1.1 Temperature profiles in planar walls ★

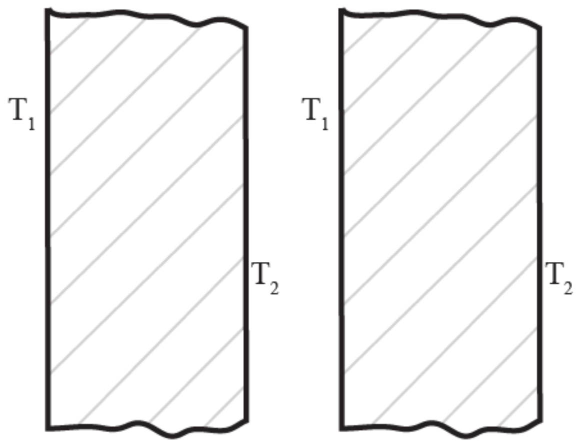
Both sides of a planar wall are heated to a constant temperature of T_1 and T_2, where $T_1 > T_2$.

Tasks:
Qualitatively sketch the temperature profile for steady-state conditions, if

a) the conductivity remains constant

b) the conductivity is a function of the temperature following the equation:

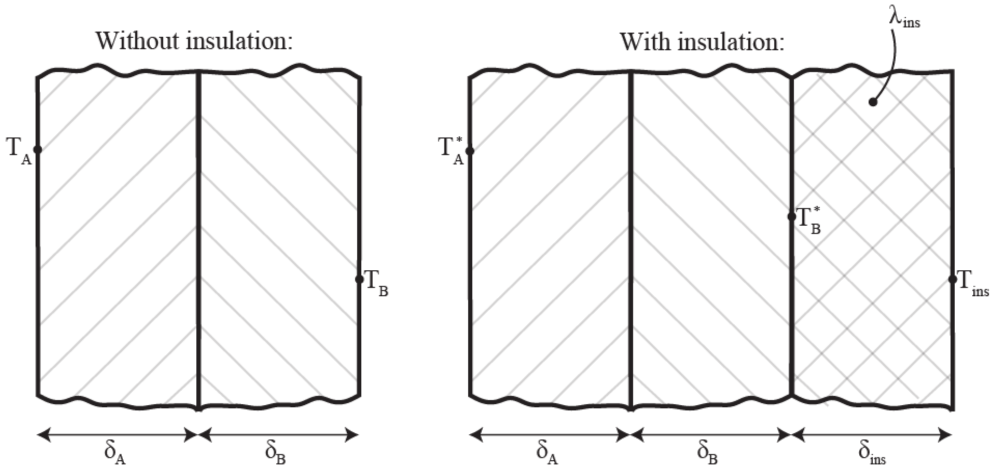
$$\lambda = \lambda_0(1 + \gamma(T - T_0)) \text{ with } \gamma > 0$$
$$(\lambda_0 = \text{thermal conductivity at reference temperature } T_0)$$



a) b)

1.2 The onion layer principle ★★

A solar panel manufacturer makes use of heat processing applications that include preheating, curing, heat treating, and finishing. The manufacturer has an old and new type of industrial oven. The newer one has an additional insulation layer.



Measurements of the surface temperature of the old type, comprising a $\delta_A = 12.5\,\text{cm}$ thick layer of material A and a $\delta_B = 20\,\text{cm}$ thick layer of material B, gave the following results:

T_A	260	°C	surface temperature of layer A
T_B	32	°C	surface temperature of layer B

For the newer type, with the additional insulation layer of $\delta_{ins} = 2.5\,\text{cm}$ ($\lambda_{ins} = 0.075\,\text{W/mK}$), the following values were measured:

T_A^*	305	°C	surface temperature of layer A
T_B^*	219	°C	temperature of the contact area of layer B and the insulating layer (previously the surface temperature of layer B)
T_{ins}	27	°C	surface temperature of the insulating layer

Tasks:

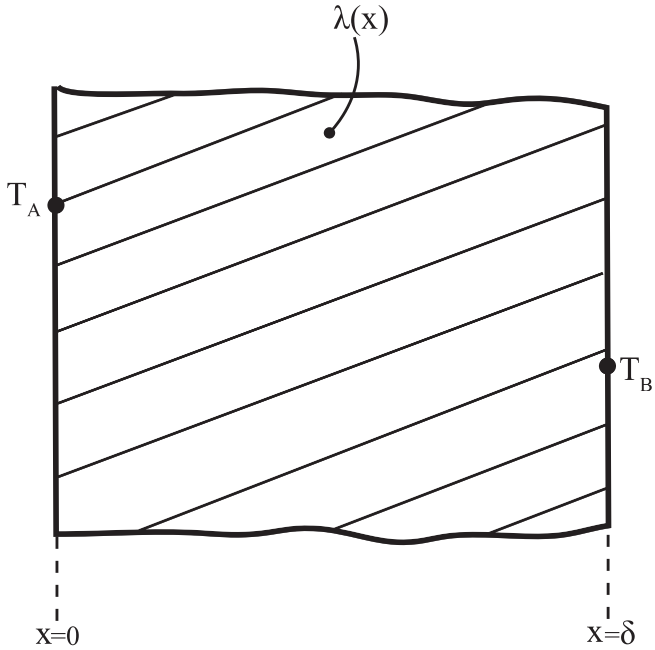
a) Determine the difference in transmitted heat flux per unit area $\dot{q}''$ with and without the insulating layer; assume steady-state conditions.

1.3 Heat Conduction Equation ★ ★ ★

Both sides of a planar wall are heated to a constant temperature of T_{A} and T_{B}, respectively; where $T_{\mathrm{A}} > T_{\mathrm{B}}$.
The thermal conductivity is a function of the position inside the planar wall:

$$\lambda(x) = \lambda_0 + \frac{\gamma}{\delta} \cdot x$$

Hints:
Assume one-dimensional steady-state heat transfer in x-direction.

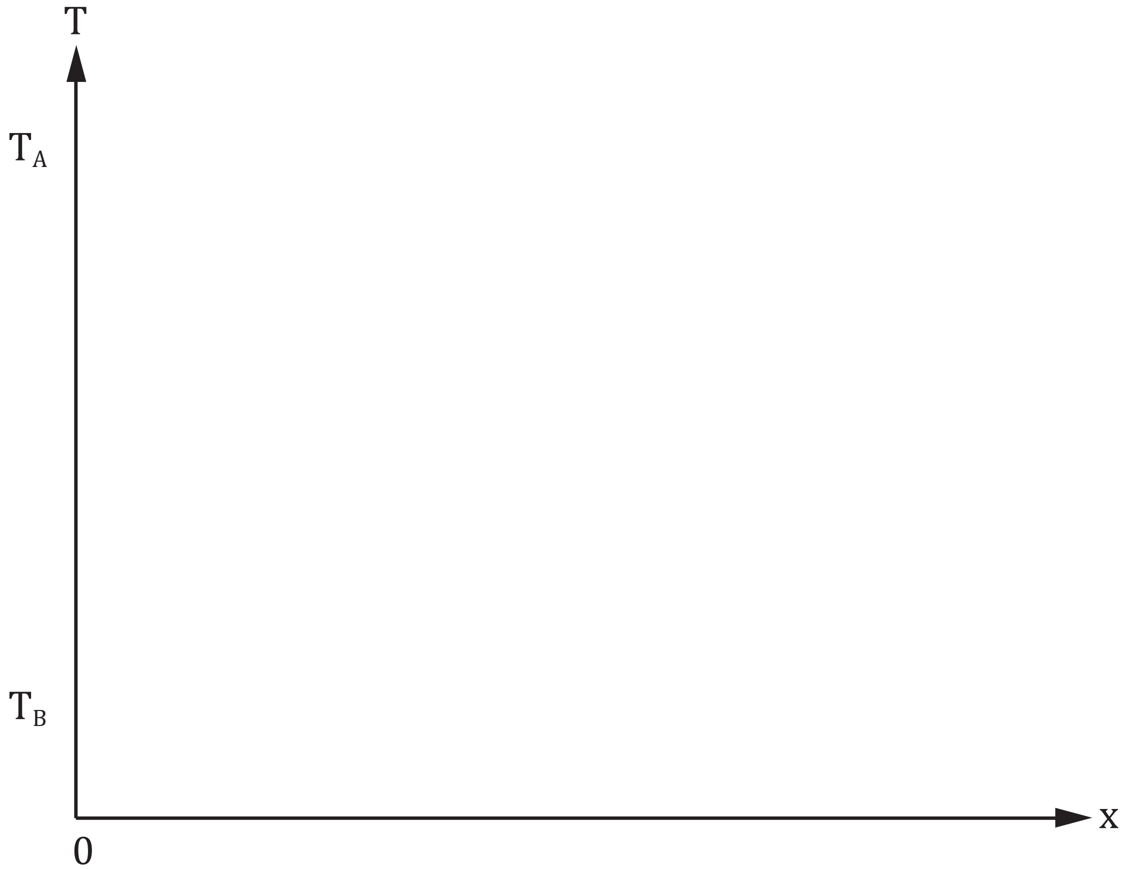


Tasks:

a) Setup an energy balance and derive the heat conduction equation.

b) Derive the function of the temperature profile inside the planar wall with use of the heat conduction equation obtained in question a).

c) Make a sketch of the temperature profile inside the plane wall in x-direction.



T
T_A
T_B
0
x