Problem 5.9.51

Known:

\( T_i = 30.5 \degree C \)
\( T_\infty = 32.7 \degree C \)

Schematic:

Find:

Temperature versus time uses energy balance.

Strategy:

This is a transient, lumped parameter problem (there is only one temperature). It asks to derive the solution for lumped parameter starting from GE and BC, therefore solutions in the book should not be used. We perform energy balance on the artery segment as it exchanges heat with blood flowing over it.

Solution:

1

\[
V \rho C_p \frac{dT}{dt} = -hA(T - T_b)
\]

2

\[
\int_{t_i}^{t_f} \frac{dT}{T - T_b} = - \int_{t_i}^{t_f} \frac{hA}{V \rho C_p} dt
\]

\[
\ln(T - T_b) - \ln(T_i - T_b) = \ln\left(\frac{T - T_b}{T_i - T_b}\right) = - \frac{hA}{V \rho C_p} t
\]

\[
T = T_b + (T_i - T_b) \exp\left(- \frac{hA}{V \rho C_p} t\right)
\]

3
Plot $\ln \left( \frac{T - T_h}{T_i - T_h} \right)$ versus time and you will get a line that the slope $= -\frac{hA}{V\rho C_p}$ which can be used to determine $h$. 