Experiment 1:

Battery: v = 1.446v

Resistor: 9.8k ohms

Capacitor: 1000uF

[1]

[2]

KVL [3]

NOTEBOOK:

V\_resistor=IR

V\_resistor=(C dv(t)/dt) R

Substitute into kvl

V\_battery = V\_resistor + V\_capacitor

Here we are assuming the capacitor leaks no current.

V\_battery = RC dv(t)/dt + v(t)

We solve this first order differential.

Substituting,

The following differential equation was obtained after substituting equation [2] into equation [1], and applying Kirchhoff’s Voltage Law [3], and it models the potential difference maintained by the capacitor.

image3.jpg [EQUATION NUMBER X]

Where:

R is resistance of the resistor

C is capacitance of the capacitor

v(t) is the potential of the capacitor

v\_s is the potential of the supply (change v\_r(t) to v\_s)

METHOD BEGINS HERE (change all my equation numbers so they match up with the report:

To experimentally verify this data, the circuit in **Fig X.** was used. The capacitor chosen had a capacitance of 1000μF. The potential drop at the capacitor was calculated with KVL [3], as the other two potential changes in the circuit are known quantities. A first order differential equation was used to model the potential of the capacitor as a function of time, which as then solved to analyze the data.

INSERT RC CIRCUIT

Caption: **Fig X. The circuit used to record capabilities of the capacitor.** To avoid issues with measuring potential over the capacitor when it is near full charge and extremely high resistance, potential was measured over the resistor.

ANALYSIS:

Solving the differential equation, the following function was obtained theoretically.

[#Y]

Similarly, the following function was obtained via regression of the recorded data points, with a coefficient of determination of 0.942.

[#Z]

INSERT CHART 1 (the one with 3 trend curves)

Caption: **Fig X. The three V vs t curves for the measured potential, theoretical potential function [Y], and regression curve function [Z].** The curves are disjoint due to a small amount of leakage current across the capacitor.

The capacitor only charged to around 97.6% of the battery’s potential. A small voltage was still measured across the resistor even as the capacitor was nearing its capacity. As a capacitor charges, its resistance increases until it can be viewed as an open circuit. However, due to the leakage current of the capacitor, some current was still flowing through the circuit, leading to the 0.03V discrepancy. This discrepancy also resulted in a fairly poor fit for the regression function. Solutions are addressed in the sources of error.

INSERT CHART 2 (the one with 2 lines)

Caption: **Fig Y. The charging and discharging curves for the capacitor.** The curves are symmetrical within multimeter reading error.

The charging and discharging curves were, as expected, vertically symmetric to each other. This was because the capacitor charges and discharges at the same rate, namely the absolute value of the first derivative of equation [X]. This results from the underlying symmetry of the capacitor; two identical conductive plates sandwiching a dielectric material.

SOURCES OF ERROR:

To reduce current leakage in a capacitor, the dielectric material could be upgraded to a better material or a vacuum. However, it is impossible to make a capacitor without current leakage due to the existence of an electric field.

To obtain a stronger fit for the regressions, more data points would be needed from a supply in excess of 12 V. Also, to reduce the signal to noise for reverse bias measurement, a second transistor could be used to amplify the current once more.

To reduce the noise, more care should be placed into the selection of equipment. This noise was non-trivial as different power supplies, multimeters, and LabQuests were used over several lab days.