School of Electrical and Computer Engineering, Cornell University

ECE 303: Electromagnetic Fields and Waves

Fall 2007

Exam 3 **November 15, 2007**

INSTRUCTIONS:

• Only work done on the blue exam booklets will be graded – do not attach your own sheets to the exam booklets under any circumstances

• Every problem must be done in a separate blue booklet – so you must have 3 separate blue booklets before starting the exam

• To get partial credit you must show all the relevant work

• Correct answers with wrong reasoning will not get points

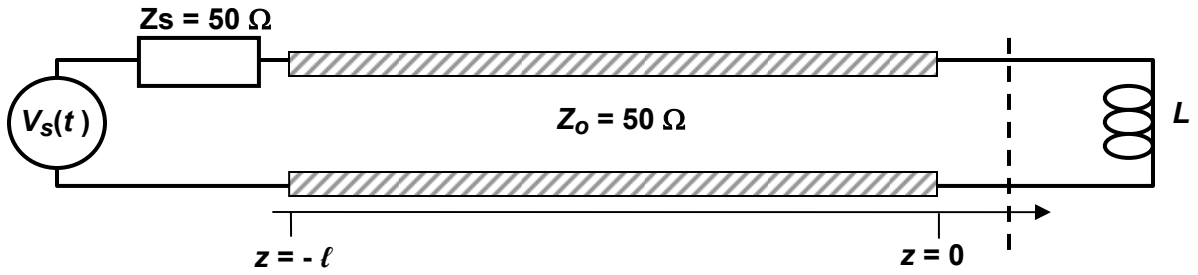
• All questions do not carry equal points

• All questions do not have the same level of difficulty

DO NOT WRITE IN THIS SPACE

Problem 1 (40 points)

Consider the transmission line circuit shown below:



Assume that $\ell = 3$ cm, $v = 3\times10^8$ m/s, and $L = 0.1$ nH.

a) If the source voltage is a step function given by: $V_s(t) = 4u(t)$, find and plot the currents $I_+(z,t)$, $I_-(z,t)$, $I(z,t)$ on the transmission line at time $t = 3\ell/2v$. Use the attached sheet to plot your results. **Indicate the current values.** Partial credit will be given only if proper work is shown.

For parts (b) and (c) assume that the source voltage is equal to 4 Volts and it was turned on a very long time ago in the past at time $t = -\infty$. At time $t = 0$, the source voltage is turned off (i.e. it becomes 0 Volts).

b) Find the Thevenin equivalent circuit for the circuit on the **LEFT** of the dashed line, and indicate the values of the Thevenin impedance and the time-dependent Thevenin voltage for times $0 < t < 3\ell/v$. You need to make a sketch of the Thevenin voltage for times $0 < t < 3\ell/v$.

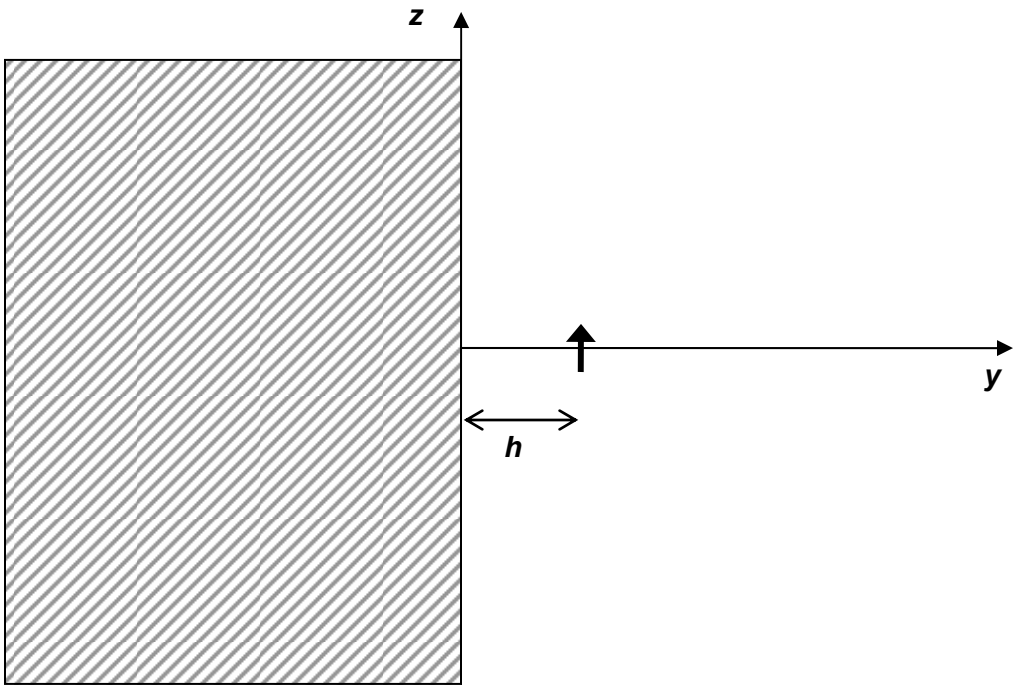
c) Find and plot the voltages $V_+(z,t)$, $V_-(z,t)$, $V(z,t)$ on the transmission line at time $t = 3\ell/2v$. Use the attached sheet to plot your results. **Indicate the voltage values.** Partial credit will be given only if proper work is shown.

For part (d) assume that the source impedance Z_s is 150 Ω instead of 50 Ω. Also assume that the source voltage is equal to 4 Volts and it was turned on a very long time ago in the past at time $t = -\infty$. At time $t = 0$, the source voltage is turned off (i.e. it becomes 0 Volts).

d) Find and plot the voltages $V_+(z,t)$, $V_-(z,t)$, $V(z,t)$ on the transmission line at time $t = \ell/2v$. Use the attached sheet to plot your results. **Indicate the voltage values.** Partial credit will be given only if proper work is shown.

Problem 2 (30 points)

Consider a Hertzian dipole antenna that is placed on the y-axis closed to an infinite perfect metal plane (that completely occupies the –ve side of the y-axis), as shown below.



Assume that the current phasor of the dipole is given by $I = I_o\ e^{j\pi/3}$ and the length of the dipole is d.

a) Find the expression for the far-field electric field vector $\vec{E}_{ff}(\vec{r})$ for the radiation emitted by the dipole.

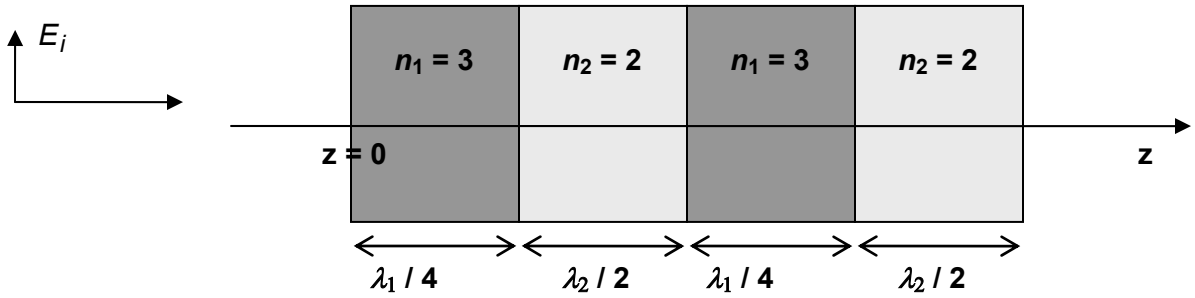
b) Find the expression for the total radiation power emitted by the dipole in terms of the current phasor $I = I_o\ e^{j\pi/3}$ of the dipole.

c) Find the expression for the radiation pattern $p(\theta,\phi)$ for the dipole radiation.

d) Sketch the radiation pattern $p(\theta,\phi)$ in the ***x-y* plane** assuming that the distance h equals $\lambda / 2$.

Problem 3 (30 points)

a) Consider a dielectric stack with thicknesses and refractive indices as shown below:

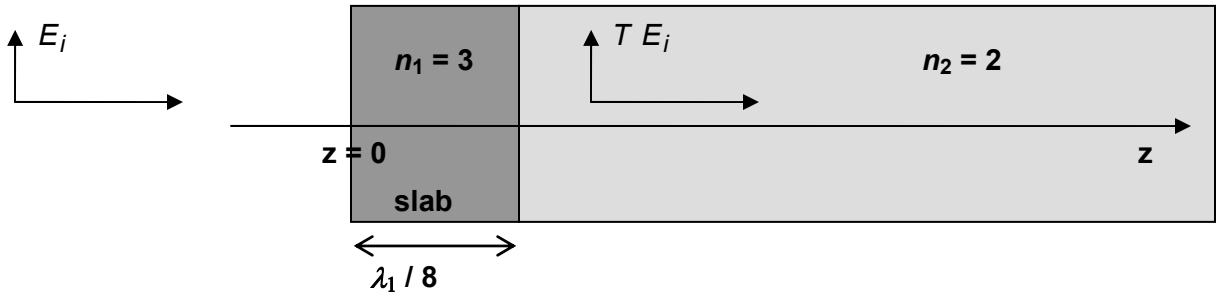


If the incident plane wave is:

$\hat{y}\, E_i\, e^{-jkz}$

find the reflection coefficient Γ at the z=0 interface.

b) Consider a dielectric slab with thickness and refractive index as shown below. To the right of the slab is an infinite medium of refractive index equal to 2.



If the incident plane wave is:

$\hat{y}\, E_i\, e^{-jkz}$

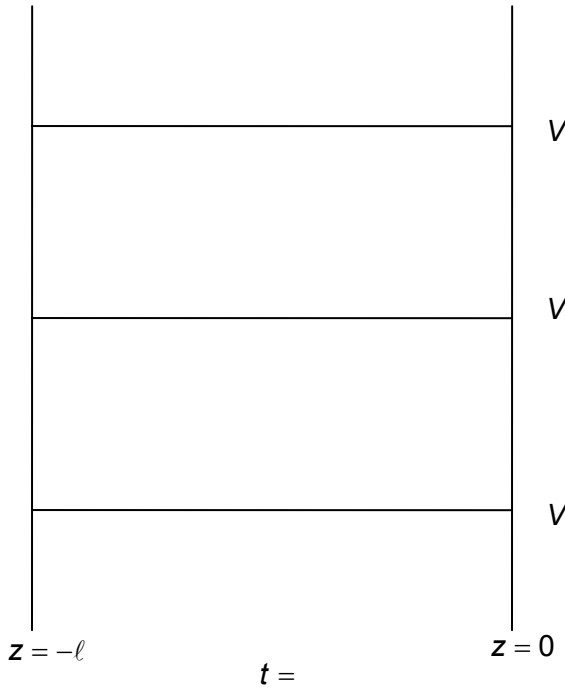
find the reflection coefficient Γ at the z=0 interface.

c) In part (b) if the wave transmitted through the slab, on the right side of the slab, is written as:

$\hat{y}\, TE_i\, e^{-jkz}$

find the magnitude of the transmission coefficient T.

Problem and Part Number:



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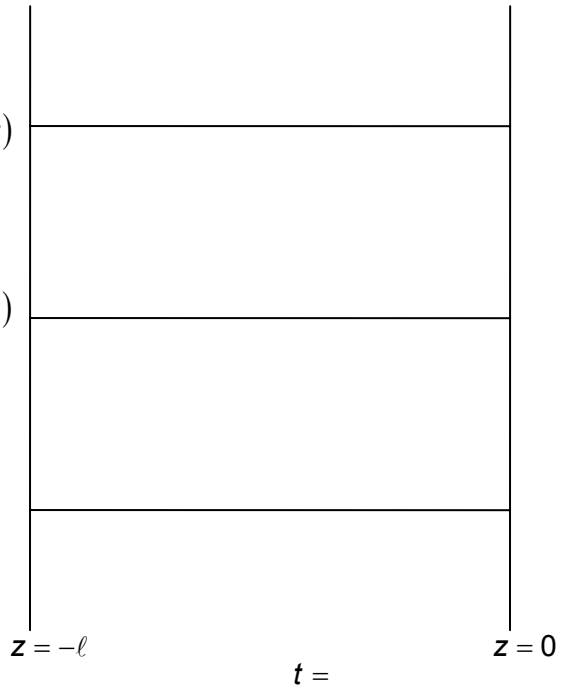

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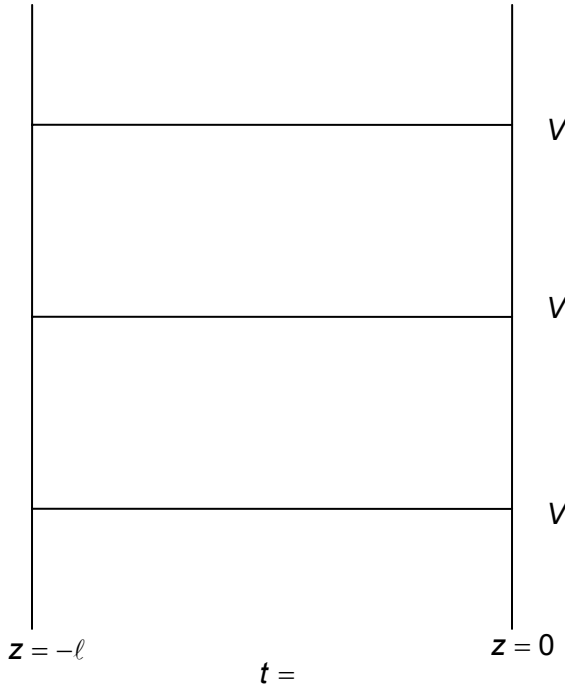

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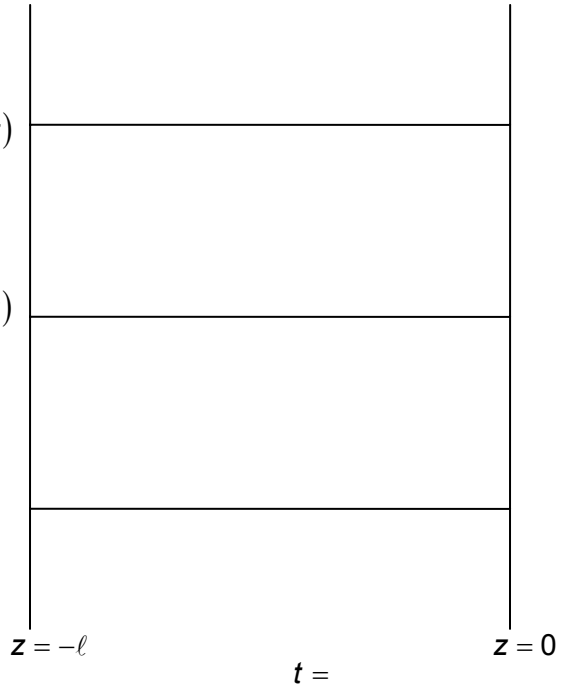

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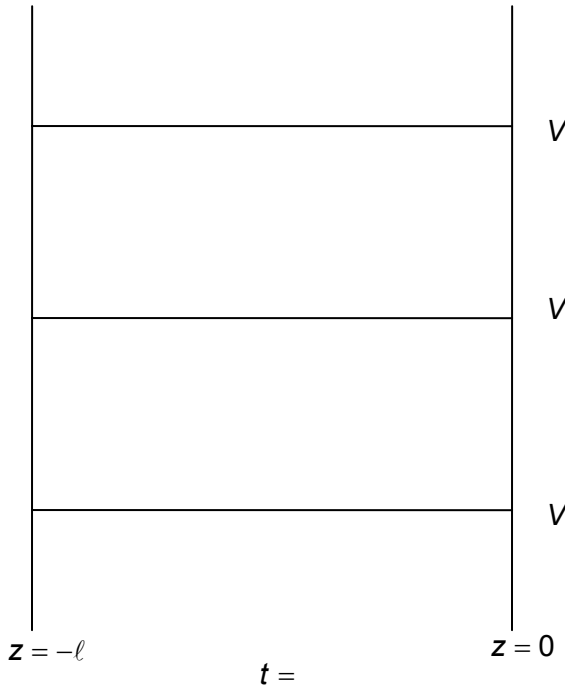

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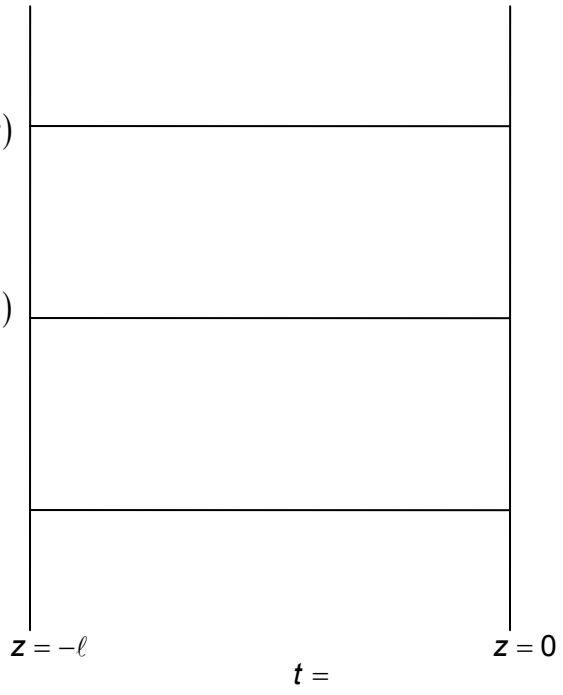

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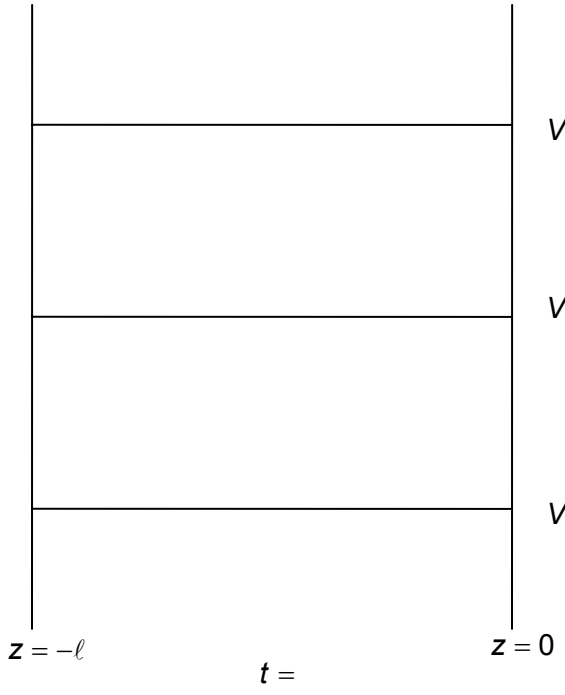

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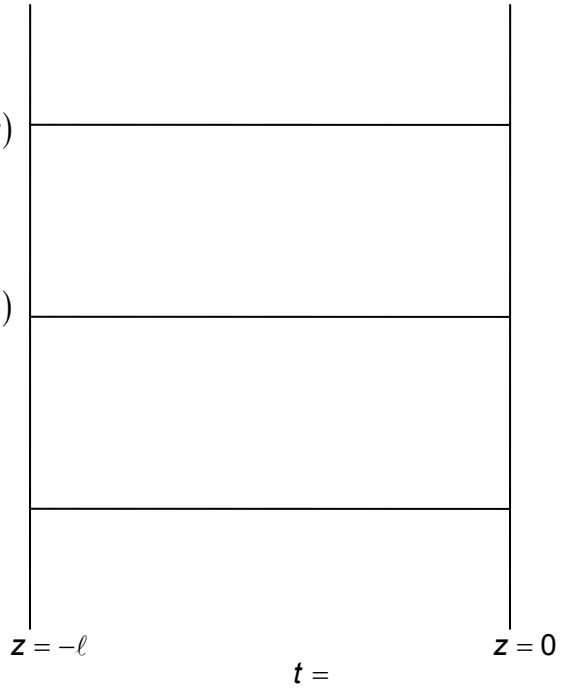

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The Complete Smith Chart