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 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),

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

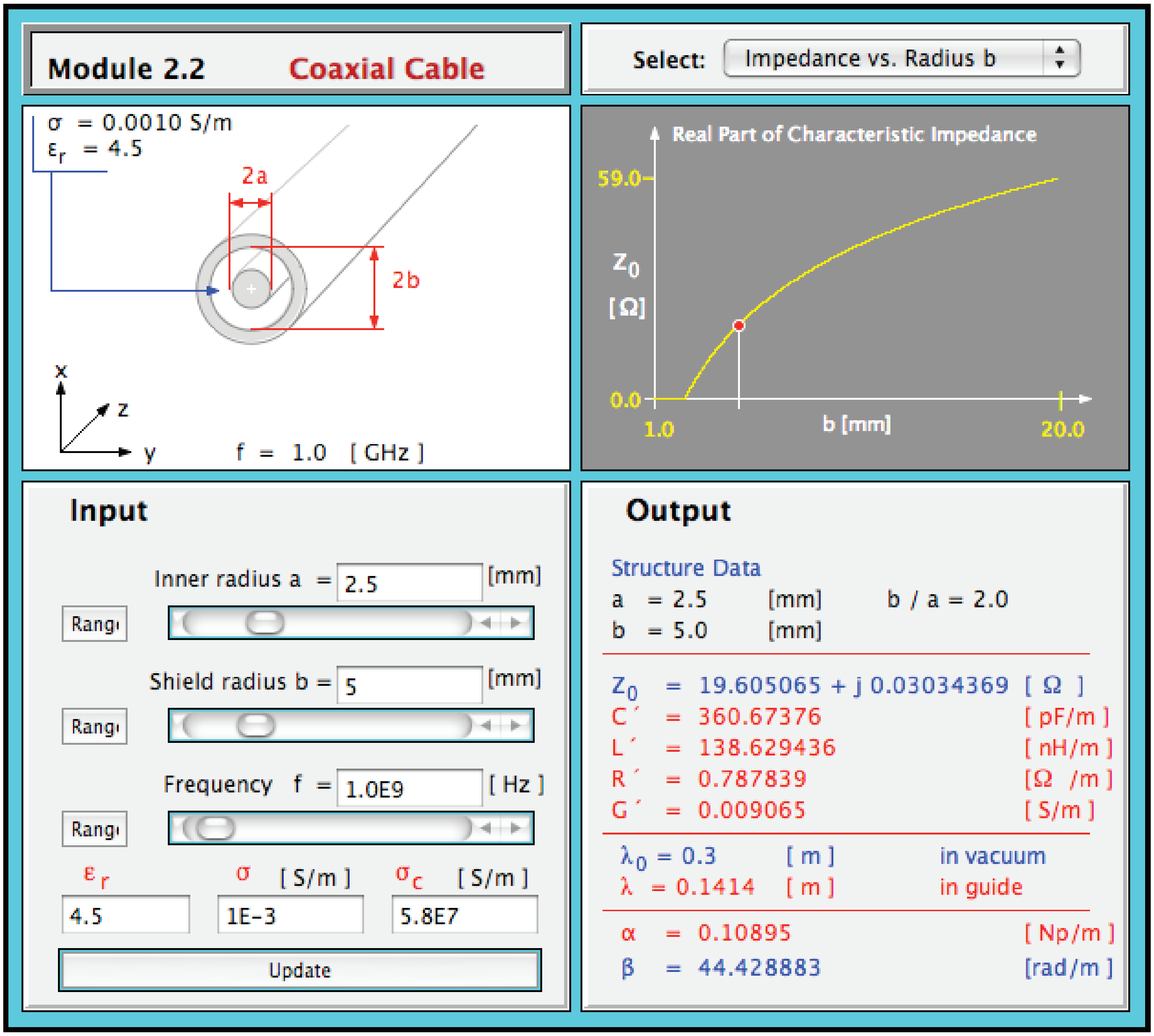
From Eq. (2.8),

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

From Eq. (2.9),

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

(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]
Shield radius b = 5 [mm]
Frequency f = 1.0E9 [Hz]
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]