

11-37 An egg is dropped into boiling water. The cooking time of the egg is to be determined.

Assumptions **1** The egg is spherical in shape with a radius of $r_o = 2.75$ cm. **2** Heat conduction in the egg is one-dimensional because of symmetry about the midpoint. **3** The thermal properties of the egg are constant. **4** The heat transfer coefficient is constant and uniform over the entire surface. **4** The Fourier number is $\tau > 0.2$ so that the one-term approximate solutions (or the transient temperature charts) are applicable (this assumption will be verified).

Properties The thermal conductivity and diffusivity of the eggs are given to be $k = 0.6$ W/m. $^{\circ}$ C and $\alpha = 0.14 \times 10^{-6}$ m 2 /s.

Analysis The Biot number for this process is

$$Bi = \frac{hr_o}{k} = \frac{(1400 \text{ W/m}^2 \cdot ^{\circ}\text{C})(0.0275 \text{ m})}{(0.6 \text{ W/m} \cdot ^{\circ}\text{C})} = 64.2$$

The constants λ_1 and A_1 corresponding to this Biot number are, from Table 11-2,

$$\lambda_1 = 3.0877 \quad \text{and} \quad A_1 = 1.9969$$

Then the Fourier number becomes

$$\theta_{0,sph} = \frac{T_0 - T_{\infty}}{T_i - T_{\infty}} = A_1 e^{-\lambda_1^2 \tau} \longrightarrow \frac{70 - 97}{8 - 97} = (1.9969) e^{-(3.0877)^2 \tau} \longrightarrow \tau = 0.198 \approx 0.2$$

Therefore, the one-term approximate solution (or the transient temperature charts) is applicable. Then the time required for the temperature of the center of the egg to reach 70 $^{\circ}$ C is determined to be

$$t = \frac{\tau_o^2}{\alpha} = \frac{(0.198)(0.0275 \text{ m})^2}{(0.14 \times 10^{-6} \text{ m}^2/\text{s})} = 1070 \text{ s} = \mathbf{17.8 \text{ min}}$$

