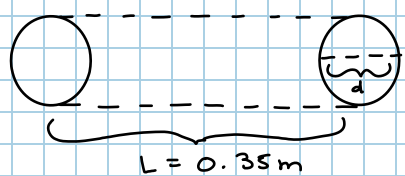
Problem 30.68

Thursday, May 08, 2014
6:04 PM

The conductive tissues of the upper leg can be modeled as a 35-cm-long, 16-cm-diameter cylinder of muscle and fat. The resistivities of muscle and fat are 13 Ωm and 25 Ωm, respectively. One person's upper leg is 82%muscle, 18% fat. The resistivity of the whole leg will be a weighted average of the resistivities of muscle and fat. This is not the same as treating the system as two resistors (one made of muscle and the other of fat) in parallel; the muscle and fat are mixed together, not separate side by side.

Part A: What current is measured if a 1.9V potential difference is applied between the person's hip and knee?



$d = 0.16\,m$

$\rho_{muscle} = 13\,\Omega\cdot m$ $\quad A = \pi r^2$

$\rho_{fat} = 25\,\Omega\cdot m$ $\quad A = 2\pi r h + 2\pi r^2$

$r = 0.08\,m$ $\quad 0.82 \rightarrow$ muscle

$0.18 \rightarrow$ fat

$\Delta V = 1.9\,V$

$$R_{muscle} = \frac{\rho L}{A} = \frac{13\,\Omega\cdot m\,(0.35\,m)}{\pi(0.08\,m)^2} = 226.3\,\Omega$$

$$R_{fat} = \frac{\rho L}{A} = \frac{25\,\Omega\cdot m\,(0.35\,m)}{\pi(0.08\,m)^2} = 435.2\,\Omega$$

$$I_{muscle} = \frac{\Delta V}{R} = \frac{1.9\,V}{226.3\,\Omega} = 8.4 \times 10^{-3}\,A$$

Multiply by 0.82 $\rightarrow I_{muscle} = 6.88 \times 10^{-3}\,A$

$$I_{fat} = \frac{\Delta V}{R} = \frac{1.9\,V}{435.2\,\Omega} = 4.4 \times 10^{-3}\,A$$

Multiply by 0.18 $\rightarrow I_{fat} = 7.9 \times 10^{-4}\,A$

$$I_{total} = I_{muscle} + I_{fat} = 7.67 \times 10^{-3}\,A$$