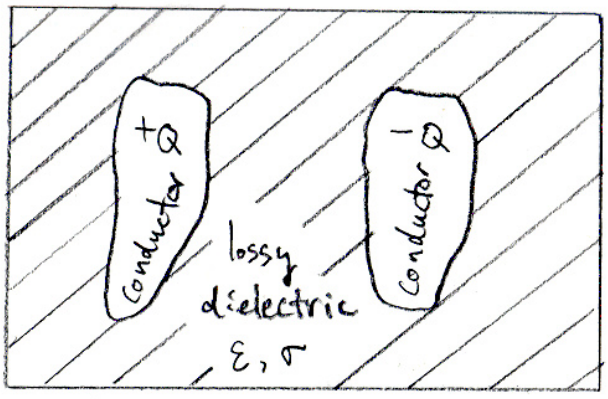
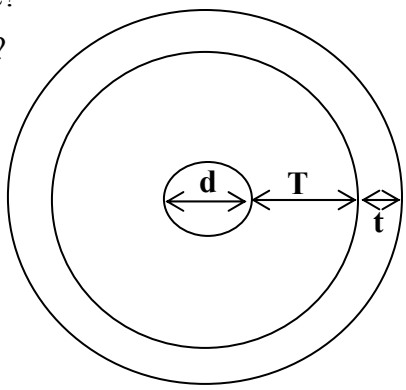
# Problem Set #2

## ECE357 /ECE320
## University of Toronto

1. Starting with general transmission line equations in the time domain, derive the transmission line wave equation for the current $i(z,t)$.
2. Derive the transmission line wave equation for current in sinusoidal steady state form.
3. Prove that the solution to $\frac{\partial^2 \overline{V}(z)}{\partial z^2} = \gamma^2 \overline{V}(z)$ is given by $\overline{V}(z) = V_0^+ \exp(-\gamma z) + V_0^- \exp(+\gamma z)$.
4. For a distortion-less line, find the propagation constant, attenuation constant, phase constant, phase velocity and characteristic impedance.
5. The figure shows two charged conductors immersed in a lossy dielectric of conductivity $\sigma$ and dielectric constant $\varepsilon$.
   a. Show that $RC = \frac{C}{G} = \frac{\varepsilon}{\sigma}$, where $R = \frac{1}{G}$ is the resistance associated with the lossy dielectric and $C$ is the capacitance between the two conductors.
   b. From the results in part (a), find the leakage conductance per unit length of coaxial cable of inner radius $a$ and outer radius $b$.



6. The figure shows a RG58C/U coaxial cable, idealized to solid outer conductor. Let us assume that the cable is a low loss (high frequency limit) transmission line with characteristic impedance of $Z_0 = 50\Omega$.




   a. What is the transmission line capacitance?
   b. What is the transmission line inductance?
   c. What is the transmission line resistance?
   d. What is the transmission line conductance?
   e. Find a frequency range for which the high frequency assumption used is valid.

   Inner conductor: Copper, $d = 0.9$ mm, $\rho_c = 1.7 \times 10^{-8}\,\Omega\,\text{m}$

   Dielectric: Polyethylene, $T = 1.02$ mm, $\rho_d = 10^{14}\,\Omega\,\text{m}$, $\varepsilon_r = 2.3$

   Outer conductor: Copper, $t = 1$ mm, $\rho_c = 1.7 \times 10^{-8}\,\Omega\,\text{m}$

7. The attenuation constant of a $50\Omega$ distortionless line is 0.01dB/m and its capacitance is 0.1nF/m.
   a. What are the values of the line resistance, conductance, and inductance per meter?
   b. What is the phase velocity of the propagating waves?
   c. What are the ratios of the magnitude of the propagating fields at 1km and 5km with respect to the starting point at $z = 0$?

8. Use the relation $\alpha = \dfrac{P_{dis}}{2P(z)}$ to find the attenuation constant for a low loss line (high frequency limit).