**Lab: How do Phones Charge? (Revisited) *(Instructor Version)***

*If you had your students complete the first phone charging lab then inform your students they will need to find their data from when they completed that lab. Start with Activity 2. If your students lost their data, have them complete Activity 1 before coming to class. They will need the Data Collecting Table again to record their data.*

*If you did not do the first phone charging lab, you will need to spend two days on this lab. Day one you will need 5-10 minutes at the end of class to explain activity 1 to your students. During this time, you can discuss good data collecting techniques and how to individualize the project (different time intervals, having phone on airplane mode, watching videos while charging, etc.) Day two will take most of the 50 minutes class.*

**Motivation:** Revisiting the same problem done earlier in the semester now that we can find a better equation to model the data. Show students an everyday application of logistic models.

**Objectives:** Students will be able to find the equation of a logistic equation to model data.

**Materials:** Data from the “How do Phones Charge?” lab. If your students do not have this data still, have them complete Activity 1. If your students do have the data, start with Activity 2.

**Activity 1:**

*Each student can record the data at home so no class time is wasted. You should spend about 5 minutes before students collect data to discuss good data collecting techniques.*

Use your data from the previous time you worked with this example. If you lost your data or did not do the last problem, follow the steps below:

Start with a cell-phone or tablet that is completely out of battery. Yes, that means you must kill your battery in your phone or tablet. To gather your data, charge your phone and record the percentage of battery you have at equal time intervals until your phone is fully charged. Note: Your phone should be on (to see the percentage) but for accurate data, you should refrain from using your phone until all the data is collected.

**Activity 2:**

*This activity should take about 15-20 minutes. Students might need a reminder to set up a system of equations using two data points and the general exponential equation shown to find both A and k.*

Use two of your first few data points to create an exponential model for the percent charge of the phone/tablet, $f(t)=Ae^{kt}$, where $t$ is the number of minutes after charging has begun.

**Activity 3:**

*This activity should take about 15-20 minutes)*

1. Use your exponential model to predict the percent charge of the battery at the following times:
	1. 5.5 minutes after charging began
	2. 13 minutes after charging began.
2. Use your exponential model to determine how long it will take for your battery to be 75% charged.
3. Does your data truly follow an exponential curve? Why or why not?

**Activity 2:**

*You should take about 5 minutes to discuss logistic equations and when they are used.*

A logistic growth model is used to model populations where the growth is constrained by variable resources. That is, the growth is restricted to a certain amount, $d$. Use your data to find the logistic model for your data.

Logistic Growth Model: $f\left(t\right)=\frac{d}{1+ke^{-ct}}$ where $c, d, k$ are positive constants.

**Activity 3:**

*This activity will take about 30 minutes.*

*For questions 1 and 2, you can have your students do a think, pair, share activity. Think, pair, share is exactly what it says. Students think individually for 2-3 minutes, then have your students pair up and discuss what they think for 2-3 minutes and then finally bring the class back together as a whole and share what they came up with for 5-10 minutes. You could do think, pair, share for questions 1 and then again for question 2.*

1. Is there a restriction to the amount that the phone/tablet battery can be charged? If so, this value would be the value of $d$.
2. Does charging your phone/tablet follow a logistic growth model? Why or why not?
3. Use two of your data points to create a logistic growth model to represent the percent charge after $t$ minutes of charging. You will use these data points to create a system of equations to solve for $k$ and $c$. *Students might need a reminder to set up a system of equations using two data points and the general exponential equation shown to find both k and c.*