ME109 – Heat Transfer

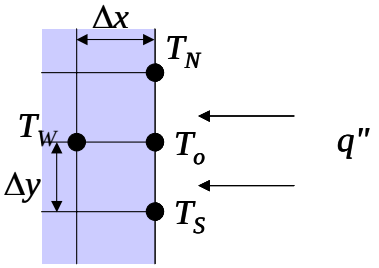
Midterm 1- Fall'01

Instructor: Prof. A. Majumdar

Oct. 12, 2001; 10:10 am - 11:00 am; Maximum Points = 30

NOTE: This is an open book, open notes exam.

1. For solving a 2-D transient heat conduction problem, a node, T_o, is placed on the boundary surface as shown in the figure below. The surface is exposed to a radiative heat flux of q'', which is absorbed at the boundary surface. Using the first law of thermodynamics, derive a nodal equation for T_o in an explicit scheme in terms of the temperature of surrounding nodes and q''. Determine the stability criterion for this scheme. (10)



2. A stainless steel ball of radius 1 mm used in a ball bearing is to be heat treated. It is initially at 300K and is immersed in a furnace where hot gases at 1000 K is blown over it such that the heat transfer coefficient is 100 W/m^2-K. The thermal conductivity of stainless steel is 10 W/m-K, density, ρC = 3 x 10^6 J/m^3-K. How long will it take for the ball to reach 900 K? (10)

3. A thin tube of radius R is covered with an insulation layer of thickness D and thermal conductivity k. The outside surface of the insulation layer is exposed to convection with heat transfer coefficient, h. Determine the thickness, D_{min}, when the total thermal resistance between the inside of the tube and the outside convection is minimum. Show that the resistance is minimum for that thickness. Neglect the thermal resistance of the tube material and the fluid inside the tube. (10)