AESB2320, 2015-16
Part 2 Examination - 1 July, 2016

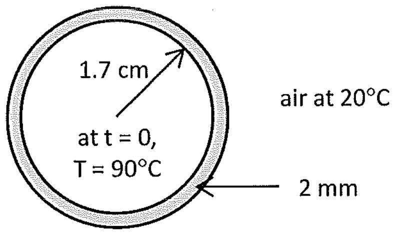
Write your solutions *on your answer sheet*, not here.
In all cases ***show your work***.
Beware of unnecessary information in the problem statement.

To avoid any possible confusion,
<u>state the equation numbers and figure numbers</u> of equations and figures you use <u>along with the text you are using (BSL1, BSL2 or BSLK).</u>

1. Rocky has burned his mouth biting into a kroket, and he wonders how the inside of a kroket stays so hot. He imagines two models for the cooling process. One is described in this problem, and one in problem 2. In both cases, assume that the kroket is a cylinder, infinitely long. (If you don't know what a kroket is, just follow the description of the process.)

   A kroket has a crust surrounding a filling. For this problem, assume that the filling inside the crust stays at a uniform temperature at all times. The filling is a cylinder, 3.4 cm in diameter; around this is a layer of crust 2 mm thick. Cooling is controlled by the combination of convective heat transfer from air to the crust and conduction through the crust. The heat-transfer coefficient at the crust surface is h = 20 W/m^{2}K. The thermal conductivity of the crust is k = 0.2 W/(m K). The properties of the filling are given below.

   a. What is the overall heat-transfer coefficient between the air and the filling?
   b. Assume the filling is at T = 90°C at time t = 0. The surrounding air is at 20°C. How long would it take the center of the kroket to cool off to 50°C? (If you can't figure out how to do part (a), state clearly what value you are using for the overall heat-transfer coefficient.)
   c. Which is more important to the cooling process: convective heat transfer to the surface, or heat conduction through the crust? Briefly justify your answer.

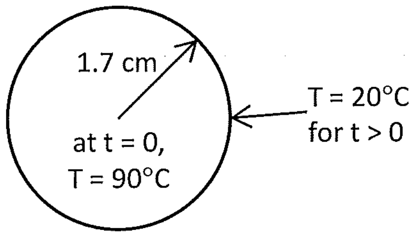


(40 points)

<u>properties of filling</u>

ρ= 1000 kg/m^3 k = 0.680 W/(m K) C_p = 4190 J/(kgK)

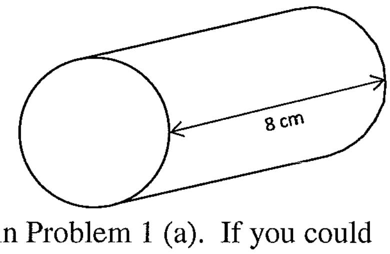
2. Assume now instead that internal heat conduction is what matters. Assume that the filling has the properties listed in problem 1 and that there is no convection within the filling. At time zero the filling is at a uniform temperature of 90°C. Starting at time zero the radial surface is reduced to and maintained at 20°C. How long would it take the temperature at the center to fall to 50°C?



(20 points)

3. Based on your answers to problems 1 and 2, which is the best answer? Briefly justify your choice If you couldn't finish one question or the other, state clearly how you would answer this question if you had those answers.
(15 points)

4. A kroket is actually a cylinder about 8 cm long, not infinitely long along its axis. Assume it has flat (planer) opposite surfaces on both ends, both covered in crust like the radial surface. By how much would that change your answer to question 1? Assume the same overall heat-transfer coefficient applies here as in Problem 1 (a). If you could not finish problem 1, state clearly how accounting for the cylinder having finite length would change the answer.
(15 points)



5. Finally, back to problem 1. Rocky estimated that the heat-transfer coefficient h is 20 W/m^2K based on a kroket sitting in still air. Suppose instead he held the kroket in front of a fan, with vigorous convection of air past the kroket. Would the value of h increase, decrease, or remain the same? Briefly justify your answer.
(10 points)