TYBTech(Mechanical) / MTech(Thermal)
Computational Fluid Dynamics
Assignment No. 3
Date of submission – 4 March 2024

1. Consider a one-dimensional plane wall of thickness 100 mm. The conductivity of the wall material is 0.1 W/m-K. The left face of the wall is exposed to a heat flux of 200 W/m^2 and also to a hot fluid with temperature 300^{o}C. Assume a heat transfer coefficient of 25 W/m^2-K between the left face and the hot fluid. The right face of the wall is maintained at 50^{o}C. Assume steady-state conditions.
   (a) Solve this problem numerically and compare the results with the analytical solution.
   (b) Determine and compare (i) the temperature at the left face, and (ii) the heat flux leaving the right face.
   (c) Plot the temperature within the wall.
   (d) Finally, determine if the heat balance is obeyed in the numerical solution.
   You can decide your own grid spacing (for all problems), and determine roughly the "coarsest" grid for "sufficient" accuracy.

2. Consider a one-dimensional slab with conductivity 1 W/m-K. The slab width is 20 cm. The left face of the slab is at 100^{o}C and the heat flux at the right face is 1 kW/m^2. The slab experiences a volumetric heat generation rate given by S = 1000 - 5T W/m^3. Determine the steady-state temperature distribution in the slab, for two grid spacing with the requirement that there should be at least 20 CVs in each case. Determine the overall heat balance.

3. Consider a one-dimensional composite wall under steady-state conditions. The wall is composed of two materials A and B, with the arrangement A-B (from left to right). Assume all contact resistances negligible. The left face of the wall is exposed to a hot fluid at temperature 800^{o}C, and the heat transfer coefficient between the hot fluid and the left face is 25 W/m^2-K. The length and conductivity information for the two materials is as follows: L_A = 0.4 m, L_B = 0.2 m, k_A = 10 W/m-K, k_B = 0.1 W/m-K. The right face of the wall is exposed to a cold fluid at 20^{o}C, with a heat transfer coefficient of 10 W/m^2-K. Solve this problem numerically and compare the results with the analytical solution. Plot the temperature distribution within the wall. Suggest and implement a method to determine the interface temperatures (in the numerical solution), and compare the results with the analytical values.

4. Find the temperature distribution and steady state heat flux through an infinite slab, 5 cm thick whose one end is maintained at 600^{0}C and the other end is maintained at 30^{0}C. The thermal conductivity of the material varies linearly with temperature in the following manner: k = 0.05(1+ 0.008T) W/mK where T is in ^{0}C.

5. The governing differential equation for a thin fin with uniform cross-sectional area, where the heat loss to the surrounding is purely by radiation, is given by $\frac{d^2T}{d^2x} - C\left(T^4 - T_\infty^4\right) = 0$,
where C is a constant. Making suitable assumptions, what is the expression for C? Following the standard procedure of the Finite Volume discretization process and using source term linearization, derive the discretization equation (DE) in usual form

$$a_P T_P = \sum a_{nb} T_{nb} + b$$

Simply outline the numerical procedure that you will employ to handle this conduction-radiation situation.