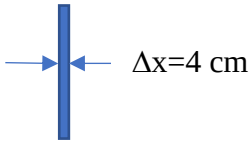
SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
Department of Materials and Metallurgical Engineering

MET 422 Homework 06 Due 11:00 pm Oct 29

Submit to the Dropbox named Homework 06

1) A 4-cm thick mullite ($3Al_2O_3*2SiO_2$) ceramic plate shown at 300 K is plunged into flowing liquid Al at 1000 K. How long will it take, to the nearest second, for the plate's center to reach 600 K? Solve numerically via 1D USS HC worksheet. Assume the exterior faces of the mullite immediately reach 1000 K upon immersion into the molten Al and ignore end and edge effects, i.e. T=f(t x), only.
Mullite properties in cgs units
k =0.060 $W*cm^{-1}*K^{-1}$,
Cp = 0.800 $J*g^{-1}*K^{-1}$
ρ = 2.70 $g*cm^{-3}$
Making α = 0.0278 cm^2/s



Tip: you may model the entire thickness, 2L, with BC's of 1000 K at -L and +L or model the half thickness with a zero flux boundary at the center x=0 and a 1000 K fixed T BC at x=L. Submit pdf of the Excel sheet. Ans: 46 s

2) For forced convection, h = f(ρ, Cp, η, k, D, V) resulting in Nu = f(Re, Pr).
For natural convection in which only the changing fluid density drives fluid movement

h = f(ρ, Cp, η, k, D, g$\beta\Delta$T),

where g$\beta\Delta$T is the driving force term. The definition of B is

$$\beta = -\frac{1}{\rho}\frac{\partial \rho}{\partial T}$$

Find the independent dimensionless groups for the Nu number for natural convection using Buckingham Pi Theory or inspection, if apparent. Note, the units on gBΔT are m/s^2. Ans: see p 258

3) Show steps 1, 2, and 3 in the derivation of the 1D USS HC PDQ in spherical coordinates resulting in

$$\alpha\left[\frac{\partial^2 T}{\partial r^2}+\frac{2}{r}\frac{\partial T}{\partial r}\right]=\frac{\partial T}{\partial t}$$

Ans: 10-23 - Class Supplemental Lecture.