☐PHYS115 ☐PHYS121 ☐PHYS123
☐PHYS116 ☑PHYS122 ☐PHYS124

Lab Cover Letter

Author (*You*) Trevor Nichols Signature: Trev N.

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Lab Partner(s) Lauren Lee, Shrivani

Date Performed 2024-10-17 Date Submitted 2024-10-23

Lab (*such as #1: UNC*) A4 RL-LIR

TA: Eli Doyle

GRADE (*to be filled in by your TA*) See your TA for detailed feedback.
An '*x*' next to a subcategory means you need to improve this aspect of your work.

Paper Subtotals (points)

( ) ***General*** **(6)**
_____ Sig. figs.
_____ Units
_____ Clarity of Presentation
_____ Format

( ) ***Abstract*** **(4)**
_____ Quantity or principle
_____ How measurement was made
_____ Numerical Results
_____ Conclusion

( ) ***Intro & Theory*** **(9)**
_____ Basic principle
_____ Main equations to be used
_____ Apparatus
_____ What will be plotted
_____ Fitting parameters related

( ) ***Exp. Procedures*** **(15)**
_____ Description
_____ Stating and justifying uncertainties
_____ Data Record
_____ Quality of Lab Work

( ) ***Analysis & Error Analysis*** **(20)**
_____ Discussion
_____ Equations & Calculations
_____ Presentation inc. Graphs, Tables
_____ Results Reported & Reasonable
_____ Underlined items addressed

( ) ***Discussion & Conclusions*** **(6)**
_____ Numerical comparison of results
_____ Logical conclusions
_____ Discussion of pos. errors
_____ Suggestions to reduce errors

( ) **Paper Total (60 points)**
(30 points for CME or EPF)

( ) **Notebook (10 points)**
_____ Format (*proper style, following directions*)
_____ Apparatus (*brief description of equipment, including sketches*)
_____ Data (*including computer file names and manually recorded data*)
_____ Experimental Technique (*describing your procedures; stating & justifying uncerts.*)
_____ Analysis (*results and errors*)

( ) **Worksheet(s)/Fill-in-the-Blank-Report (30 points)** *if applicable*

( ) **Adjustments** – late submissions, improper procedures, etc. – or bonus points for exceptional work.

( ) Total Grade

Graded by __________ *(TA's initial)*

4

RC-CIR Worksheet


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Trevor Nichols, Lauren Lee, Shravani
PHYS 122-119B
Station 31
Lab 4: RC-CIR (RC Circuits)
2024-10-23T23:21:13-04:00

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44106-7079
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1

(Section E.2.) The nominal values of the resistance and capacitance are $10\ k\Omega$ and $47\ \mu F$, respectively. What are your measured values?

Answer

$R = 10.3 \pm 1\%\ k\Omega$
$C = 43.5 \pm 2\%\ \mu F$

2

(Section E.2.) What is the value of the time constant based on the measured values and nominal (labeled) values?

Answer

$\tau_{measured} = 0.43\ s$
$\tau_{labeled} = 0.45 \pm 0.01\ s$

3

(Section E.7.) What is the maximum amount of charge stored on the capacitor during charging?

Note that you have taken two pairs of data sets, two while charging the capacitor and two while discharging it. From those graphs, read off the voltage across the resistor and the voltage across the capacitor at the end of each run.

✓ **Answer**

$Q = 60 \pm 1\ \mu C$

Charging
$V_R = -1.411 \pm 0.001\ V$
$V_C = 1.376 \pm 0.001\ V$

Discharging
$V_R = 1.450 \pm 0.001\ V$
$V_C = -1.445 \pm 0.001\ V$

4

(Section E.7.) What should the two pairs of voltages add up to? Do they? Why or why not?

✓ **Answer**

They should add up to zero because as they charge or discharge, the state should be cyclical and the voltage should return to its original state.

5

(Section G) What are the five values of the time constant?

Compare these five values of the time constant to each other and discuss whether or not they are in agreement, within estimated errors.

✓ **Answer**

$\tau_{measured} = 0.45 \pm 0.01\ s$

$\tau_{charging_C} = 0.474 \pm 0.0007\ s$
$\tau_{discharging_C} = 0.4752 \pm 0.0006\ s$
$\tau_{charging_R} = 0.4711 \pm 0.0007\ s$
$\tau_{discharging_R} = 0.4722 \pm 0.0007$

$\tau_{mean} = 0.473 \pm 0.001$

I think yes, it does correspond with each other as they are easily within two STD of each other.

6

(Section G) Does the residual plot indicate you had a good fit or a bad fit? Explain.

Answer

Yes, it indicates we have an absolutely amazing fit, as the errors are statistically insignificant. Our r^2 was also very high, with over 3 sigfigs of correlation at 0.99981.

7

(Section H) What are your measured values of the resistance and capacitance of the two capacitors?

Answer

$R = 10.3 \pm 1\% \ k\Omega$
$C_1 = 43.5 \pm 2\% \ \mu F$
$C_2 = 43.0 \pm 2\% \ \mu F$

8

(Section H) What is your calculated time constant for parallel capacitors? For series capacitors?

Answer

$\tau_{calc_{parallel}} = 0.89 \pm 0.02 \ s$
$\tau_{calc_{series}} = 0.2 \pm 0.3 \ s$

9

(Section H) What is the time constant from the fit for parallel capacitors? For series capacitors?

Answer

$$\tau_{fit_{parallel}} = 0.9083 \pm 0.0007\ s$$
$$\tau_{fit_{series}} = 0.2265 \pm 0.0007\ s$$

10

(Section I) What are your measured values of the resistance and capacitance? What is the theoretical time constant?

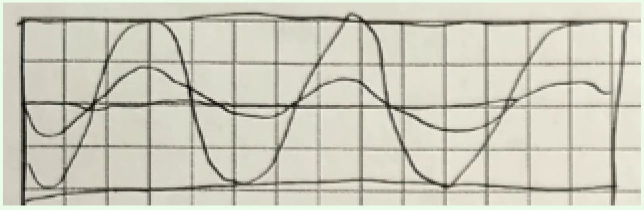
Answer

$$R = 0.97 \pm 1\%\ k\Omega$$
$$C = 0.446 \pm 2\%\ \mu F$$
$$\tau = 0.43 \pm 0.01\ ms$$

11

(Section I-analog differentiator) Sketch the waveforms you see for the sine wave and its derivative.

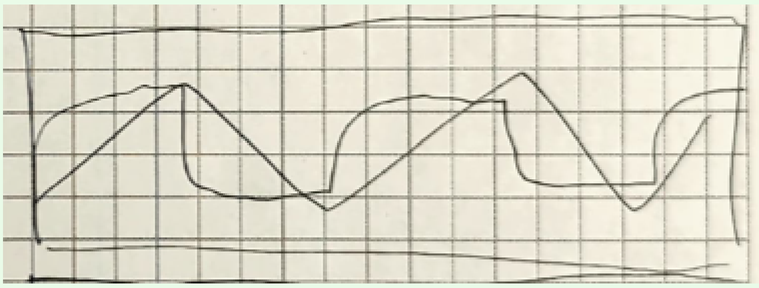
Answer



12

(Section I-analog differentiator) Sketch the waveforms you see for the triangle wave and its derivative.

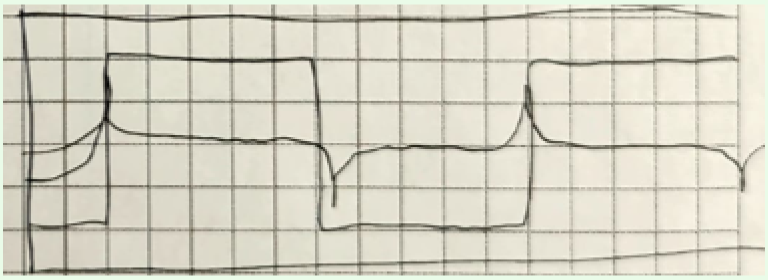
Answer



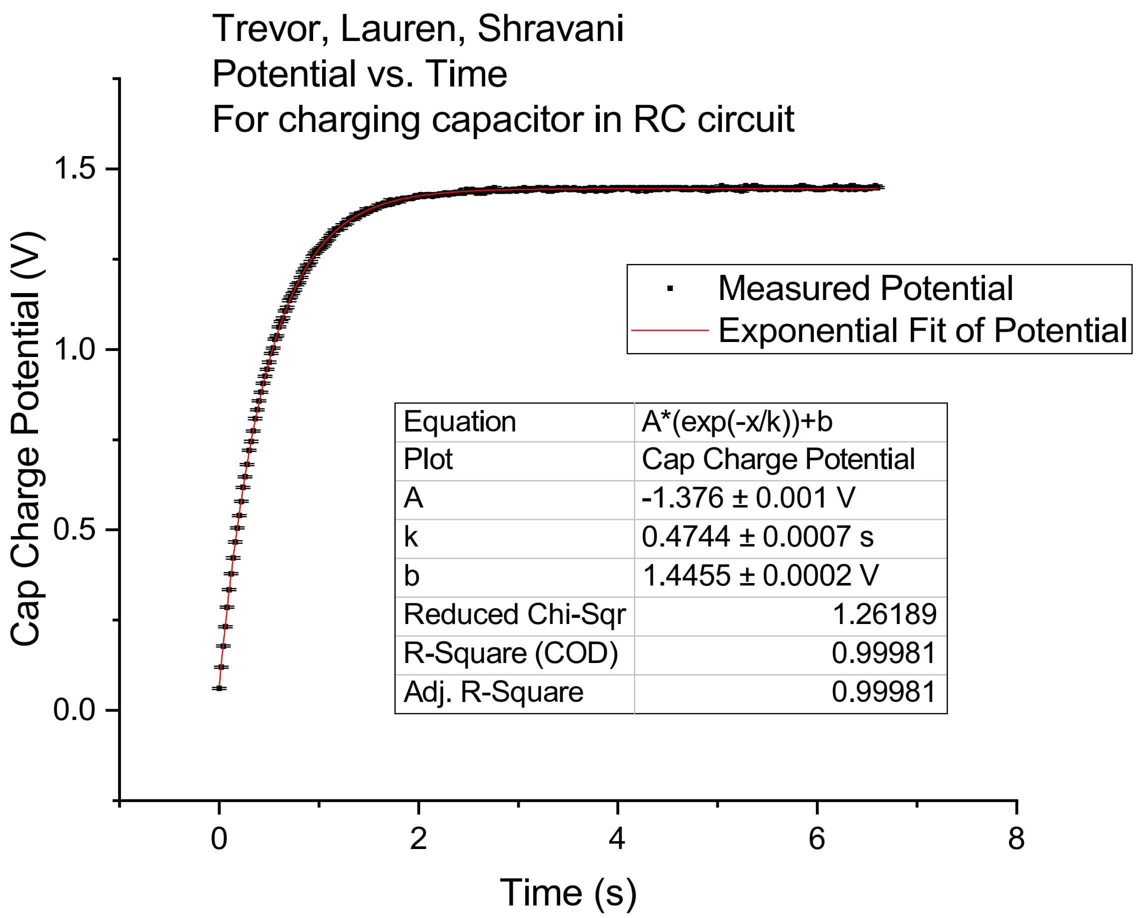
13

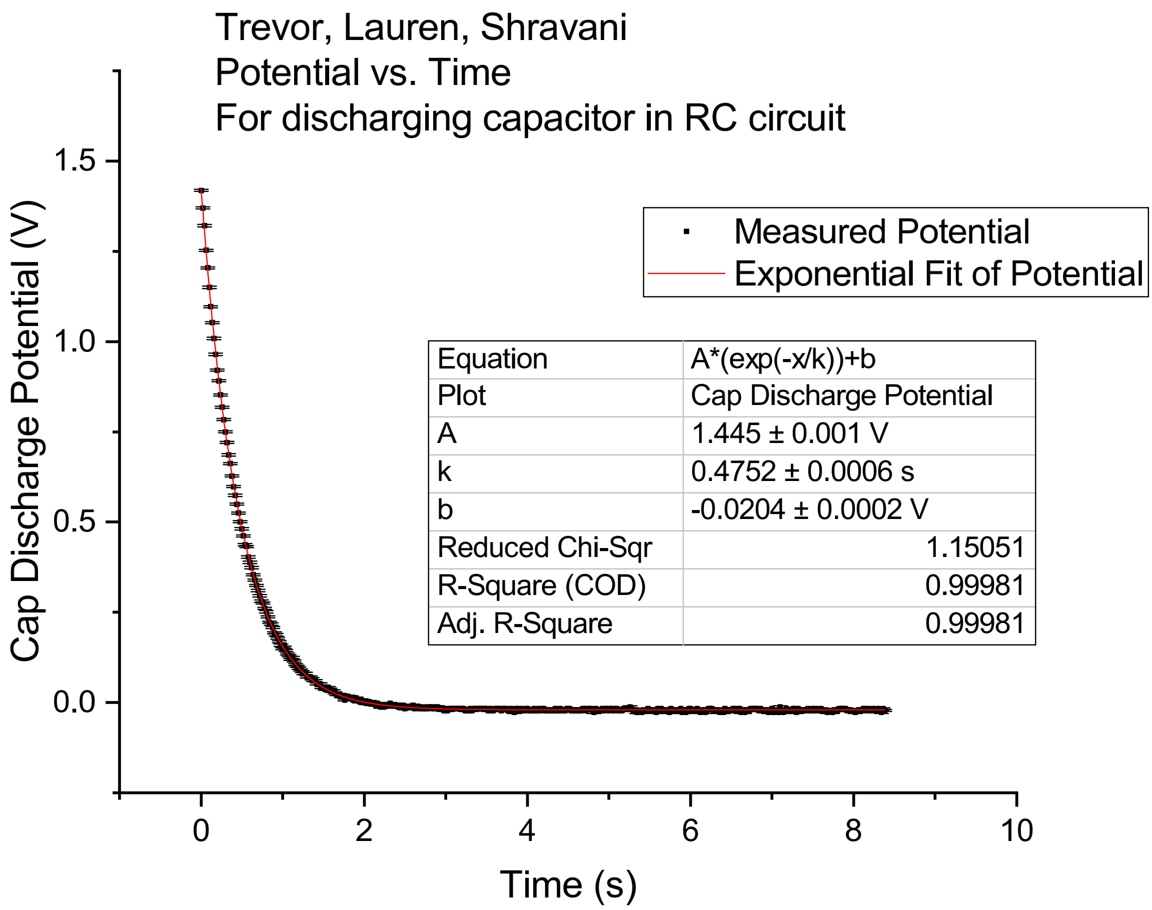
(Section I-analog differentiator) Sketch the waveforms you see for the square wave and its derivative.

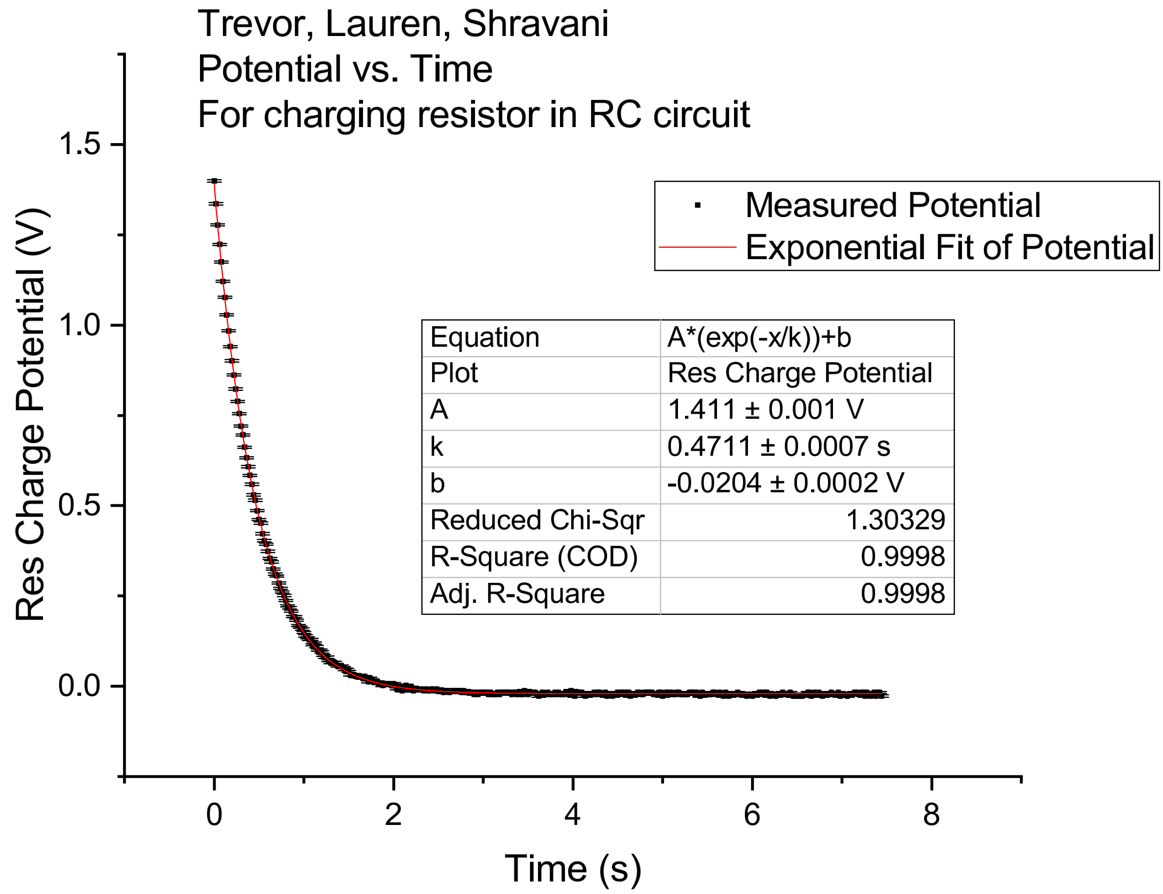
✓ **Answer**



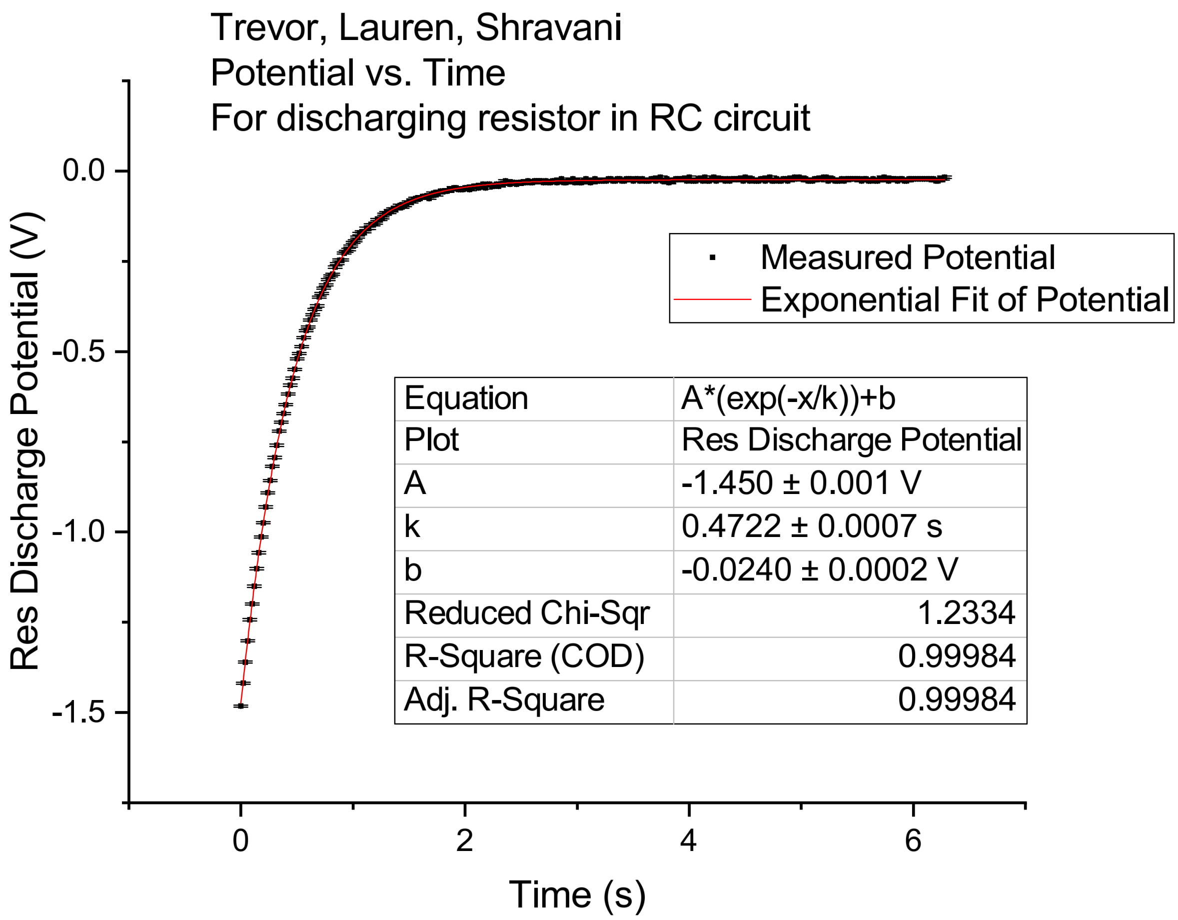
Graphs


Trevor, Lauren, Shravani
Potential vs. Time
For charging capacitor in RC circuit
Cap Charge Potential (V)
Time (s)
Measured Potential
Exponential Fit of Potential
Equation A*(exp(-x/k))+b
Plot Cap Charge Potential
A -1.376 ± 0.001 V
k 0.4744 ± 0.0007 s
b 1.4455 ± 0.0002 V
Reduced Chi-Sqr 1.26189
R-Square (COD) 0.99981
Adj. R-Square 0.99981

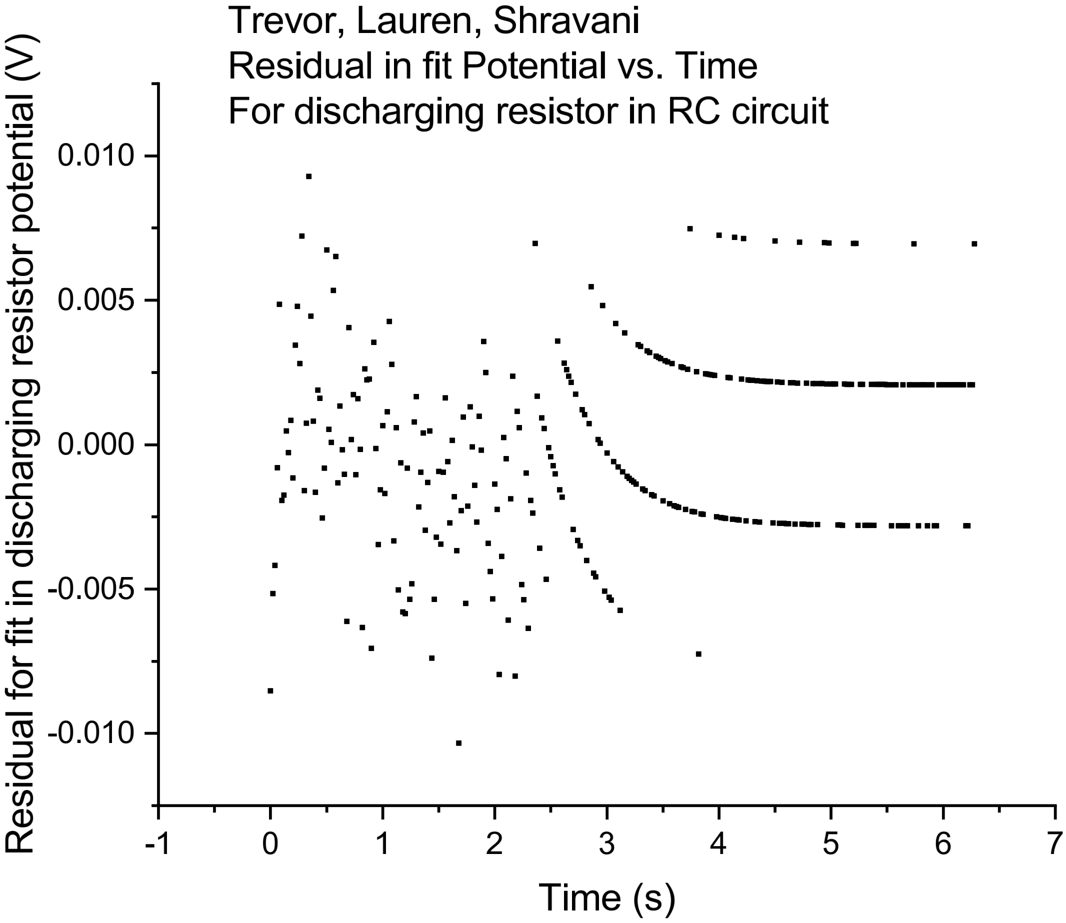

Trevor, Lauren, Shravani
Potential vs. Time
For discharging capacitor in RC circuit
Cap Discharge Potential (V)
Time (s)
Measured Potential
Exponential Fit of Potential
Equation A*(exp(-x/k))+b
Plot Cap Discharge Potential
A 1.445 ± 0.001 V
k 0.4752 ± 0.0006 s
b -0.0204 ± 0.0002 V
Reduced Chi-Sqr 1.15051
R-Square (COD) 0.99981
Adj. R-Square 0.99981

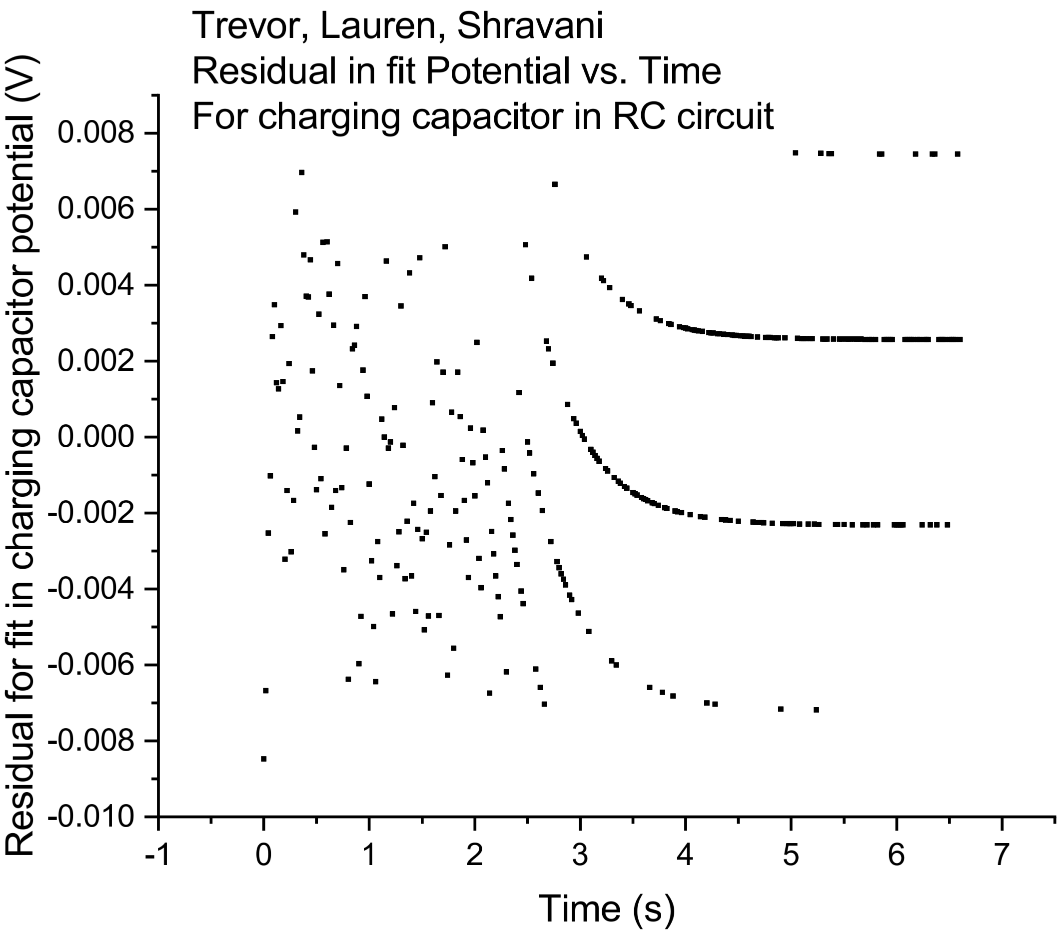


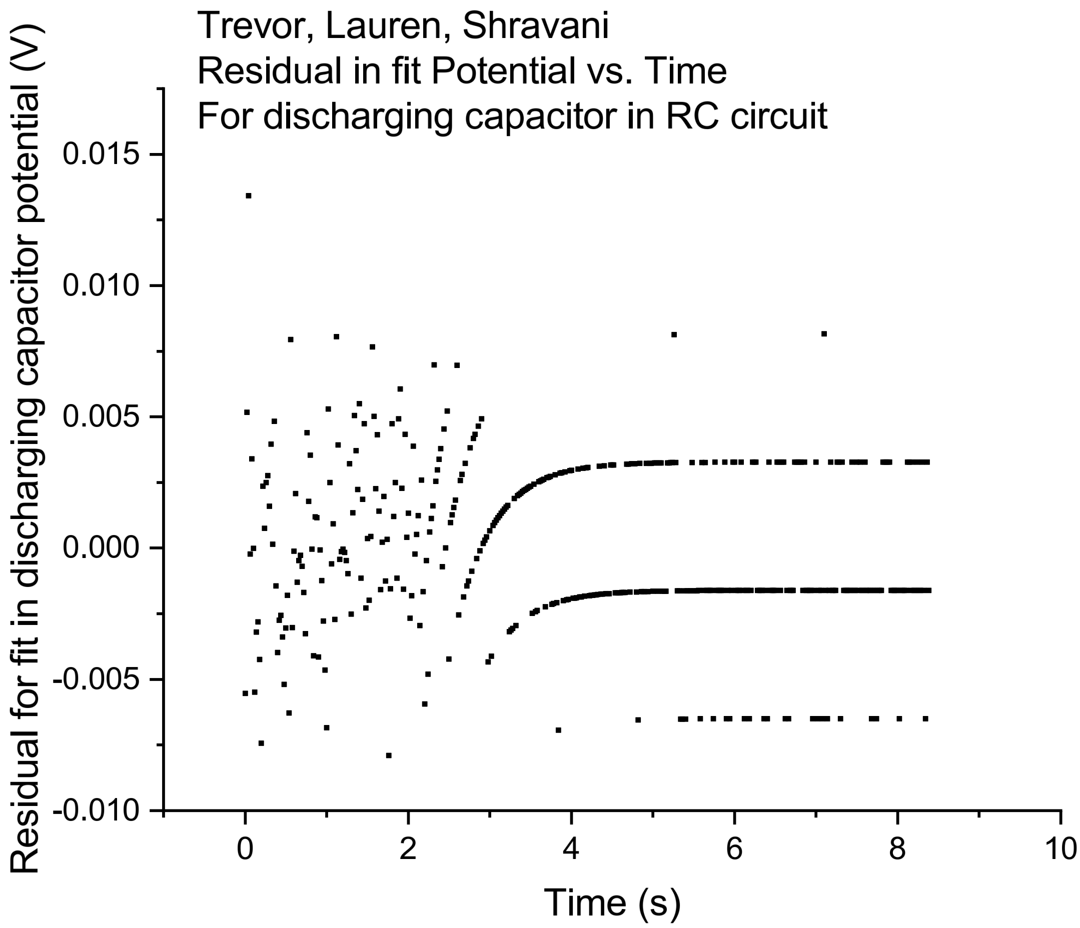
Equation	A*(exp(-x/k))+b
Plot	Res Charge Potential
A	1.411 ± 0.001 V
k	0.4711 ± 0.0007 s
b	-0.0204 ± 0.0002 V
Reduced Chi-Sqr	1.30329
R-Square (COD)	0.9998
Adj. R-Square	0.9998

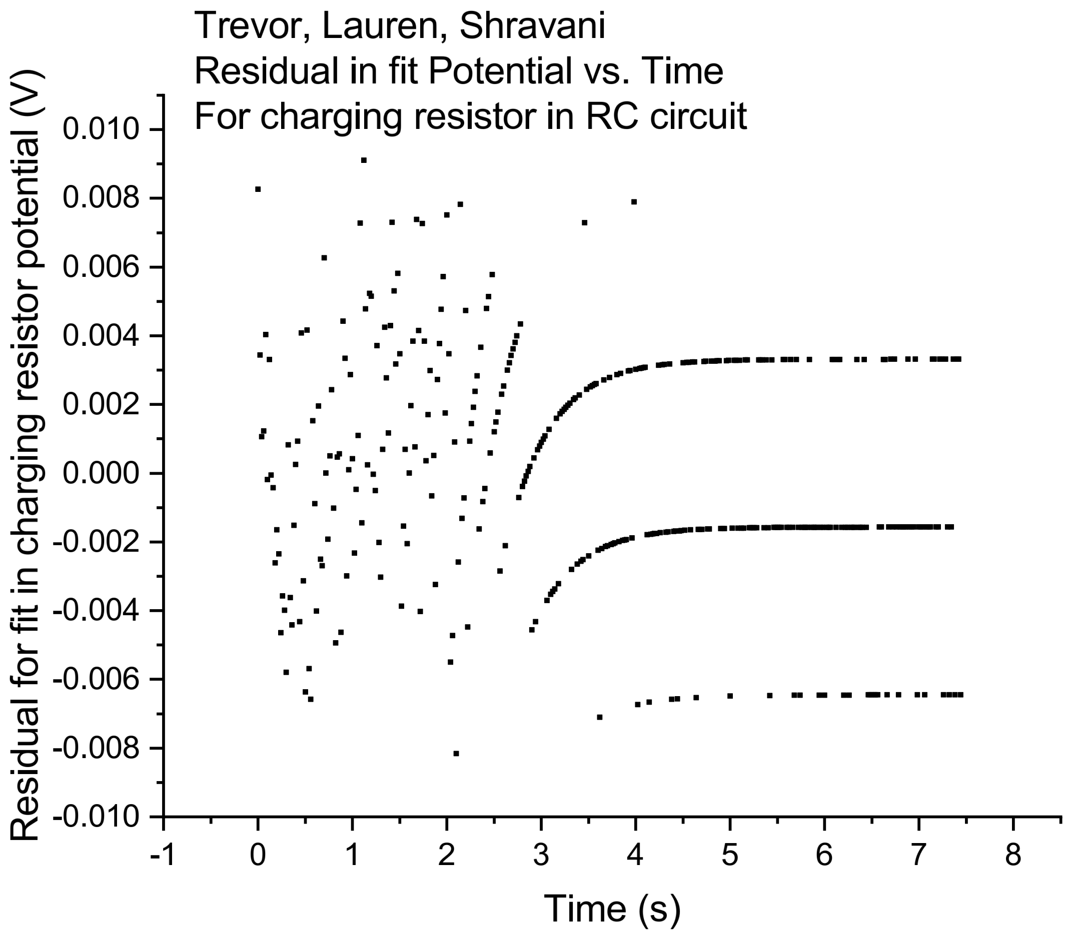


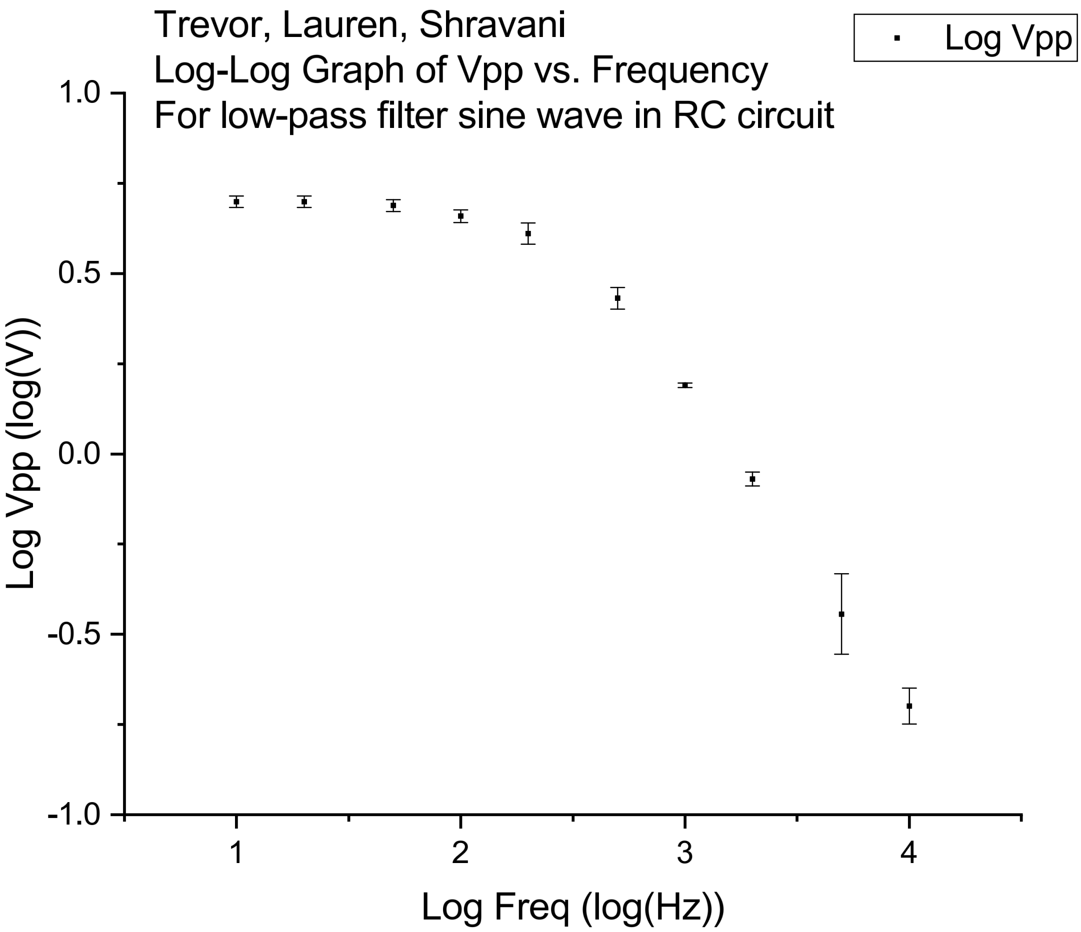
Equation	A*(exp(-x/k))+b
Plot	Res Discharge Potential
A	-1.450 ± 0.001 V
k	0.4722 ± 0.0007 s
b	-0.0240 ± 0.0002 V
Reduced Chi-Sqr	1.2334
R-Square (COD)	0.99984
Adj. R-Square	0.99984


Trevor, Lauren, Shravani
Residual in fit Potential vs. Time
For discharging resistor in RC circuit
Residual for fit in discharging resistor potential (V)
0.010
0.005
0.000
-0.005
-0.010
-1
0
1
2
3
4
5
6
7
Time (s)


Trevor, Lauren, Shravani
Residual in fit Potential vs. Time
For charging capacitor in RC circuit
Residual for fit in charging capacitor potential (V)
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
-0.010
-1
0
1
2
3
4
5
6
7
Time (s)


Trevor, Lauren, Shravani
Residual in fit Potential vs. Time
For discharging capacitor in RC circuit
Residual for fit in discharging capacitor potential (V)
0.015
0.010
0.005
0.000
-0.005
-0.010
0
2
4
6
8
10
Time (s)


Trevor, Lauren, Shravani
Residual in fit Potential vs. Time
For charging resistor in RC circuit
Residual for fit in charging resistor potential (V)
0.010
0.008
0.006
0.004
0.002
0.000
-0.002
-0.004
-0.006
-0.008
-0.010
-1
0
1
2
3
4
5
6
7
8
Time (s)


Trevor, Lauren, Shravani
Log-Log Graph of Vpp vs. Frequency
For low-pass filter sine wave in RC circuit
Log Vpp
1.0
0.5
0.0
-0.5
-1.0
Log Vpp (log(V))
1
2
3
4
Log Freq (log(Hz))

Trevor Nichols, Lauren Lee, Shravani TA: Eli

Lab #4 PHYS 122:119B Station 31

Baseline measurement: $\mu = 1.467$
$STD = 0.002990$
$n = 1001$

- Connect the logger Pro device
- Take 20 s voltage reading of a battery to find the STD/error in the measurement device.
- Measure a 10 kΩ res. and two 47 mF caps.
- Put probes across capacitor & record charge & discharge
- Put probes across resistor & record charge & discharge

This lab is about measuring the resistance and capacitance of capacitors in an R/C circuit.

- Graph data and fit the exp function.
- Fit the data and extract the V_0 & RC
- Now replace the cap with two, parallel & series, collect data and see the diff

Resistor:
10.30 kΩ ± 1%

Cap 1:
43.5 mF
± 2%

Cap 2:
43.0 mF
± 2%

$RC = 448.05$ mF kΩ $= 0.44805$ s

$\delta_{RC} = RC\left(\left(\frac{\delta_R}{R}\right)^2 + \left(\frac{\delta_C}{C}\right)^2\right)^{1/2} = 10$ ms

$\delta_\tau = RC\left(\left(\frac{\delta_R}{R}\right)^2 + \left(\frac{\delta_C}{C}\right)^2\right)^{1/2} = \boxed{0.45 \pm 0.01 \text{ s}}$

$\tau = RC$

		Charge Cap	Discharge Cap	Charge Res	Discharge Res
(V)	V_0	1.37602 ± 0.001	1.44447 ± 0.001	1.41141 ± 0.001	1.44972 ± 0.001
(s)	RC	0.47935 ± 0.0007	0.47524 ± 0.0006	0.47108 ± 0.0007	0.47221 ± 0.0007

$V_C(t) = V_0\left(1 - e^{-t/RC}\right)$

$V_R(t) = V_0 e^{-t/RC}$

$\delta_{M_{RC}} = \left(\delta_{RC1}^2 + \delta_{RC2}^2 + \delta_{RC3}^2 + \delta_{RC4}^2\right)^{1/2}$

$= 0.001$

$M_{RC} = 0.473 \pm 0.001$

Parallel capacitors charging: $RC = 0.9083$ s ± 0.0007

$C_{tot} = 43.5 + 43.0 = 86.5 \pm 1.2$
$RC = 0.89 \pm 0.02$

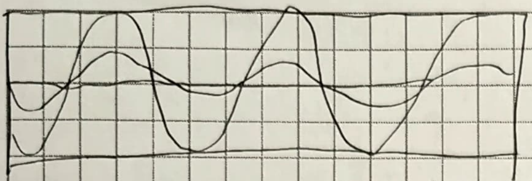
Series capacitors charging: $RC = 0.2265$ s ± 0.0007

$C_{tot} = 1/(1/43.5 + 1/43.0) = 21.6$
$RC = 0.223$

Part I

$R = 0.97$ kΩ ± 1%
$C = 0.446$ mF ± 2%

Before



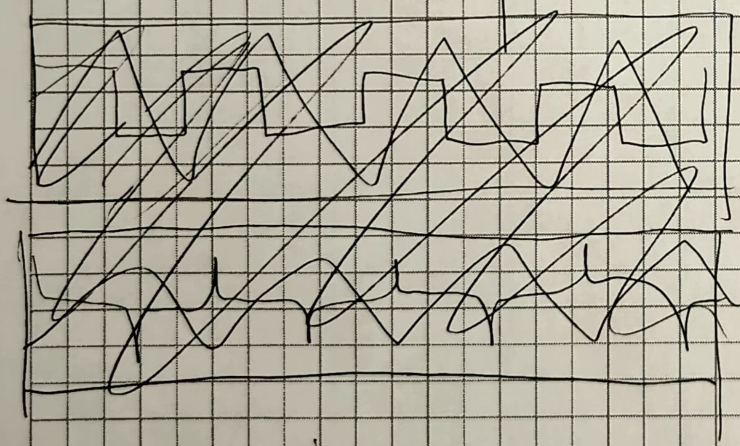
$V_{pp} = 4.76\text{ V}$

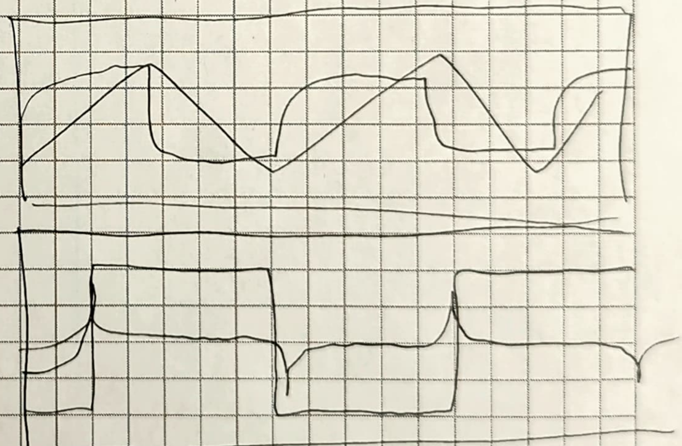
Freq = 500.4 Hz

$V_{pp} = 2.72\text{ V}$

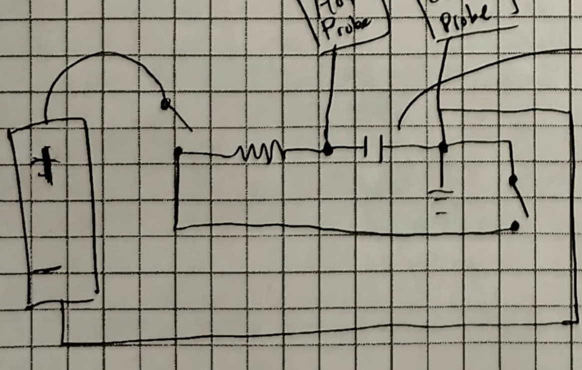
Freq = 500.0 Hz

Freq	V_{pp} (V)	measured freq (Hz)
10	5.00 ± 0.08	10.00
20	5.00 ± 0.08	20.00
50	4.88 ± 0.08	50.00
100	4.56 ± 0.08	100.0
200	4.08 ± 0.12	200.0
500	2.70 ± 0.08	500.2 Hz
1000	1.55 ± 0.01	1.00 kHz
2000	0.852 ± 0.016	2.00 kHz
5000	0.360 ± 0.004	5.00 kHz
10000	0.200 ± 0.01	10.00 kHz





Measuring Cap:



Double or put two in series for later in lab