Goal: Refer to Example 3-16 in Cheng (page 119). Assuming the same r_i and r_o and requiring the maximum electric field intensities in the insulting materials not exceed 25% of their dielectric strengths, determine the voltage rating of the coaxial cable a) if $r_p = 1.75r_i$, b) if $r_p = 1.35r_i$, and c) Plot the variations of E_r and V versus r for both part a) and part b).

Steps:

1. Determine an expression for the electric field in the coaxial cable if rubber is used as insulation.

   Solution:

   $$\frac{\rho_l}{2\pi\varepsilon_o}\left(\frac{1}{3.2r_i}\right)$$

2. Determine an expression for the electric field in the coaxial cable if polystyrene is used as insulation.

   Solution:

   $$\frac{\rho_l}{2\pi\varepsilon_o}\left(\frac{1}{2.6r_i}\right)$$

3. Determine an expression for the voltage rating of the cable for $r_p = kr_i$, where k is a constant.

   Solution:

   $$\begin{aligned} & -\int_{r_o}^{r_p} E_p\, dr - \int_{r_p}^{r_i} E_r\, dr \\ = \; & \frac{\rho_l}{2\pi\varepsilon_o}\left(\frac{1}{\varepsilon_{r_p}}\ln\frac{r_o}{r_p} + \frac{1}{\varepsilon_{r_r}}\ln\frac{r_p}{r_i}\right) \\ = \; & \frac{\rho_l}{2\pi\varepsilon_o}\left(\frac{1}{\varepsilon_{r_p}}\ln\frac{r_o}{kr_i} + \frac{1}{\varepsilon_{r_r}}\ln k\right) \end{aligned}$$

4. For $r_p = 1.75r_i$, determine the voltage rating of the cable.

   Solution: First, we ρ_l via

   $$\frac{\rho_l}{2\pi\varepsilon_o}\left(\frac{1}{3.2r_i}\right) = (0.25)(25\times 10^6)$$

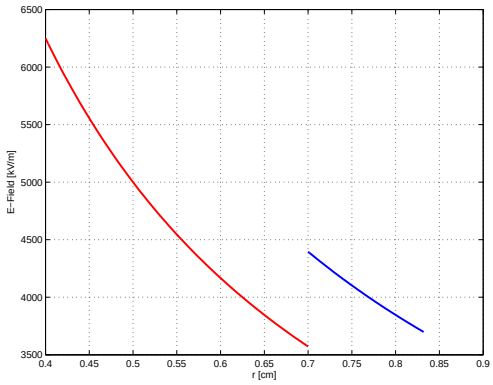
   Voltage rating = 19.3 kV

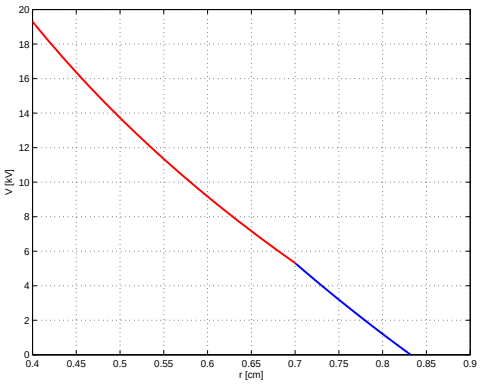
5. For $r_p = 1.35r_i$, determine the voltage rating of the cable.

   Solution: Voltage rating = 20.803 kV

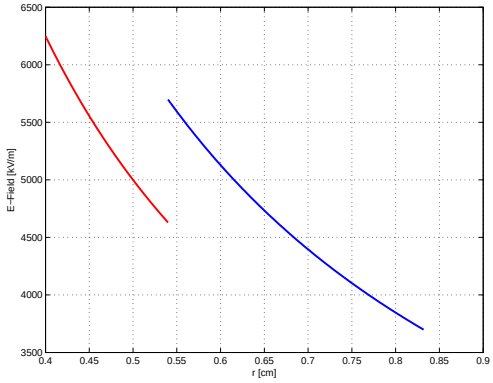
6. Sketch the voltages inside the cable as a function of r.

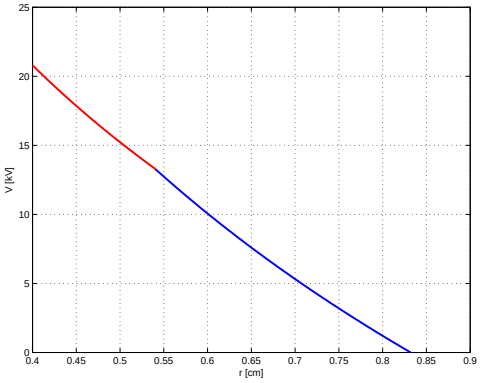
   Solution:
   Cheng 3-29 (a)





Cheng 3-29 (b)





Answer:

(a) Voltage rating=19.3 kV

(b) Voltage rating=20.803 kV

(c) Plots