5. Consider a medium in which the heat conduction equation is given in its simplest form as $0 = r\frac{\partial^2 T}{\partial r^2} + 2\frac{\partial T}{\partial r}$

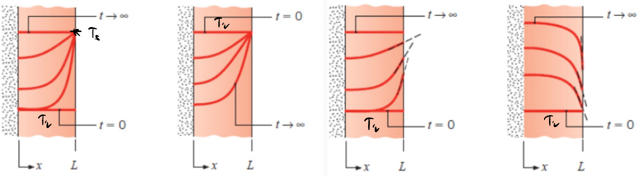
(a) Is heat transfer steady or transient? Steady

(b) Is heat transfer one-, two-, or three-dimensional? One

(c) Is there heat generation in the medium? No

(d) Is the thermal conductivity of the medium constant or variable? Constant

6. Temperature distributions within a series of one-dimensional plane walls at an initial time, at steady state, and at several intermediate times are as shown. For each case, write the appropriate form of the heat diffusion equation. Also write the equations for the initial condition and the boundary conditions that are applied at x = 0 and x = L. If volumetric generation occurs, it is uniform throughout the wall. The properties are constant.



(a) (b) (c) (d)

$$\rho c \cancel{\frac{\partial T}{\partial t}}^{\,0} = \dot{q} + \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$$

$$\frac{\partial^2 T}{\partial x^2} + \frac{\dot{q}}{k} = 0$$

0 (∵ at $t \to \infty$, constant Temperature)

(a) $\rho c \frac{\partial T}{\partial t} = \cancel{\dot{q}} + \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$

$t = 0$, $T = T_i$

$t > 0$, $\frac{\partial T}{\partial x} = 0$ $(x = 0)$

$T = T_s$ $(x = L)$

$t = \infty$, $T = T_s$

(b) $\rho c \frac{\partial T}{\partial t} = \dot{q} + \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$

$t = 0$, $T = T_i$

$t > 0$, $\frac{\partial T}{\partial x} = 0$ $(x = 0)$

$T = T_s = T_i$ $(x = L)$

$t = \infty$, $\frac{\partial T}{\partial x} = 0$ $(x = 0)$

$T = T_s$ $(x = L)$

(c) $\rho c \frac{\partial T}{\partial t} = \cancel{\dot{q}}^{\,0} + \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$

$t = 0$, $T = T_i$

$\left.\frac{\partial T}{\partial x}\right|_{x=0} = 0$

at $x = L$, $t > 0$:

(d) $\rho c \frac{\partial T}{\partial t} = \dot{q} + \frac{\partial}{\partial x}\left(k \frac{\partial T}{\partial x}\right)$

$t = 0$, $T = T_i$

$\left.\frac{\partial T}{\partial x}\right|_{x=0} = 0$

at $x = L$, $t > 0$: $-k\left.\frac{\partial T}{\partial x}\right|_{x=L} = h[T(L,t) - T_\infty]$