Lab 06: Newton's Law of Cooling

Calculus I

21 October 2024, College of the Atlantic

- Please work in groups of two or three
- Please write your answers on this sheet, make a scan of it as a pdf, and upload it google classroom at the end of lab.

Names: _____

Part 0: Setting things up

1. Grab a temperature probe and connect it to your computer.
2. Go to `https://graphicalanalysis.app`. Click on "sensor data collection". And after a few more clicks you should be ready to collect data.
3. Start the Graphical Analysis program. In the upper right, click on table and meter. Experiment with the temperature probe and the software to get a feel for how it works.

Part I: Thinking about Cooling

1. When an object cools off, under many conditions its temperature T as a function of time t is described by a function of the following form:

$$T(t) = A + (B - A)e^{-kt} . \tag{1}$$

(This form for $T(t)$ follows from Newton's Law of Cooling.) Determine the physical meaning of the constants A, B, and k. It may help to plug in numbers for the constants and graph the equation on a computer.

2. Equation (1) can also be written

$$T(t) = ae^{-ct} + b . \tag{2}$$

How are a, b, and c related to A, B, and k?

Part III: Do the Experiment!

1. Pour water into the container and then start recording the temperature. Let the experiment run for around 15 minutes.

2. Some advice:

   (a) **Important:** The device defaults to only taking measurements for 3 minutes. We'll need a lot more than this. Click on the "Mode: Time Based" box in the lower left of the program, and you'll get a menu that will let you change how long measurements are taken for. Choose 2000 seconds.

   (b) Let the thermometer equlibrate with the hot water before you start taking measurements.

   (c) Put a piece of paper over the container. The reason for this is to minimize the amount of water that evaporates.

   (d) Be careful. Hot water is hot.

   (e) I have found that if my computer goes into sleep/screensaver mode, the temperature probe stops taking measurements. So I'd suggest making sure your computer stays awake for the duration of the experiment.

Part IV: Analyze your Results

1. You should get a $T(t)$ function that looks like a pretty good exponential. Let's fit a curve to the data. To do so, click on the graph icon on the lower left, choose "Apply Curve Fit", and then choose "Natural Exponent".

2. What values do you get for a, b, and c? Do they make sense?

3. What is the "half-life" of the temperature? That is, how long would it take the temperature to cool off halfway: the time t at which $T(t) = (1/2)T_0$. Find this using algebra and the c value you got from the fit to your data. What are the units on your answer? Does the answer seem reasonable?