Emissivity:

The intent of the experiment was to measure the emissivity of the rod in three different states: in its original condition, covered with electrical tape, and buffed to be as shiny as possible. Our expectation was that these three states would each a distinct emissivity, with the taped rod having a higher emissivity and the buffed rod having a lower emissivity. This was not borne out by the data. Every run of our simulation optimization program resulted in an outcome of either almost 1 (0.9999999…) or basically 0 (~10-10). The actual state of the rod had little to no effect on which of these two results were produced; the starting value we gave the optimization program tended to have more of an influence.

We believe that these aberrant results were due to the behavior of our optimization program. In the eyes of the program the terms σ(u(t,x)4-uamb4) and (u(t,x)-uamb) are roughly of the same magnitude, and it tries to balance the ratio of ε/kc. Because the radiation term does tend to be bigger, it ends up trying to maximize ε and minimize kc, but we bounded ε at 1 (the maximum physically possible). If we leave it unbounded, the program tends to increase ε and bring kc to almost 0, because it is easier to optimize with just the one necessary term. Because we were unable to get any realistic values of emissivity, we decided that it would be better to state this fact than try to come up with an arbitrary uncertainty for a value that is obviously physically wrong.

Uncertainty due to lab setup:

* Thermocouple fluctuations (key source):   
  Thermocouple readings fluctuated a lot, and we fed them into both an instrument amplifier and an op-amp inverter circuit before we tried to do any kind of filtering. Even then, our filtering was a simple low-pass circuit that was intended to filter out high-frequency noise but in practice did very little. This meant that consecutive readings of temperatures (converted from the thermocouple voltage readings) had a huge uncertainty, as they regularly fluctuated with a range of ±2°C for readings taken half a second apart. We tried to smooth out the noise in our data with MATLAB’s smoothing functionality, but even the smoothed data had frequent spikes. This had a large effect on all of our future efforts at fitting parameters to the data.
* Heat loss of power resistor:   
  The end of the rod with the power resistor had different physical conditions (especially emissivity) than the rest of the rod. Obviously, it was a heat source when plugged in, but it became a heat sink when we unplugged it and took data as the rod cooled. While cooling, the end of the rod closest to the resistor often dropped to lower temperatures than the rest of the rod, most likely due to the presence of the resistor. We attempted to model this in our simulation, using “power 2” as a representation of the power lost through the resistor while the rod was cooling. This added another parameter that we needed to fit, however, and made the finite difference formula we used a worse representation of the physical state of the rod.
* Factors affecting convective constant:  
  The convective coefficient is a complicated thing and is affected by a number of different things beyond just the geometry of the rod that we were unable to entirely control. It is affected by the air speed and ambient temperature of the rod, so it would change if say, somebody walked by and caused a wind current near the rod, or if the ambient temperature in the lab changed over the course of the day. It also might have been affected by the rubber bands that we used to isolate the rod from the clamp that held it vertical, which could affect the geometry of the rod while taking data.