Capacitors

PY208m

1 Purpose

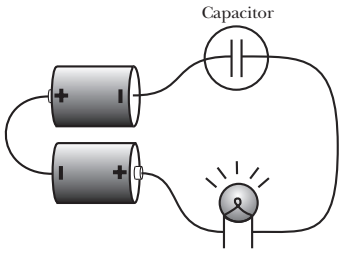
You will charge and discharge a capacitor with a round bulb and with a long bulb. Based on your observations, you will form a hypothesis comparing the amount of charge that accumulates on the capacitor's plates for each situation. To test your hypothesis you will perform an experiment, and analyze your data using error bars.

The notation **RECORD** marks things that should be recorded in your spreadsheet.

2 Charging and discharging a capacitor

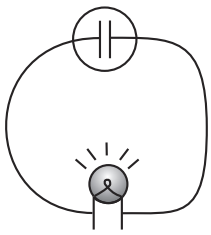
First, simply observe what happens when you charge and discharge a capacitor.

1. To ensure that the capacitor is initially uncharged, connect a wire across it for several seconds.
2. *Charging a capacitor:* Connect the capacitor in series with a ROUND bulb and two batteries, as shown in the diagram below.



   What do you observe?

3. *Discharging a capacitor:* Remove the batteries and connect the ROUND bulb directly to the capacitor, as shown in the diagram below.



   What do you observe?

4. Repeat the procedures in parts 1, 2, and 3 to charge and discharge the capacitor with the ROUND bulb. Record the length of time that the phenomena you observed takes place for both cases (charging and discharging the capacitor).

5. To ensure that the capacitor is fully uncharged, connect a wire across it for several seconds.
6. *Charging a capacitor:* Connect the capacitor in series with a LONG bulb and two batteries.

   What do you observe?
7. *Discharging a capacitor:* Remove the batteries and connect the LONG bulb directly to the capacitor.

   What do you observe?
8. Repeat the procedures in parts 5, 6, and 7 to charge and discharge the capacitor with the LONG bulb.
9. What aspects of the charging and discharging process are different for the LONG bulb vs. the ROUND bulb?

3 The effect of different bulbs on the final charge on a capacitor

In this portion of the lab you will:

- Formulate and clearly state a hypothesis
- Perform an experiment to test your hypothesis
- Draw a conclusion regarding your hypothesis, taking into account the error of your measurements

Equipment: Two batteries, round bulb, long bulb, capacitor, connecting wires. You may also need other equipment, such as a stopwatch or a compass.

3.1 Hypothesis

In section 2 you observed different behavior (time, brightness) when charging a capacitor through a long bulb vs. through a round bulb.

1. In which situation (long bulb vs. round bulb) do you think more charge accumulates on the plates of the capacitor? Formulate a hypothesis about this. **RECORD**

   It is ok if your hypothesis turns out to be incorrect - that's what experiments are for!
2. Give a reason why you think your hypothesis is probably correct. **RECORD**

3.2 Planning the experiment

Suppose you were to perform the following experiment to test your hypothesis. Think about how the results of the experiment might allow you to tell if your hypothesis is correct or incorrect. Don't do any experiments yet. Read all of section 3.2 first, and record what you would expect to see in the Excel spreadsheet.

1. Charge capacitor through ROUND bulb.
2. Discharge capacitor through ROUND bulb, and record how long the bulb stays lit.
3. Charge capacitor through LONG bulb.
4. Discharge capacitor through ROUND bulb, and record how long the bulb stays lit.

3.2.1 Predictions based on hypothesis

Think about how performing this experiment would allow you to determine if your hypothesis is correct or not.

(a) If your hypothesis is correct, what should you observe? Should the effects be large or small? **RECORD**

(b) If your hypothesis is incorrect, what should you observe? Should the effects be large or small? **RECORD**

5. Check your reasoning about what you should observe with a neighboring group. You do not have to have the same hypothesis, but you should agree on how your observations will enable you to tell if your hypothesis is correct.

3.3 Error bars

Repeated measurements rarely give exactly the same result. In order to decide if measured values are significantly different, scientists and engineers use *error bars*. *Read the brief guide to error bars at the end of this document.* You will use error bars indicating the *maximum deviation* in your data to support your conclusions.

3.4 Do the experiment

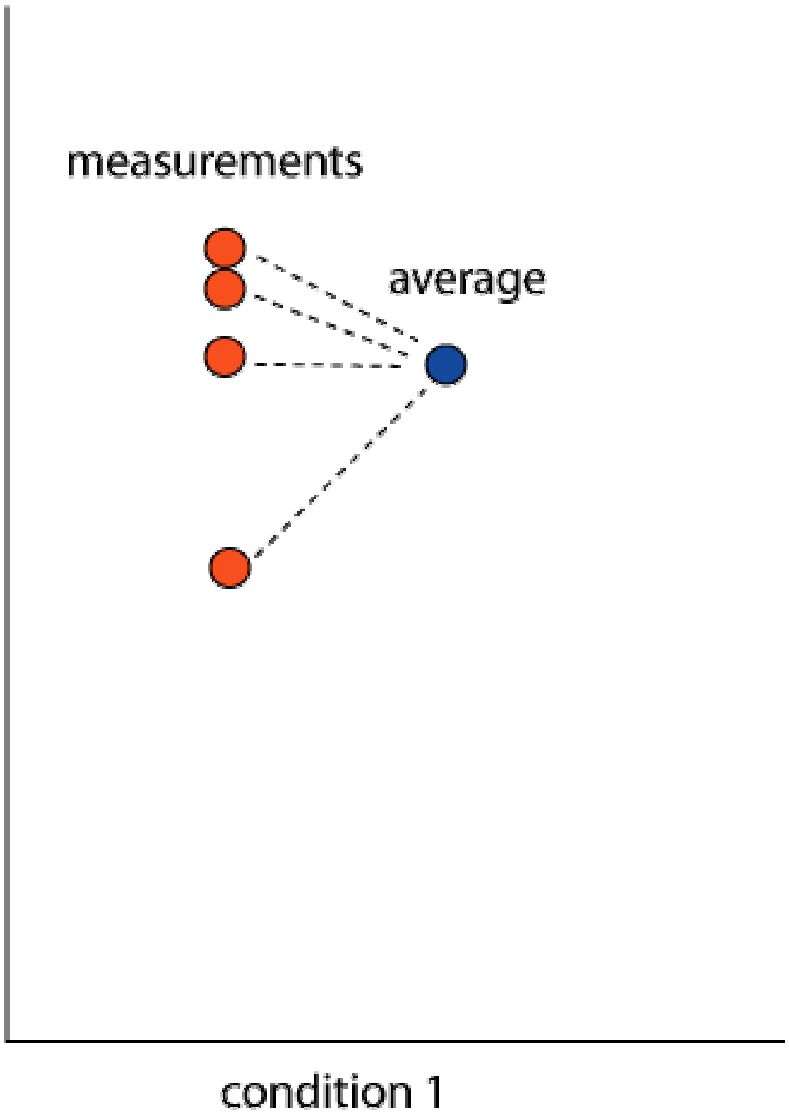
Always have the same person determine when the bulb stops glowing, because different people may decide differently, which can introduce an additional and undesirable source of variation.

1. Perform the experiment in section 3.2, parts 1 - 4. (If you have a different or better idea for an experiment, discuss this with your instructor.) Repeat all measurements 4 times. **RECORD**
2. For the first set of measurements (charging with a ROUND bulb and discharging with a ROUND bulb), what is the average discharge time? **RECORD**
3. What is the maximum deviation of the first set of measurements? **RECORD**
4. For the second set of measurements (charging with a LONG bulb and discharging with a ROUND bulb), what is the average discharge time? **RECORD**
5. What is the maximum deviation of the second set of measurements? **RECORD**

3.5 Analysis and conclusions

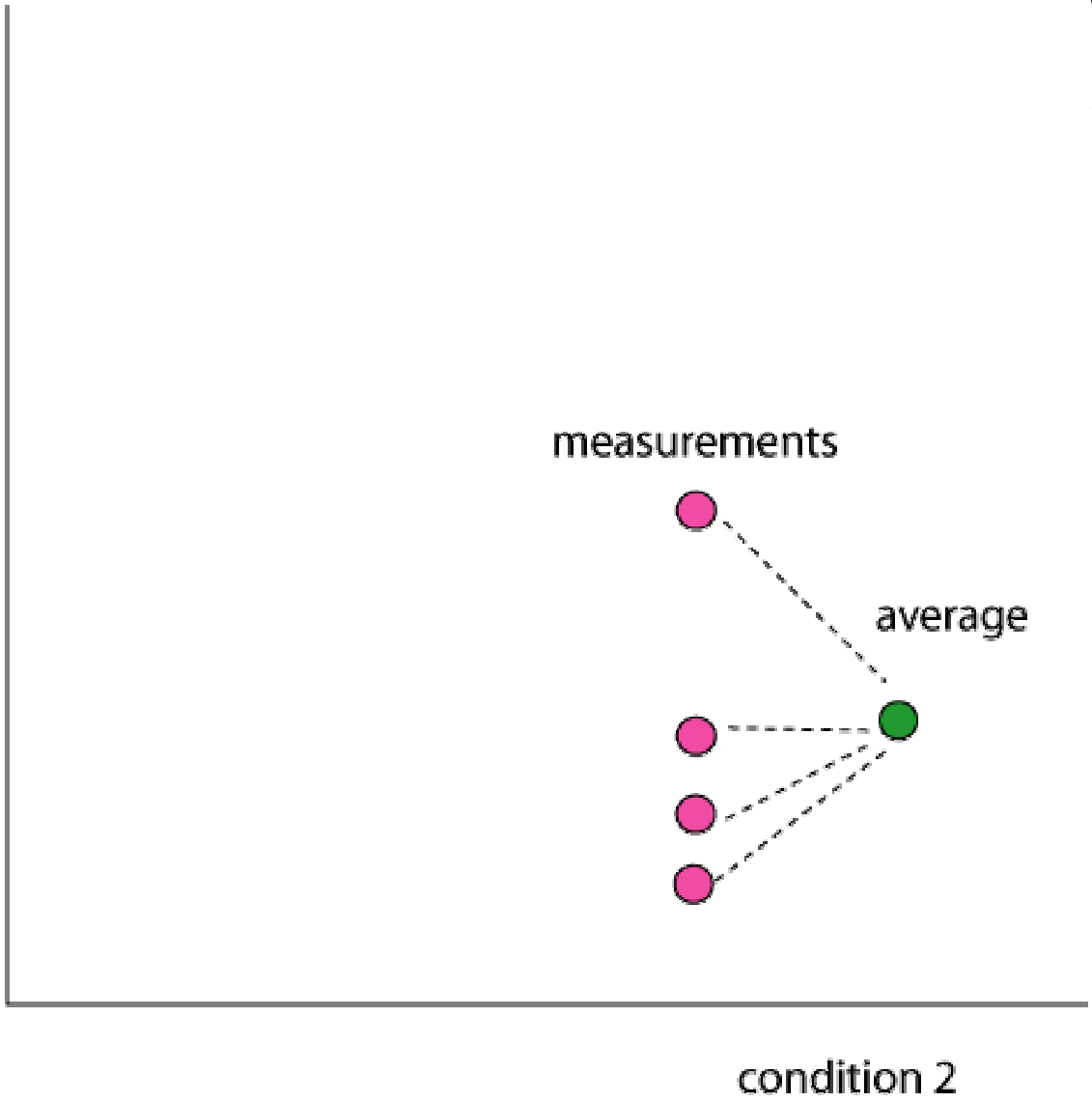
1. Copy your data into the indicated column in the Excel spreadsheet. The spreadsheet will create a plot of the average discharge times with error bars.
2. Explain clearly and rigorously (do not leave out steps in reasoning) whether your results confirm or contradict your hypothesis. **Do not change your hypothesis!** **RECORD**
3. Are the size of the effects consistent with the nature of your hypothesis?
4. Explain your hypothesis and conclusions to a neighboring group.

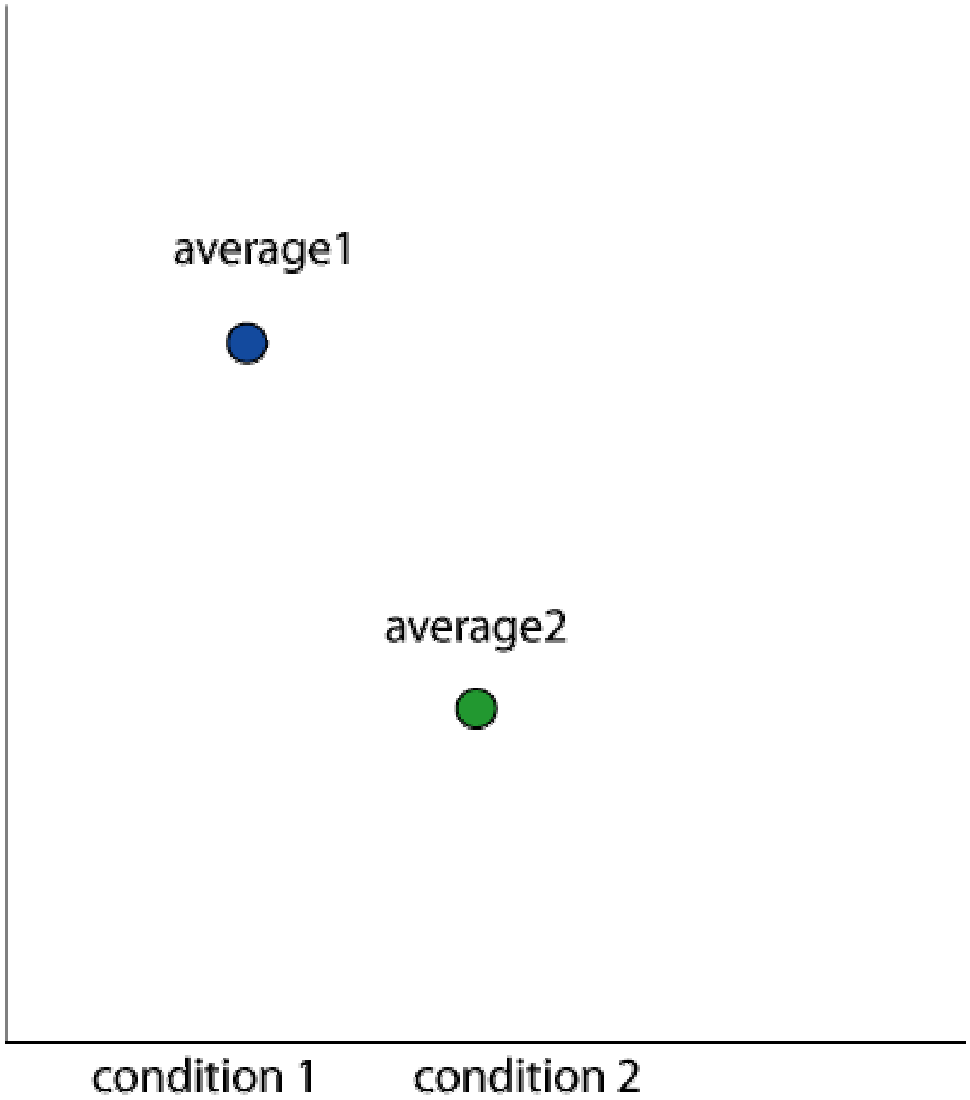
The Recorder should answer the questions in WebAssign and upload your spreadsheet.
February 28, 2008



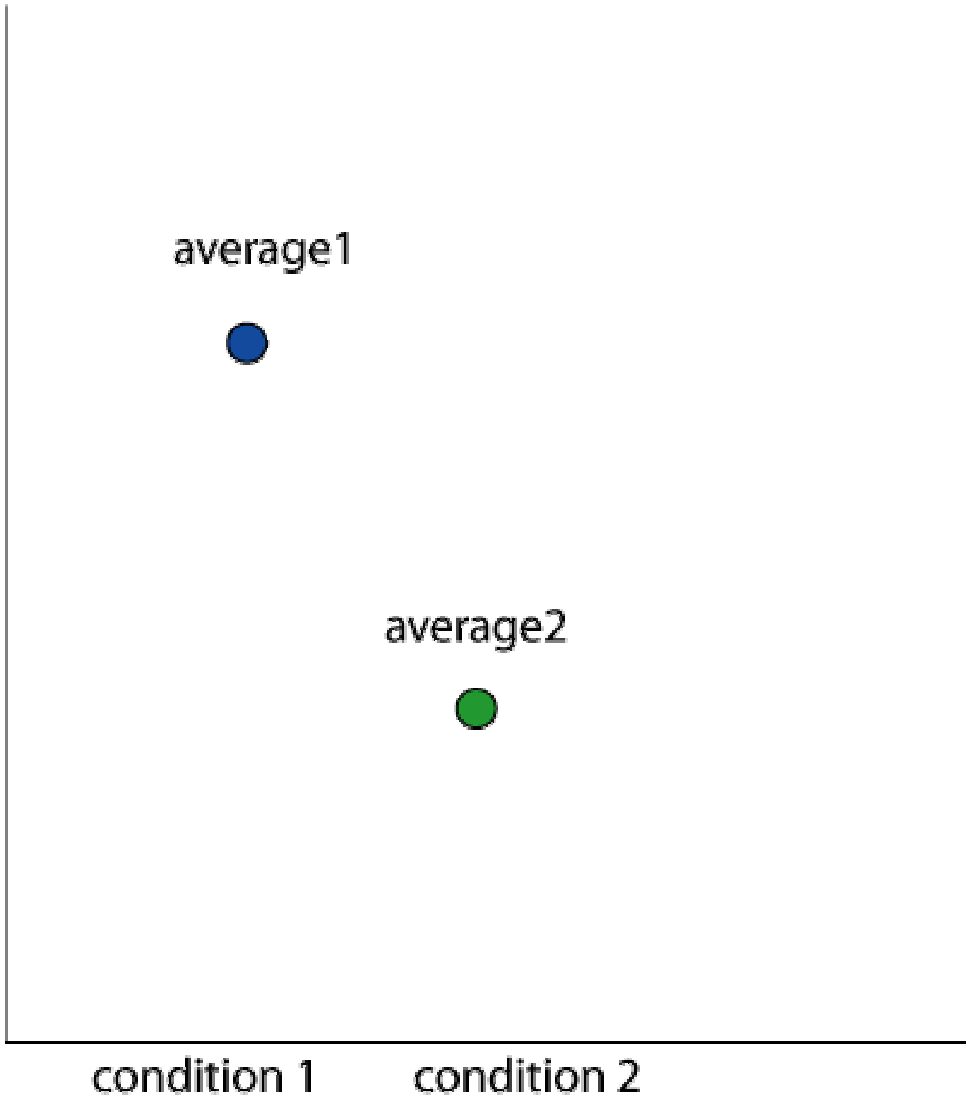
When we need an accurate measurement of something, we usually repeat the measurement several times and calculate an average value.

We go through the same process for our next measurement.



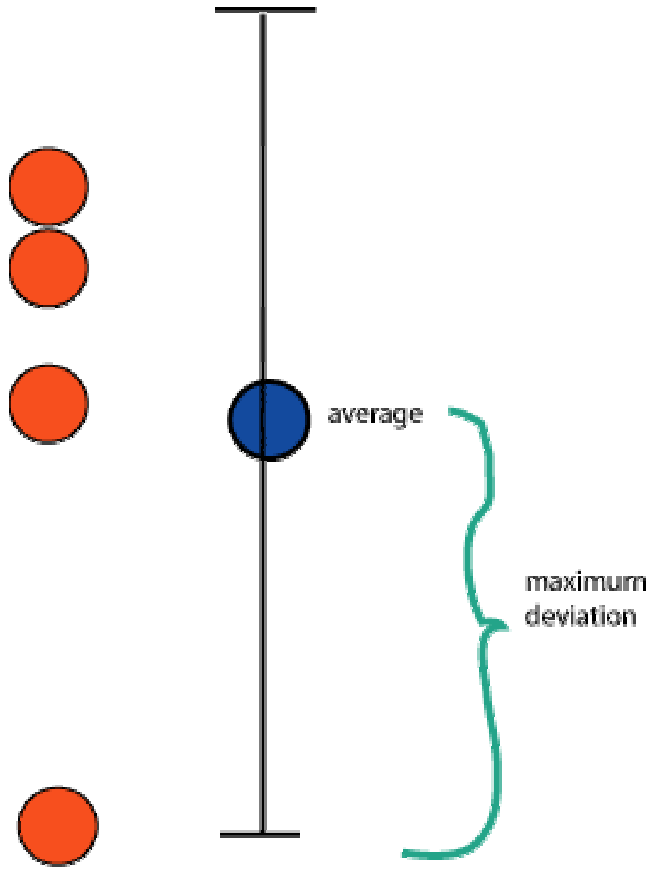


Sometimes we need to compare two measurements in order to decide if they are different. Comparing average values is more informative than comparing single measurements.



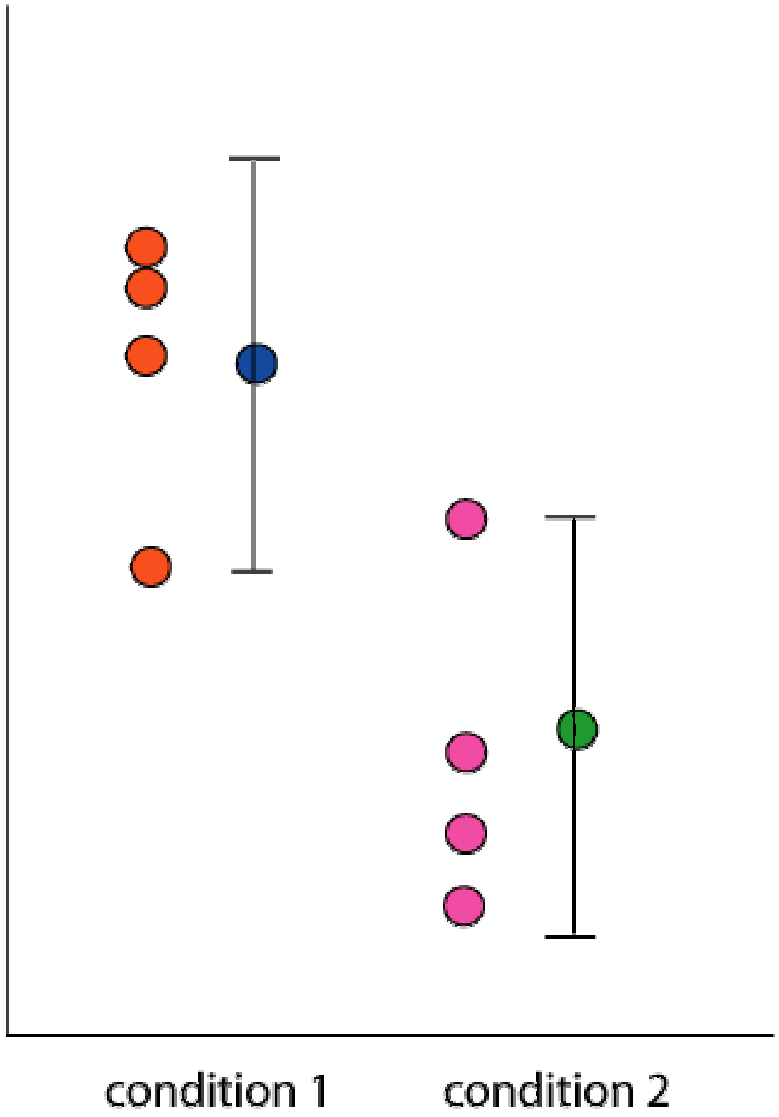
But how can we be sure these values are really different?

Perhaps our measurements aren't very precise…

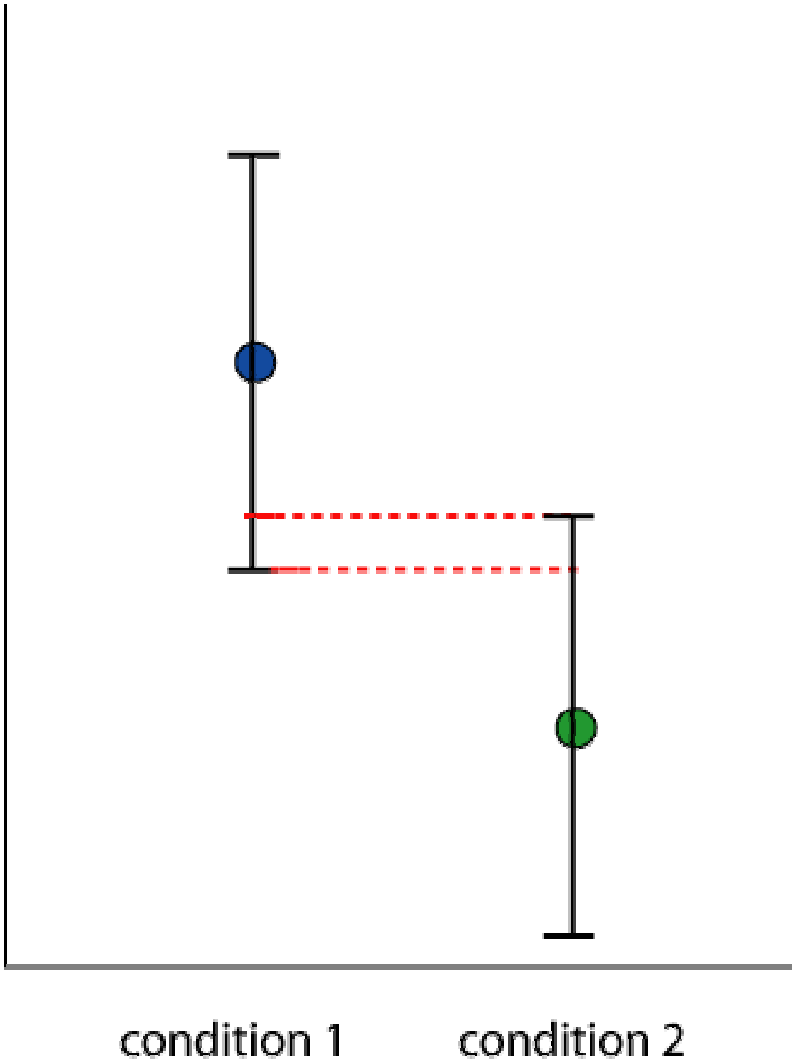


One way to take into account measurement accuracy is to draw ERROR BARS for each average value.

A simple way to construct an error bar is to use the MAXIMUM DEVIATION of a single data point from the average.

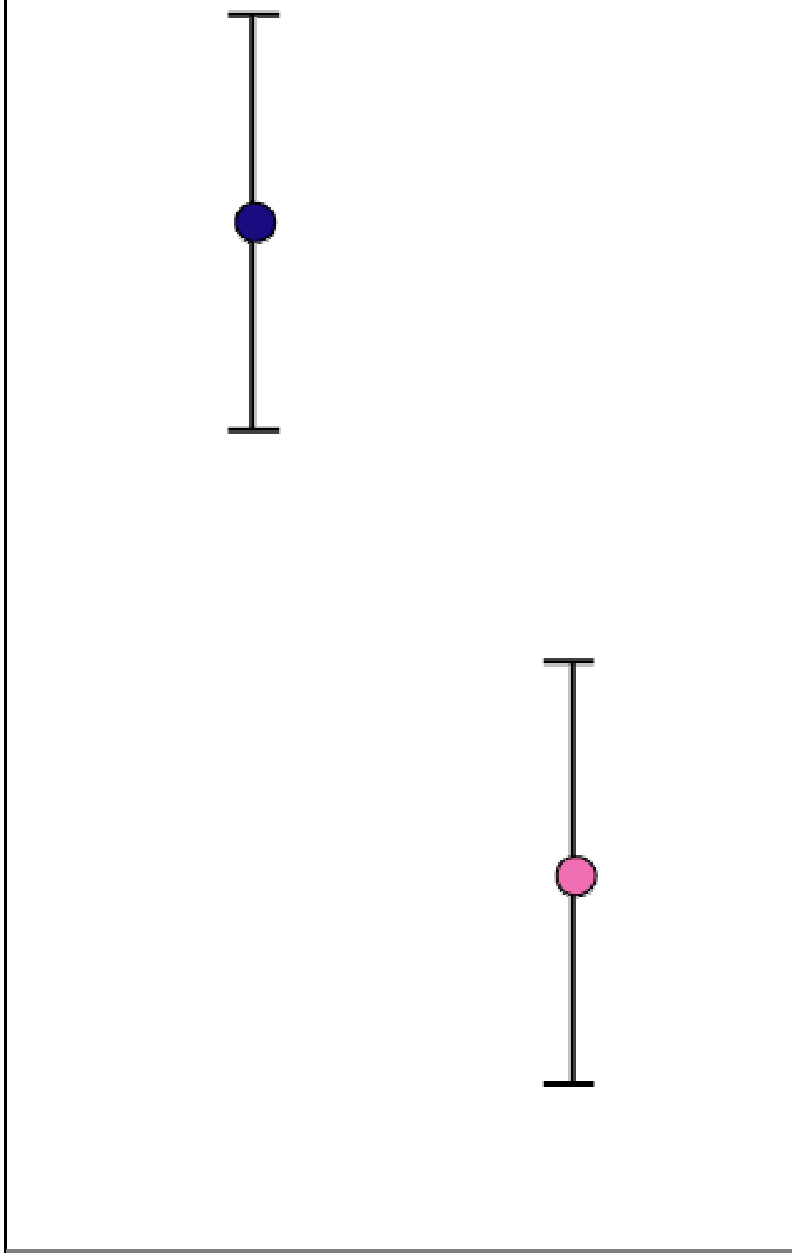


We construct error bars for each repeated measurement.



If the error bars for two measurements overlap, then we cannot conclude that the values are truly different.

In this case, we say the values are NOT SIGNIFICANTLY DIFFERENT.



If the error bars for two average values don’t overlap, a conclusion that they are different is justifiable.