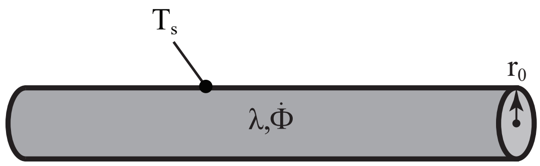
Exercise II.10 (Resistance wire ⋆):

A long homogeneous resistance wire is used to heat the air in a room by the passage of an electric current. Heat is generated in the wire uniformly at a constant rate $\dot{\Phi}'''$ as a result of resistance heating.



Given parameters:

- Outer radius of the wire: $r_0 = 5$ mm
- Heat generation in the wire: $\dot{\Phi}''' = 5 \cdot 10^7$ W/m^3
- Temperature of the outer surface of the wire: $T_s = 180$ °C
- Thermal conductivity of the wire: $\lambda = 6$ W/mK

Hints:

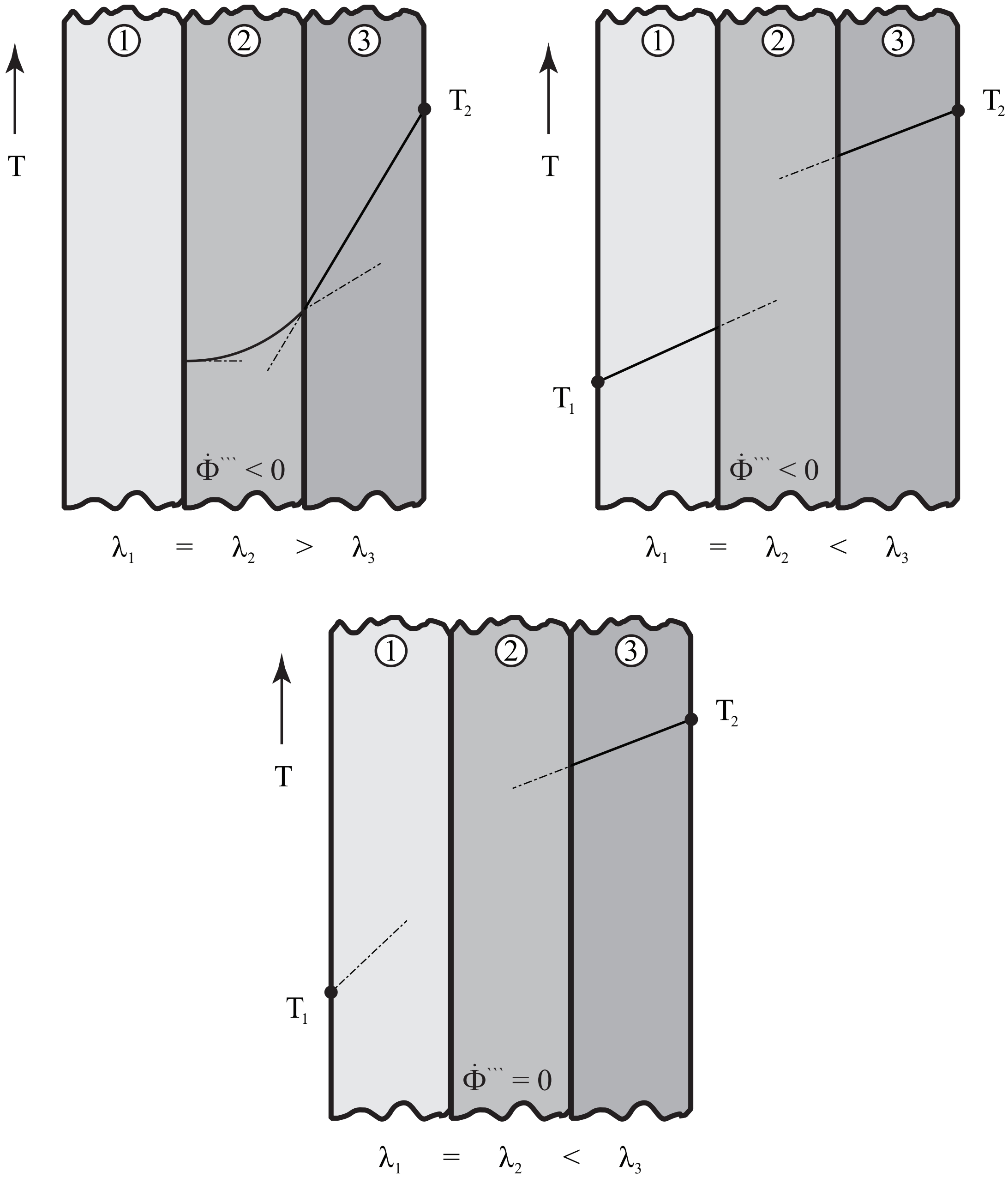
- The problem is one-dimensional in radial direction.
- Assume steady-state conditions.

Tasks:

a) Derive the heat conduction equation by setting up an energy balance.

b) Determine the temperature at $r_1 = 3.5$ mm.

Exercise II.11 (Multi-layer walls with source ⋆⋆):

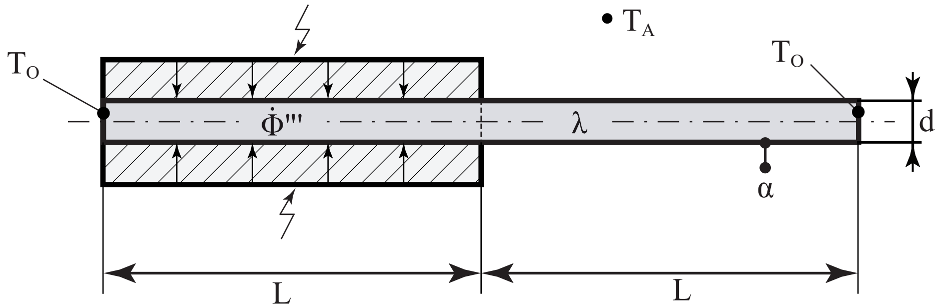


Tasks:

a) Complete the temperature profiles in the three-layered walls.

Exercise II.12 (Copper rod ⋆⋆⋆)**:**

Both ends of a copper rod with a length L and a diameter d are kept at the same temperature T_O. The left half of the rod is insulated against all radial heat losses. An electric heating element generates Joule's heat of heat flux density $\dot{\Phi}'''$. The right half of the rod is subjected to a flow of the ambient air with an air temperature of T_A, yielding a heat transfer coefficient α. The thermal conductivity of the rod is given as λ.



Given parameters:

- Length of the rod: $L = 1$ m
- Diameter of the rod: $d = 5.2$ mm
- Temperature of the ends of both rods: $T_O = 120$ °C
- Temperature of the ambient: $T_A = 100$ °C
- Heat transfer coefficient: $\alpha = 6$ W/m^{2}K
- Thermal conductivity of the rod: $\lambda = 372$ W/mK

Hint:

- Place the origin of the coordinate system in the middle of the rod.

Tasks:

a) Derive the equation for the temperature profile in the rod by setting up an energy balance.

b) Determine an expression for $\dot{\Phi}'''$ such that the temperature in the center of the rod is also T_O, similar to the temperatures at its ends.

c) Calculate the value for $\dot{\Phi}'''$ for the conditions postulated in b).

d) Determine the extremes of the temperature distribution for the given values. Give their position and values, additionally, sketch the temperature profile.