Problems from chapter 4

4.2

The left side of a slab of thickness L is kept at 0°C. The right side is cooled by air at T_∞°C blowing on it. h_{RHS} is known. An exothermic reaction takes place in the slab such that heat is generated at $A(T - T_\infty)$ W/m^3, where A is a constant. Find a fully dimensionless expression for the temperature distribution in the wall.

4.13

What is the minimum length, l, of a thermometer well necessary to ensure an error less than 0.5% of the difference between the pipe wall temperature and the temperature of fluid flowing in a pipe? The well consists of a tube with the end closed. It has a 2 cm O.D. and a 1.88 cm I.D. The material is type 304 stainless steel. Assume that the fluid is steam at 260°C and that the heat transfer coefficient between the steam and the tube wall is 300 W/m^{2}K. [3.44 cm.]

4.23

A fin of triangular axial section (cf. Fig. 4.12) 0.1 m in length and 0.02 m wide at its base is used to extend the surface area of a 0.5% carbon steel wall. If the wall is at 40°C and heated gas flows past at 200°C (h = 230 W/m^{2}K), compute the heat removed by the fin per meter of breadth, b, of the fin. Neglect temperature distortion at the root.

4.29

You want to rig a handle for a door in the wall of a furnace. The door is at 160°C. You consider bending a 40 cm length of 6.35 mm diam. 0.5% carbon steel rod into a U-shape and welding the ends to the door. Surrounding air at 24°C will cool the handle (h = 12 W/m^{2}K including both convection and radiation). What is the coolest temperature of the handle? How close to the door can you grasp the handle without getting burned if T_{burn} = 65°C? How might you improve the design?