# WATER PROBE AND RAINFALL SENSOR UPDATE

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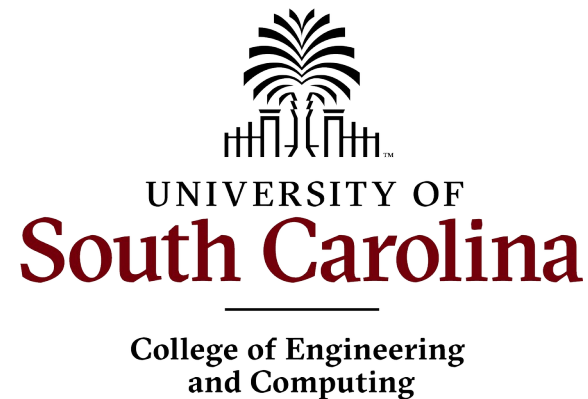
# RAINFALL SENSOR



- Case

- Electronics

- Issues
  - Vibrations
  - Increased variance during the day
  - Out of range



24 hour ambient



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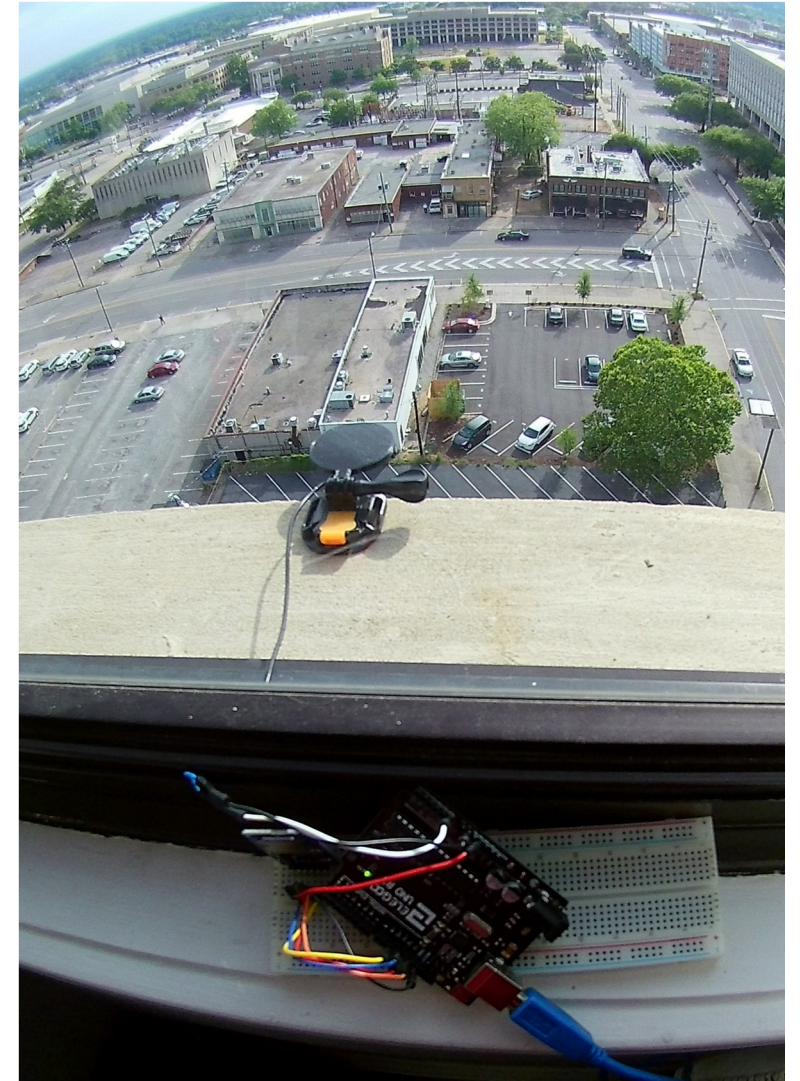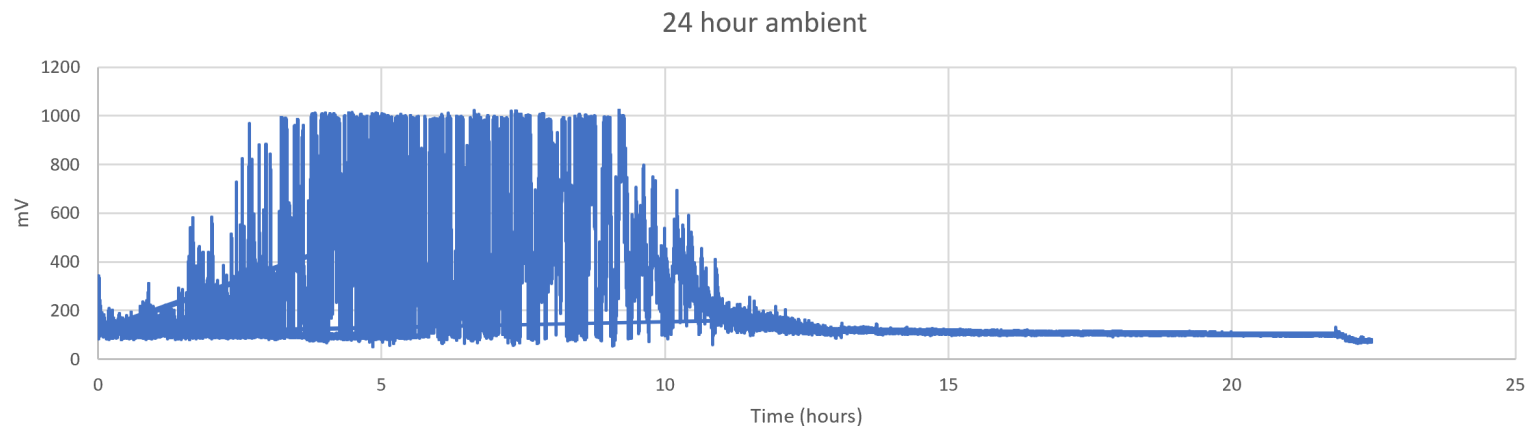
# PIEZOELECTRIC RAINFALL SENSOR

- Conversion Factor

- Piezo: measurement mV
  - Deflection- caused by Force

- Need "Velocity" – inches per hour

- Mathematical(ish)
  - Voltage = Energy per electrical charge ~  Energy (constant amperes)
  - Voltage ~ K.E. =  (assume terminal velocity)
  -  Velocity


- Statistically
  - Linear Regression:

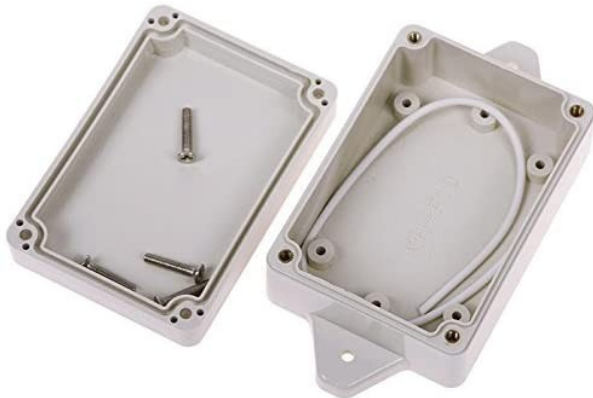**U of SC** **Engineering and Computing**

# AUTO RIGHTING

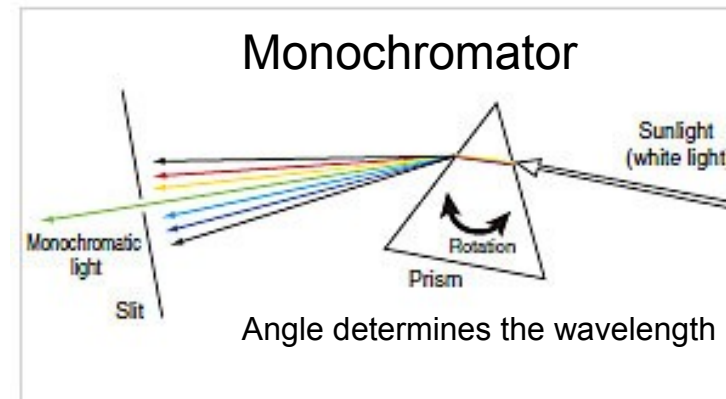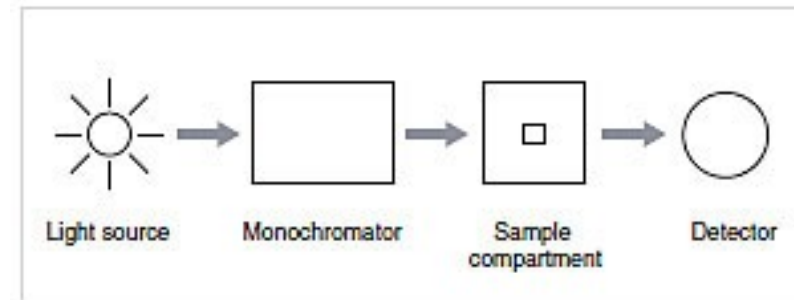- It is auto righting!
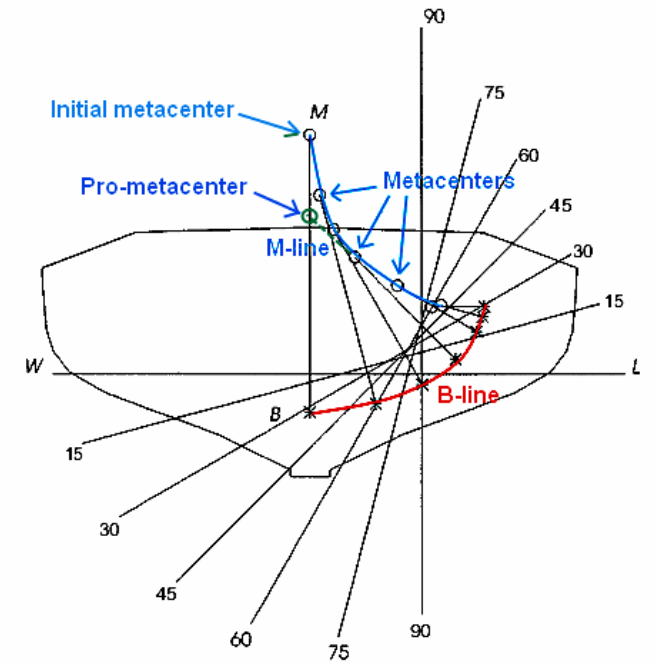
# WATERPROOF

- Mostly: only one leak
- Small imperfection in base print causing leak
- Higher quality prints take days
  - Still not guaranteed
- Waterproof Electronics box

# MEASURING NITRATES

| Parameter | Sensor type | Possible spill / hazard | Sampling method |
|-----------|-------------|-------------------------|-----------------|
| Water level | Ultrasound | All | in situ |
| Rain fall | Acoustic | All | in situ |
| pH | pH-sensitive electrode | Mine tailing / coal ash | in situ |
| Salinity | Electrical conductivity | Mine tailing / coal ash | in situ |
| Ionic strength | Calculated using conductivity and PH | Chemical Spill | in situ |
| Dissolved oxygen | Dynamic Luminescence Quenching | Organic matter | in situ |
| Total dissolved solids | Electrical conductivity | Suspended particulate matter | both |
| Nitrate | UV Absorption (nm) Spectroscopy | Agricultural runoff | sample return |
| Gadolinium | Nuclear Magnetic Resonance | Human sewage spills | sample return |
| Algae | Machine vision | Harmful algal plumes | in situ |

- Chemical Test: Ring Test (iron(II) sulfate and sulfuric acid)
- In Situ with UV absorption?
  - Servo: to move the diffuser
  - Monochromator
  - Source (Sun?)
  - Detector (photosensor)
- Measurement range
- Detect other materials in the water?



Light source → Monochromator → Sample compartment → Detector



Monochromator

Sunlight (white light)

Monochromatic light

Slit

Rotation

Prism

Angle determines the wavelength

# NEXT STEPS

- Rainfall
  - Case V1
  - Regression Equation
  - Mounting System
- Water Probe
  - Case V3
    - Field testing
  - Test Sensor System

# SOURCES

- https://pubs.rsc.org/en/content/articlelanding/2018/en/c8en00588e#!divAbstract

- http://www.pitt.edu/~asher/homepage/spec_pdf/UV%20Resonance%20Raman%20Spectroscopic%20Detection%20of%20Nitrate.pdf

- https://www.shimadzu.com/an/uv/support/fundamentals/monochromators.html
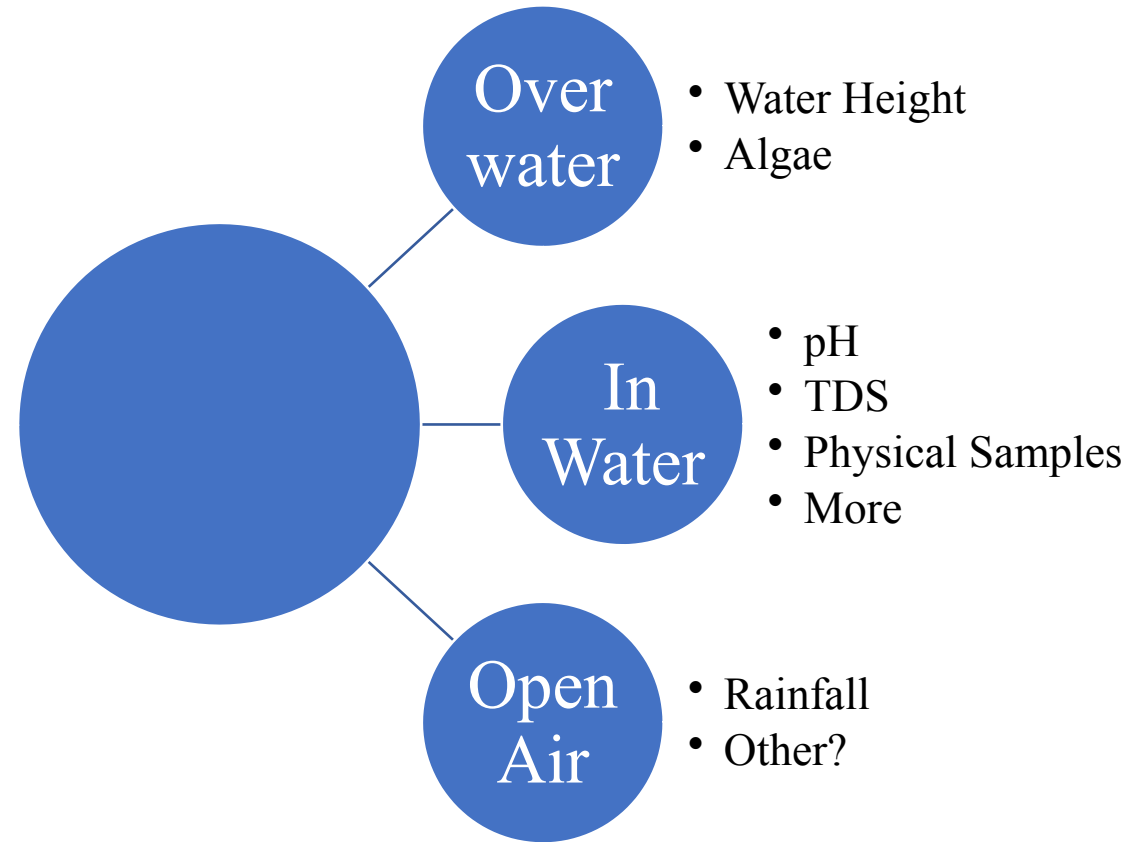
# DISSOLVED OXYGEN

# BATTERY

- Samsung cylinder batteries?
  - Stackable
  - Flexible design
  - One charger for all
- LiPo
- Charging?
- Replacing

# TABLE OF PARAMETERS

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# PACKAGE CONDITIONS



**Over water**
- Water Height
- Algae

**In Water**
- pH
- TDS
- Physical Samples
- More

**Open Air**
- Rainfall
- Other?

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# 3 PACKAGES

- Above water package
  - Currently the water height sensor package
  - Add camera for algae machine vision detection capabilities
- In water package
  - Under development
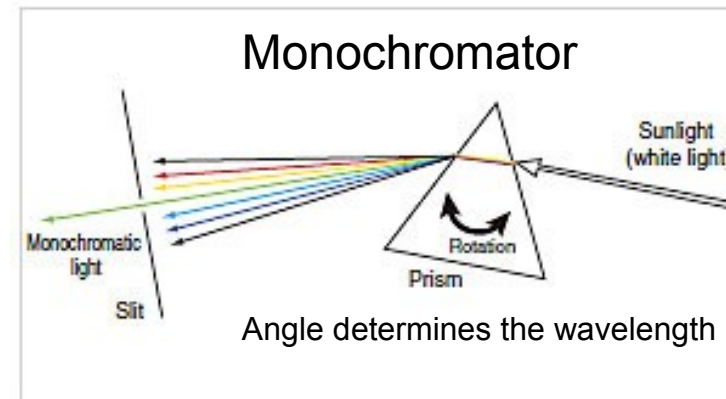- Open air package
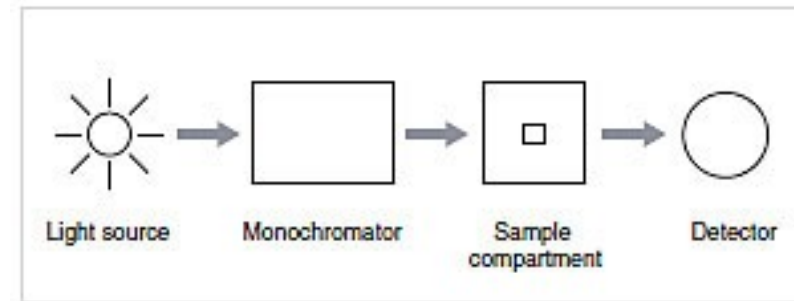  - Testing/development

# PROBE SWAP

- Easier
- Eliminates Docking

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Slit

Prism

Rotation

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# NITRATES

- Determination of Nitrate in Water Containing Dissolved Organic Carbon by Ultraviolet Spectroscopy

- 200-205 nm & 300 nm

- 2 wavelengths avoid organic intereference

# DISSOLVED OXYGEN

- Rapid and precise determination of dissolved oxygen by spectrophotometry: Evaluation of interference from color and turbidity

- 430nm

- Low organic interference

# UV ABSORPTION

- Sample return
  - Easiest
- Fixed wavelengths
  - Nitrates only
- Spectrum
  - Moving parts
  - accuracy
  - Slit size  precision
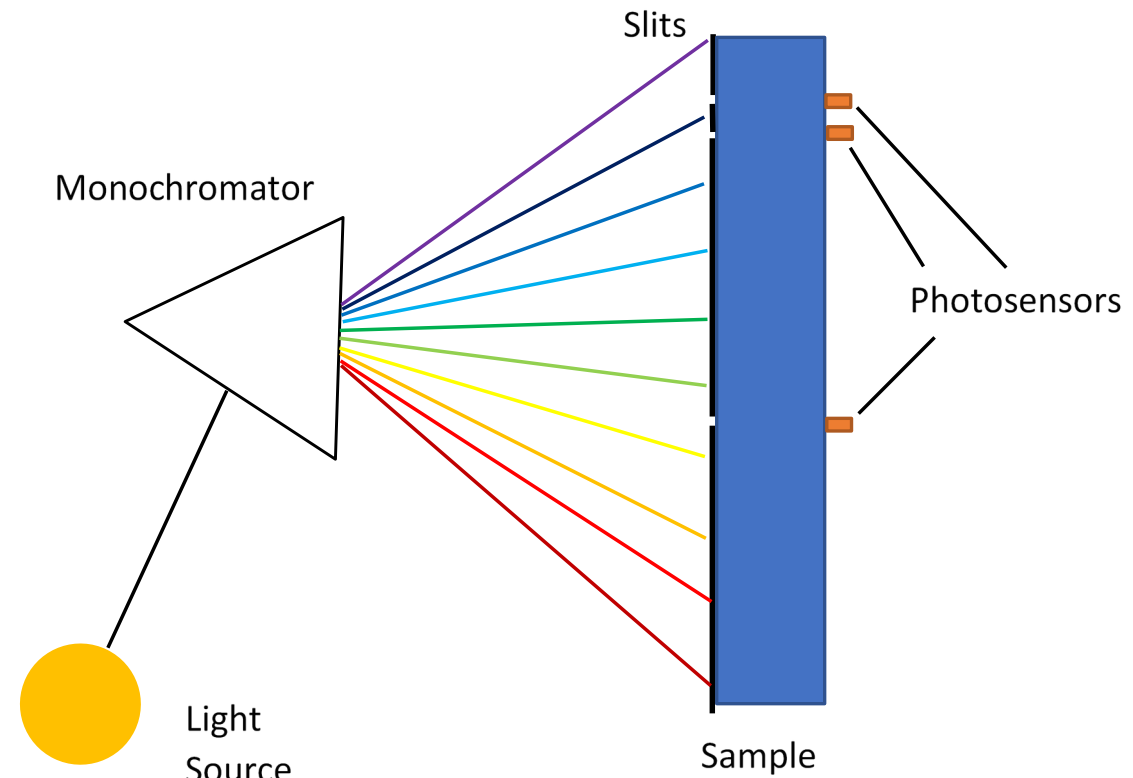


Slits

Monochromator

Photosensors

Light
Source

Sample

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# BATTERY

- Samsung cylinder batteries?
  - Stackable
  - Flexible design
  - One charger for all
- LiPo
- Charging?
- Replacing

# DATA

- USGS only registered 0.02 in rainfall event
- USGS records rainfall for every quarter hour
- Very windy
- Increase sample size decrease the sample rate



USGS 021695045 TRIB TO ROCKY BRANCH AB GERVAIS ST AT COLUMBIA, SC



Rainfall

Legend: Average — Rainfall event ( per USGS) — Temperature



Enviromential Conditions

Legend: Humidity (%) — Temperature (F) — Wind (MPH) — Pressure
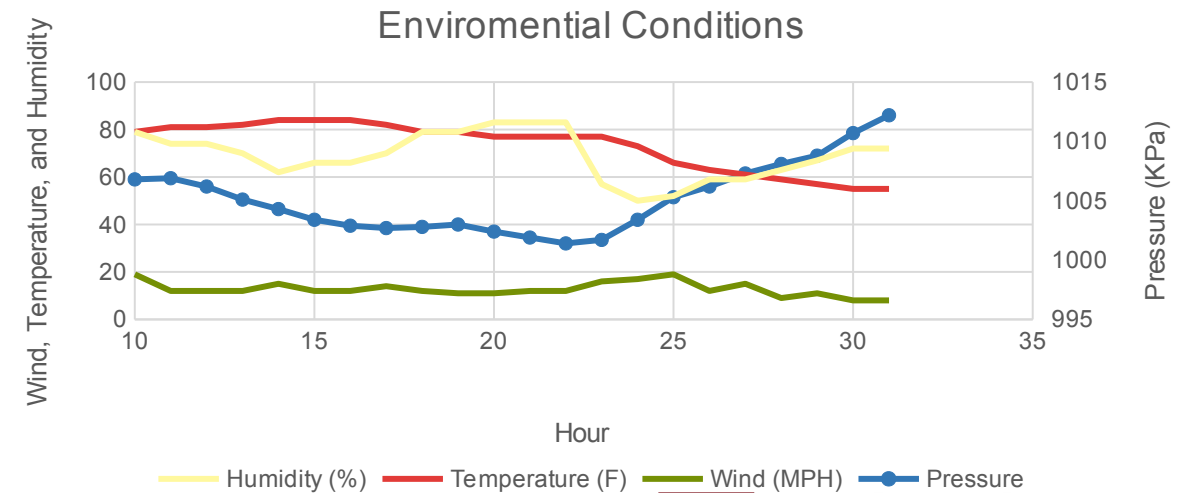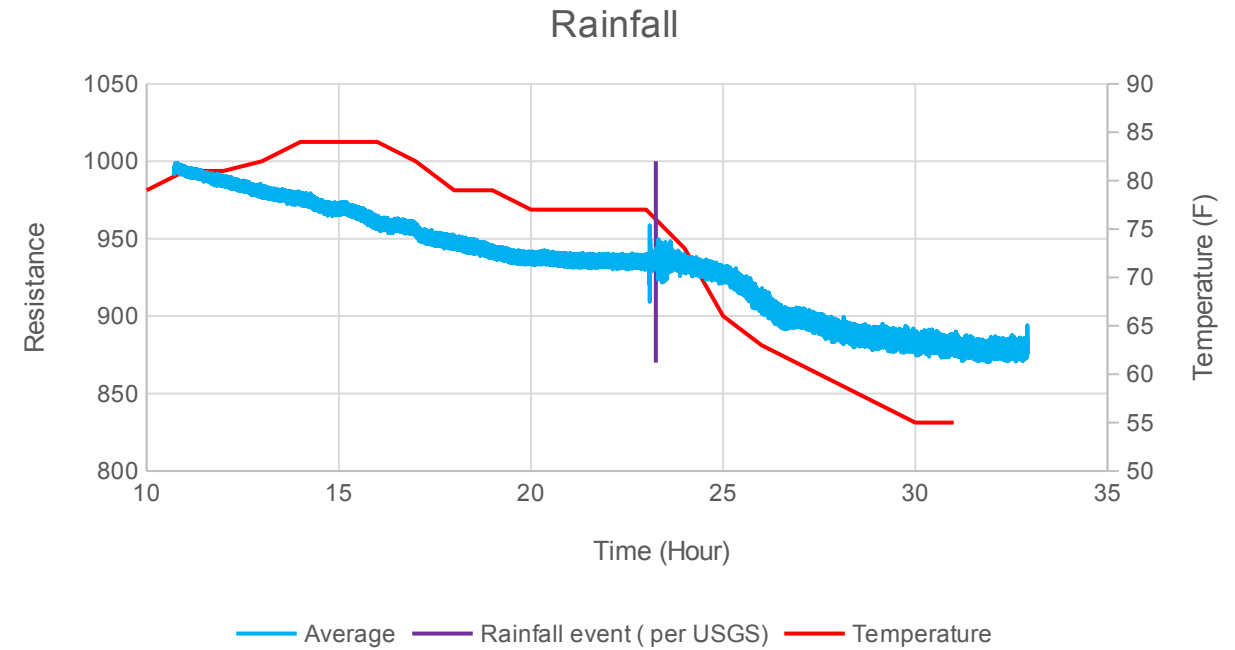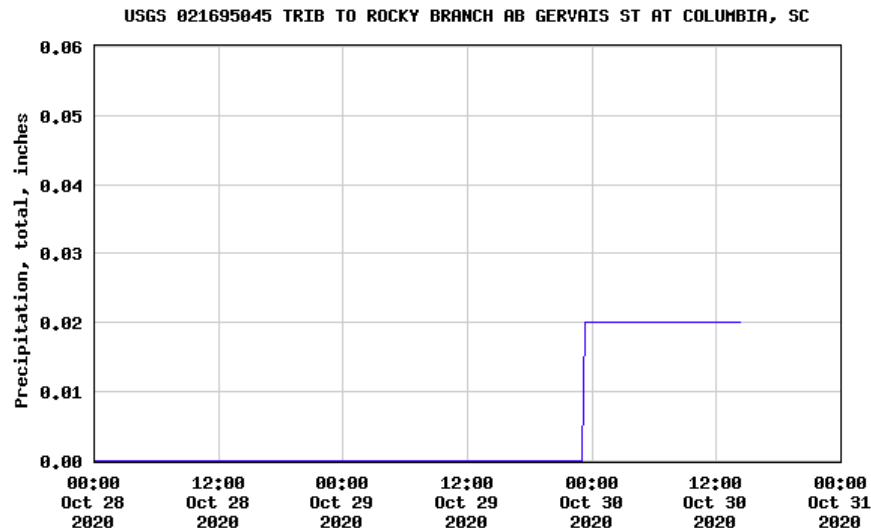
# REDESIGN TOP PIECE

- Deformation internal electrode holder
  - Due to heat
  - Make thicker and connect

- Reciprocal Function
  - V=IR = I*(1/H)
  - Flatten the curve
    - Increase the current
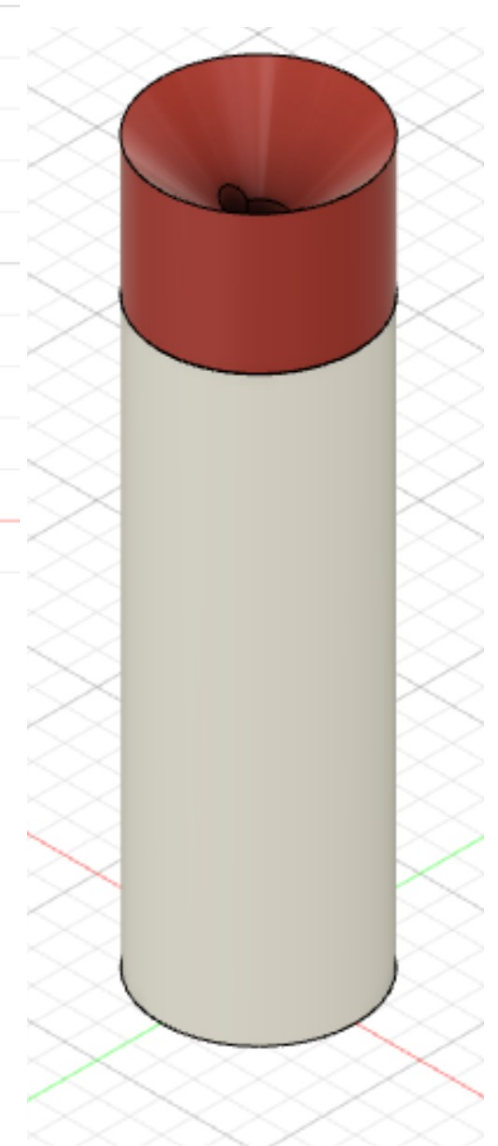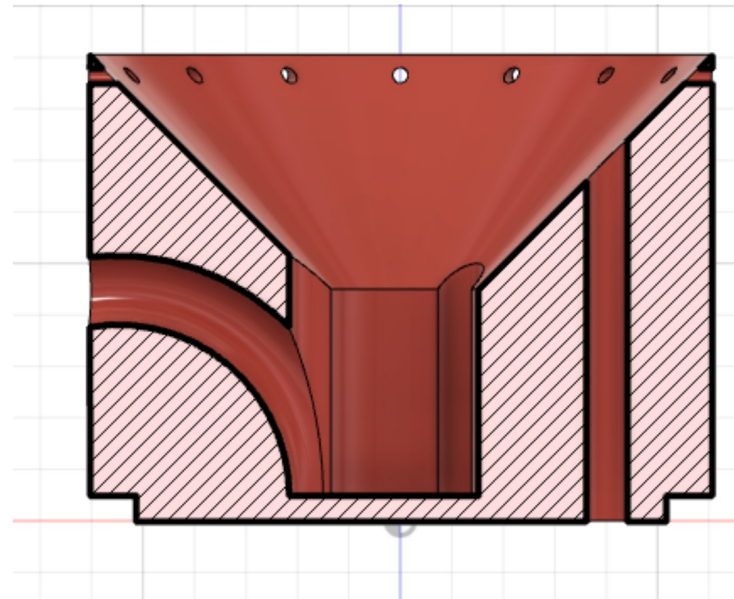    - Angle the electrodes?
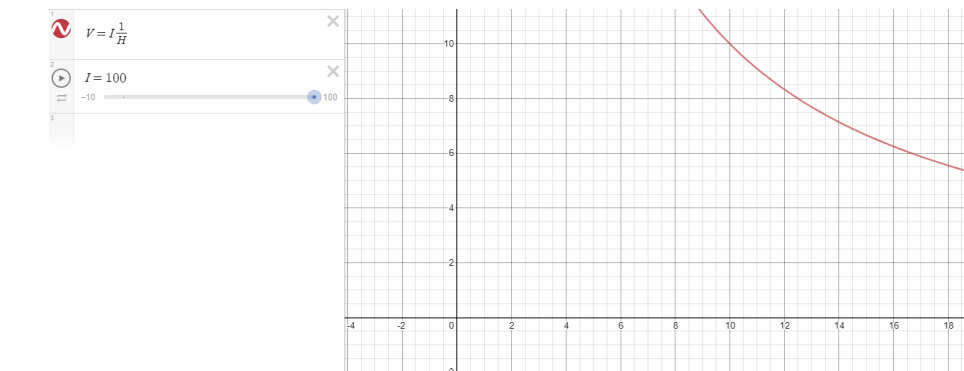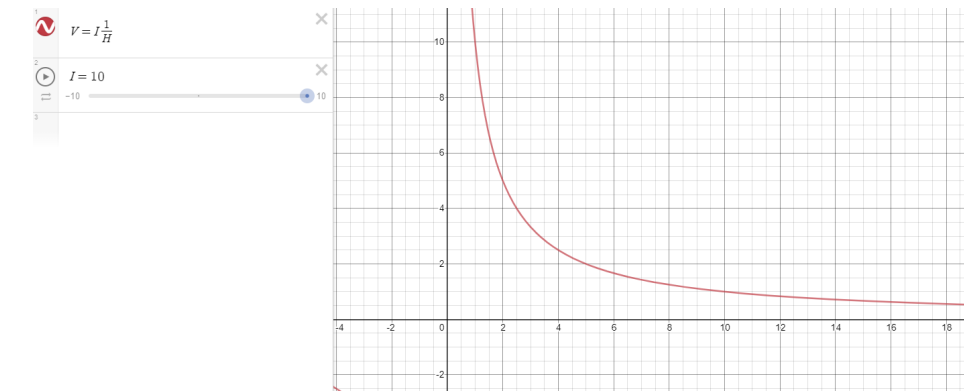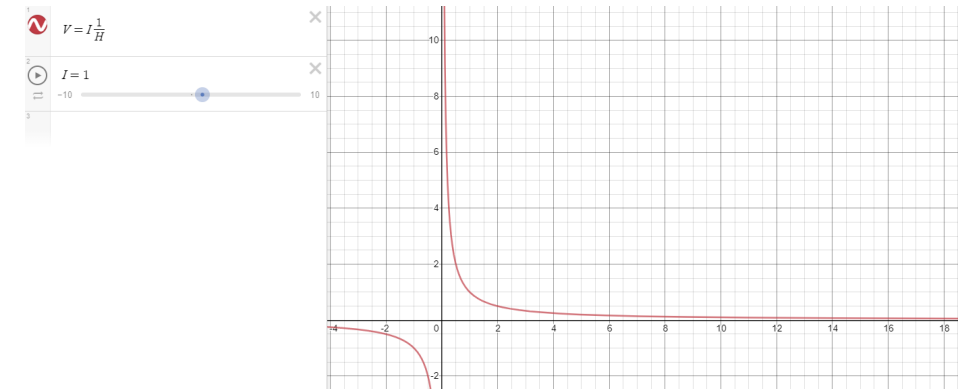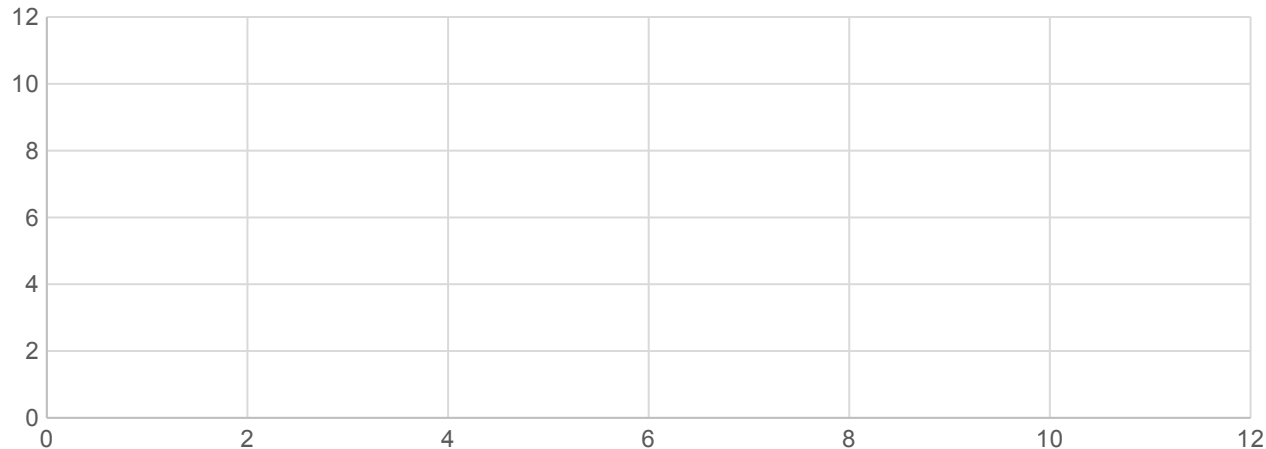
# NEW TOP

- Issues
  - Want resolution
  - Want a better capture ratio
    - Disrupted due to wind and drone docking port
- Funnel intake
  - Increase SA?
    - Better for wind events
  - Reduced Height?
- Magnetic mount area
  - Ferrous steel
  - 400 grade SS
  - Mesh
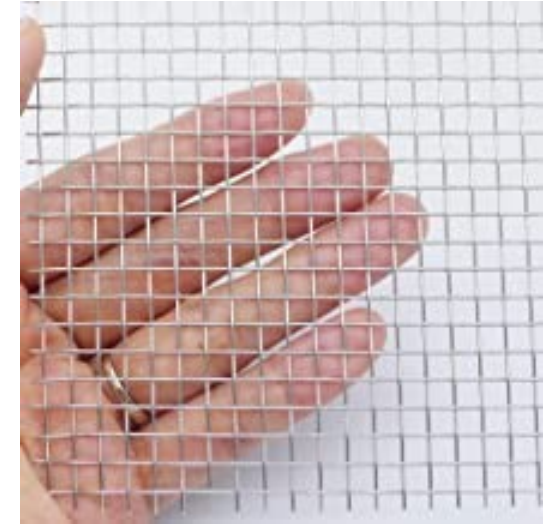
# NEW TOP

- Reduced overall height (reduction of 40mm)

- Easier assembly

- Internal wiring

- More accurate data (ratio of ~16:1)

# CAPACITANCE





- Starting capacitance of 11.2768 pF (for rainfall of 0.01 in at a separation of 1mm)*

- Issue: Arduino can measure down to 100 nF*

- How to fix the issue
  - Different circuit?
  - Increase intake ratio
  - Change to PCB sensor (coat with a material)

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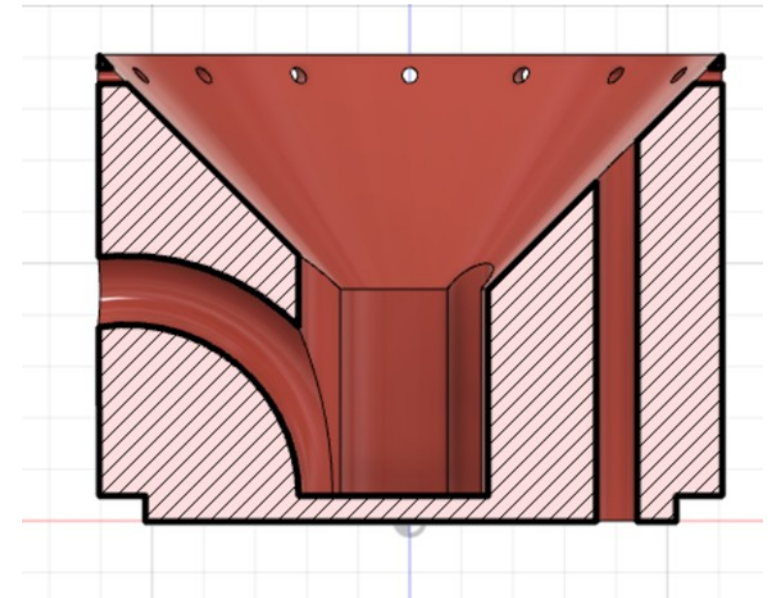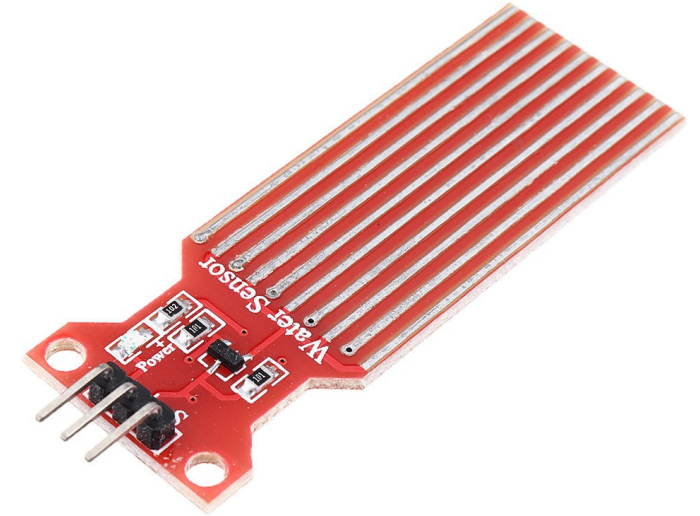
# RAINFALL SENSOR

- No moving parts
- High accuracy: drop counting
- Counts individual drops per area
- Converted to inches/hour
- Water drains out the bottom

Funnel

Internal Nozzle

Electrodes