OCN 479-001: Smart Coasts

Week 7

Power Budget,
Sensor specs,
Metadata vs datadata

Power Budgeting

How do you figure out how long something will last in the field?

How much capacity you have/how much sensor(s) will draw

Power Budget for Sensor

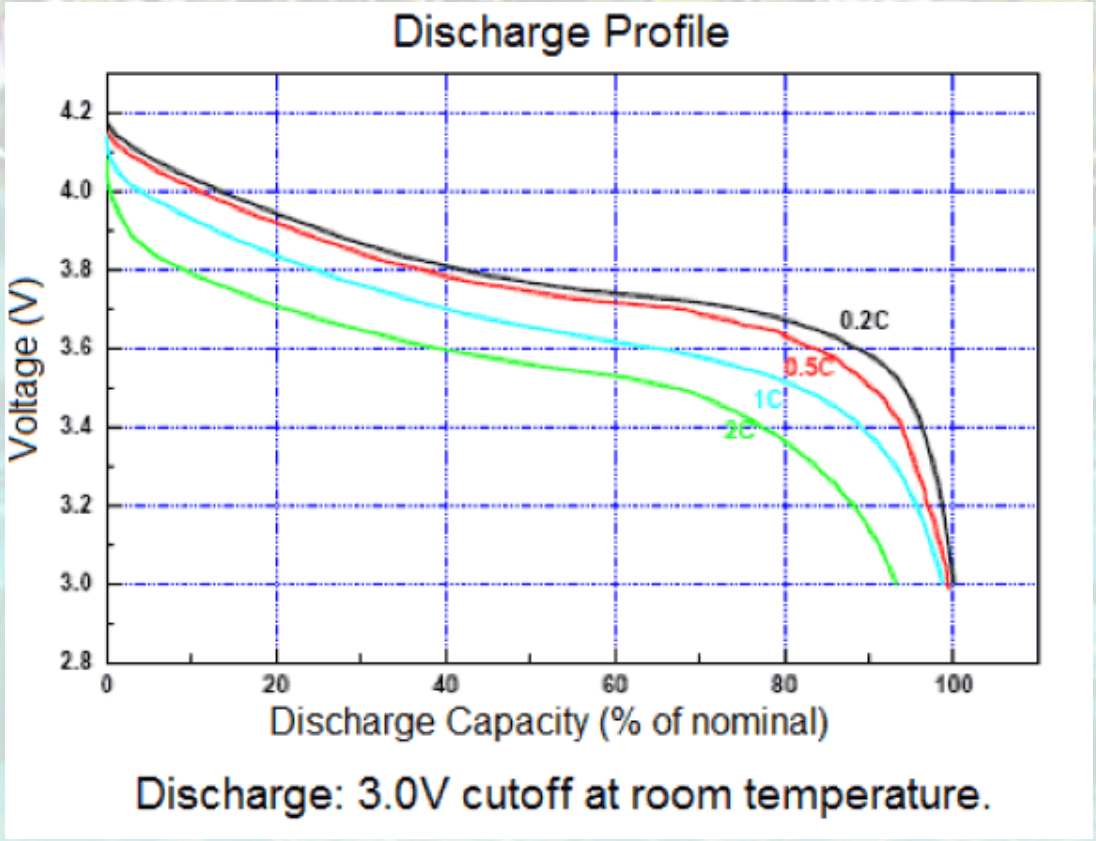
- Step 1: look up component datasheets, e.g.,

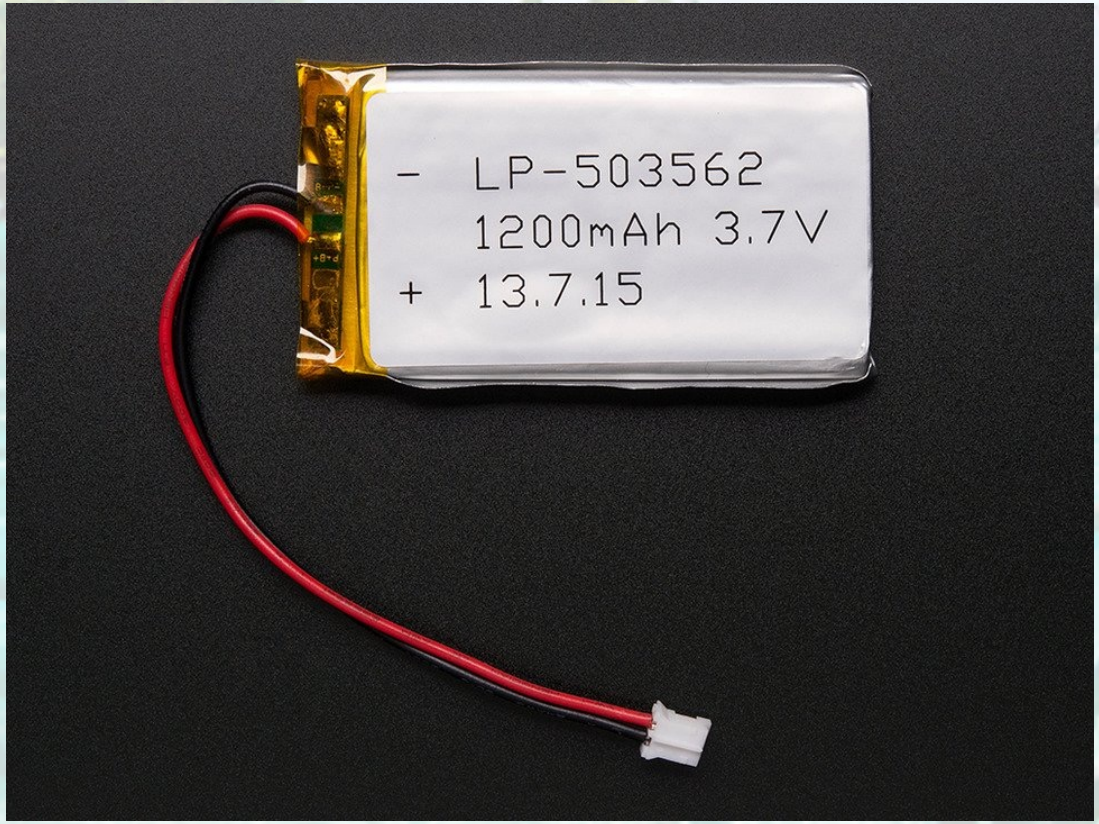
Electrical/Mechanical

Power Input	5-14 VDC, stabilized to within 10%
Current Consumption	40 mA average
	< 150 mA peak current (averaged during IR lamp ON, 120 msec)
	< 300 mA peak power (during IR lamp start-up, the first 50 msec)
Dimensions	5.1 x 5.7 x 1.4 cm (Length x Width x approximate Height)
Electrical Connections	Terminals not mounted (G+, G0, OUT1, OUT2, Din1, Din2, Status, TxD, RxD)

3.7 V "nominal"

- Step 2: look up how much power you have, multiply A-h by V to get W-h





https://community.particle.io/t/can-argon-or-xenon-read-the-battery-state/45554/45?u=fragma

https://www.adafruit.com/product/258

Simple Estimate

- We have 1200 mA*hr * 3.7 V = 4.44 W*hr
- We will use > 40 mA * 5 V (for K-30; ignore microcontroller for now) = 200 mW = 0.2 W

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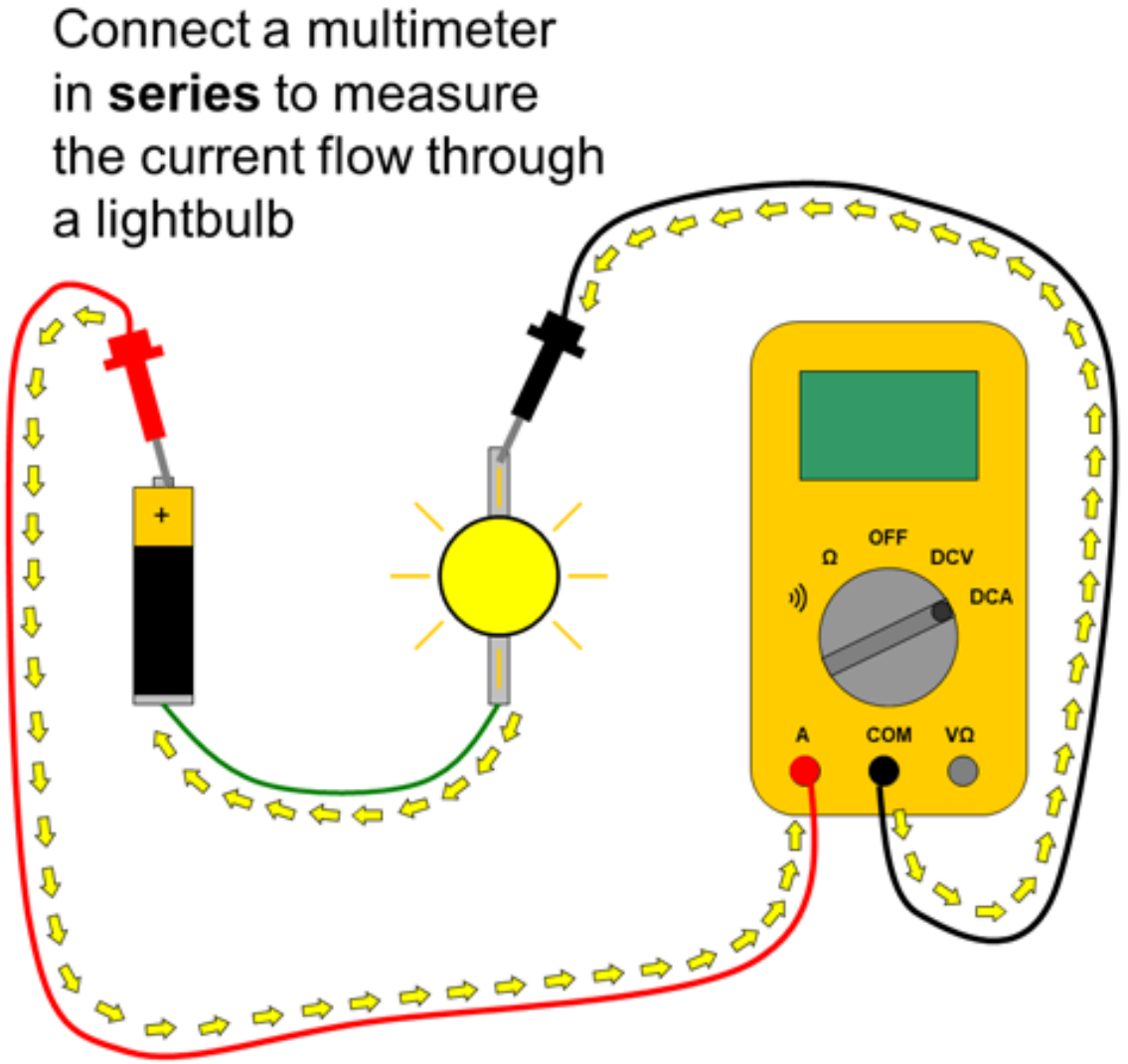
- So 4.44 W*hr/0.2 W = 22 hours

Taking it further: measure current in all states

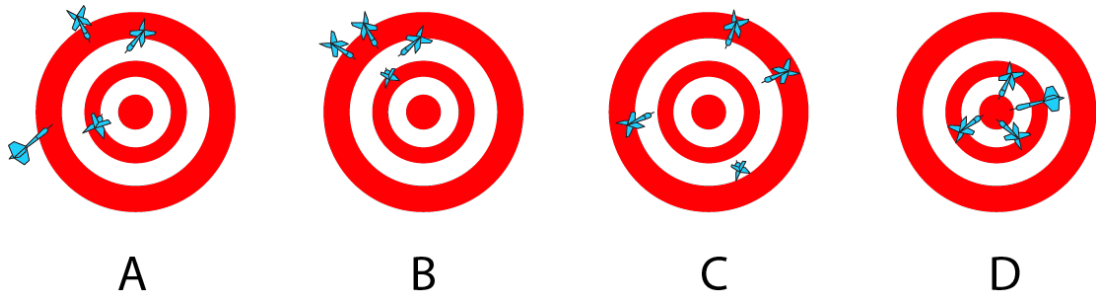
(e.g., sampling, sleeping, publishing)



https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-multimeter

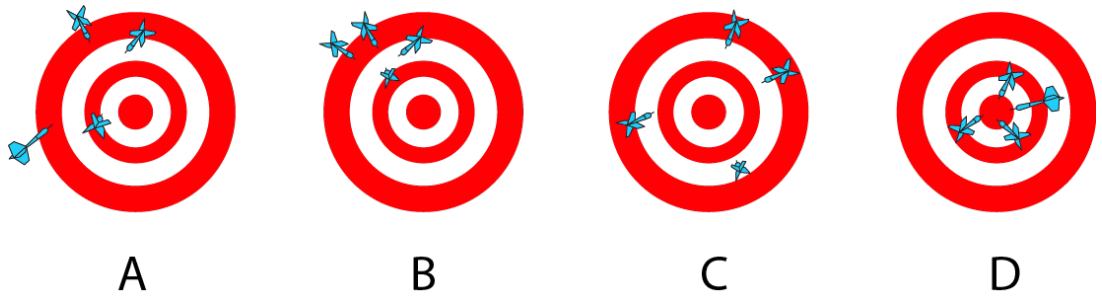
Sensor Specifications

Important Metrics



- Match a letter from the left to the following:
  - Accurate but imprecise
  - Precise but inaccurate
  - Imprecise and inaccurate
  - Precise and accurate

Important Metrics



- Match a letter from the left to the following:

C
- Accurate but imprecise
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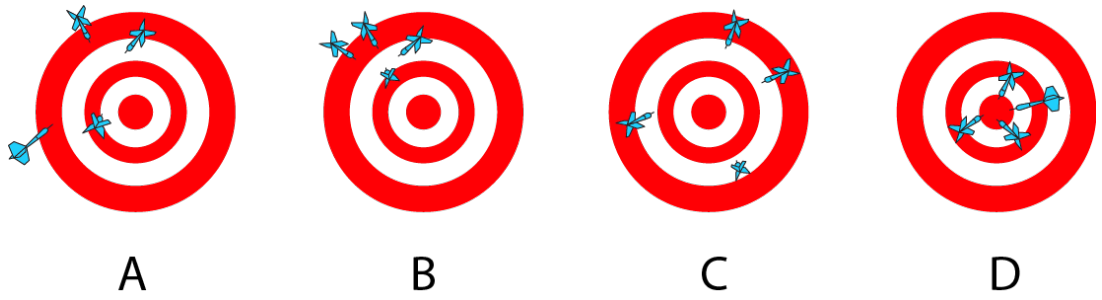
Important Metrics



- Match a letter from the left to the following:

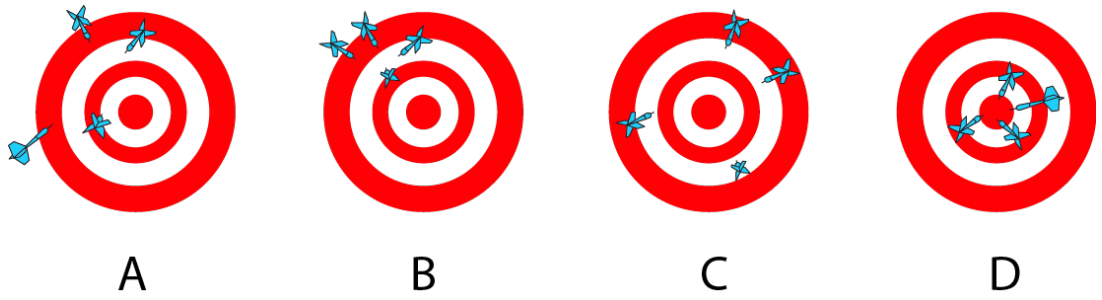
C • Accurate but imprecise

B • Precise but inaccurate

• Imprecise and inaccurate

• Precise and accurate

Important Metrics



- Match a letter from the left to the following:
  - C • Accurate but imprecise
  - B • Precise but inaccurate
  - A • Imprecise and inaccurate
  - D • Precise and accurate

Important Metrics

- Example: ”true” temperature is 100 °C
- Take 10 samples. Get average and stdev (report as average±stdev)

- Accurate but imprecise: thermometer measures 100.1±36 °C
- Inaccurate but precise: thermometer measures 56±0.2 °C
- Inaccurate, imprecise: 56±36 °F
- Accurate, precise: 100.1±0.2 °C

Important Metrics

- Exam
  temp
- Take
  aver
  (rep
  aver

Extremely important:
"accuracy" and "precision" are relative terms.

Values ascribed to them depends on application!

ermometer
±36 °C
nometer
2 °C
precise:

- Accurate, precise: 100.1±0.2 °C

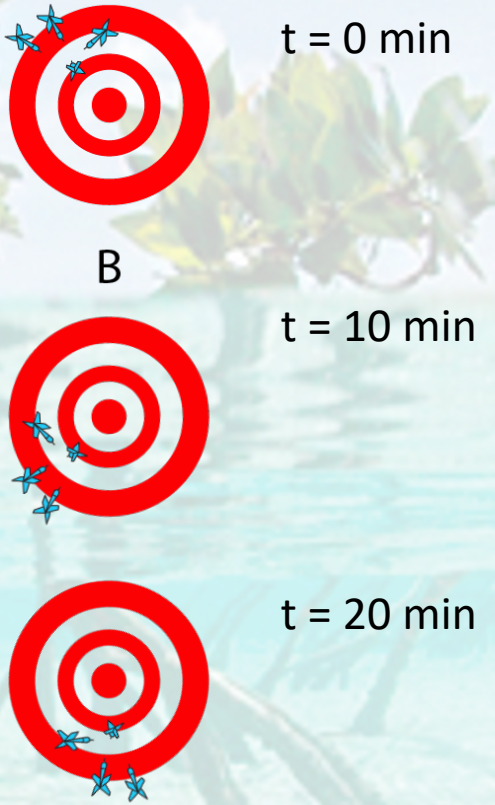
Important Metrics

- Accuracy, precision

https://manoa.hawaii.edu/exploringourfluidearth/physical/world-ocean/map-distortion/practices-science-precision-vs-accuracy

Important Metrics

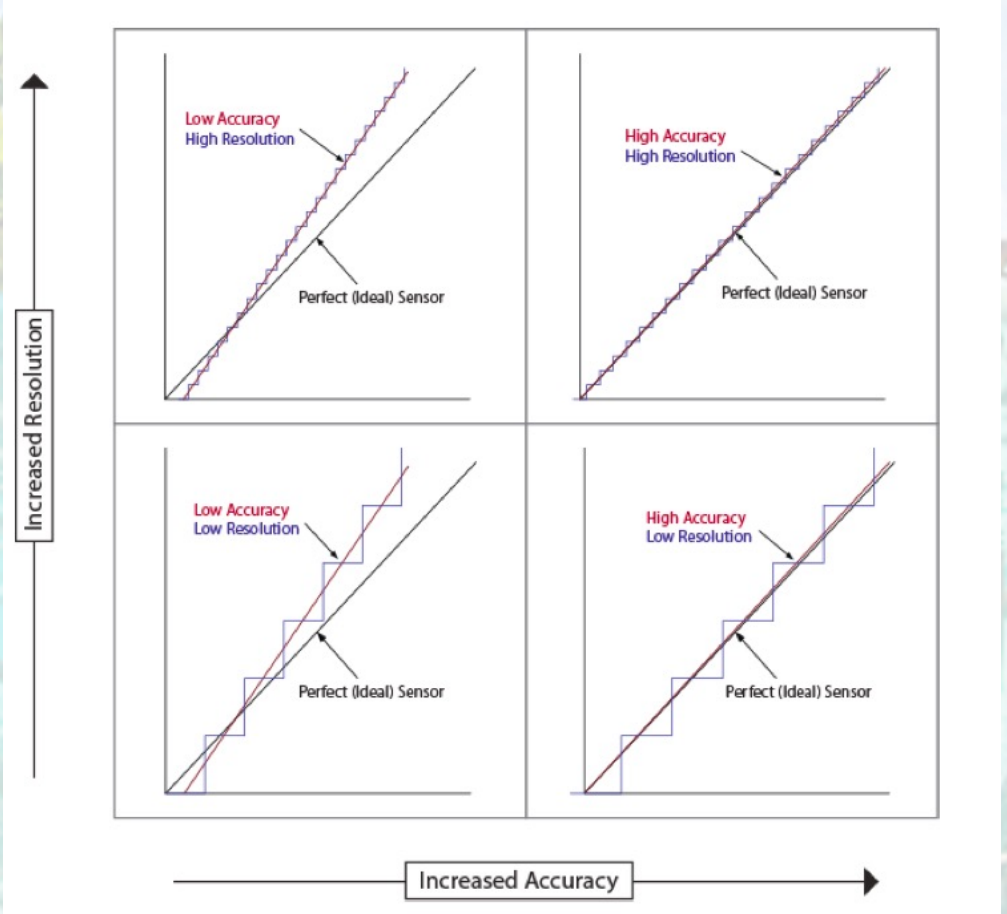
- Accuracy, precision, **stability**
- Continuing previous example:
  - Actual temperature not changing, but measurements are:
    - **t = 0 min, T = 99.8±0.2 °C**
    - **t = 10 min, T = 101.4±0.1 °C**
    - **t = 20 min, T = 103.7±0.2 °C**



https://manoa.hawaii.edu/exploringourfluidearth/physical/world-ocean/map-distortion/practices-science-precision-vs-accuracy

Important Metrics

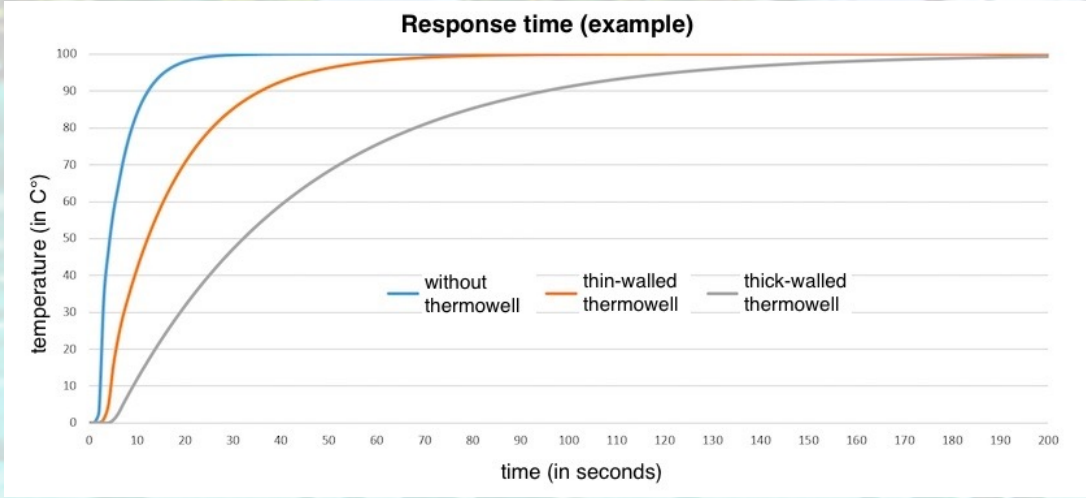
- Accuracy, precision, stability, **resolution**
- Does your thermometer tell you temperature to 1 degree? 0.1? 0.01?
- Just because there are more decimal points (higher resolution) does not mean it is more accurate!



https://www.allsensors.com/engineering-resources/white-papers/accuracy-and-precision-for-mems-pressure-sensors

Important Metrics

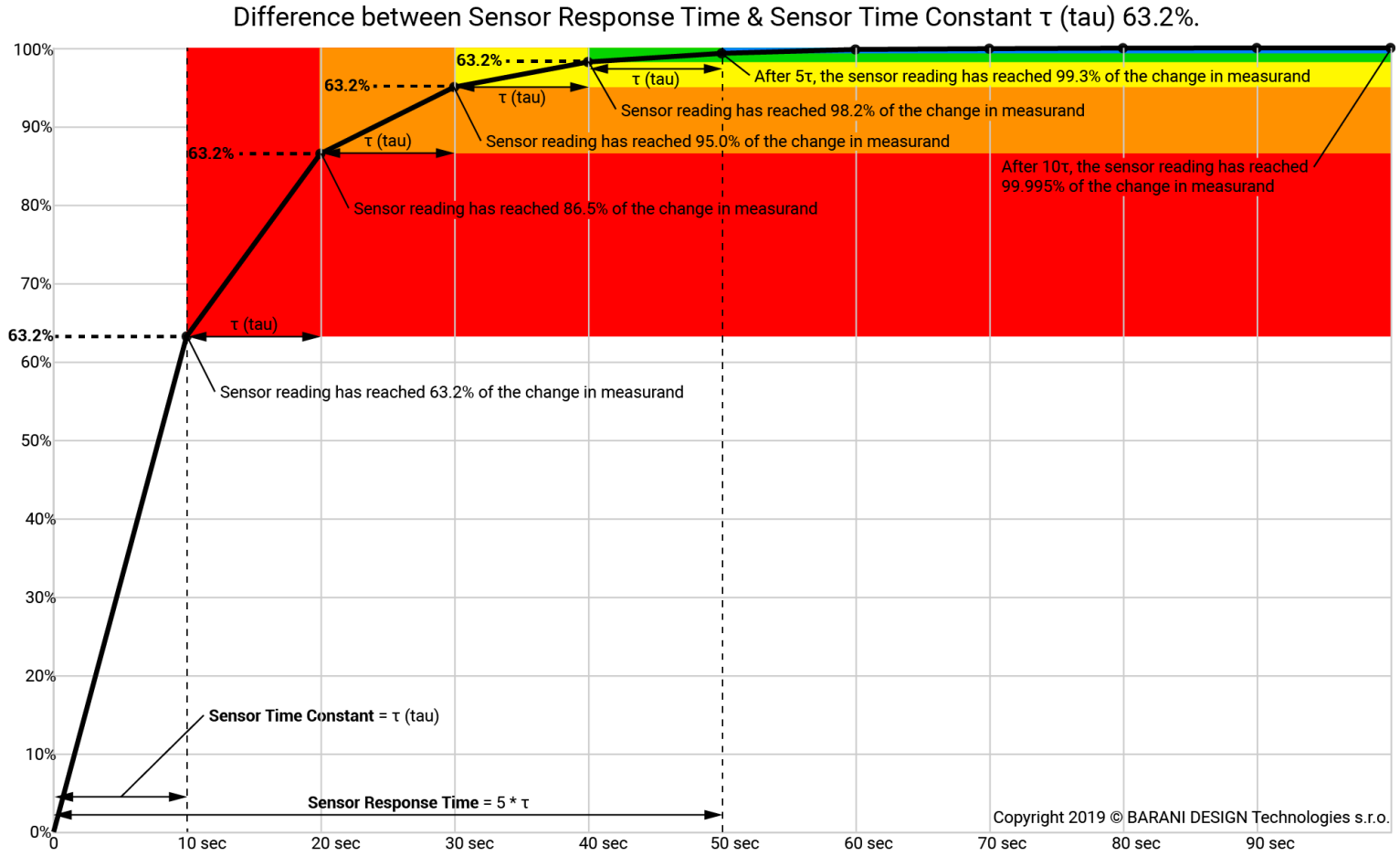
- Accuracy/precision/stability/resolution
- **Response time** (imagine you move a thermometer from an icewater bucket to a pot of boiling water; how long will it take for the thermometer to change temps?)



https://blog.wika.us/products/temperature-products/temperature-sensors-thermowells-and-response-times/

Response time defined

$$T = (T_2 - T_1)\left(1 - \exp(-t/\tau)\right) + T_1$$



https://www.baranidesign.com/faq-articles/2019/5/6/difference-between-sensor-response-time-and-sensor-time-constant-tau

Available technologies

- Which value do sensor manufacturers use? (Whatever they want—zero consistency in this arena)
- If your project requires accuracy, precision, stability, response time, etc., VERIFY for yourself
- Some manufacturers very honest, some report “best case scenario” or results of one specific, narrowly defined test

Spec sheet example

SPECS	VARIATIONS	DOCUMENTS	ACCESSORIES

Product Number	030-8-0006
Measurement range CO_2	0 to 5,000 ppm / 0 to 3%vol
Accuracy	±30 ppm ±3% of reading
Dimensions	51 mm x 58 mm x 12 mm
Operation temperature range	0 to 50 °C
Power supply	4.5 to 14.0 V DC
Communication	Uart (Modbus)
Outputs	
OUT $_1$ linear output	0 to 4 V DC = 0 to 2,000 ppm
OUT $_2$ linear output	1 to 5 V DC = 0 to 2,000 ppm
OUT $_3$ digital output	700/800 ppm
OUT $_4$ digital output	900/1,000 ppm

- What is accuracy @ current atmospheric CO2?
- Just because it works over a range of temp, pressure, salinity, etc. doesn’t mean it performs the same!

Spec sheet example

Specifications

Reads	Dissolved Oxygen
Range	0 – 100 mg/L
Accuracy	+/- 0.05 mg/L
Response time	~0.3 mg/L/per sec
Temperature range °C	1 – 60 °C
Max pressure	3,447 kPa (500PSI)
Max depth	352m (1,157 ft)
Connector	Male SMA / Male BNC *(optional)*
Cable length	1 meter
Internal temperature sensor	No
Time before recalibration	~1 Year
Life expectancy	~4 Years
Maintenance	~18 Months

Data and Metadata

Data vs. Metadata

- Data:
  - A measurement (from a sensor, analyzer, a ruler, etc.)
  - Observations, including numbers and words

Data vs. Metadata

- Data:
  - A measurement (from a sensor, analyzer, a ruler, etc.)
  - Observations, including numbers and words
- Metadata
  - Data about the data
  - How were data collected?
  - What was the instrument?
  - When was it last calibrated?
  - What are its calibration coefficients?
  - Who made the measurement?

Why?

- Research is meant to be reproducible
  - By you
  - By anyone who reads your paper, lab notebook, etc.
- You'll remember very little of your past work after weeks/months/years

```
Current time    5/22/2019 15:14
First sample    5/22/2019 15:14
Time zone   Local
File name   tanktest.txt
User initials   tw
Sampling period (s) 900
Standard interval   192
Standard multiple   2
pH Sample average   10
Pump on time (s)    10
Valve on time (s)   10
Sample Delay (s)    35
Standard Delay (s)  35
Low battery voltage (V) 10
TCOffset    0
Eo_int_25C  -0.4
Eo_ext_25C  -1.4
Default salinity (ppt)  33.5
Sensor name na
DuraFET SN  na
CAP adapter SN  na
ISE SN  na
MicroCAT SN na
Pump SN na
Pressure sensor full-scale (psi)    100
Vint gain   1
Vint sample rate (sps)  5
Deploy mode (pump on)

Sample #    Sample Time Main Batt   Vtherm  Vint    Vext Ref    Iso Batt    Controller Temp pH Temp Pressure (dBar) pH Int      pH Ext  Counter Le
#000000 5/22/2019 15:14 15.96   1.1449  0.049919    -1.003229   5.71    22.84   20.171  0.032   7.639134        6.124978    0   0.3379  5730    15
#000001 5/22/2019 15:30 15.96   1.15816 0.050541    -1.00323    5.73    21.98   19.784  0.063   7.652584    -0.01345    6.128183    0   0.3842  57
#000002 5/22/2019 15:45 15.96   1.16591 0.050774    -1.003203   5.73    21.57   19.56   0.057   7.658213    -0.005629   6.129792    0   0.4149  57
#000003 5/22/2019 16:00 15.96   1.17086 0.05083 -1.003249   5.71    21.33   19.417  0.141   7.660209    -0.001996   6.129409    0   0.4303  5730
#000004 5/22/2019 16:15 15.96   1.17413 0.050962    -1.00317    5.71    21.17   19.323  0.112   7.663165    -0.002956   6.130948    0   0.4469  57
#000005 5/22/2019 16:30 15.96   1.17641 0.051031    -1.003147   5.71    21.05   19.258  0.109   7.66483 -0.001665   6.131639    0   0.4468  5730
#000006 5/22/2019 16:45 15.96   1.17829 0.051071    -1.003129   5.73    20.96   19.204  0.136   7.665905    -0.001075   6.132409    0   0.4691  57
```

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1   Current time    5/22/2019 15:14
2   First sample    5/22/2019 15:14
3   Time zone   Local
4   File name   tanktest.txt
5   User initials   tw
6   Sampling period (s) 900
7   Standard interval   192
8   Standard multiple   2
9   pH Sample average   10
10  Pump on time (s)    10
11  Valve on time (s)   10
12  Sample Delay (s)    35
13  Standard Delay (s)  35
14  Low battery voltage (V) 10
15  TCOffset    0
16  Eo_int_25C  -0.4
17  Eo_ext_25C  -1.4
18  Default salinity (ppt)  33.5
19  Sensor name na
20  DuraFET SN  na
21  CAP adapter SN  na
22  ISE SN  na
23  MicroCAT SN na
24  Pump SN na
25  Pressure sensor full-scale (psi)    100
26  Vint gain   1
27  Vint sample rate (sps)  5
28  Deploy mode (pump on)
29
30  Sample #    Sample Time Main Batt   Vtherm  Vint        Temp pH Temp Pressure (dBar) pH Int      pH Ext  Counter Le
31  #000000 5/22/2019 15:14 15.96   1.1449  0.049919    -1.003      7.639134        6.124978    0   0.3379  5730    15
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35  #000004 5/22/2019 16:15 15.96   1.17413 0.050962    -1.003      7.663165    -0.002956   6.130948    0   0.4469  57
36  #000005 5/22/2019 16:30 15.96   1.17641 0.051031    -1.003      7.66483 -0.001665   6.131639    0   0.4468  5730
37  #000006 5/22/2019 16:45 15.96   1.17829 0.051071    -1.003      7.665905    -0.001075   6.132409    0   0.4691  57
```

METADATA

COLUMN HEADERS

DATA

This week—>Fall Break—>

- Consider what should be in your metadata and data. What info will you need?
- Build sensors on breadboards and make measurements
- Present (no slides needed) to class on **Oct. 20** on wiring and code—how does your sensor do what it does? What is your plan for the second half of the semester?