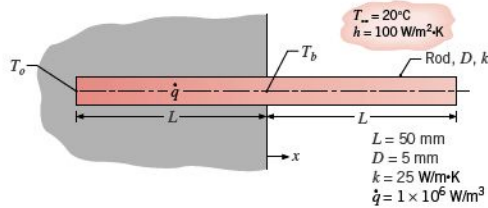


■ Problems

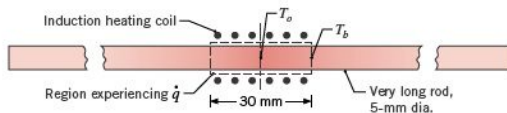
- (a) Derive an expression for the exposed surface temperature T_o as a function of the prescribed thermal and geometrical parameters. The rod has an exposed length L_o , and its tip is well insulated.
- (b) Will a rod with $L_o = 200$ mm meet the specified operating limit? If not, what design parameters would you change? Consider another material, increasing the thickness of the insulation, and increasing the rod length. Also, consider how you might attach the base of the rod to the furnace wall as a means to reduce T_o .

3.112 A metal rod of length $2L$, diameter D , and thermal conductivity k is inserted into a perfectly insulating wall, exposing one-half of its length to an air stream that is of temperature T_∞ and provides a convection coefficient h at the surface of the rod. An electromagnetic field induces volumetric energy generation at a uniform rate \dot{q} within the embedded portion of the rod.



- (a) Derive an expression for the steady-state temperature T_b at the base of the exposed half of the rod. The exposed region may be approximated as a very long fin.
- (b) Derive an expression for the steady-state temperature T_o at the end of the embedded half of the rod.
- (c) Using numerical values provided in the schematic, plot the temperature distribution in the rod and describe key features of the distribution. Does the rod behave as a very long fin?

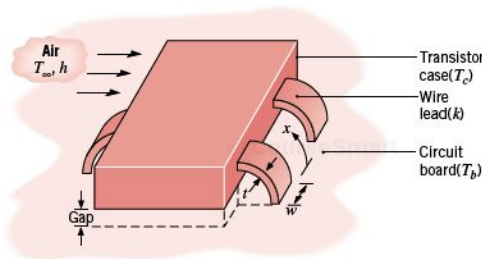
3.113 A very long rod of 5-mm diameter and uniform thermal conductivity $k = 25$ W/m·K is subjected to a heat treatment process. The center, 30-mm-long portion of the rod within the induction heating coil experiences uniform volumetric heat generation of 7.5×10^6 W/m³.



The unheated portions of the rod, which protrude from the heating coil on either side, experience convection with the ambient air at $T_\infty = 20^\circ\text{C}$ and $h = 10$ W/m²·K. Assume that there is no convection from the surface of the rod within the coil.

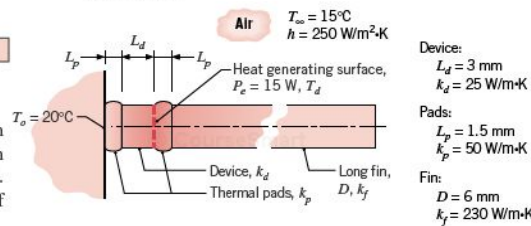
- (a) Calculate the steady-state temperature T_o of the rod at the midpoint of the heated portion in the coil.
- (b) Calculate the temperature of the rod T_b at the edge of the heated portion.

3.114 From Problem 1.71, consider the wire leads connecting the transistor to the circuit board. The leads are of thermal conductivity k , thickness t , width w , and length L . One end of a lead is maintained at a temperature T_c corresponding to the transistor case, while the other end assumes the temperature T_b of the circuit board. During steady-state operation, current flow through the leads provides for uniform volumetric heating in the amount \dot{q} , while there is convection cooling to air that is at T_∞ and maintains a convection coefficient h .



- (a) Derive an equation from which the temperature distribution in a wire lead may be determined. List all pertinent assumptions.
- (b) Determine the temperature distribution in a wire lead, expressing your results in terms of the prescribed variables.

3.115 A disk-shaped electronic device of thickness L_d , diameter D , and thermal conductivity k_d dissipates electrical power at a steady rate P_e along one of its surfaces. The device is bonded to a cooled base at T_o using a thermal pad of thickness L_p and thermal conductivity k_p . A long fin of diameter D and thermal conductivity k_f is bonded to the heat-generating surface of the device using an identical thermal pad. The fin is cooled by an air stream, which is at a temperature T_∞ and provides a convection coefficient h .



- Device:
 - $L_d = 3$ mm
 - $k_d = 25$ W/m·K
- Pads:
 - $L_p = 1.5$ mm
 - $k_p = 50$ W/m·K
- Fin:
 - $D = 6$ mm
 - $k_f = 230$ W/m·K