Chapter 2, Solution 36C.

The mathematical expression for the temperature distribution of the medium initially is called the initial condition. We need only one initial condition for a heat conduction problem regardless of the dimension since the conduction equation is first order in time (it involves the first derivative of temperature with respect to time). Therefore, we need only 1 initial condition for a two-dimensional problem.

Chapter 2, Solution 36C.

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Chapter 2, Solution 37C.

A heat transfer problem that is symmetric about a plane, line, or point is said to have thermal symmetry about that plane, line, or point. The thermal symmetry boundary condition is a mathematical expression of this thermal symmetry. It is equivalent to insulation or zero heat flux boundary condition, and is expressed at a point \( x_0 \) as
\[
\frac{\partial T}{\partial x}(x_0, t) = 0.
\]

Chapter 2, Solution 38C.

The boundary condition at a perfectly insulated surface (at \( x = 0 \), for example) can be expressed as
\[
-k \frac{\partial T}{\partial x}(0, t) = 0 \quad \text{or} \quad \frac{\partial T}{\partial x}(0, t) = 0
\]
which indicates zero heat flux.

Chapter 2, Solution 39C.

Yes, the temperature profile in a medium must be perpendicular to an insulated surface since the slope \( \frac{\partial T}{\partial x} = 0 \) at that surface.
Chapter 2, Solution 40C.

We try to avoid the radiation boundary condition in heat transfer analysis because it is a non-linear expression that causes mathematical difficulties while solving the problem; often making it impossible to obtain analytical solutions.

Chapter 2, Solution 42.

Heat is generated in a long wire of radius \( r_o \) covered with a plastic insulation layer at a constant rate of \( \dot{e}_{\text{gen}} \). The heat flux boundary condition at the interface (radius \( r_o \)) in terms of the heat generated is to be expressed. The total heat generated in the wire and the heat flux at the interface is

\[
\dot{E}_{\text{gen}} = \dot{e}_{\text{gen}} \pi r_o^2 L
\]

\[
\dot{q}_s = \frac{\dot{Q}_s}{A} = \frac{\dot{E}_{\text{gen}}}{A} = \frac{\dot{e}_{\text{gen}} \pi r_o^2 L}{2} = \frac{\pi \dot{e}_{\text{gen}} r_o L}{2}
\]

Assuming steady one-dimensional conduction in the radial direction, the heat flux boundary condition can be expressed as

\[
-k \frac{dT(r_o)}{dr} = \frac{\dot{e}_{\text{gen}} r_o}{2}
\]

Chapter 2, Solution 46.

Heat conduction through the bottom section of a steel pan that is used to boil water on top of an electric range is considered. Assuming constant thermal conductivity and one-dimensional heat transfer, the mathematical formulation (the differential equation and the boundary conditions) of this heat conduction problem is to be obtained for steady operation.

**Assumptions** 1 Heat transfer is given to be steady and one-dimensional. 2 Thermal conductivity is given to be constant. 3 There is no heat generation in the medium. 4 The top surface at \( x = L \) is subjected to convection and the bottom surface at \( x = 0 \) is subjected to uniform heat flux.

**Analysis** The heat flux at the bottom of the pan is
\[ \dot{q}_s = \frac{\dot{Q}_s}{A_s} = \frac{E_{\text{gen}}}{\pi D^2 / 4} = \frac{0.85 \times (1250 \text{ W})}{\pi (0.20 \text{ m})^2 / 4} = 33,820 \text{ W/m}^2 \]

Then the differential equation and the boundary conditions for this heat conduction problem can be expressed as

\[ \frac{d^2 T}{dx^2} = 0 \]
\[ -k \frac{dT(0)}{dx} = \dot{q}_s = 33,280 \text{ W/m}^2 \]
\[ -k \frac{dT(L)}{dx} = h[T(L) - T_\infty] \]

**Chapter 2, Solution 50.**

A spherical metal ball that is heated in an oven to a temperature of \( T_i \) throughout is dropped into a large body of water at \( T_\infty \) where it is cooled by convection. Assuming constant thermal conductivity and transient one-dimensional heat transfer, the mathematical formulation (the differential equation and the boundary and initial conditions) of this heat conduction problem is to be obtained.

**Assumptions**
1. Heat transfer is given to be transient and one-dimensional.
2. Thermal conductivity is given to be constant.
3. There is no heat generation in the medium.
4. The outer surface at \( r = r_0 \) is subjected to convection.

**Analysis**
Noting that there is thermal symmetry about the midpoint and convection at the outer surface, the differential equation and the boundary conditions for this heat conduction problem can be expressed as

\[ \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 \frac{\partial T}{\partial r} \right) = \frac{1}{\alpha} \frac{\partial T}{\partial t} \]
\[ \frac{\partial T(0,t)}{\partial r} = 0 \]
\[ -k \frac{\partial T(r_0,t)}{\partial r} = h[T(r_0) - T_\infty] \]
\[ T(r,0) = T_i \]