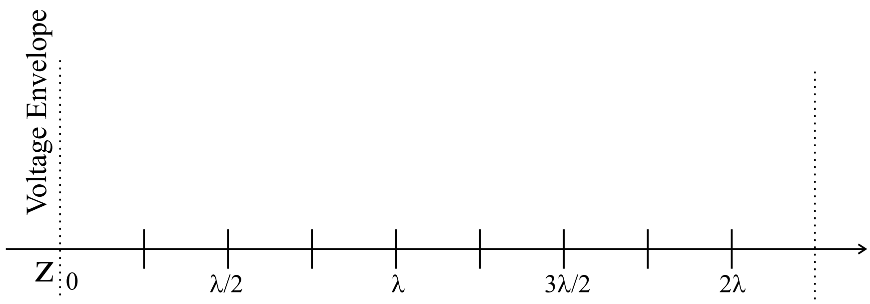
(2) **Descriptive Answer Section**

(a) **Phasor Quantities:** Explain in words the difference between the physical voltage $v(z,t)$, the phasor voltage $v(z)$, and the envelope $R(z)$ of sinusoidal voltages on a transmission line.

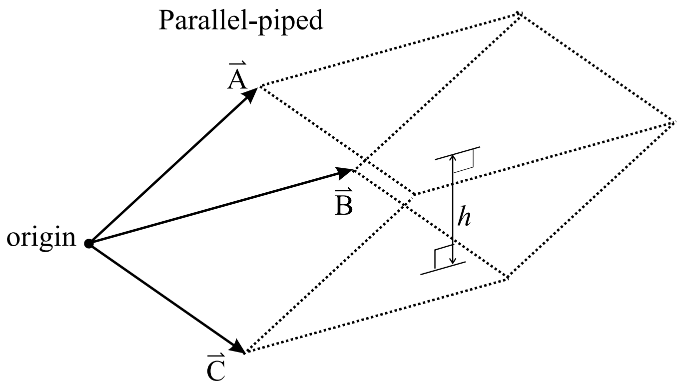
(b) **Leaky Feeder Line:** Industry sells two types of leaky feeder cables. The first type radiates a constant power along the length of the line, providing uniform radio coverage along the entire length. The second type radiates an exponentially decreasing amount of power along the length of the line to provide non-uniform radio coverage. Both are manufactured in a similar manner, taking regular coaxial cable and puncturing the outer conductor in places along the length so that some of the wired power escapes through radiation. The line loss due to radiation is proportional to the frequency of puncturing. Which type of leaky feeder cable can be manufactured with uniform puncturing along the length and why?

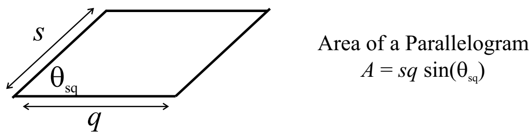
(c) **Superconductors for Power Storage:** Some engineers have proposed that superconductor transmission lines can be used for storing AC power for a very long time. Since there are no ohmic losses ($R = 0$) on a superconductive transmission line, the attenuation constant is equal to 0. Below is an example of a steady-state transmission line that is suddenly switched off of the AC power supply at $t = 0$. In the graphs below, sketch the envelope of the total current and the total voltage that continues to oscillate on the line. (Hint: for this particular example, the voltages and currents on the line remain the same after the switch is opened $t = 0$.)





(d) **Volume of a Parallel-piped:** Three vectors $\vec{A}$, $\vec{B}$, and $\vec{C}$ are used to define a six-sided volume in space called a *parallel-piped*, pictured below. Derive a formula for the parallel-piped in terms of the three vectors.

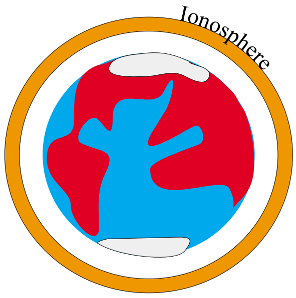




Hint: The volume of the parallel-piped is equal to the surface area of one side multiplied by the height, h, separating it from its opposite side.

Work-out Problem Section

(3) **Fields in the Ionosphere:** The ionosphere of earth occurs above 80 km from the surface of the earth. (The earth, itself, has a radius of 6000 km). The ionosphere is populated with free electrons that were dissociated from molecules and atoms by the solar radiation. You find one model in the research literature for the distribution of charge density (C/m^3) as a function of radius and elevation angle:



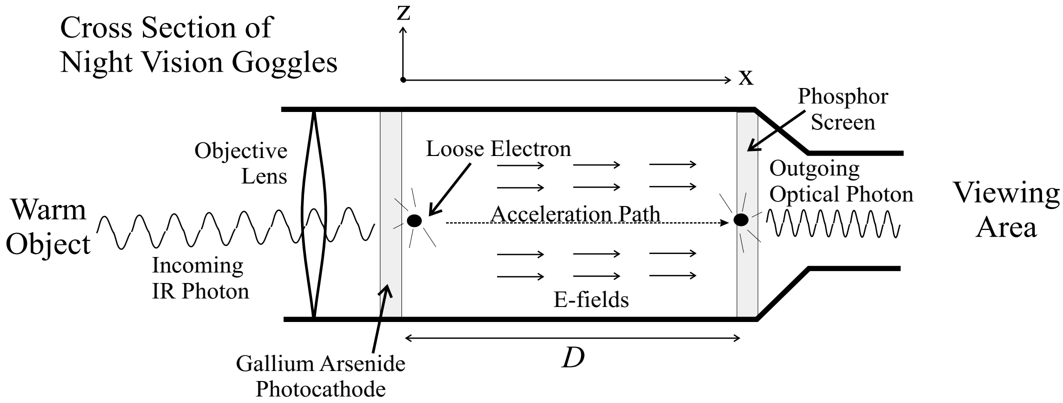
$$\rho(r, \phi, \theta) = \begin{cases} 0 & r < 6080 \text{ km} \\ -10^{-10} \sin(\theta) & 6080 \text{ km} \leq r < 6180 \text{ km} \\ 0 & r \geq 6180 \text{ km} \end{cases}$$

(a) What is the total amount of charge in the ionosphere?

(b) We are interested in calculating the electric field in deep space due to all charges in the ionosphere on earth. For this we can approximate the earth as a point charge. Write the equation for total electric field due to the ionosopheric charge as a function of $\vec{r}$, assuming that the earth is at the origin of the coordinate system.

(c) Set up the integral (but do not evaluate) for calculating the exact electric field for the scenario in (b), this time *not* making the point charge approximation.

(4) **Night Vision Goggles:** Commercial night vision goggles operate by receiving invisible infrared photons which, upon striking a thin Gallium-Arsenide *photocathode*, release a single electron into an acceleration chamber. In this chamber, strong electric fields accelerate the electron and smash it into a phosphor screen, where optical photons are released for the viewing person to see.



The E-field of the acceleration chamber is given by the following equation:

$$\vec{E}(\vec{r}) = 10,000 \sin\left(\pi \frac{x}{D}\right) \hat{a}_x$$

How much work is done on the electron (-1.60×10^{-19} C) before it is smashed onto the phosphor screen?

(5) **Vector Algebra Proofs:** Prove the following relationships using basic definitions (on your equation sheet) from vector algebra.

(a) $\frac{|\vec{a}\times\vec{b}|}{\vec{a}\cdot\vec{b}} = \tan\theta_{AB}$

(b) $\vec{a}\cdot(\vec{a}\times\vec{b}) = 0$

(c) $\vec{a}\cdot\vec{a} = |\vec{a}|^2$

(d) $\vec{a}\times\vec{b} = -\vec{b}\times\vec{a}$