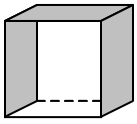
ta3220 Fluid Flow and Heat Transfer
"Complex" Heat transfer problems

1. Three sides of a cube of lead 0.1 m on a side are perfectly insulated as shown below. (That is, the top, left and right surfaces are perfectly insulated.) The cube is initially at temperature 100°C. At time t=0, the cube is placed in a tank of vigorously stirred fluid maintained at 0°C. Determine temperature at the warmest spot in the solid after 40 sec. with the following assumptions:

   a) Assume that heat transfer between the fluid and the solid surfaces controls the heat-transfer process. The heat-transfer coefficient at the solid surface is 2,500 W/(m^2 K).
   b) Assume that internal conduction within the cube controls the heat-transfer process.
   c) Which answer, (a) or (b), is closest to the true answer?
   d) Is the actual temperature after 40 sec greater or less than this value?

properties of lead

k = 34.6 W/(m K) C_p=125.7 J/(kg K) ρ = 11,340 kg/m^3



top, left and right surfaces perfectly insulated; other surfaces in contact with fluid

2. Two solids, a sphere and a cube, both of the same material and both weighing 1 kg, are both initially at 300 K. Suddenly both are immersed in a hot oil at 400 K, so that the *surface temperature of both immediately rises to 400 K*. How long does it take for temperature at the center of each solid to rise to 350 K?

Properties of solid material

k = 35 W/(m K) C_p = 130 J/(kg K) ρ = 11,000 kg/m^3

3. Revisit problem 2, but instead do not assume that the surface temperature immediately rises to that of the oil.
   a) Assume instead that convection to the solid surface controls the process and that the heat-transfer coefficient is h = 500 W/(m^2 K). How long until the center of the sphere and cube each reach 350 K?
   b) Which assumption, that here or in PS 12, is the most realistic for this problem?