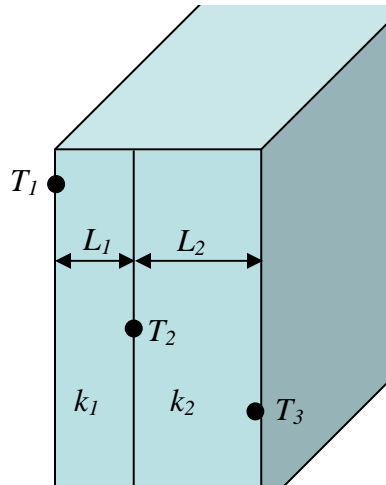


MAE 3314: Heat Transfer
Homework #1 (Due date – 2/9/10)

1. (i) Calculate the steady state heat transfer rate through the composite wall in W/m^2 . [10 pts], (ii) Find T_2 in K. [10 pts]



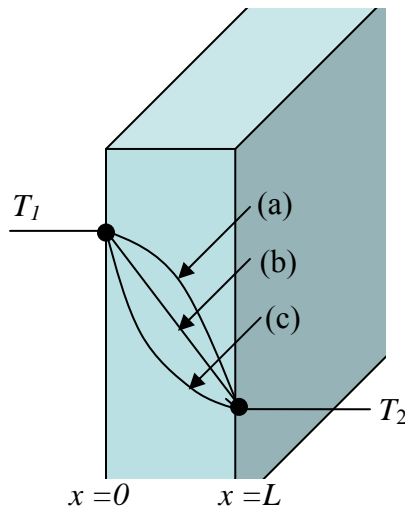
$L_1 = 0.2$ m
 $L_2 = 0.03$ m

$T_1 = 1250$ K
 $T_2 = ?$
 $T_3 = 310$ K

$k_1 = 1.0$ W/m·K
 $k_2 = 0.07$ W/m·K

** Clarify all the assumptions you made to solve the question.*

2. Find analytical expression for the temperature distribution $T(x)$ in the plane wall which has uniform surface temperatures T_1 ($x=0$) and T_2 ($x=L$) and $T_1 > T_2$. Thermal conductivity varies linearly with temperature, i.e. $k = k_0(1+bT)$. Consider three different cases, (i) $b > 0$, (ii) $b = 0$, and (iii) $b < 0$. For each case, which one is the closest $T(x)$ profile in Figure below? [15 pts]



3. A hollow cylinder having inner and outer radii r_1 and r_2 , respectively, is subjected to a steady heat transfer resulting in constant surface temperature T_1 and T_2 at r_1 and r_2 . If the thermal conductivity can be expressed as $k = k_0(1+bT)$, find an analytical expression for the heat transfer (heat rate) per unit length ($= q/L$) of the

cylinder. [15 pts]

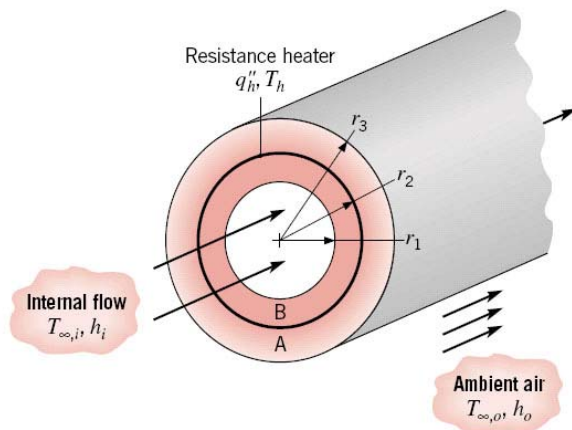
4. Find the temperature profile, $T(r)$ within solid sphere which generates heat ($\dot{q} > 0$) by solving heat equation. The radius of sphere is r_o and the surface temperature of the sphere is T_s . [20 pts]

<Hints> - Use spherical coordination.

- Two boundary conditions: at $r = 0$ (center), $\frac{dT}{dr} = 0$ (no heat transfer)
 at $r = r_o$, $T = T_s$

* Show your own step-by-step derivation. Final answer can be found in the textbook, Appendix C, Table C.3 (p.970).

5. 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. [25 pts]



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.

(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 (heat rate per unit tube length, q') to the outer and inner fluids ($= q'_o / q'_i$). How might the variables of the problem be adjusted to minimize this ratio?

6. A thin-walled copper tube having an outside metal radius $r = 0.008$ m carries steam at 383 K. It is inside a room where the surrounding air temperature is 298 K. It is insulated with 85 % magnesia insulation having an approximate thermal conductivity of 0.071 W/m-K. What is the critical insulation thickness at which the heat flow per unit length of tube is maximum? External air convective coefficient $h = 4.0$ W/m²-K. [15 pts]