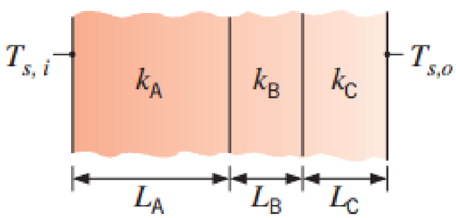
TEM – Transferência de Energia e Massa 2015/16,
Teste 1 (1 de abril)

<u>**Justifique todas as respostas recorrendo a equações quando conveniente**</u>

Problema 1 (6/20)

A figura representa uma parede formada por 3 camadas com diferentes espessuras e condutividades. Em condições estacionárias:

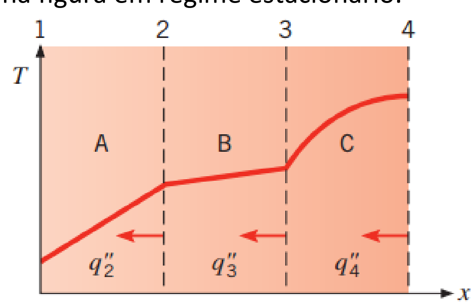


K_A=3 W/m.K; K_B=1 W/m.K; K_C=0.5 W/m.K;
L_A=0.2m; L_B=0.1m; L_C=0.1m;
h_i=2W/m2.K; h_e=2W/m2.K;

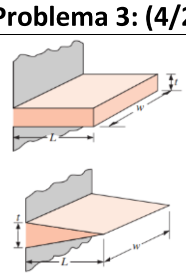
a) Esboce a evolução de temperatura através da parede quando a temperatura do ar interior são 25ºC e a do ar exterior são 10ºC.
b) Escreva as equações necessárias para calcular Tsi, Tso e o fluxo de calor, ignorando a radiação.
c) Considere que a temperatura da superfície exterior calculada na alínea b) eram 12 ºC. Se repetisse os cálculos considerando radiação nessa parede (emissividade 0.8) e radiação solar de 100W/m^2 a temperatura obtida seria maior ou menor?

Problema 2 (10/20)

Considere o perfil de temperatura mostrado na figura em regime estacionário.

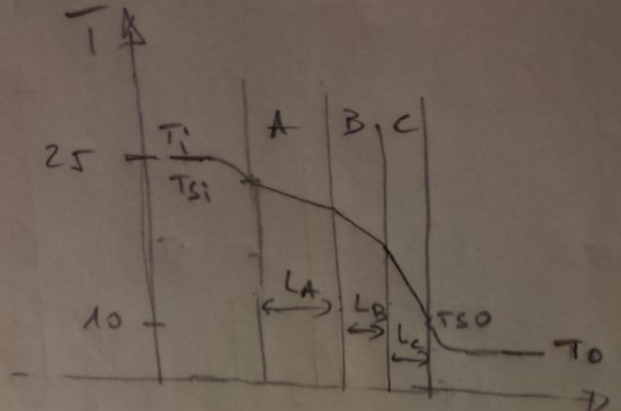


a) Quais são os valores relativos de q''_2, q''_3, q''_4?
b) Que camada tem a maior condutividade?
c) Relacione o calor gerado em C com o fluxo q''_3
d) Escreva as equações de evolução para as camadas B and C.
e) Se a taxa de geração de calor em C fosse subitamente duplicada, qual seria a taxa inicial de variação da temperatura nessa camada?

Problema 3: (4/20)	
	A Figura representa uma alheta rectangular e outra triangular. As alhetas triangulares são mais leves (e gastam menos material), mas a secção transversal diminui ao longo do trajecto do calor por condução. Num gráfico compare os perfis de temperatura esperados para ambas as geometrias. Qual tem o maior fluxo de calor?

Problem 1

a)



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

$$\frac{\partial T}{\partial x} = c_1$$

$$T = c_1 x + b$$

- Evolutions will be linear.
- The heat flux will be the same in every layer

$$q'' = \left(k \frac{\partial T}{\partial x}\right)_A = \left(k \frac{\partial T}{\partial x}\right)_B = \left(k \frac{\partial T}{\partial x}\right)$$

The slope of the straight line will be higher when the conductivity will be lower.

b) $q'' = h_i (T_i - T_{si}) = h_e (T_{so} - T_o)$

$$q'' = K_A \left(\frac{T_{si} - T_{AB}}{L_A}\right) = K_B \left(\frac{T_{AB} - T_{BC}}{L_B}\right) = K_C \left(\frac{T_{BC} - T_{so}}{L_C}\right)$$

We have 5 equations and 5 unknowns (q'', T_{si}, T_{AB}, T_{BC}, T_{so})

using the concept of resistence one would get:

$$q'' = \frac{1}{R_{TOT}} (T_i - T_o)$$

$$R_{TOT} = \frac{1}{h_i} + \frac{L_A}{K_A} + \frac{L_B}{K_B} + \frac{L_C}{K_C} + \frac{1}{h_e}$$

And the calculation would become very easy.

c) If T_{so} was the radiated heat flux would be

$$q_{rad} = \varepsilon \sigma T_{so}^4 = 0.8 \times 5.670 \times 10^{-8} \times (273 + 12) = 299 \, W/m^2 > 100$$

and the temperature would be smaller.

Problem 2

a) • Stationary and linear profile implies no heat generation and uniforme heat flux across the surface $q''_2 = q''_{3}$

• Stationary and non-linear profile implies heat generation $q''_{3} > q''_{4}$

• Zero gradient at surface 4 implies no heat flux: Adiabatic wall

b) The heat leaving flux C is equal to the heat flux entering into B and into A. The maximum conductivity corresponds the the lower slope, i.e. to B

c) $q''_{3} \times A_s = \dot{q}_r A_s \times L_c \Rightarrow \dot{q}_r = \frac{q''_3}{L_c}$

All the heat generated inside c has to leave across interface 3.

d) B: $\frac{\partial^2 T}{\partial x^2} = 0$

e: $\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + q_c = 0$

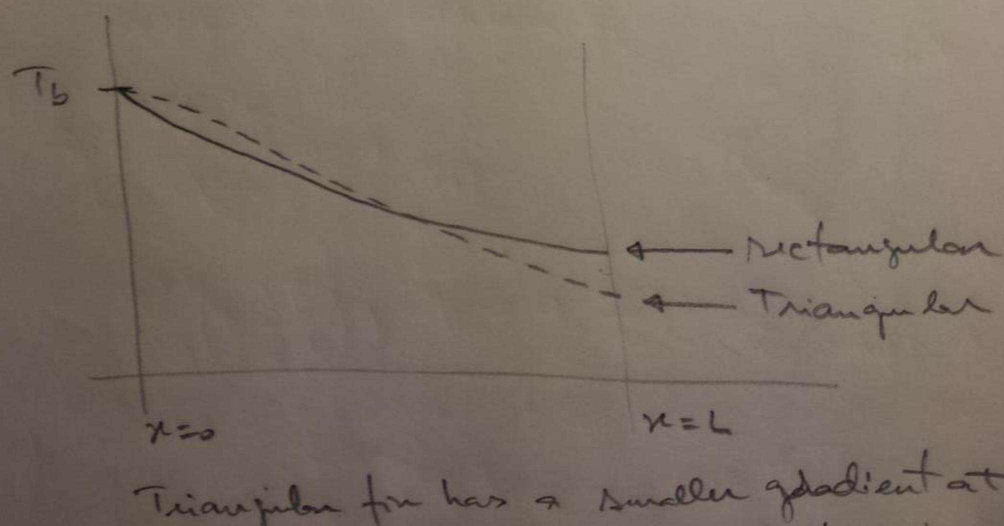
e) $\underbrace{\left(\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right) + \dot{q}_r\right)}_{\text{equal zero at } t=t_0} + \dot{q}_r = \rho c_p \frac{\partial T}{\partial t}$

$\Rightarrow \left(\frac{\partial T}{\partial t}\right)_{t=0} = \frac{\dot{q}_r}{\rho c_p}$

Problem 3

a) If The surface temperature along both fins was the same, convective (and radiative) heat fluxes would be The same, but conduction heat fluxes could not because The cross section is decreasing. So to have The same conduction heat fluxes The longitudinal gradient has to decay

But if the longitudinal gradient decays The convection heat flux decays and Thus The conduction heat flux has to be smaller in the triangular fin. This means that the gradient at the base of The fin has to be smaller.



Triangular fin has a smaller gradient at the basis and lower average Surface temperature