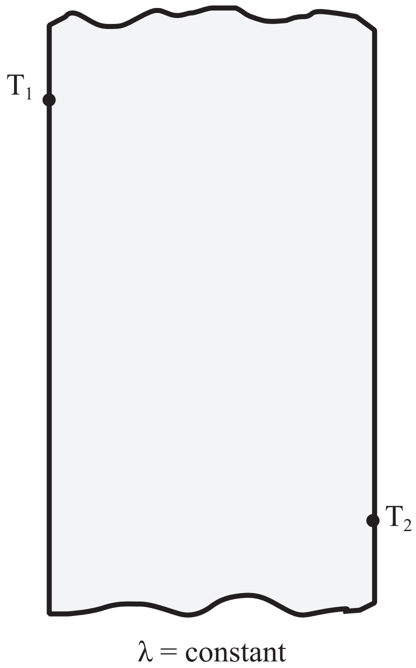
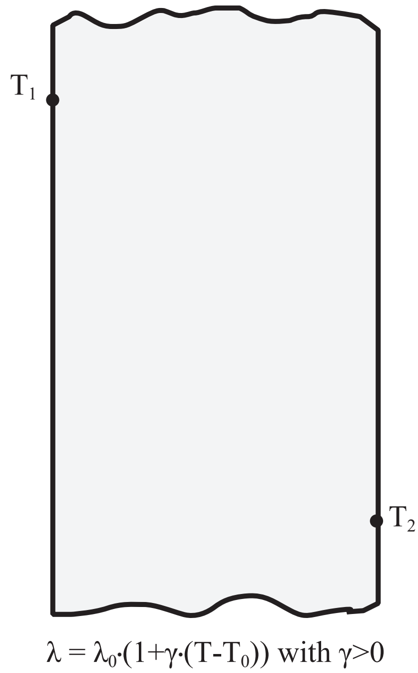
Section II

Conduction exercises

Exercise II.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:

a) Sketch the steady-state temperature profile for a constant thermal conductivity.

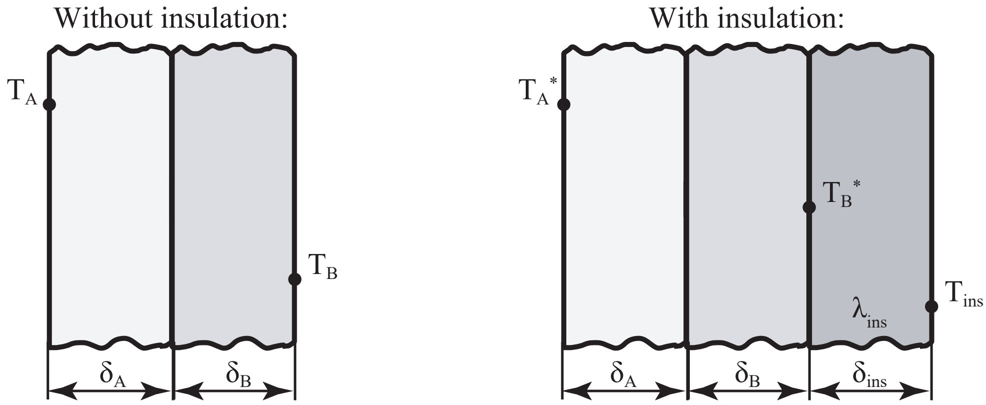
b) Sketch the steady-state temperature profile for the conductivity being temperature-dependent:

$$\lambda = \lambda_0(1 + \gamma(T - T_0)), \text{ with } \gamma > 0,$$

where λ_0 is the thermal conductivity at the temperature T_0.

Exercise II.2: (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 a new type of industrial oven. The newer one has an additional insulation layer.



Given parameters:

Old oven:

- Surface temperature of layer A: $T_A = 260\ °C$
- Surface temperature of layer B: $T_B = 32\ °C$
- Thickness of layer A: $\delta_A = 125$ mm
- Thickness of layer B: $\delta_B = 200$ mm

New oven:

- Surface temperature of layer A: $T_A^* = 305\ °C$
- Surface temperature of layer B: $T_B^* = 219\ °C$
- Surface temperature of insulation layer: $T_{ins} = 27\ °C$
- Thickness of layer A: $\delta_A = 125$ mm
- Thickness of layer B: $\delta_B = 200$ mm
- Thickness of insulation layer: $\delta_{ins} = 25$ mm
- Thermal conductivity of insulation layer: $\lambda_{ins} = 0.075$ W/mK

Hint:

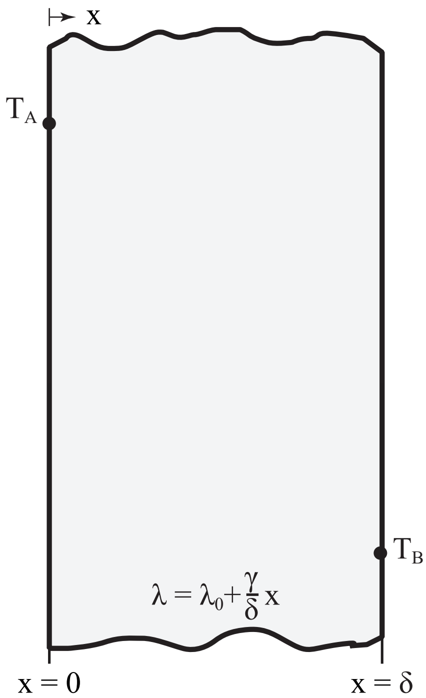
- Assume steady-state conditions.

Tasks:

a) Determine the heat flux per unit area $\dot{q}''$ for the situations without and with the insulating layer.

Exercise II.3: (Heat conduction equation ⋆⋆⋆)

Both sides of a planar wall are heated to a constant temperature of T_A and T_B, respectively; where $T_A > T_B$.



Given parameters:

- Thermal conductivity as a function of the position in the wall:

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

Hints:

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

Tasks:

a) Derive the function of the temperature profile inside the plane wall.

b) Sketch the temperature profile inside the plane wall in the x-direction.