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3.22	Consider a plane composite wall that is composed of two
	materials of thermal conductivities $k_A = 0.1 \text{ W/m} \cdot \text{K}$ and
	$k_{\rm R} = 0.04 \text{W/m} \cdot \text{K}$ and thicknesses $L_{\rm A} = 10 \text{mm}$ and
	$L_{\rm B} = 20$ mm. The contact resistance at the interface be-
	tween the two materials is known to be 0.30 m ² · K/W.
	Material A adjoins a fluid at 200°C for which $h = 10$

 $W/m^2 \cdot K$, and material B adjoins a fluid at 40° C for which $h = 20 W/m^2 \cdot K$.

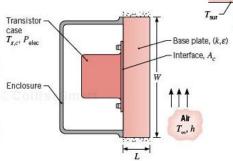
- (a) What is the rate of heat transfer through a wall that is 2 m high by 2.5 m wide?
- (b) Sketch the temperature distribution.

MECHANICAL ENGINEERING DEPARTMENT

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Contact Resistance

3.28 Consider a power transistor encapsulated in an aluminum case that is attached at its base to a square Transistoraluminum plate of thermal conductivity $k = 240 \text{ W/m} \cdot \text{K}$, thickness $L=6~\mathrm{mm},$ and width $W=20~\mathrm{mm}.$ The case is joined to the plate by screws that maintain a contact pressure of 1 bar, and the back surface of the plate transfers heat by natural convection and radiation to ambient air and large surroundings at $T_{\infty} = T_{\text{sur}} = 25^{\circ}\text{C}$. The surface has an emissivity of $\varepsilon = 0.9$, and the convection coefficient is $h = 4 \text{ W/m}^2 \cdot \text{K}$. The case is completely enclosed such that heat transfer may be assumed to occur exclusively through the base plate.



(a) If the air-filled aluminum-to-aluminum interface is characterized by an area of $A_c = 2 \times 10^{-4} \,\mathrm{m}^2$ and a roughness of 10 µm, what is the maximum allowable power dissipation if the surface temperature of the case, $T_{s,c}$, is not to exceed 85°C?

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Alternative Conduction Analysis

3.32 Consider a tube wall of inner and outer radii r_i and r_o , whose temperatures are maintained at T_i and T_o , respectively. The thermal conductivity of the cylinder is

are constants. Obtain an expression for the heat transfer per unit length of the tube. What is the thermal resis-																																							
per unit length of the tube. What is the thermal resis-																									+			+	+		+		H	+					Н
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	temperature dependent and may be represented by an expression of the form $k = k_o(1 + aT)$, where k_o and a are constants. Obtain an expression for the heat transfer per unit length of the tube. What is the thermal resistance of the tube wall?																																						
	expression of the form $k = k_o(1 + aT)$, where k_o and a are constants. Obtain an expression for the heat transfer per unit length of the tube. What is the thermal resis-																																						
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A thin electrical heater is wrapped around the outer sur-
face of a long cylindrical tube whose inner surface is
maintained at a temperature of 5°C. The tube wall has
inner and outer radii of 25 and 75 mm, respectively, and
a thermal conductivity of 10 W/m · K. The thermal con-
tact resistance between the heater and the outer surface of

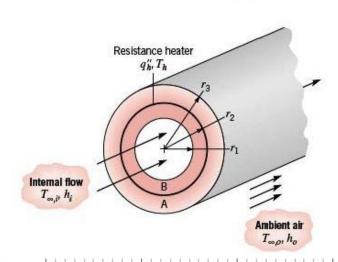
the tube (per unit length of the tube) is $R'_{t,c} = 0.01 \,\mathrm{m}\cdot\mathrm{K/W}$. The outer surface of the heater is exposed to a fluid with $T_\infty = -10^{\circ}\mathrm{C}$ and a convection coefficient of $h = 100 \,\mathrm{W/m^2}\cdot\mathrm{K}$. Determine the heater power per unit length of tube required to maintain the heater at $T_o = 25^{\circ}\mathrm{C}$.

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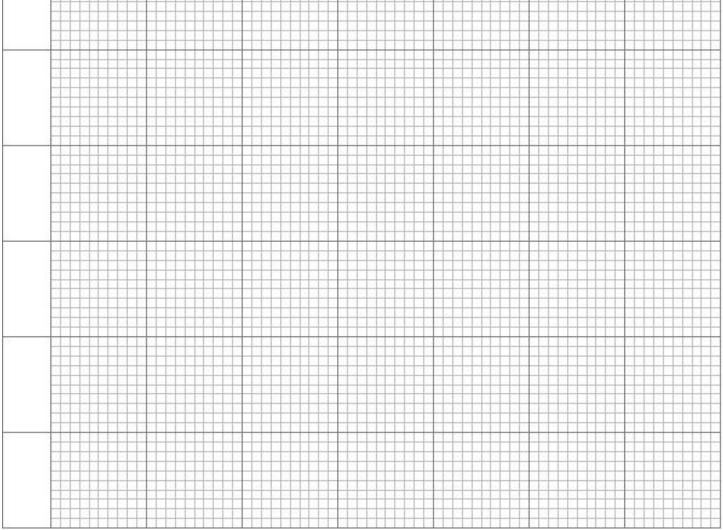
3.46 A composite cylindrical wall is composed of two materials of thermal conductivity k_A and k_B, which are separated by a very thin, electric resistance heater for which interfacial contact resistances are negligible.



Liquid pumped through the tube is at a temperature $T_{\infty,i}$ and provides a convection coefficient h_i at the inner surface of the composite. The outer surface is exposed to ambient air, which is at $T_{\infty,o}$ and provides a convection coefficient of h_o . Under steady-state conditions, a uniform heat flux of q_h'' is dissipated by the heater.

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- (a) Sketch the equivalent thermal circuit of the system and express all resistances in terms of relevant variables.
- (b) Obtain an expression that may be used to determine the heater temperature, T_h.
- (c) Obtain an expression for the ratio of heat flows to the outer and inner fluids, q'_o/q'_i. How might the variables of the problem be adjusted to minimize this ratio?





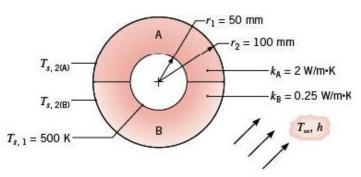
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3.52 Steam flowing through a long, thin-walled pipe maintains the pipe wall at a uniform temperature of 500 K.The pipe is covered with an insulation blanket comprised of two different materials, A and B.



The interface between the two materials may be assumed to have an infinite contact resistance, and the entire outer surface is exposed to air for which $T_{\infty} = 300 \text{ K}$ and $h = 25 \text{ W/m}^2 \cdot \text{K}$.

- (a) Sketch the thermal circuit of the system. Label (using the above symbols) all pertinent nodes and resistances.
- (b) For the prescribed conditions, what is the total heat loss from the pipe? What are the outer surface temperatures $T_{s,2(A)}$ and $T_{s,2(B)}$?

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Conduction with Thermal Energy Generation

3.70 Consider cylindrical and spherical shells with inner and outer surfaces at r_1 and r_2 maintained at uniform temperatures $T_{s,1}$ and $T_{s,2}$, respectively. If there is uniform heat generation within the shells, obtain expressions for the steady-state, one-dimensional radial distributions of the temperature, heat flux, and heat rate. Contrast your results with those summarized in Appendix C.

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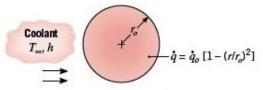


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3.94 Radioactive wastes are packed in a thin-walled spherical container. The wastes generate thermal energy nonuniformly according to the relation $\dot{q} = \dot{q}_o [1 - (r/r_o)^2]$, where \dot{q} is the local rate of energy generation per unit volume, \dot{q}_o is a constant, and r_o is the radius of the container. Steady-state conditions are maintained by submerging the container in a liquid that is at T_∞ and provides a uniform convection coefficient h.

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Determine the temperature distribution, T(r), in the container. Express your result in terms of \dot{q}_o , r_o , T_∞ , h, and the thermal conductivity k of the radioactive wastes.

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