2-1 Consider steady heat flow through a plane wall with no internal heat generation. Assume constant thermal conductivity in the wall. The wall is subject to a constant heat flux of magnitude $q_0$ at $x=0$ and has a convection boundary at $x=L$ with heat transfer coefficient $h$ and environment temperature $T_{env}$.

a. Determine the temperature distribution in the wall in terms of these parameters.

2-2 Consider steady heat flow through a plane wall with no internal heat generation. The thermal conductivity of the material is a linear function of temperature ($k(T) = k_0 + BT$, where $k_0$ and $B$ are known constants).

a. Use the direct integration technique to find $T(x)$ in the wall. How does temperature vary with $x$ in this case (linear, parabolic, cubic, etc.)?

2-3 Calculate the heat loss per unit area through a wall with the following construction:

<table>
<thead>
<tr>
<th>$\Delta x$</th>
<th>$k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 mm</td>
<td>40 W/m$^\circ$C</td>
</tr>
<tr>
<td>50 mm</td>
<td>0.046 W/m$^\circ$C</td>
</tr>
<tr>
<td>3 mm</td>
<td>40 W/m$^\circ$C</td>
</tr>
</tbody>
</table>

Account for convection on each side of the wall with $h = 5 \text{ W/m}^2\text{-K}$. and consider the inside wall temperature at 50°C and the outside wall temperature at 29°C.

2-4 Saturated steam at 500 kPa flows in a steel pipe (50mm diameter and 4mm wall thickness). A convection environment of $h = 10 \text{ W/m}^2\text{-K}$ and $T_{env} = 25°C$ surrounds the pipe.

a. Compute the heat loss per unit length for the bare pipe

b. A layer of fiberglass insulating material 25mm thick is added to the pipe. Compute the heat loss per unit length.

2-5 Thin electric heating tape is used to wrap an exposed water pipe in the crawl space of a house to protect the water in the pipe from freezing in the winter when $h=10 \text{ W/m}^2\text{-K}$ and $T_{env}=-10°C$. The pipe is steel 25mm in diameter and has a wall thickness of 3mm. No insulation is applied over the heating tape. What heating rate per unit length is required?

2-6 A spherical container is devised for storing radioactive material. The inner diameter is $d_1=250\text{mm}$, and the first shell of material is lead and extends to diameter $d_2=300\text{mm}$. The outer layer is a thin layer of stainless steel (AISI 302) extending to $d_3=310\text{mm}$. The core is filled with material which generates heat at a rate of $q'''=5E5 \text{ W/m}^3$. If the entire sphere is exposed to convection with $h=500 \text{ W/m}^2\text{-K}$ and $T_{env}=10°C$, determine:

a. the rate of heat loss (kW) from the package

b. the maximum temperature in the walls. Compare this to the melting point of lead – is this problematic?