Problem 1 - resistance and attenuation of coaxial cables

In the waves section of the course, we will learn that waves penetrate into a material a distance known as a skin depth, \( \delta = (\pi f \mu \sigma)^{-0.5} \).

a. Calculate the skin depth in copper at 1 kHz and 15 MHz.

b. An RG-58 cable has a polyethylene dielectric (\( \varepsilon_r = 2.3 \) and \( \sigma = 10^{-13}/\text{ohm m} \)) and copper conductors. The inner conductor extends from \( r = 0 \) to \( r = a \approx 0.4 \text{ mm} \) and the outer conductor extends from \( r = b \approx 1.4 \text{ mm} \) to 1.53 mm.
   1) Calculate the resistance per unit length, \( r \), and conductance per unit length, \( g \), at 1 kHz. Use \( \sigma = 1\text{E-13} \text{ [S/m]} \) for the polyethylene and \( \sigma = 5.8\text{E7} \text{ [S/m]} \) for copper.
   2) Repeat for 15 MHz.

c. The inductance and capacitance per unit length, \( I \) and \( C \), have already been calculated (Lesson 1.1). They are 0.25 \( \mu \text{H/m} \) and 100 \( \text{pF/m} \) respectively. At 15 MHz,
   1) determine the characteristic impedance, \( Z_C \),
   2) the propagation constant, \( \gamma = \alpha + j\beta \)
   3) the distance a wave travels before the voltage is attenuated to \( 1/e \) of its original value.
   4) The reflection coefficient for a 93 \( \Omega \) load.

d. What parameters are essentially the same for low-loss and lossless lines? What is new?