SMG-8306 Transmission lines and waveguides

Small Exam I, February 3rd 2012. Answer to three of the four questions.
Each question gives in maximum 4 points
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1. (a) It can be shown that the propagation of signals can be analyzed using the 2nd order wave equation

\[ \frac{\partial^2 V(z)}{\partial z^2} = LC \frac{\partial^2 V(z)}{\partial t^2}. \]  

i. Consider a reasonable starting point and derive the wave equation.
ii. Assume a lossless line, find a solution to the equation.

(b) Consider how to approximate the derivatives in eqn. (1) and present a numerical scheme in view of the FDTD-codes (similarly as was done with the leap-frog scheme).

(4 p.)

2. (a) Express the Poynting theorem and give interpretation of it and its terms.
(b) Correct or incorrect? To get points, support your answer by an argument or an example.

i. Surface current is an idealization that helps in analyzing cases that include very good conductors at high frequencies.
ii. Consider a transmission line (whose characteristic impedance is \( Z_0 \)) of length \( l \) connected to a load (characterized as \( Z_L \)). The impedance seen at the generator end is

\[ Z_i = \frac{Z_0 Z_L + Z_0 \tanh \gamma l}{Z_0 - Z_L \tanh \gamma l}. \]

(4 p.)

3. (a) Prepare a concise description about the core assumptions inherent in analysis of transmission lines.
(b) Outline a procedure to find out the parameters of a lossless transmission line.

(4 p.)

4. (a) Define in a few words:

i. phase velocity
ii. quasi-TEM wave

(b) Let\( s\) consider a plane wave that is travelling along \( z\)-axis and whose electric field is \( E(x, t) = E_0 \cos(\omega t - kz)j \). Let it travel in medium whose relative permittivity is 4 and relative permeability 1. Let frequency be 3.0GHz and \( E_0 = 30V/m.\)

i. Find the amplitude and direction of magnetic field.
ii. Find the phase velocity and wavelength.
iii. Find the phase shift (in degrees) between positions \( z_1 = 0.5m \) and \( z_2 = 1.7m.\)

(4 p.)