Solution to Physlets 11

Problem 19.9

By pushing the sliders in opposite directions, I achieved the maximum thermal gradients. First, I moved the top slider all the way to the left and the bottom slider all the way to the right. In this case, I recorded the following temperatures:

\[ T_{\text{left}} = 200 \, \text{K} \]
\[ T_{\text{interface}} = 320 \, \text{K} \]
\[ T_{\text{right}} = 400 \, \text{K} \]

Now, moving the top slider all the way to the right and the bottom slider all the way to the left, I found the following temperatures:

\[ T_{\text{left}} = 232.99 \, \text{K} \]
\[ T_{\text{interface}} = 213.196 \, \text{K} \]
\[ T_{\text{right}} = 200 \, \text{K} \]

Measuring the thicknesses of the media, I found the green to be 0.04 m thick while the red was 0.02 m thick.

Now I know the heat transfer rate across the left interface must equal that across the center interface must equal that across the right interface. Using the first set of data, I find:

\[
\frac{H}{A} = \frac{k_{\text{th}}}{l} \Delta T = \frac{k_{\text{green}}}{0.04 \, \text{m}} (320 \, \text{K} - 200 \, \text{K}) = (3000 \, \frac{k}{\text{m}})k_{\text{green}}
\]
\[
= \frac{k_{\text{red}}}{0.02 \, \text{m}} (400 \, \text{K} - 320 \, \text{K}) = (4000 \, \frac{k}{\text{m}})k_{\text{red}}
\]

\[ k_{\text{green}} = \frac{4}{3} k_{\text{red}} \]

So the green material has the higher thermal conductivity. To confirm, I used the second set of data…

\[
\frac{H}{A} = \frac{k_{\text{th}}}{l} \Delta T = \frac{k_{\text{green}}}{0.04 \, \text{m}} (232.99 \, \text{K} - 213.196 \, \text{K}) = (494.85 \, \frac{k}{\text{m}})k_{\text{green}}
\]
\[
= \frac{k_{\text{red}}}{0.02 \, \text{m}} (213.196 \, \text{K} - 200 \, \text{K}) = (659.8 \, \frac{k}{\text{m}})k_{\text{red}}
\]

\[ k_{\text{green}} = \frac{4}{3} k_{\text{red}} \]

Yup. The same answer.
Problem 20.2

The **left wall** has the higher temperature. In collisions with the left wall, the particle speeds are observed to increase. In collisions with the right wall, they decrease. Since temperature is related to thermal energy, and hence, rms speeds, increased speeds indicate increased temperatures.