ME 24-731
Conduction and Radiation Heat Transfer

Assignment No: 7
Due Date: May 2, 2000
Spring 2000
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1. Consider the two-dimensional square enclosure shown in Figure 1. The walls of the enclosure are gray-diffuse. The intervening medium is non-participating. The temperature is given on 3 walls, and the heat flux is known on the remaining wall.

   (a) Using Hottel's cross strings method, find all the necessary view factors to do an enclosure radiation calculation.

   (b) Write a computer code to solve the enclosure problem. The code should

      i. allow you to set the number of surfaces in the enclosure

      ii. read from a file the following information (1) a flag tagging each surface as a given-heat flux or a given temperature surface, (2) the relevant temperature/heat flux boundary value, (3) the area of each surface, (4) the emissivity, and (5) the view factors for each surface to all other surfaces in the enclosure

      iii. solve for the temperature of each surface for which heat flux is given, and for the heat flux when the temperature is given.

   (c) Print the computed temperatures and heat fluxes for each surface. Show that heat balance is satisfied.

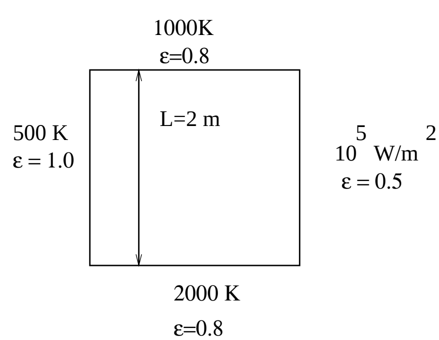

Figure 1: Domain for Problem 1

2. Now consider a variant of Problem 1, shown in Figure 2. Instead of the bottom surface being a known-temperature boundary, consider it to be the upper surface of a slab of conducting material of thickness d =0.1m. The conductivity of the solid is 500 W/mK. Since d/L $\ll$ 1, the conduction in the slab may be considered approximately one-dimensional in the y direction. The bottom surface of the slab is now given to be T_{s2}= 2000 K. Assume steady state.

   (a) Approximate the heat flux in the solid as

$$-k\frac{dT}{dy} = -k\frac{(T_{s1} - T_{s2})}{d}$$

   (b) Solve iteratively for the temperature T_{s1} using the code developed in the previous problem.

   (c) Print the heat fluxes and temperatures on all surfaces and ensure that heat balance is obtained.

3. If the conduction problem were not one-dimensional, but truly multi-dimensional, we may discretize the solid into control volumes as done in previous assignments, and solve for the solid temperature field numerically. A typical control volume with a face facing the enclosure is shown in Figure 2. Let the extents of the control volume be Δx and Δy.

   (a) Assuming steady state, write the discrete equation for the heat balance in the control volume.

   (b) Outline a procedure for obtaining the all the surface temperatures and heat fluxes as well as the cell-centroid temperatures in the solid.

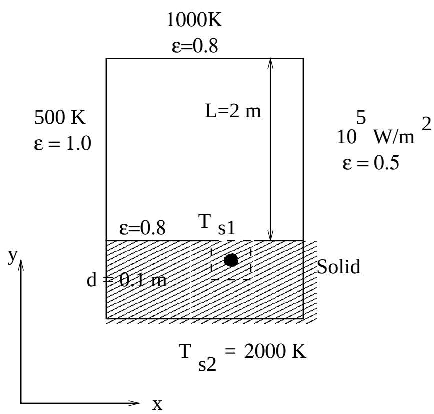

Figure 2: Domain for Problems 2 and 3