27. (a) Let ΔT be the change in temperature and κ be the coefficient of linear expansion for copper. Then $\Delta L = \kappa L\, \Delta T$ and

$$\frac{\Delta L}{L} = \kappa\, \Delta T = (1.7 \times 10^{-5}/\mathrm{K})(1.0°\mathrm{C}) = 1.7 \times 10^{-5} \ .$$

This is equivalent to 0.0017%. Since a change in Celsius is equivalent to a change on the Kelvin temperature scale, the value of κ used in this calculation is not inconsistent with the other units involved. Incorporating a factor of 2 for the two-dimensional nature of A, the fractional change in area is

$$\frac{\Delta A}{A} = 2\kappa\, \Delta T = 2(1.7 \times 10^{-5}/\mathrm{K})(1.0°\mathrm{C}) = 3.4 \times 10^{-5}$$

which is 0.0034%. For small changes in the resistivity ρ, length L, and area A of a wire, the change in the resistance is given by

$$\Delta R = \frac{\partial R}{\partial \rho}\, \Delta\rho + \frac{\partial R}{\partial L}\, \Delta L + \frac{\partial R}{\partial A}\, \Delta A \ .$$

Since $R = \rho L/A$, $\partial R/\partial\rho = L/A = R/\rho$, $\partial R/\partial L = \rho/A = R/L$, and $\partial R/\partial A = -\rho L/A^2 = -R/A$. Furthermore, $\Delta\rho/\rho = \alpha\, \Delta T$, where α is the temperature coefficient of resistivity for copper ($4.3 \times 10^{-3}/\mathrm{K} = 4.3 \times 10^{-3}/\mathrm{C}°$, according to Table 27-1). Thus,

$$\begin{aligned} \frac{\Delta R}{R} &= \frac{\Delta\rho}{\rho} + \frac{\Delta L}{L} - \frac{\Delta A}{A} \\ &= (\alpha + \kappa - 2\kappa)\, \Delta T = (\alpha - \kappa)\, \Delta T \\ &= (4.3 \times 10^{-3}/\mathrm{C}° - 1.7 \times 10^{-5}/\mathrm{C}°)\, (1.0\, \mathrm{C}°) = 4.3 \times 10^{-3} \ . \end{aligned}$$

This is 0.43%, which we note (for the purposes of the next part) is primarily determined by the $\Delta\rho/\rho$ term in the above calculation.

(b) The fractional change in resistivity is much larger than the fractional change in length and area. Changes in length and area affect the resistance much less than changes in resistivity.