This test demonstrates my work towards two of the course objectives. The first being "Solve steady one-dimensional heat conduction problems, multi-dimensional heat conduction problems, and unsteady heat conduction problems". My work on the first question demonstrated this because it required solving a one-dimensional unsteady heat conduction problem. Since the plastic rod in question one was infinitely long, heat conduction only occurred in one dimension radially. The rod also began at a uniform initial temperature and was being cooled by a fluid on its outside surface, so this was an example of an unsteady heat conduction problem. The second objective is "Explain the physical meaning of dimensionless parameters and their relation to different heat transfer problems". My work on the second question demonstrated this because it required me to calculate a dimensionless parameter, Fourier number. It is necessary to calculate Fourier number to ensure it is greater than 0.2 to so that I can check the validity of a one term approximation for unsteady heat conduction such as in problem one. Fourier number is also required to because it is used in the unsteady heat conduction equations. The last objective is "Use commercial computer programs to numerically solve heat transfer systems. The second question on the test demonstrated this because it required me to use COMSOL to solve the first question and check the percentage difference between the analytical and numerical solutions.

After reviewing the available solution of the test, I can safely say that my test solutions match the available solutions. I didn't make any mistakes on this test. The advice I would give myself would be continuing studying, doing practice problems, and taking my time.

WRITING RUBRIC

1. Purpose 0.5/10.0
2. Drawings 1.0/10.0
3. Sources 0.5/10.0
4. Design considerations 1.0/10.0
5. Data and variables 0.5/10.0
6. Procedure 2.5/10.0
7. Calculations 2.0/10.0
8. Summary 0.5/10.0
9. Materials 0.5/10.0
10. Analysis 1.0/10.0

TOTAL 10.0/10.0

PROBLEM 1)

1. Correct (T-Tinf)/(Ti-Tinf) equation 1/10
2. Compute alpha 1/10
3. Iteration process 1/10
    a. Assume "D" 1/10
    b. Biot to read table 1/10
    c. Get C1 and Ze1 1/10
    d. Theta0 1/10
4. Temperature at surface 1/10
5. Temperature at r=r0/2 1/10
6. Final result correctness 1/10

TOTAL **10/10**

PROBLEM 2)

1. Right geometry 1/6
2. Right material properties 1/6
3. Right BC 1/6
4. Right initial conditions 1/6
5. Change “h” until matching Theta0 1/6
6. Final result correctness 1/6

TOTAL **6/6**

FINAL GRADE:

10.0/10.0 + (80/2)*(10/10+6/6) = 90

My greatest strength on this test was my ability to use COMSOL. I felt confident in my ability to use COMSOL to iterate for the diameter of the rod until the center temperature of the rod was correct for the second question. I also felt quite strong in my ability to use Excel iterate for the diameter when solving the first problem analytically. I would say my weakness was on first problem and using the Bessel function in Excel. I haven’t used this function before taking this class, so I didn’t feel extremely confident because I don’t have much practice with it and the different types. However, I was able to improve my confidence by comparing the value given by Excel to table B.4 and the values did match, which alleviated some of my worry.

One thing that I encountered while working on the test was an error with my Bessel function. I had originally used the Bessel I function as instructed in class. However, I didn’t realize this was a problem until I calculated the solution for the temperature at the surface of the rod. I knew that rod was being cooled from the outside so the center temperature of 30°C was a maximum and it had to be larger than cooling temperature of 25°C, so I knew the result needed to be between 25°C and 30°C. When I got the result approximately 34°C, I knew something wasn’t right and I retraced my tests and determined that the Bessel function was the problem and needed to be a Bessel J function. After correcting this, the result was approximately 28°C when ultimately matched the COMSOL result with 1%. My result for the temperature at half the radius also matched within 1%. The steps I use are to read each question and look at drawings, if they are present, one at a time and not worry about the next question. Next, I write the purpose, create a drawing, write the sources, design considerations, data and variables, write the procedure based on what needs to be calculated from the purpose, perform the calculations and check my numbers again, read the problem again to ensure that I have solved the problem correctly and answered all parts, write the summary, materials, look back over the problem and write the analysis. I did this for both problems. I wouldn't change anything about it, I believe it worked quite well since my test solution matches the available solution very well. I have learned about unsteady heat conduction and the many methods that can be used to solve them such as lumped capacitance when $Bi<0.1$, unsteady heat conduction for semi-infinite bodies, one term approximation for one-dimensional and multidimensional unsteady heat conduction when $Fo>0.2$. I have also learned how to use COMSOL to solve unsteady heat conduction problems.

Engineers would use these concepts in the metal industry such as in heat treatment. An engineer could model the piece of metal as block, cylinder, or sphere based on the geometry and could determine the amount of energy needed to heat the metal up to the temperature required for heat treatment. They could calculate the Biot number to determine if lumped capacitance can be used. If not, they could use a one term approximation if Fourier number is large enough. Unsteady heat conduction could be used to determine the time required to reach this temperature. If lumped capacitance is valid, the temperature will be uniform throughout, if not, it will be necessary to look at the temperature profile within the body at that time. Once at the temperature, engineers can determine temperature of the cooling fluid or convective heat transfer coefficient required to remove the heat quickly in set period of time for the heat treatment process.

I don't know where I'll be using these concepts yet, although I am confident that I will need them because heat transfer in many cases is unsteady. I haven't been able to utilize these concepts in other classes or work yet. I spent approximately 6 hours total on the test. The first two hours were spent on the first question. This one took longer because I had to figure out the Bessel functions and set up my Excel spreadsheet to solve for the diameter However, after it was set up, it made the calculations much easier when solving for the temperatures because I could use the same sheet. I spent another three hours on the second question mostly waiting on the COMSOL to compute the temperatures when I was iterating and also cleaning up the COMSOL report. I spent another hour just reviewing my calculations, writing, COMSOL file, report, and ensuring I answered all questions.