1D Conduction

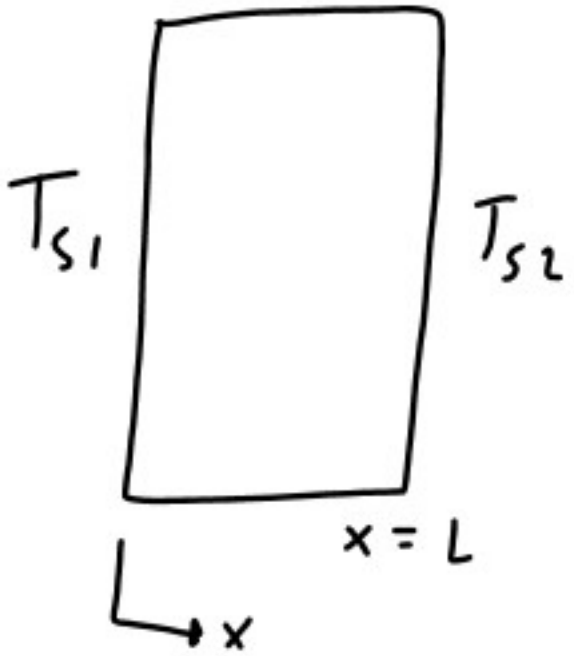
outlet

inlet

$T_{\infty 1}$ T_{s1} T_{s2} $T_{\infty 2}$

Water Air

$$\nabla^2 T + \cancel{\frac{\dot{q}}{k}}_{0} = \frac{1}{\alpha} \cancel{\frac{\partial T}{\partial t}}_{0}$$ steady state



$$\nabla^2 T = 0$$

$$\frac{\partial^2 T}{\partial x^2} = 0$$

$$T(x) = C_1 x + C_2$$

$T(0) = T_{s1}$ $\quad$ $C_1 \cdot 0 + C_2 = T_{s1}$ $\quad$ $C_2 = T_{s1}$

$T(L) = T_{s2}$ $\quad$ $C_1 L + C_2 = T_{s2}$ $\quad$ $C_1 L + T_{s1} = T_{s2}$ $\quad$ $C_1 = \dfrac{T_{s2} - T_{s1}}{L}$

$$T(x) = (T_{s2} - T_{s1}) \frac{x}{L} + T_{s1}$$

$$T(x) = (T_{s2} - T_{s1}) \frac{x}{L} + T_{s1}$$

$$\frac{\partial T}{\partial x} = \frac{T_{s2} - T_{s1}}{L}$$

$$\frac{\partial^2 T}{\partial x^2} = 0 \quad \checkmark$$

$$R \equiv \frac{\Delta T}{q}$$

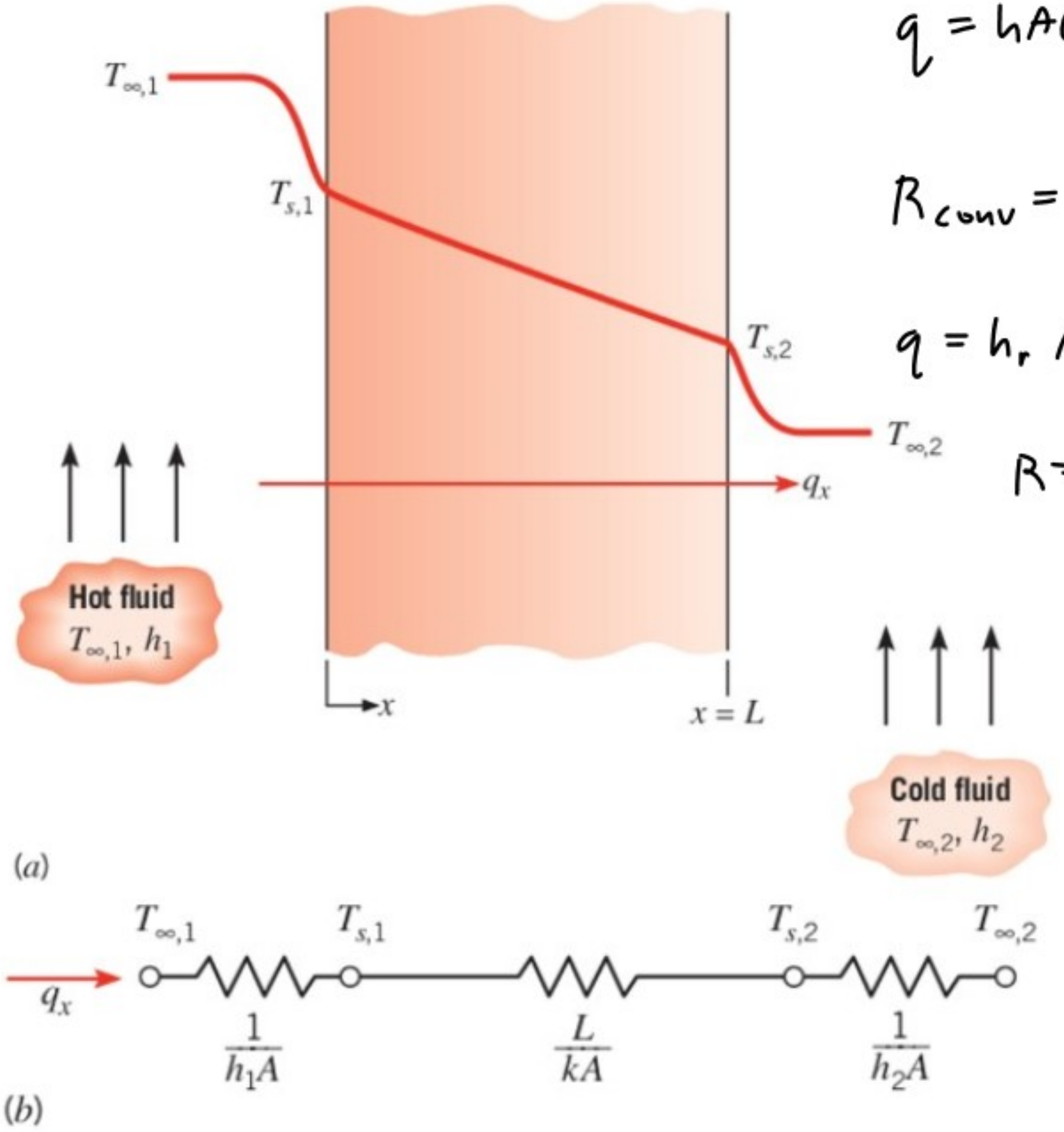
$$R_{cond} = \frac{T_{s1} - T_{s2}}{q} = \frac{L}{kA}$$

$$q = hA(T_s - T_\infty)$$

$$R_{conv} = \frac{T_s - T_\infty}{q} = \frac{1}{hA}$$

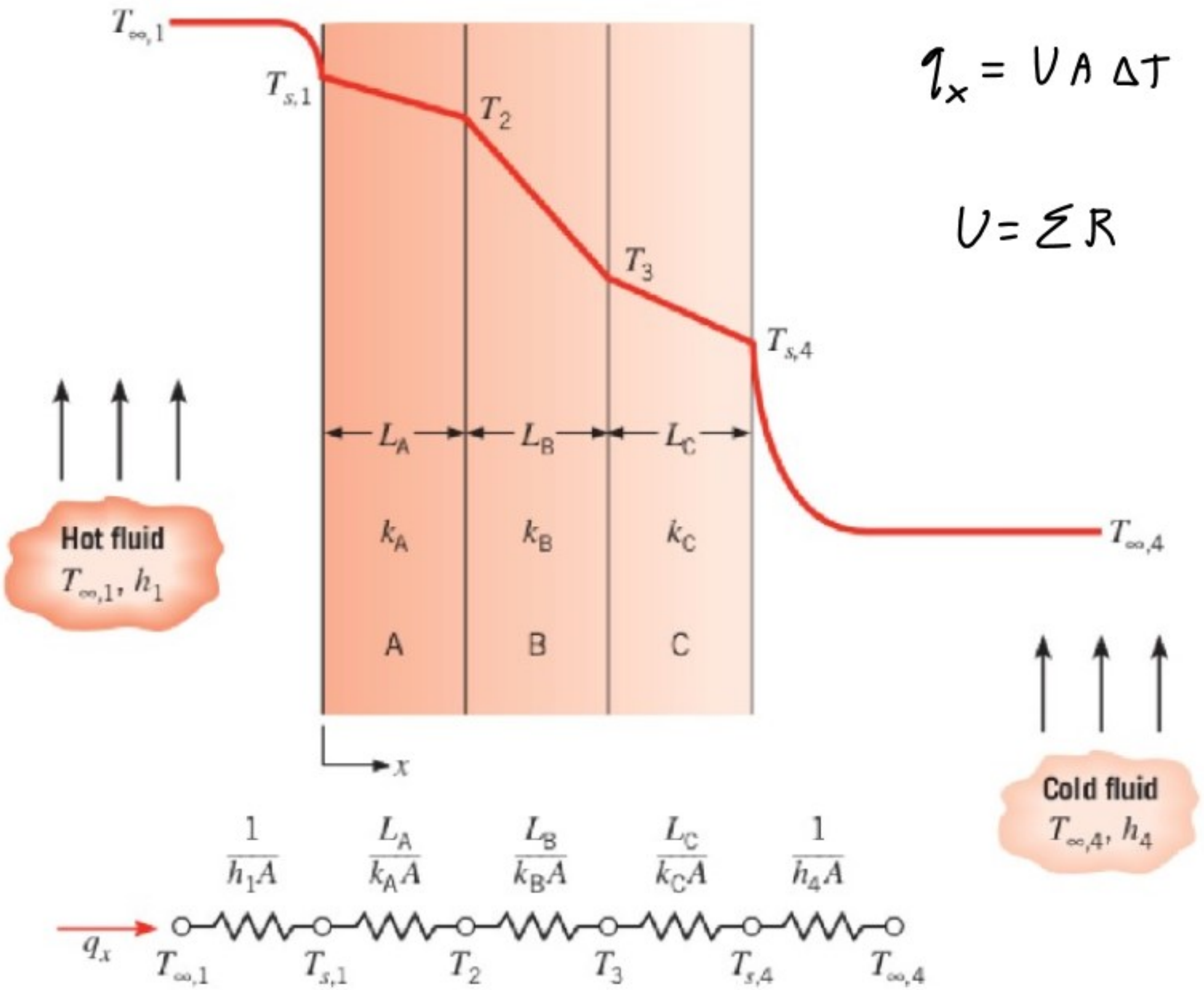
$$q = h_r A(T_s - T_{sur})$$

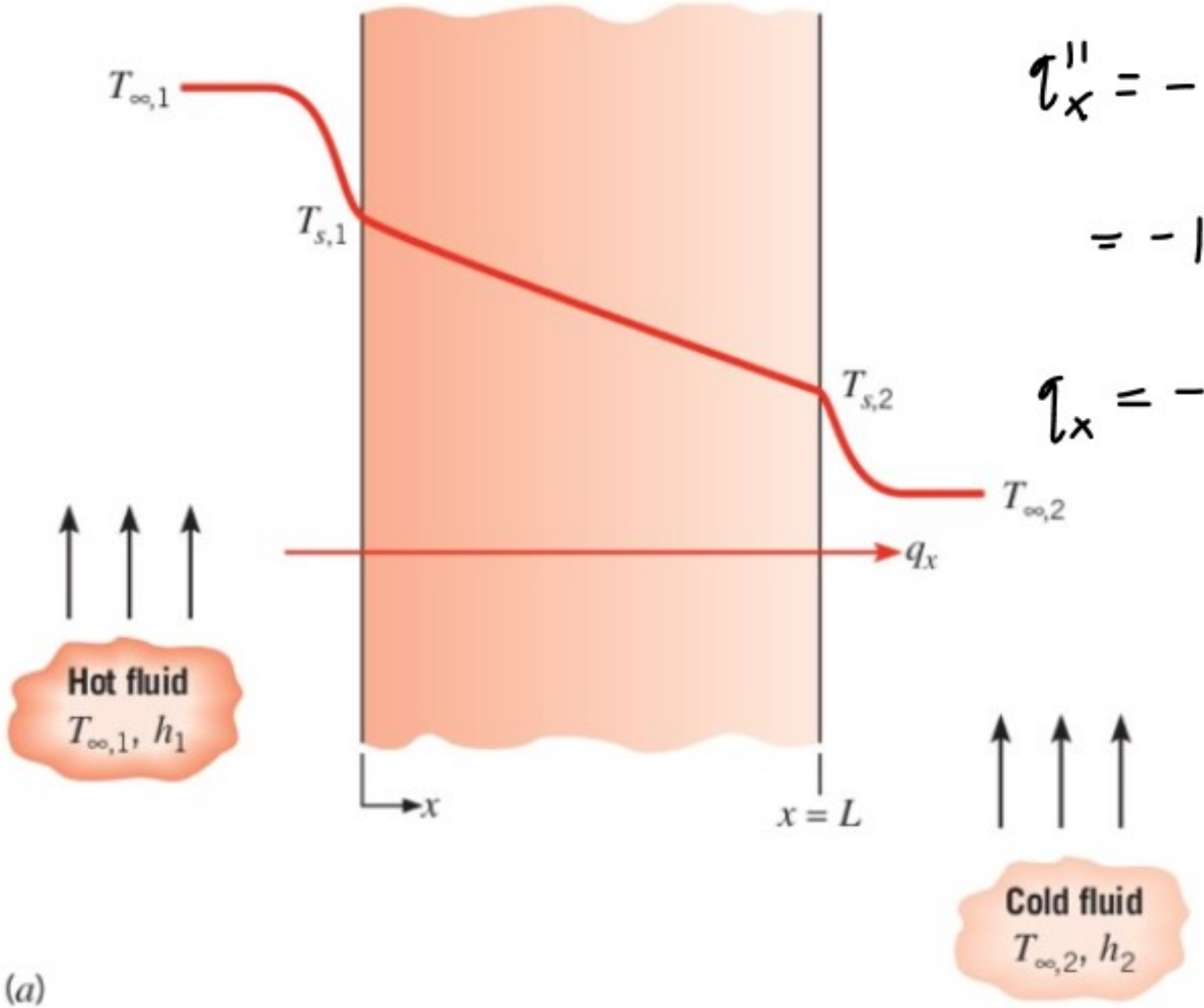
$$R = \frac{T_s - T_{sur}}{q} = \frac{1}{h_r A}$$



$$q_x = U A \Delta T$$

$$U = \Sigma R$$



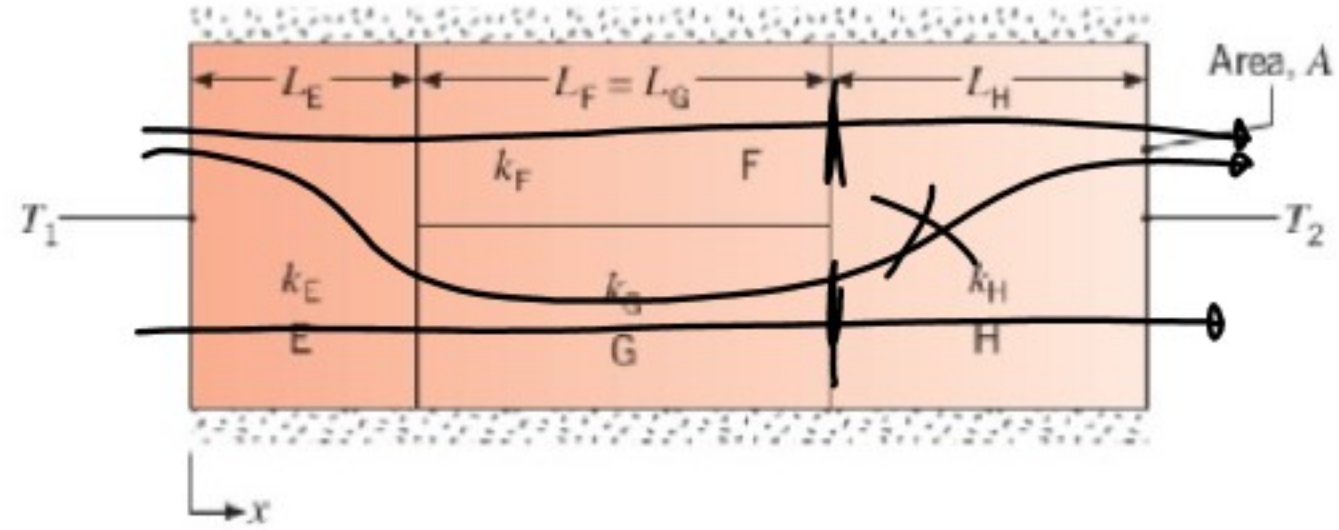


(a)

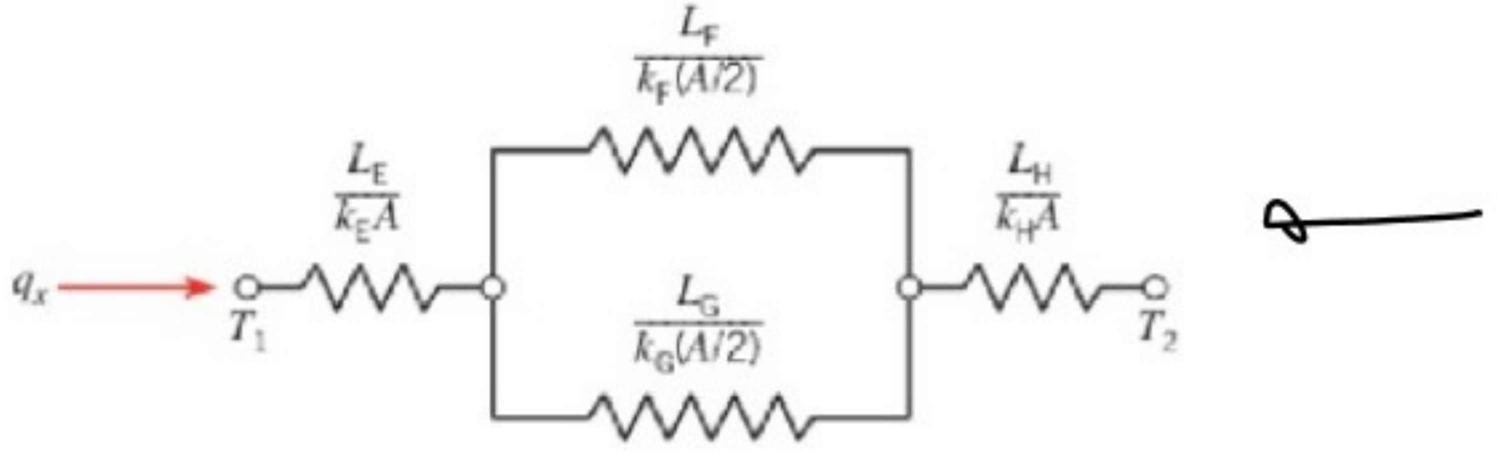
$$q''_x = -k \frac{dT}{dx}$$

$$= -k \frac{T_{s2} - T_{s1}}{L}$$

$$q_x = -kA \frac{T_{s2} - T_{s1}}{L}$$

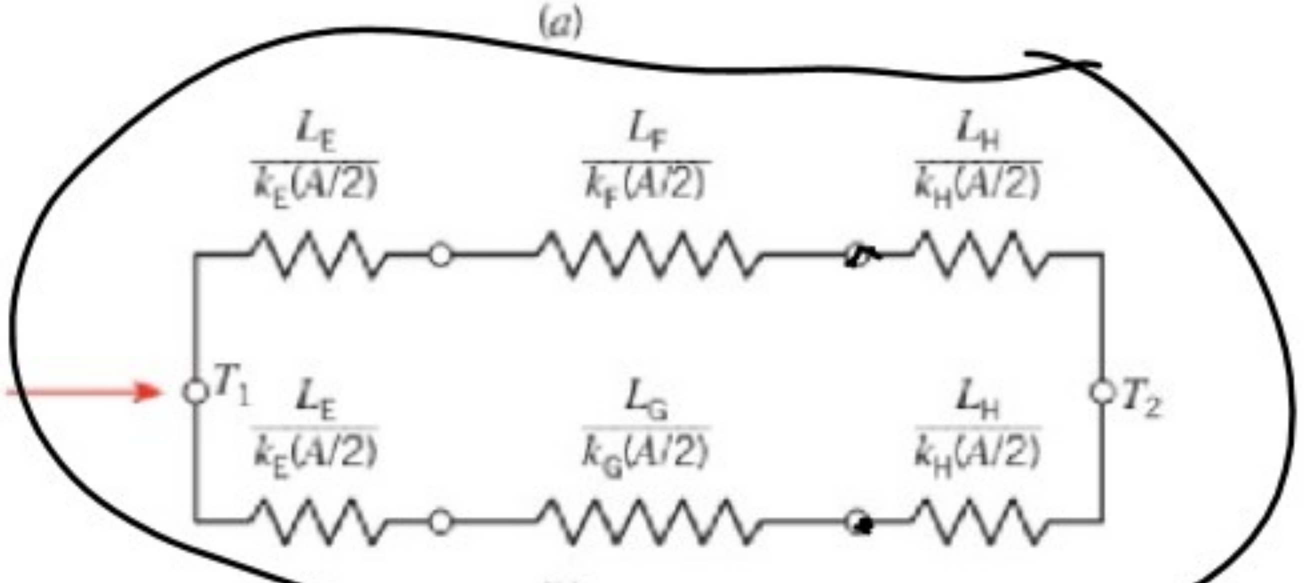


L_E
$L_F = L_G$
L_H
Area, A
T_1
T_2
k_F
F
k_E
E
k_G
G
k_H
H
x



$\frac{L_F}{k_F(A/2)}$
$\frac{L_E}{k_E A}$
$\frac{L_H}{k_H A}$
q_x
T_1
T_2
$\frac{L_G}{k_G(A/2)}$

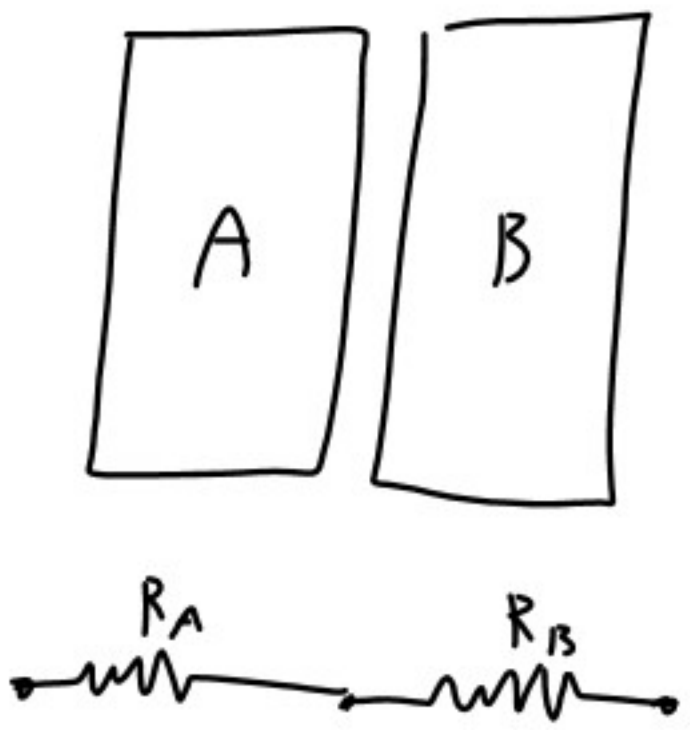
(a)



$\frac{L_E}{k_E(A/2)}$
$\frac{L_F}{k_F(A/2)}$
$\frac{L_H}{k_H(A/2)}$
q_x
T_1
T_2
$\frac{L_E}{k_E(A/2)}$
$\frac{L_G}{k_G(A/2)}$
$\frac{L_H}{k_H(A/2)}$

(b)

Contact Resistance



$$R_c = \frac{T_A - T_B}{q}$$

$$R''_c = \frac{T_A - T_B}{q''}$$

$$q = -kA\frac{\nabla T}{L}$$

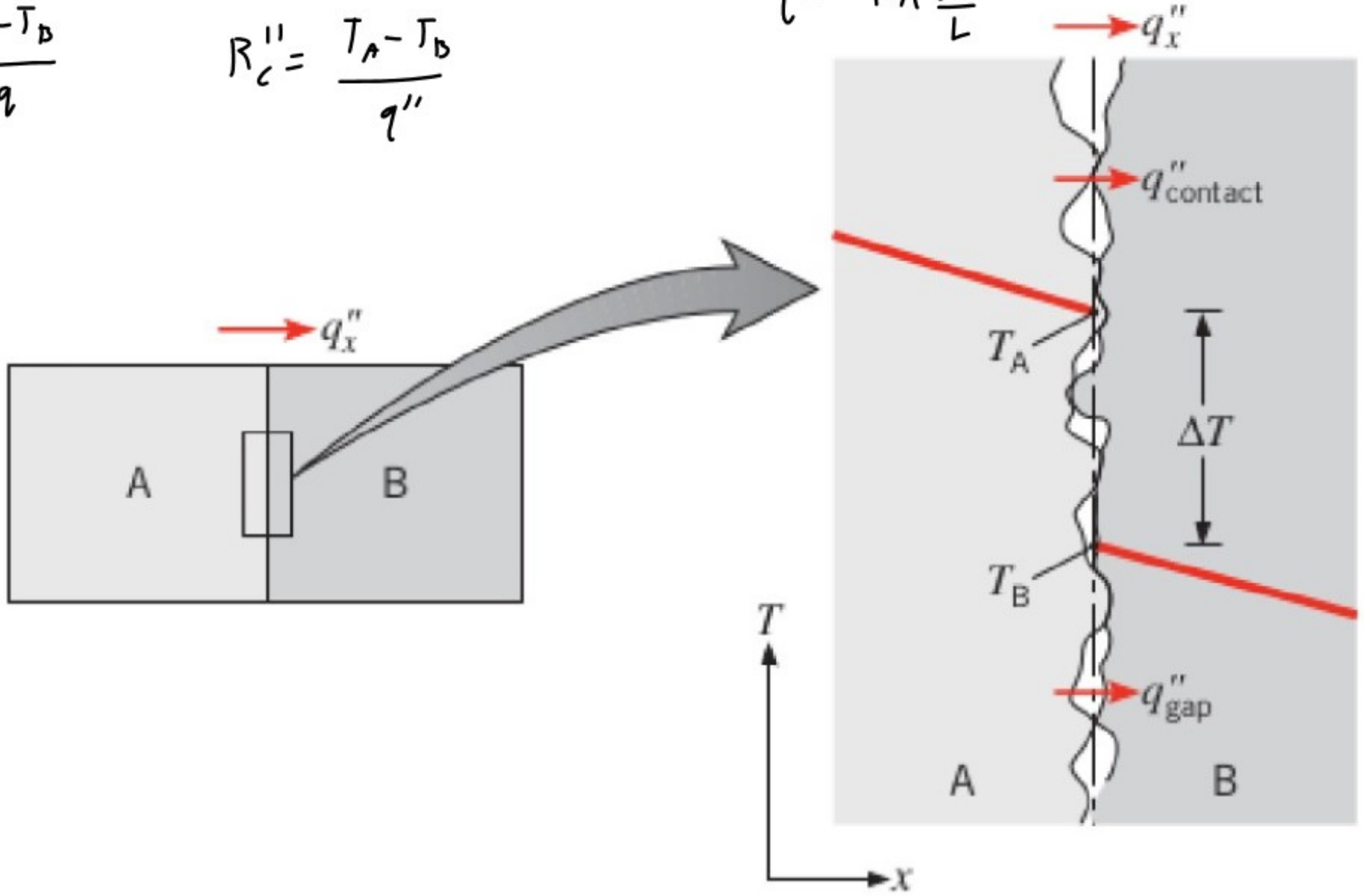
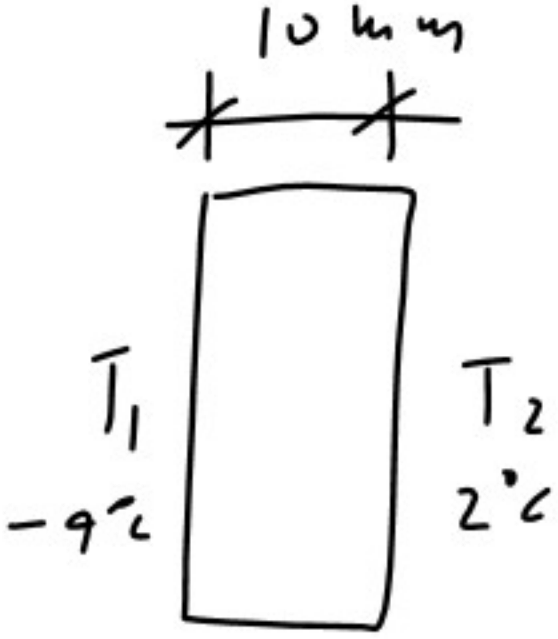


Table 3.1 Thermal contact resistance for (*a*) metallic interfaces under vacuum conditions and (*b*) aluminum interface (10-μm surface roughness, 10^5 N/m^2) with different interfacial fluids [1]

Thermal Resistance, $R''_{t,c} \times 10^4$ ($m^2 \cdot K/W$)

(*a*) Vacuum Interface			**(*b*) Interfacial Fluid**	
Contact pressure	100 kN/m^2	10,000 kN/m^2	Air	2.75
Stainless steel	6–25	0.7–4.0	Helium	1.05
Copper	1–10	0.1–0.5	Hydrogen	0.720
Magnesium	1.5–3.5	0.2–0.4	Silicone oil	0.525
Aluminum	1.5–5.0	0.2–0.4	Glycerine	0.265

3.7 A t = 10-mm-thick horizontal layer of water has a top surface temperature of $T_c = -4°C$ and a bottom surface temperature of $T_h = 2°C$. Determine the location of the solid–liquid interface at steady state.



Assume k constant

$$T(x) = (T_2 - T_1)\frac{x}{L} + T_1$$

$$= (2 - -4)\frac{x}{10\,mm} - 4 = \frac{6°C}{10\,mm}x - 4°C$$

$$T(x) = 0°C = \frac{6°C}{10\,mm}x - 4°C \Rightarrow 4°C = \frac{6°C}{10\,mm}x$$

$$\frac{10\,mm\ 4°C}{6°C} = x = \boxed{6.6\overline{6}\ mm}$$