Activity 18

TEACHER INFORMATION

Charging Up, Charging Down: Exponential Models

1. There are currently 2 different combinations of equipment that will work for collecting voltage data. The most common method, which works for both the TI-83 Plus and TI-84 Plus families of calculators, is to use a Voltage Probe attached to a CBL 2 or LabPro.

   The TI-84 Plus calculator has a USB port located at the top right corner. Using the USB port, an EasyLink with a Voltage Probe can be connected to collect voltage data. For more information on EasyLink refer to Page *ix* located in the front section of this book.

2. When connecting an EasyLink to a TI-84 Plus calculator using USB, the EasyData application automatically launches when the calculator is turned on and at the home screen.

3. The activity is written to use the standard base *e* exponential function $y = Ve^{-Kx}$. You may want to use the form $y = ab^x$ instead. The latter form is the built-in exponential fit of the calculator, and so would avoid having the students convert the base of an expression.

4. As long as the battery produces at least 5 V it can be used in the activity. Retired smoke detector batteries are ideal.

5. The suggested resistor and capacitor values can be changed. As long as the *RC* product is on the order of 15 seconds the experiment will work. Keep the resistor to less than 100kΩ to avoid measurement problems due to the input impedance of the LabPro or CBL 2. If the *RC* product is any shorter than 1 second, students will have trouble catching the start of the decay. The 100-kΩ resistor can be obtained from Radio Shack, #271-1347. The 220-µF capacitor is Radio Shack #272-1017.

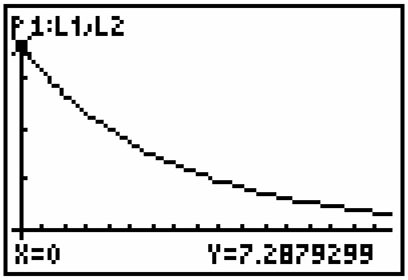
6. With the suggested *RC* value, all of the voltage readings will be positive. If a shorter *RC* value is used, and the data collection time is not changed, it is possible that some voltage readings will be non-positive after the capacitor is discharged. In this case the exponential fit will fail.

7. Try other *RC* products to observe faster and slower decay rates.

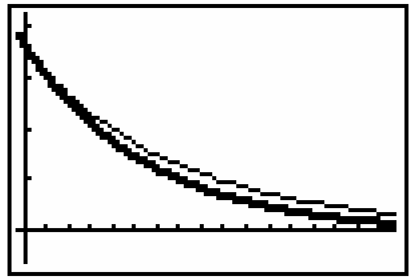
8. Typical resistors and capacitors are only nominally the value indicated; they may be up to 40% different from the marked value. For this reason, a class set of supposedly identical resistors and capacitors may yield quite different decay curves.

9. Note that 100 KΩ means 100 000 Ω. The ohm (Ω) is a measure of resistance. 220 µF means 0.000 220 F. The Farad (F) is a measure of capacitance. You may want to review metric prefix usage with your students.

SAMPLE RESULTS



Raw graph from EasyData



Data and model with *K* a little large

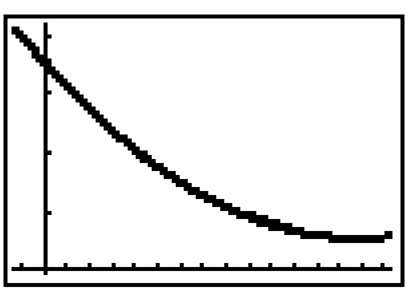
DATA TABLE

R (Ω)	100 000
C (F)	0.000220
V	7.28
K	0.042
$t_{1/2}$ (from graph)	17 s
$t_{1/2}$ (from *K*)	16 s

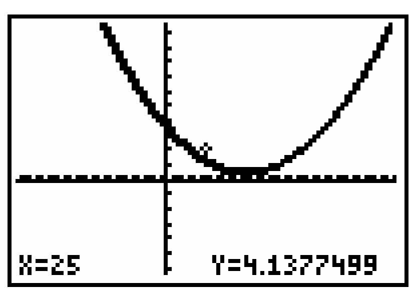
ANSWERS TO QUESTIONS

1. The two half-life values are nearly the same.
2. The value of *V* is a simple multiplicative factor that changes the *y*-intercept. *K* determines the rate of decay of the exponential function; larger *K* means the function drops off more quickly.
3. Since the exponential function never reaches zero for any finite time, by the model the capacitor voltage never reaches zero.
4. *K* is nearly the same as 1/*RC*. For the same capacitor, a larger resistor would decrease the value of *K*, and so by the model the capacitor would take longer to discharge.

EXTENSION



Quartic fit displayed over data



Quartic fit after zooming out

