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Calibration of
Conductivity Sensors

EAS 199B
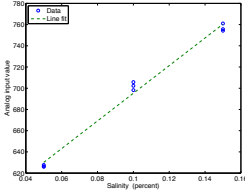
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cal · i · brate   [kal-uh-breyt]
 -verb (used with object), -brat · ed, -brat · ing.
 1. to determine, check, or rectify the graduation of (any
    instrument giving quantitative measurements).
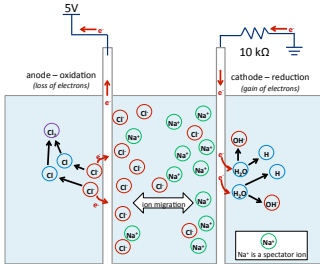
Calibration

- Associate sensor output with salt concentration
- Relate sensor output and salt concentration using an equation (linear regression)
- The goal is to be able to compute the salt concentration based on sensor output

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The Basic Idea

- Adding salt to the water will increase the availability of Cl^- ions at the anode
- More ions at the anode will increase the rate at which chemical reactions can occur
- The "electrical resistance" of the salt water will decrease as more salt is added to the water
- The analog voltage on the + side of the 10kΩ resistor will increase as more salt is added
- Correlating this voltage with the salt concentration will allow us to "calibrate" the conductivity sensor

5V

10 kΩ

anode – oxidation
(loss of electrons)

cathode – reduction
(gain of electrons)

ion migration

Na^+ is a spectator ion

Slide 1

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The Circuit and Sketch

```
int salinity_power_pin = 4;   // Digital I/O pin, Global variable

void setup()
{
  Serial.begin(9600);
  pinMode(power_pin, OUTPUT);
}

void loop()
{
  int salinity_input_pin = 2; //  Analog input pin
  int salinity;

  salinity = salinity_reading( salinity_power_pin, salinity_input_pin );
  Serial.println(salinity);
}
// ------------------------------------------------
int salinity_reading( int power_pin, int input_pin ) {

  int reading;

  digitalWrite( power_pin, HIGH );    //  Turn on the sensor
  delay(10);                          //  Wait to settle
  reading = analogRead( input_pin );  //  Read voltage
  digitalWrite( power_pin, LOW );     //  Turn off the sensor
  return reading;
}
```

Digital output

salinty sensor
(variable resistance)

Analog input

10 kΩ

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Salt Concentrations

- Each group of students should put about 1.5 inches of water in four bottles
- The four bottles should contain . . .
  - DI water
  - 0.05% weight NaCl
  - 0.10% weight NaCl
  - 0.15% weight NaCl
- Please take ONLY the amount that you will need to use TODAY
- Be sure to label your water bottles
- Swish a small amount of DI water around in your bottle to wash out impurities before filling with calibration water

Salt Concentration Label

Slide 3

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Capture data during calibration

Copy and paste to Excel

Autoscroll   No line ending   9600 baud

Click the Autoscroll button to temporarily suspend updates
to the screen. This is helpful when manually copying data
to another application.
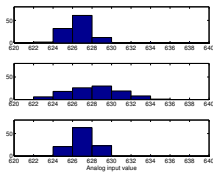
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Calibration steps in the lab

1. Configure your flow loop as required for homework
2. Implement the conductivity sensor circuit on your breadboard
3. Flush tank with DI water.
   a. Pour enough DI water into your fishtank to fill the flow loop
   b. Turn on the pump to run the flow loop for about a minute to "wash out" the impurities.
   c. Turn the three-way valve toward the drain to flush the system
   d. Repeat to completely clean the system
4. Fill the system with DI water
5. Collect calibration data
   a. Wait for the system to come into equilibrium
   b. Copy a large (50 to 100) readings from the Serial Monitor to a text file or Excel
   c. Save the file with a name that allows you to identify it later
6. Fill the system with 0.05 wt% salt water. Flush once, and refill with 0.05 wt% salt water
7. Repeat steps 5a through 5c
8. Repeat steps 5 through 7 for 0.10 wt% salt water and 0.15 wt% salt water

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Analysis of calibration data

1. Use MATLAB to create a histogram of your data
2. Compute the mean, standard deviation and median of the data
3. Record the data in the following table

Wt% NaCl	n	Mean	Standard deviation	Median
0				
0.05				
0.10				
0.15				

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Steps

1. Configure your flow loop as required for homework
2. Implement the conductivity sensor circuit on your breadboard
3. Flush tank with DI water.
   a. Pour enough DI water into your fishtank to fill the flow loop
   b. Turn on the pump to run the flow loop for about a minute to "wash out" the impurities.
   c. Turn the three-way valve toward the drain to flush the system
   d. Repeat to completely clean the system
4. Fill the system with DI water
5. Collect calibration data for DI water
6. Fill the system with 0.05 wt% salt water. Flush once, and refill with 0.05 wt% salt water
7. Collect calibration data for 0.05wt% salt water
8. Repeat steps 6 and 7 for 0.10 wt% salt water and 0.15 wt% salt water

salt concentration (%wt)	output to LCD
0.00	
0.05	
0.10	
0.15	

← collect this data

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Fit Output of Sensor to Salt Concentration