Maxwell's Equations - Differential Form (20)

1) $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$
2) $\nabla \cdot \vec{D} = \rho$
3) $\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$
4) $\nabla \cdot \vec{B} = 0$

What are the simplified differential Maxwell's equations for DC currents and static charges? (4)

What are the simplified differential Maxwell's equations for sinusoidal sources? (4)

Write down the number of the associated equation from the above list that is associated with the following statements. (12)
The displacement field normal to a dielectric-dielectric boundary is continuous.

The magnetic field tangental to a dielectric-dielectric boundary is continuous.

Time varying currents produce an electric field in wire loops.

There are no magnetic monopoles.

True or False (15)

1) The voltage in a good conductor is always near zero.

2) Electric field lines point in the direction of increasing voltage.

3) Capacitance and inductance only depend on the material properties and the geometry.

4) Diamagnetic materials have a relative permeability less than one.

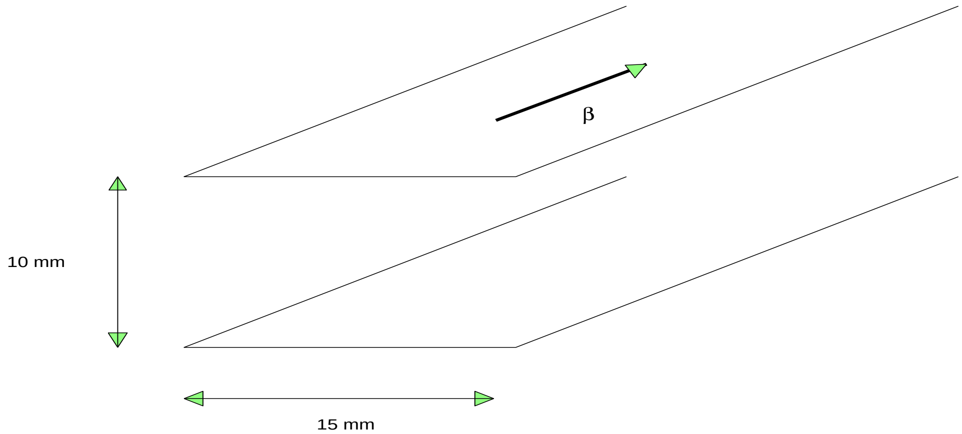
5) Holding the charge constant in a capacitor and adding a dielectric material, the electric field in the capacitor will be reduced.

6) If the input impedance of a lossless transmission line is a short circuit, the load must be an short circuit.

7) At a point significantly far from an antenna, locally, the propagating field can be considered planar.

8) I would like to see vector calculus in all my classes.

Transmission Lines (30)



A parallel plate transmission line is shown in the figure, with the direction of propagation indicated by β. Draw a cross sectional view of the line and label the voltage, current, electric field lines and magnetic field lines at an arbitrary point. Only the forward propagating wave should be considered. All vector must have an associated direction. Indicate the direction of propagation in your figure (into the page or out of the page)(8)

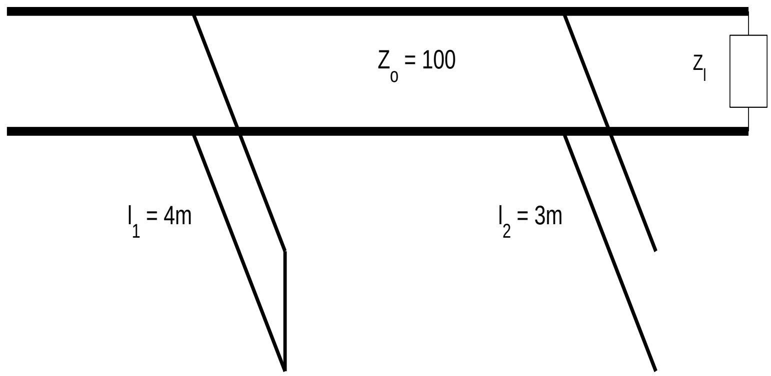
The line should have a velocity of 2.0E8 m/s and a characteristic impedance of 150 Ω. Determine the capacitance and inductance per unit length of the line. (6)

What is the relative permeability and relative permittivity of the insulating material? (5)

The insulating material has a dielectric breakdown of 125 kV/m. If the line is to be used for high power with a 1kV forward propagating wave, what is the maximum magnitude of the reflection coefficient. (6)

What is the range of possible resistive loads for this reflection coefficient. (5)

Transmission Lines - Stubs (15)



In the figure shown, two stubs are attached to the transmission line. Both the stubs and the line are lossless, have the same characteristic impedance, and have a velocity of 2E8 m/s. One stub is open and the other is short, as indicated on the figure. What frequency(s) will be blocked at the load? (15)

Magnetostatics (20)

Two equal and opposite current distributions exist in a cylindrical coordinate system. $J_i = 1\hat{z}$ A/m^2 for $a < r^2 < b$. $J_o = -J_s\hat{z}$ A/m at r = c. ($a < b < c$).

What is J_s if the net current is zero? (5)

Draw the figure you would use to apply Ampere's Law. (5)

Determine $\vec{H}$ everywhere. (8)

Which of the following will cause an increase in inductance? (2)

1) Decreasing a, holding b and c constant.
2) Decreasing b, holding a and c constant.
3) Decreasing c, holding a and b constant.
4) Increasing the current densities, keeping the total currents equal and opposite and holding a, b, and c constant.

Electrostatics (30)

A charge distribution $\rho = e^{-ax}$ C/m^3 exists between two parallel plates located at z = -1mm and z = 1mm. The left plate is grounded and the right plate is set to V = 0.7 V.

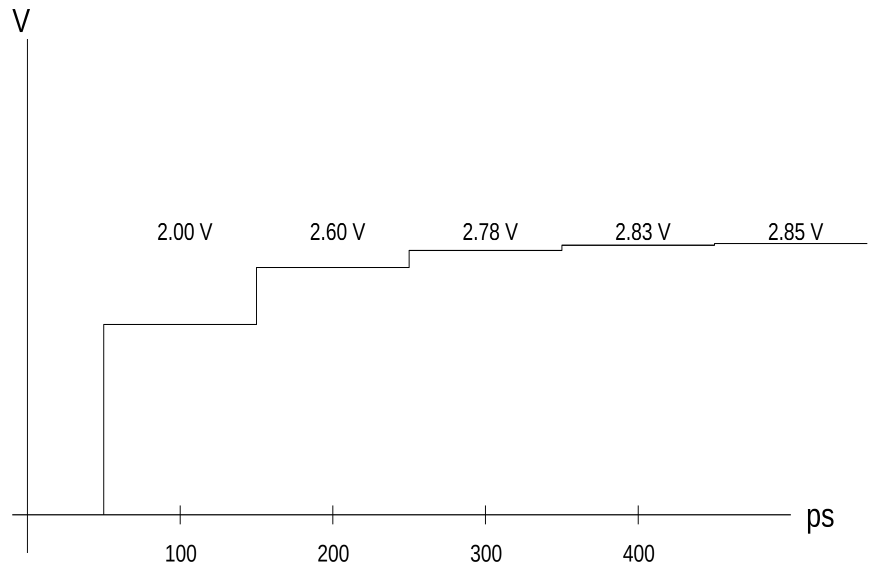
What is the voltage distribution in this region? (8)

What is the electric field? (8)

Confirm that this field is consistent with the charge distribution. (6)

What is the stored energy per unit area? (8)

Pulse Propagation (25)



The voltage at the load of a short transmission line is shown in the figure. The line has a velocity of 100E6 m/s and the source is DC and switches to 5 V at t = 0. If the load impedance is 100 Ω, what is the source impedance? (5)

(If you are stuck here, use 150 Ω)

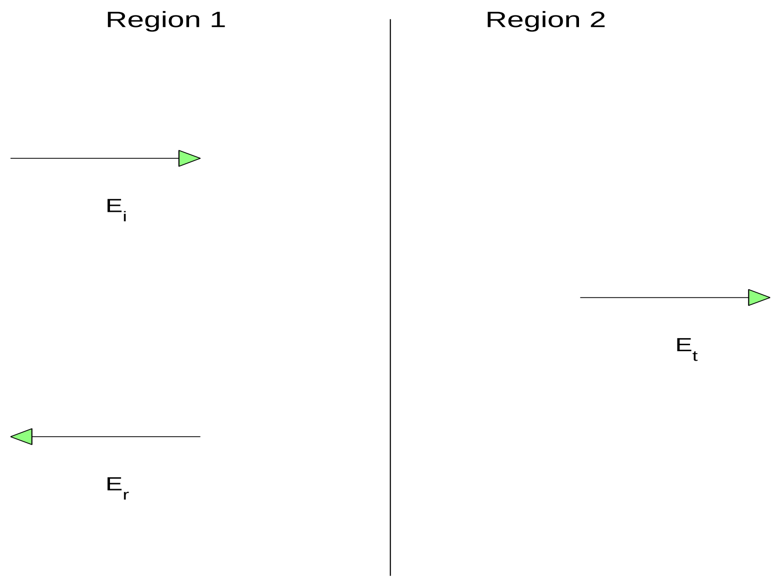
What is the the length of the line? (5)

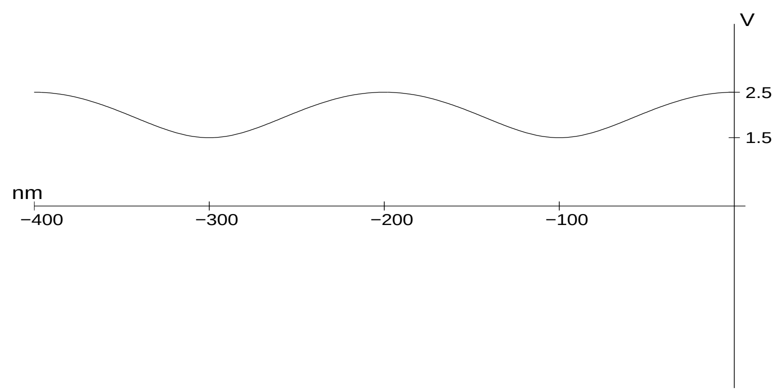
What is the line impedance? (5)

At 75ps what is the voltage at the source? (5)

At 125ps what is the voltage at the source? (5)

Plane Waves (30)





A plane wave is normally incident on a dielectric-air boundary. Both regions are lossless. The standing wave pattern is shown in the figure. (The pattern continues in the -x direction.)

What is the standing wave ratio, SWR? (3)

Which region is dielectric and which region is air? (3)

What is the reflection coefficient? (4)

What is the relative permittivity in the dielectric region? (4)

The incident electric field is polarized in the $\hat{y}$ direction and is propagating in the $\hat{z}$ direction.

What is the complete expression for $\vec{H}$ in region 1 in phasor form? (6)

What is the complete expression for $\vec{H}$ in region 2 in phasor form? (6)

What percentage of the incident power is transmitted to region 2? (4)