**Problem 2.6** A coaxial line with inner and outer conductor diameters of 0.5 cm and 1 cm, respectively, is filled with an insulating material with $\varepsilon_r = 4.5$ and $\sigma = 10^{-3}$ S/m. The conductors are made of copper.

**(a)** Calculate the line parameters at 1 GHz.

**(b)** Compare your results with those based on CD Module 2.2. Include a printout of the screen display.

**Solution: (a)** Given

$$a = (0.5/2)\text{ cm} = 0.25 \times 10^{-2}\text{ m},$$
$$b = (1.0/2)\text{ cm} = 0.50 \times 10^{-2}\text{ m},$$

combining Eqs. (2.5) and (2.6) gives

$$\begin{aligned} R' &= \frac{1}{2\pi}\sqrt{\frac{\pi f \mu_c}{\sigma_c}}\left(\frac{1}{a}+\frac{1}{b}\right) \\ &= \frac{1}{2\pi}\sqrt{\frac{\pi(10^9\text{ Hz})(4\pi\times 10^{-7}\text{ H/m})}{5.8\times 10^7\text{ S/m}}}\left(\frac{1}{0.25\times 10^{-2}\text{ m}}+\frac{1}{0.50\times 10^{-2}\text{ m}}\right) \\ &= 0.788\ \Omega/\text{m}. \end{aligned}$$

From Eq. (2.7),

$$L' = \frac{\mu}{2\pi}\ln\left(\frac{b}{a}\right) = \frac{4\pi\times 10^{-7}\text{ H/m}}{2\pi}\ln 2 = 139\text{ nH/m}.$$

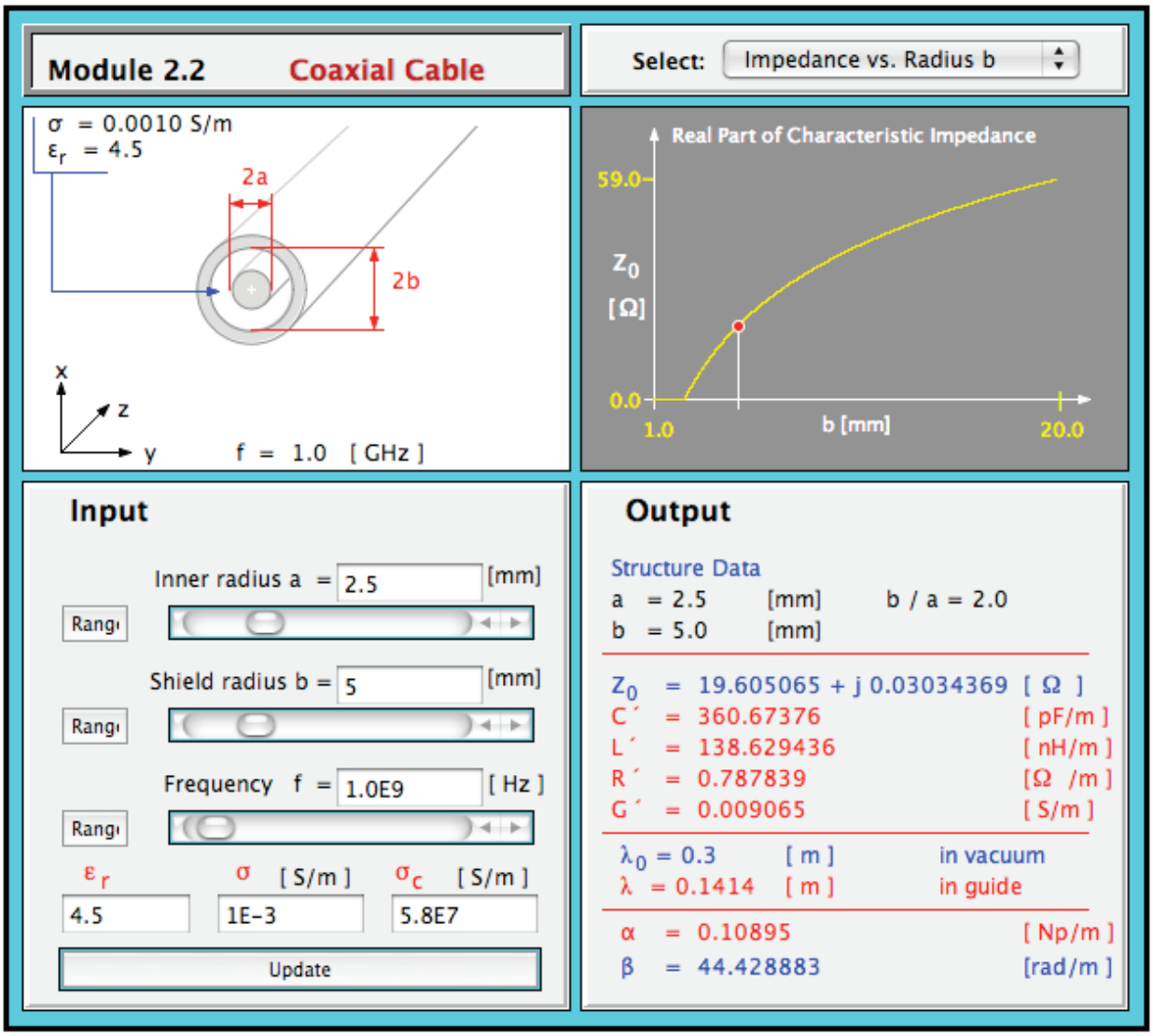
From Eq. (2.8),

$$G' = \frac{2\pi\sigma}{\ln(b/a)} = \frac{2\pi\times 10^{-3}\text{ S/m}}{\ln 2} = 9.1\text{ mS/m}.$$

From Eq. (2.9),

$$C' = \frac{2\pi\varepsilon}{\ln(b/a)} = \frac{2\pi\varepsilon_r\varepsilon_0}{\ln(b/a)} = \frac{2\pi\times 4.5\times(8.854\times 10^{-12}\text{ F/m})}{\ln 2} = 362\text{ pF/m}.$$

**(b)** Solution via Module 2.2:


Module 2.2
Coaxial Cable
Select:
Impedance vs. Radius b
σ = 0.0010 S/m
εr = 4.5
2a
2b
x
z
y
f = 1.0 [ GHz ]
Real Part of Characteristic Impedance
59.0
Z0
[Ω]
0.0
1.0
b [mm]
20.0
Input
Inner radius a = 2.5 [mm]
Rang
Shield radius b = 5 [mm]
Rang
Frequency f = 1.0E9 [ Hz ]
Rang
εr
σ [ S/m ]
σc [ S/m ]
4.5
1E-3
5.8E7
Update
Output
Structure Data
a = 2.5 [mm] b / a = 2.0
b = 5.0 [mm]
Z0 = 19.605065 + j 0.03034369 [ Ω ]
C´ = 360.67376 [ pF/m ]
L´ = 138.629436 [ nH/m ]
R´ = 0.787839 [Ω /m ]
G´ = 0.009065 [ S/m ]
λ0 = 0.3 [ m ] in vacuum
λ = 0.1414 [ m ] in guide
α = 0.10895 [ Np/m ]
β = 44.428883 [rad/m ]