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Transient Conduction

## Figures and Tables

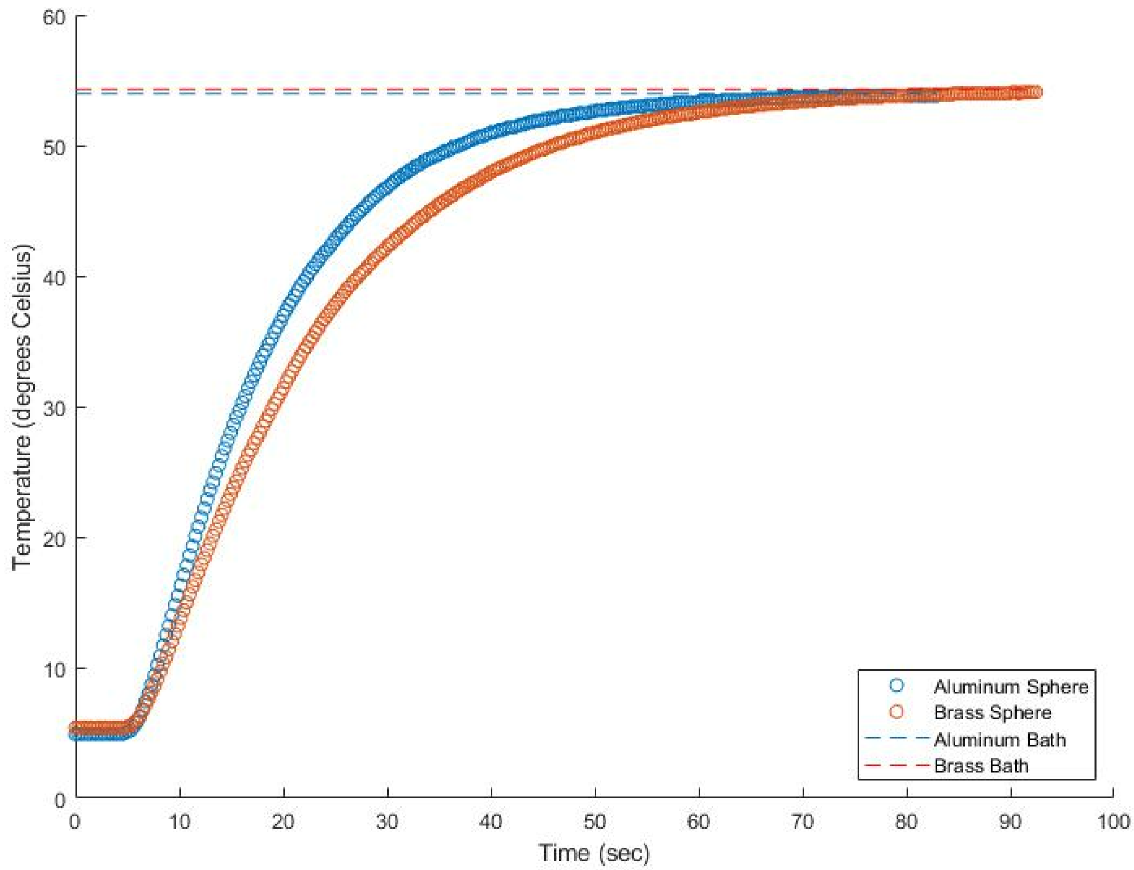



**Figure 1.** Temperature vs. time for aluminum and brass spheres

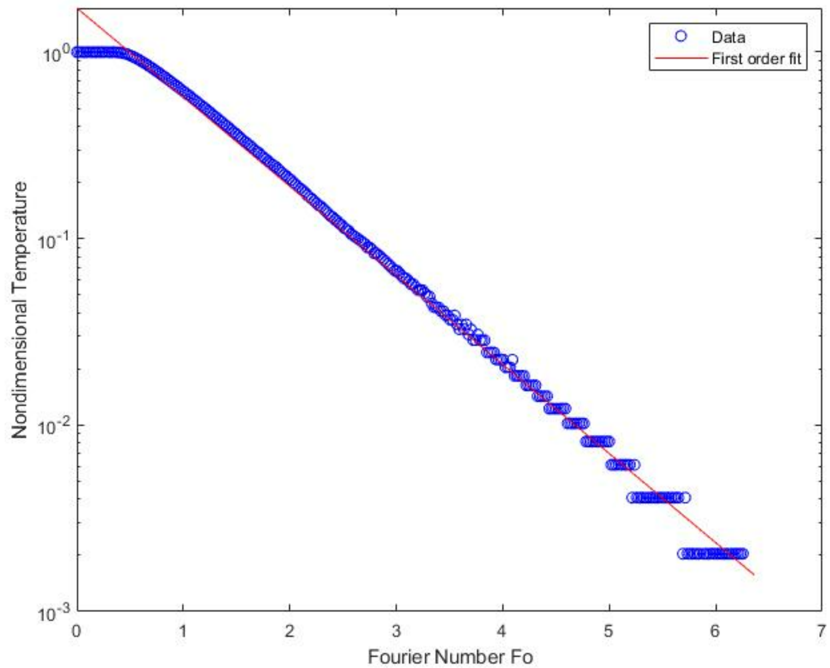



**Figure 2.** Non-dimensional temperature vs. Fourier number for Aluminum, with data fit

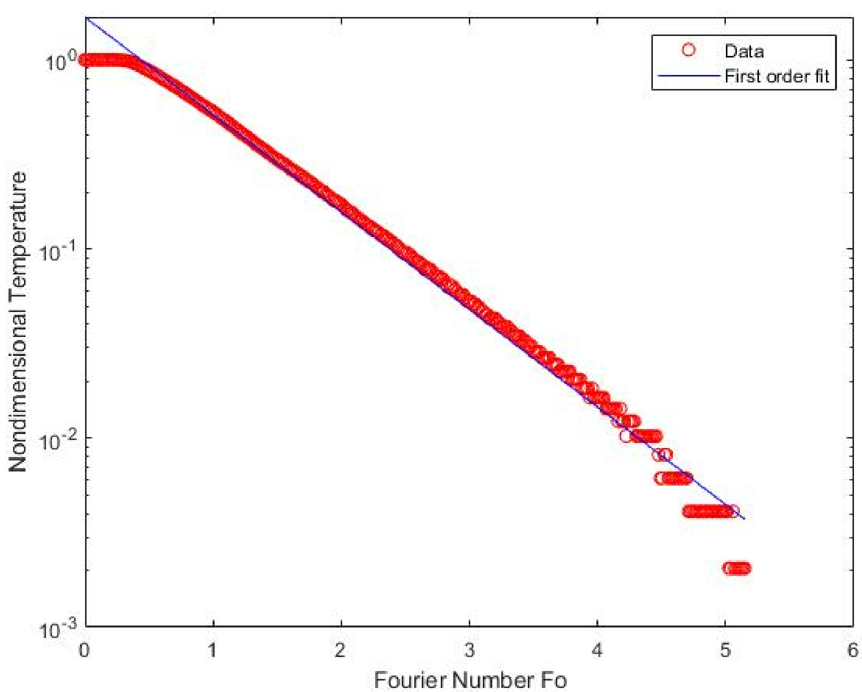



**Figure 3.** Non-dimensional temperature vs. Fourier number for Brass, with data fit

**Table 1.** Material properties: listed vs. measured*

| Material | Bi | h ($W/m^2K$) | Thermal Conductivity (W/m•K) | | |
|---|---|---|---|---|---|
| | | | Listed | Measured | % difference |
| Aluminum 2024T351 | 0.3969 | 1889 | 121.4 | 126.0 | 3.79% |
| Brass 360 | 0.4310 | 1961 | 116.0 | 111.8 | 3.62% |

*Measured thermal conductivities are determined based on the assumption that h will be the same for the same shape and fluid conditions. Thus, the measured k for aluminum is calculated using the h from brass, and vice versa.

**Short-Answer Questions:**

1. State the percent difference in h values measured between the two test cases. Is this reasonable? Briefly discuss any ideas you have for increasing the accuracy of the h values that can be obtained from this experiment.

**The calculated h for the aluminum sphere was 1889 $W/m^2K$. The calculated h for the brass sphere was 1961 $W/m^2K$. The difference is 3.75 %. This is very close! That's reasonable because the spheres are the same shape and size. Since h is a convection coefficient, the biggest difference is probably due to variations in the fluid flow around the sphere. One way this could be mitigated is to have the sphere inserted into the bath and held by a machine, instead of a human, so that both trials are exactly the same in that respect.**

2. Evaluate whether the one-term approximation for the analytical solution is appropriate in this application. To do this, quantify the "goodness" of your curve fits in Plots 2 & 3, AND state the time (in seconds), along with the corresponding $F_o$ value, after which the data appear to follow an exponential trend.

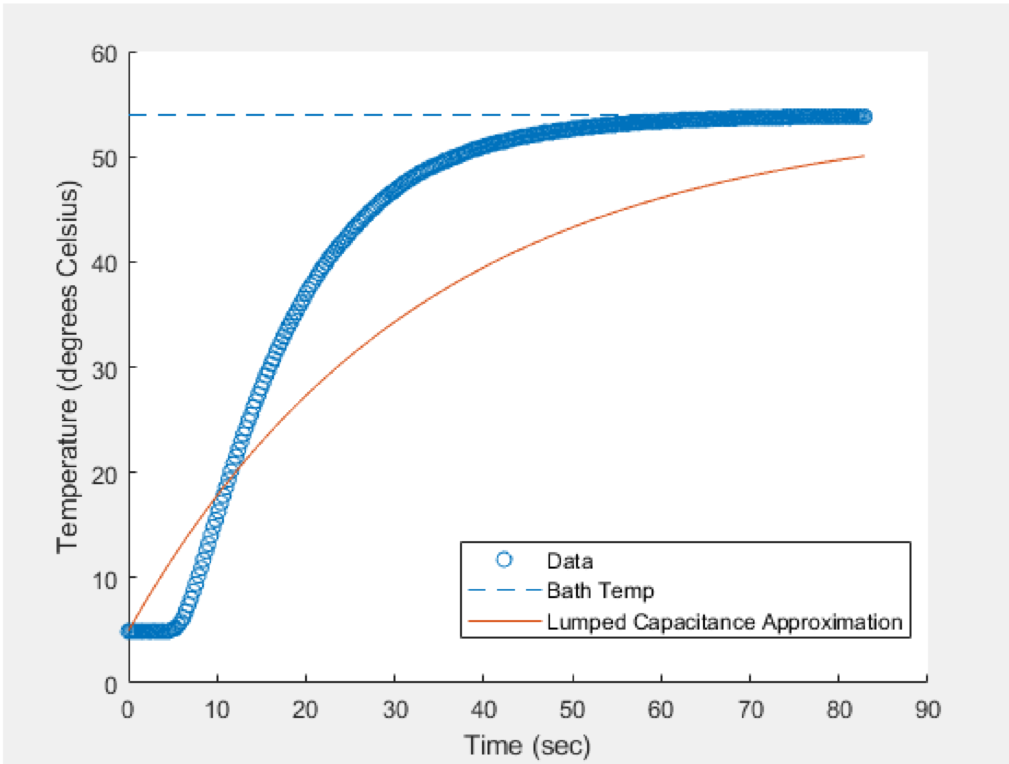
**The curves seem to start following the exponential curve fit at the following values:**
**For aluminum: $F_o = 0.5$, time = $F_o{*}r_0^2/\alpha = 6.51$ seconds**
**For brass: $F_o = 0.4$, time = $F_o{*}r_0^2/\alpha = 7.18$ seconds**

**Both polynomial fits are very good: After the curve becomes exponential, the $r^2$ values are:**

```
Command Window
For aluminum, r^2 = 0.9982 after Fo = 0.5.
For brass, r^2 = 0.9971 after Fo = 0.4.
>>
```

3. Would it be appropriate to predict the transient temperature response of the tested object using the lumped capacitance method? Provide a response in the form of two or more complete sentences that reference the magnitude of the Biot numbers for both test cases examined.

**The Biot number for the aluminum was 0.3969 and the Biot number for the brass was 0.4310. These are both considerably bigger than 0.1 – I would say that the lumped capacitance method would not be a very good approximation. The following plot of the lumped capacitance approximation over the data for aluminum shows that the approximation isn't very good:**




**Sources for Densities and Specific Heats**

http://asm.matweb.com/search/SpecificMaterial.asp?bassnum=ma2024t4
http://www.espimetals.com/index.php/technical-data/57-brass-360