WPI | Department of Physics

Worksheet for Lab 4: Resistors

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Section:

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Date:

Use this sheet to enter and submit your answers to the questions asked in the gray boxes on the Lab Instructions document. When you have completed this worksheet, save this file as a .pdf and upload the pdf to the canvas assignment associated with this lab. If you have any trouble converting to a pdf, please ask you Lab Instructor or Lab Assistant.

Remember to use complete sentences and that these text boxes will increase in size as you add more content.

Based on the data that you took today, write and answer the questions in the following sections. Remember that even though you will have the same data as your partner, the writing in these sections should be done individually.

Tables and Raw Data

Create tables for your data, use the tables that are included in the lab handout as a template for what columns to include

Trial	Rated Resistance	Rated Uncertainty	Potential	Potential Uncertainty	Current	Current Uncertainty	Calculated Resistance	Calculated Resistance Uncertainty
51 Ω (1st)	51 Ω	2.55 Ω	2.513 V	0.0002047 V	0.05006 A	3.785e-05 A	50.19976028765481	0.04205 Ω
51 Ω (2nd)	51 Ω	2.55 Ω	2.513 V	0.0002158 V	0.05007 A	3.568e-05 A	50.18973437187936	0.0365 Ω
68 Ω (1st)	68 Ω	0.68 Ω	2.527 V	0.0001985 V	0.03729 A	3.690e-05 A	67.76615714668813	0.07237 Ω
68 Ω (2nd)	68 Ω	0.68 Ω	2.527 V	0.0002131 V	0.03732 A	3.369e-05 A	67.71168274383709	0.0668 Ω
Series	119 Ω	3.23 Ω	2.546 V	0.0001933 V	0.02044 A	3.441e-05 A	124.55968688845401	0.2192 Ω
Parallel	29.14 Ω	0.95755 Ω	2.468 V	0.0002069 V	0.08769 A	3.555e-05 A	28.14460029649903	0.0138 Ω

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Experimental Method

- Set up your circuit, first. The first 51 ohm resistor, the second 51 ohm resistor, the first 68 ohm resistor, the second 68 ohm resistor, a series with 51 ohms and 68 ohms, and lastly a parallel circuit with 51 ohms and 68 ohms, are the six variations that will be available. When connecting the parallel series, be careful. Connect a circuit using a 51 ohm resistor first to make things simpler, then attach the positive pin of the 51 ohm resistor to the positive pin of the 68 ohm resistor. Last but not least, join the negative pins of the 68 and 51 ohm resistors.
- For this experiment, use LoggerPro; ensure that the voltage probe is identified and zero the sensors in LoggerPro (this will reduce systematic errors).
- Start the power source (before doing this check if the voltage and current knobs are turned all the way down). Adjust the output voltage to 2.5V while keeping an eye on the display; the current should now be between 0.01 and 0.1 amps.
- Collect the data in Logger Pro for 18 to 20 seconds after obtaining the abovementioned circumstances. There will be 180–200 data points as a result.

Data Analysis

Show your calculations for the theoretical series and parallel equivalent resistances using the equation editor in word.

Theoretical series:

Formula: $\mathbf{R_{equivalent} = R_1 + R_2 + R_3 + \ldots.}$

$R_{equivalent} = 51 + 68 = 119\ (\Omega)$

Parallel Series:

Formula: $\frac{1}{\text{Requivalent}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \ldots.$

$$\frac{1}{\text{Requivalent}} = \frac{1}{51} + \frac{1}{68} = \frac{7}{204}$$

⇨ $R_{equivalent} = \frac{204}{7} \approx 29.14\ (\Omega)$
(the answer above is rounded to 3 significant figure)

Paste your working and commented code or written math for the propagation of uncertainty.

```
import math
# this function calculate the uncertainty for 51 ohms resistor (5%)
def uncertainty_51(resistor_51):
    return 0.05*resistor_51

# this function calculate the uncertainty for 68 ohms resistor (1%)
def uncertainty_68(resistor_68):
    return 0.01*resistor_68

# this function calculate the uncertainty in a series with 51 ohms resistor and 68 ohms resistor
def series_resistance_uncertainty_rated(resistor_51, resistor_68):
    return uncertainty_51(resistor_51) + uncertainty_68(resistor_68)

# this function calculate the uncertainty in a parallel with 51 ohms resistor and 68 ohms resistor
def parallel_resistance_uncertainty_rated(resistor_51, resistor_68):
    return ((resistor_68**2)/((resistor_51+resistor_68)**2))*uncertainty_51(resistor_51) + ((resistor_51**2)/((resistor_51+resistor_68)**2))*uncertainty_68(resistor_68))

# this function calculate the uncertainty of potential in all the experiment
def potential_uncertainty(stdev_potential):
    return (stdev_potential/math.sqrt(200))

# this function calculate the uncertainty of current in all the experiment
def current_uncertainty(stdev_current):
    return (stdev_current/(math.sqrt(200)))

#this function calculate the calculated resistance uncertainty using equation 2
def calculated_resistance_uncertainty(uncertainty_potential, potential, uncertainty_current, current, resistance):
    return resistance*((uncertainty_potential/potential) + (uncertainty_current/current))

#this function calculate the calculated resistance in all the experiment
def calculated_resistance(potential, current):
    return potential/current

potential_first_51_Ohms = 2.513
potential_second_51_Ohms = 2.513
potential_first_68_Ohms = 2.527
potential_second_68_Ohms = 2.527
potential_series = 2.546
potential_parallel = 2.468

current_first_51_Ohms = 0.05006
current_second_51_Ohms = 0.05007
current_first_68_Ohms = 0.03729
current_second_68_Ohms = 0.03732
current_series = 0.02044
current_parallel = 0.08769

stdev_potential_first_51_Ohms = 0.002895
stdev_potential_second_51_Ohms = 0.003052
stdev_potential_first_68_Ohms = 0.002807
stdev_potential_second_68_Ohms = 0.003014
stdev_potential_series = 0.002734
stdev_potential_parallel = 0.002926

stdev_current_first_51_Ohms = 0.0005353
stdev_current_second_51_Ohms = 0.0005046
stdev_current_first_68_Ohms = 0.0005218
stdev_current_second_68_Ohms = 0.0004765
stdev_current_series = 0.0004867
stdev_current_parallel = 0.0005028

print("Rated resistance uncertainty for the first 51 Ohms resistor: " + str(uncertainty_51(51)))
print("Rated resistance uncertainty for the second 51 Ohms resistor: " + str(uncertainty_51(51)))
print("Rated resistance uncertainty for the first 68 Ohms resistor: " + str(uncertainty_68(68)))
print("Rated resistance uncertainty for the second 68 Ohms resistor: " + str(uncertainty_68(68)))
print("Rated resistance uncertainty for the series: " + str(series_resistance_uncertainty_rated(51,68)))
print("Rated resistance uncertainty for the parallel: " + str(parallel_resistance_uncertainty_rated(51,68)))
print("\n")
print("Potential uncertainty for the first 51 Ohms resistor: " + str(potential_uncertainty(stdev_potential_first_51_Ohms)))
print("Potential uncertainty for the second 51 Ohms resistor: " + str(potential_uncertainty(stdev_potential_second_51_Ohms)))
print("Potential uncertainty for the first 68 Ohms resistor: " + str(potential_uncertainty(stdev_potential_first_68_Ohms)))
print("Potential uncertainty for the first 68 Ohms resistor: " + str(potential_uncertainty(stdev_potential_second_68_Ohms)))
print("Potential uncertainty for the series: " + str(potential_uncertainty(stdev_potential_series)))
print("Potential uncertainty for parallel: " + str(potential_uncertainty(stdev_potential_parallel)))
print("\n")
print("Current uncertainty for the first 51 Ohms resistor: " + str(current_uncertainty(stdev_current_first_51_Ohms)))
print("Current uncertainty for the second 51 Ohms resistor: " + str(current_uncertainty(stdev_current_second_51_Ohms)))
print("Current uncertainty for the first 68 Ohms resistor: " + str(current_uncertainty(stdev_current_first_68_Ohms)))
print("Current uncertainty for the first 68 Ohms resistor: " + str(current_uncertainty(stdev_current_second_68_Ohms)))
print("Current uncertainty for the series: " + str(current_uncertainty(stdev_current_series)))
print("Current uncertainty for parallel: " + str(current_uncertainty(stdev_current_parallel)))
print("\n")
print("Calculated resistance for the first 51 Ohms resistor: " + str(calculated_resistance(potential_first_51_Ohms,current_first_51_Ohms)))
print("Calculated resistance for the second 51 Ohms resistor: " + str(calculated_resistance(potential_second_51_Ohms,current_second_51_Ohms)))
print("Calculated resistance for the first 68 Ohms resistor: " + str(calculated_resistance(potential_first_68_Ohms,current_first_68_Ohms)))
print("Calculated resistance for the second 68 Ohms resistor: " + str(calculated_resistance(potential_second_68_Ohms,current_second_68_Ohms)))
print("Calculated resistance for the series: " + str(calculated_resistance(potential_series,current_series)))
print("Calculated resistance for the parallel: " + str(calculated_resistance(potential_parallel,current_parallel)))
print("\n")
print("Calculated resistance uncertainty for the first 51 Ohms resistor: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_potential_first_51_Ohms),potential_first_51_Ohms,current_uncertainty(stdev_current_first_51_Ohms),current
print("Calculated resistance uncertainty for the second 51 Ohms resistor: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_current_second_51_Ohms),potential_second_51_Ohms,current_uncertainty(stdev_current_second_51_Ohms),curr
print("Calculated resistance uncertainty for the first 68 Ohms resistor: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_potential_first_68_Ohms),potential_first_68_Ohms,current_uncertainty(stdev_current_first_68_Ohms),current
print("Calculated resistance uncertainty for the second 68 Ohms resistor: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_potential_second_68_Ohms),potential_second_68_Ohms,current_uncertainty(stdev_current_second_68_Ohms),cu
print("Calculated resistance uncertainty for the series: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_potential_series),potential_series,current_uncertainty(stdev_current_series),current_series,calculated_resistance(potent
print("Calculated resistance uncertainty for the parallel: " + str(calculated_resistance_uncertainty(potential_uncertainty(stdev_potential_parallel),potential_parallel,current_uncertainty(stdev_current_parallel),current_parallel,calculated_resista
```

Rated resistance uncertainty for the first 51 Ohms resistor: 2.5500000000000003
Rated resistance uncertainty for the second 51 Ohms resistor: 2.5500000000000003
Rated resistance uncertainty for the first 68 Ohms resistor: 0.68
Rated resistance uncertainty for the second 68 Ohms resistor: 0.68
Rated resistance uncertainty for the series: 3.2300000000000004
Rated resistance uncertainty for the parallel: 0.9575510204081633

Potential uncertainty for the first 51 Ohms resistor: 0.0002047074131535055
Potential uncertainty for the second 51 Ohms resistor: 0.0002158089896181343
Potential uncertainty for the first 68 Ohms resistor: 0.0001984848734790639
Potential uncertainty for the first 68 Ohms resistor: 0.0002131219838496254 2
Potential uncertainty for the series: 0.00019332299397640208
Potential uncertainty for parallel: 0.0002068994441751838

Current uncertainty for the first 51 Ohms resistor: 3.7851425996915885e-05
Current uncertainty for the second 51 Ohms resistor: 3.5680608178673185e-05
Current uncertainty for the first 68 Ohms resistor: 3.6896831842314046e-05
Current uncertainty for the first 68 Ohms resistor: 3.3693638123538986e-05
Current uncertainty for the series: 3.441488704034927e-05
Current uncertainty for parallel: 3.555332895805961e-05

Calculated resistance for the first 51 Ohms resistor: 50.19976028765481
Calculated resistance for the second 51 Ohms resistor: 50.18973437187936
Calculated resistance for the first 68 Ohms resistor: 67.76615714668813
Calculated resistance for the second 68 Ohms resistor: 67.71168274383709
Calculated resistance for the series: 124.55968688845401
Calculated resistance for the parallel: 28.14460029649903

Calculated resistance uncertainty for the first 51 Ohms resistor: 0.042046342883431655
Calculated resistance uncertainty for the second 51 Ohms resistor: 0.03647854713188309
Calculated resistance uncertainty for the first 68 Ohms resistor: 0.07237440006222162
Calculated resistance uncertainty for the second 68 Ohms resistor: 0.06684284348757641
Calculated resistance uncertainty for the series: 0.21917957671349414
Calculated resistance uncertainty for the parallel: 0.013770483258178989

Results

Most of the time, the rated and calculated resistances accord. The computed resistance for the initial 51 Ohm resistor was 51 to 50.2 Ohms, which is roughly equal to the rated resistance. Likewise, the predicted resistance for the second 51 Ohm resistor was 50.2. approximately 51 Ohms. The computed resistance of the first 68 Ohm resistor is 67.8 Ohms, which is almost equivalent to the rated 68 Ohms. The computed resistance for the second 68 Ohm resistor was 67.7 Ohms, which is just 0.3 Ohms less than the rated 68 Ohms. The computed resistance for the parallel circuit was also the same as the rated resistance: 28.14 Ohms as opposed to 29.14 Ohms. In contrast to most cases, the series circuit's computed resistance of 124.6 Ohms was significantly higher than the rated resistance of 119 Ohm.

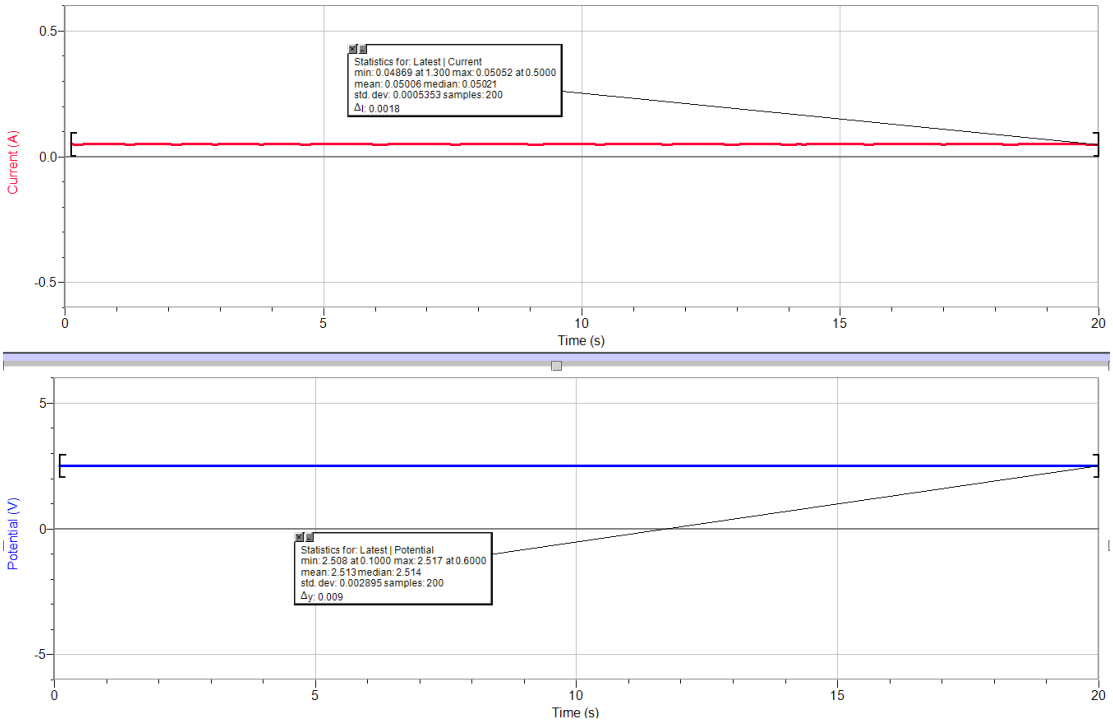
Across all experiments, the computed resistance uncertainty and the rated uncertainty are drastically different from one another. The computed resistance uncertainty for the first 51 Ohm resistor was 0.04205 Ohms, whereas the rated resistance uncertainty was 2.55 Ohms. The calculated resistance uncertainty was 0.0365 Ohms for the second 51 Ohm resistor. Quite distinct from 2.55 Ohms. The computed resistance uncertainty for the first 68 Ohm resistor was 0.07237 Ohms, while the rated uncertainty was 0.68 Ohms. The computed resistance uncertainty for the second 68 Ohm resistor was 0.0668, whereas the rated uncertainty was 0.68 Ohms. The computed resistance uncertainty was only 0.2192, whereas the parallel circuit's rated uncertainty was 3.23 Ohms. The computed resistance uncertainty in the case of the series circuit was 0.0138, while the rated uncertainty was 0.95755.

Conclusion

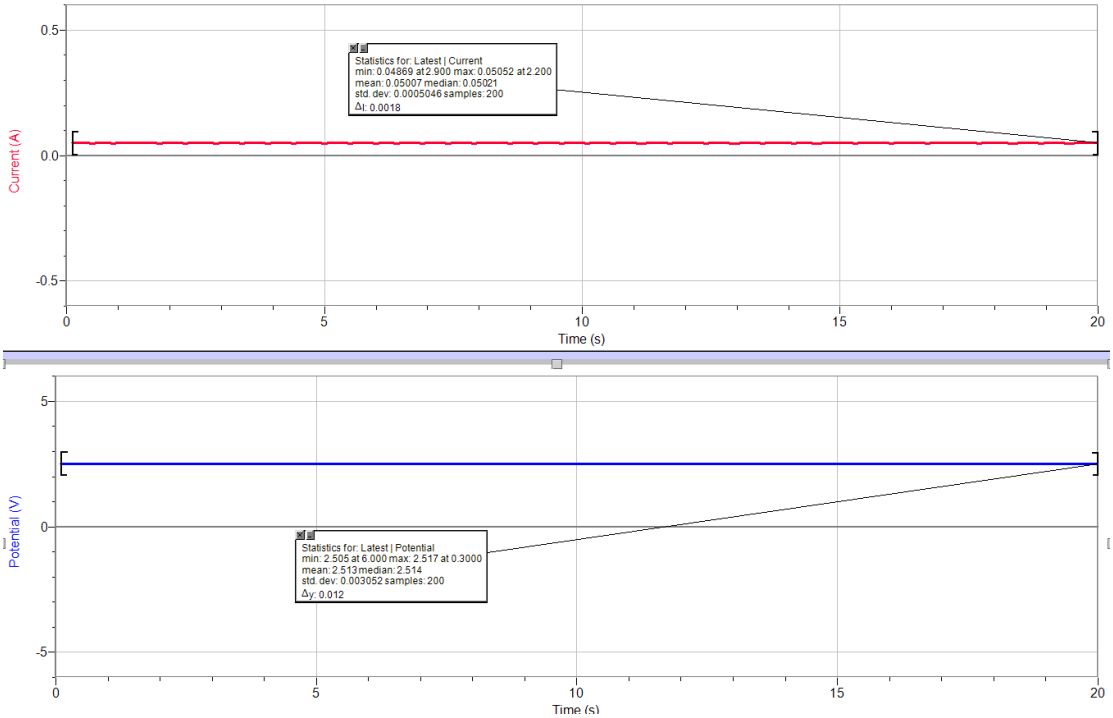
The calculated resistance uncertainty result and the estimated uncertainty are at odds. I came to the conclusion that this might be the case since several of the wires were not tightly connected to the pins and there was overlap in the wire connections. This results in inaccurate reading. The resistance in the circuit's own components, such as the wires and circuit board (which is not taken into account in the resistance functions), will also result in errors because the input voltage was so low. Using a greater resistance resistor with a higher input voltage is one technique to minimize these problems. Since their actual uncertainty is substantially lower than their rated uncertainty, the resistors, according to the estimated uncertainty, exceeded the standard provided by the makers. The computed resistance uncertainty was only 0.2192, whereas the parallel circuit's rated uncertainty was 3.23 Ohms. The computed resistance uncertainty in the case of the series circuit was 0.0138 whereas the rated uncertainty was 0.95755.

Graph and Data Checklist:

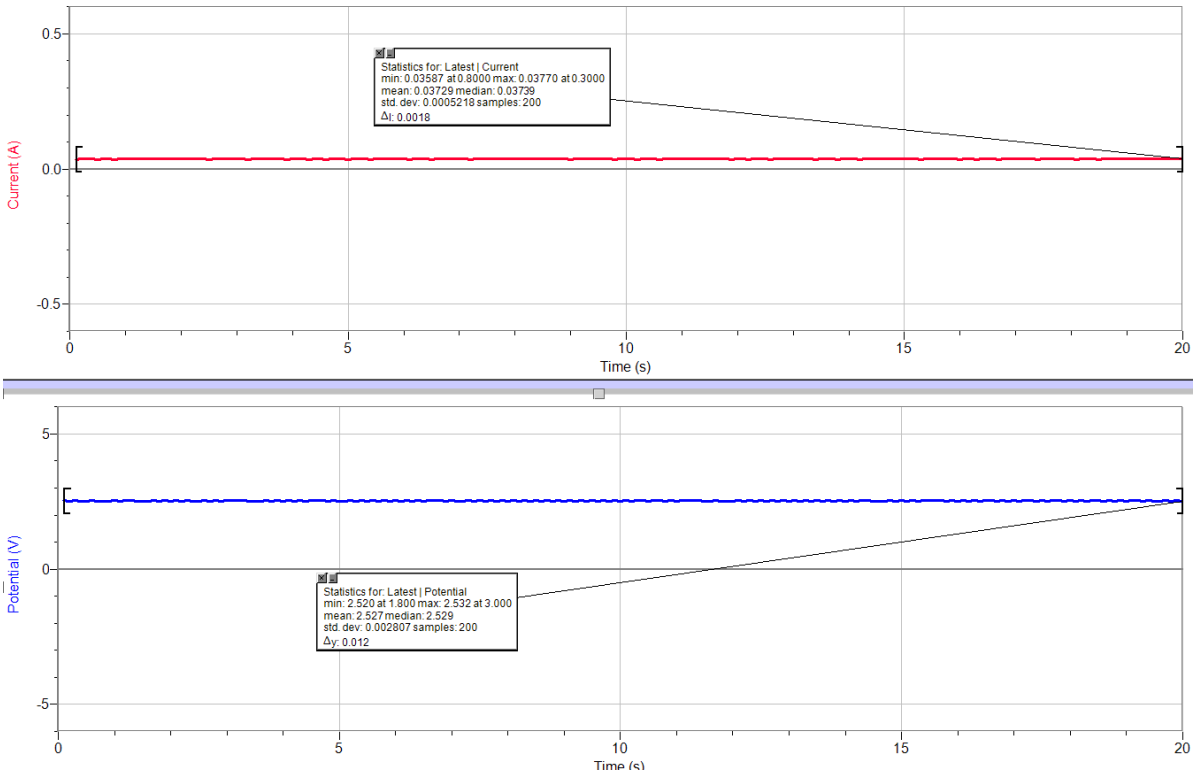
- Resistor 1 - 51 ohms



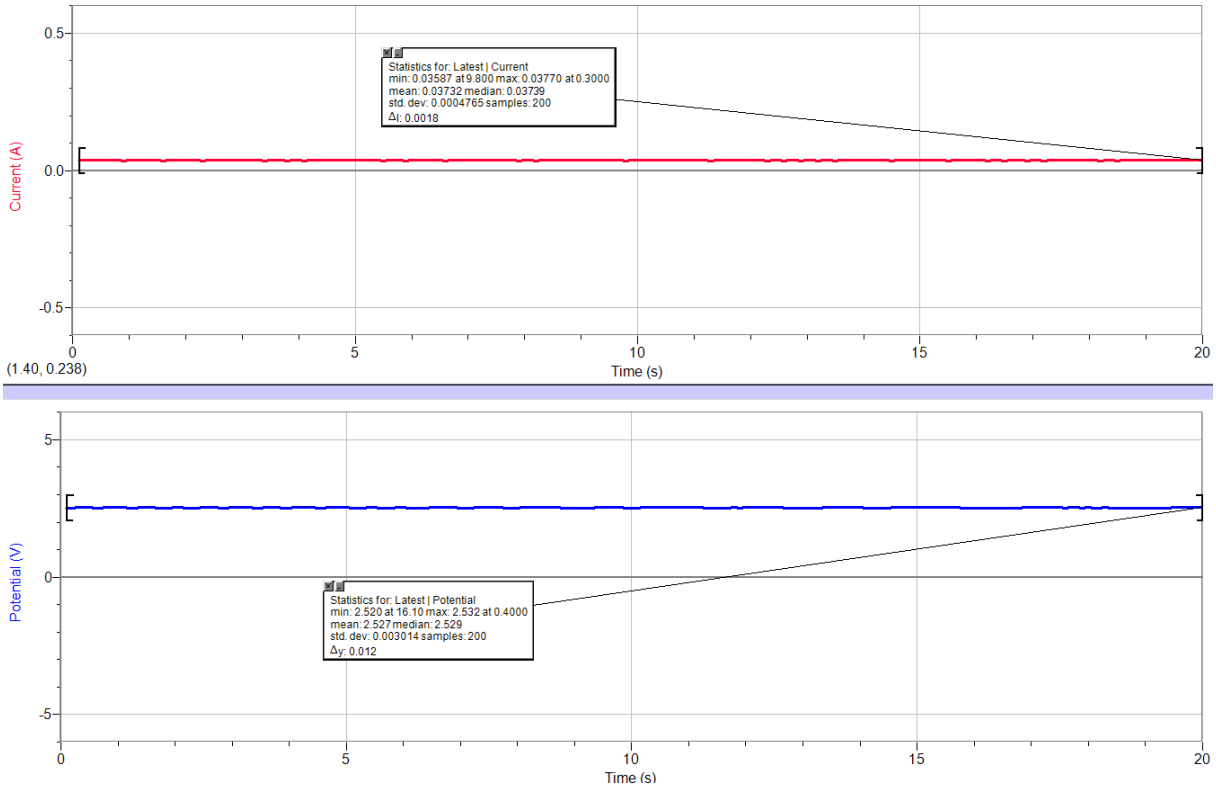
- Resistor 2 - 51 ohms



Resistor 3 - 68 ohms



Resistor 4 - 68 ohms



Resistor in series (51 and 68)