

Design Studio – Project 3 (Week 1)

This week you will:

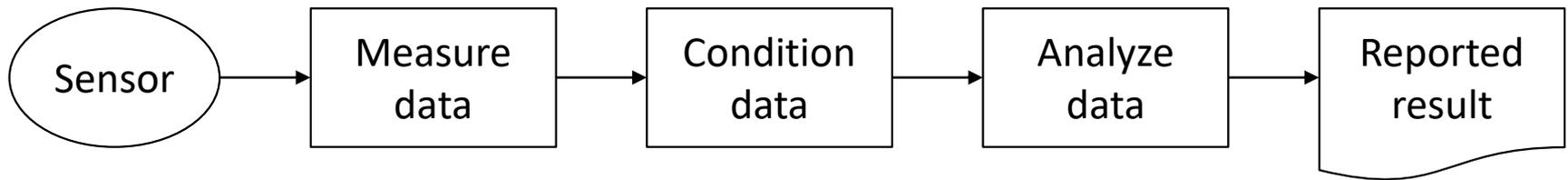
- Practice writing a good problem statement
- Discover applications of sensors
- Investigate methods for interpreting sensor data
- Identify a project for Project 3

Assignments:

- Prepare for a review of your project requirements (exercise worksheet and memo)

Project 3 – Overview

For the next five weeks of Studio, your team will be working on designing and developing Project 3, **a sensor-based application**.

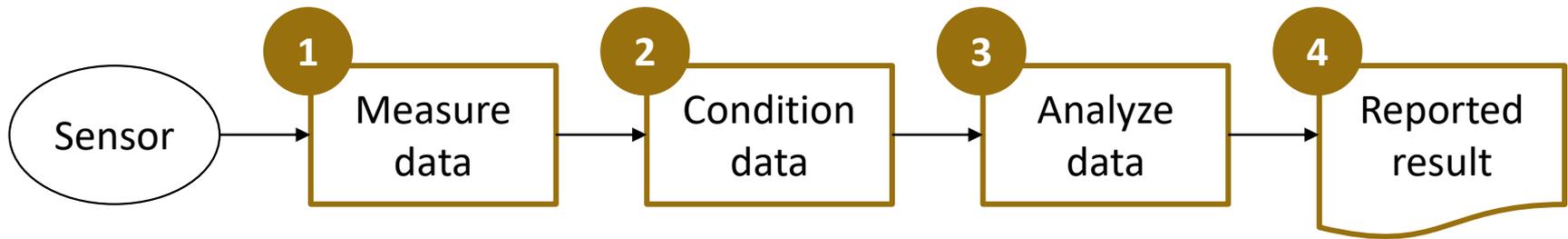


The application should:

- Measure data from one or more sensors
- Condition the data to make it more useful
- Calculate a result or detect an event within the data
- Report the result or event to the user

Project 3 – Overview

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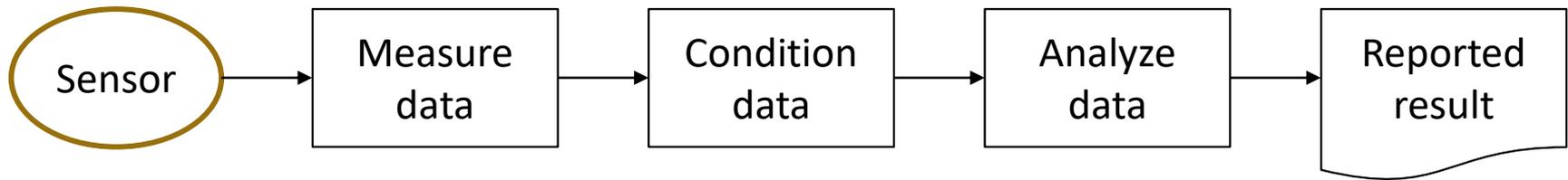


The application will be prototyped in **MATLAB**.

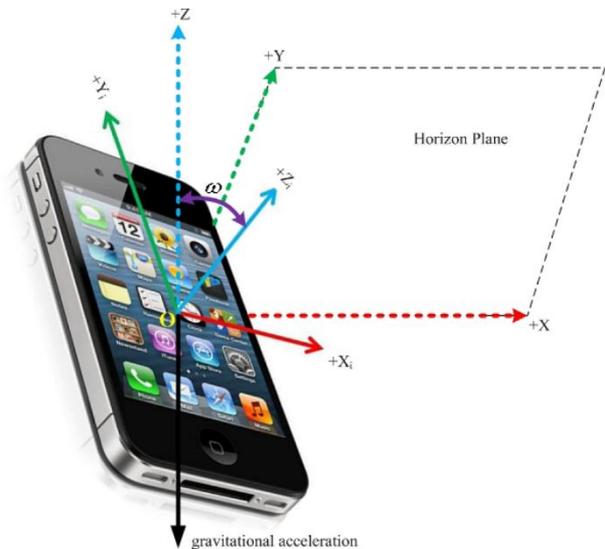
1. Read recorded sensor data from a CSV file
2. Condition the data to make it more useful (function)
3. Calculate a result or detect an event within the data (function)
4. Report the result or event to the user
(Command Window or popup)

Project 3 – Overview

While you will prototype the application using MATLAB, the sensor data for testing your design will be collected using your **smartphone**.



Your team will need to determine the necessary scenarios and environments in which to collect useful test data.



Sensors – Physics Toolbox Suite App

Smartphones have many sensors built into their hardware.

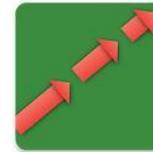
The Physics Toolbox by Vieyra Software* is a free educational app available on both Android and iOS.

It includes a suite of sensors interfaces that can be used to record data into a CSV file.

Data from a CSV file can be read into MATLAB for analysis and visualization.

* Physics Toolbox website:

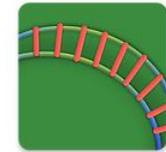
<https://www.vieyrasoftware.net/physics-toolbox-sensor-suite>



Accelerometer



Gyroscope



Roller Coaster



Orientation



Wear



Proximeter



Compass



Magnetometer



Ruler



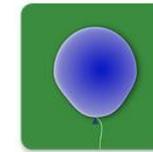
GPS



Light Meter



UV Meter



Barometer



Color Detector



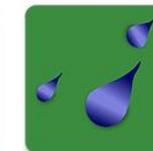
Tone Detector



Sound Meter

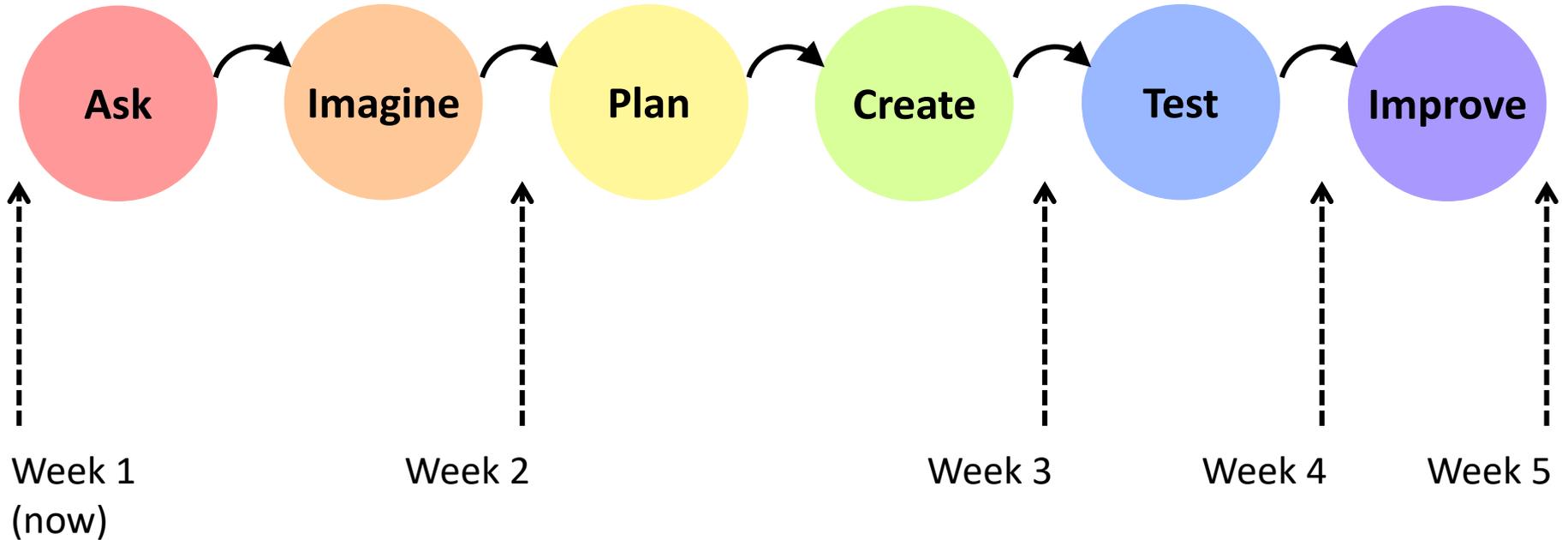


Thermometer



Hygrometer

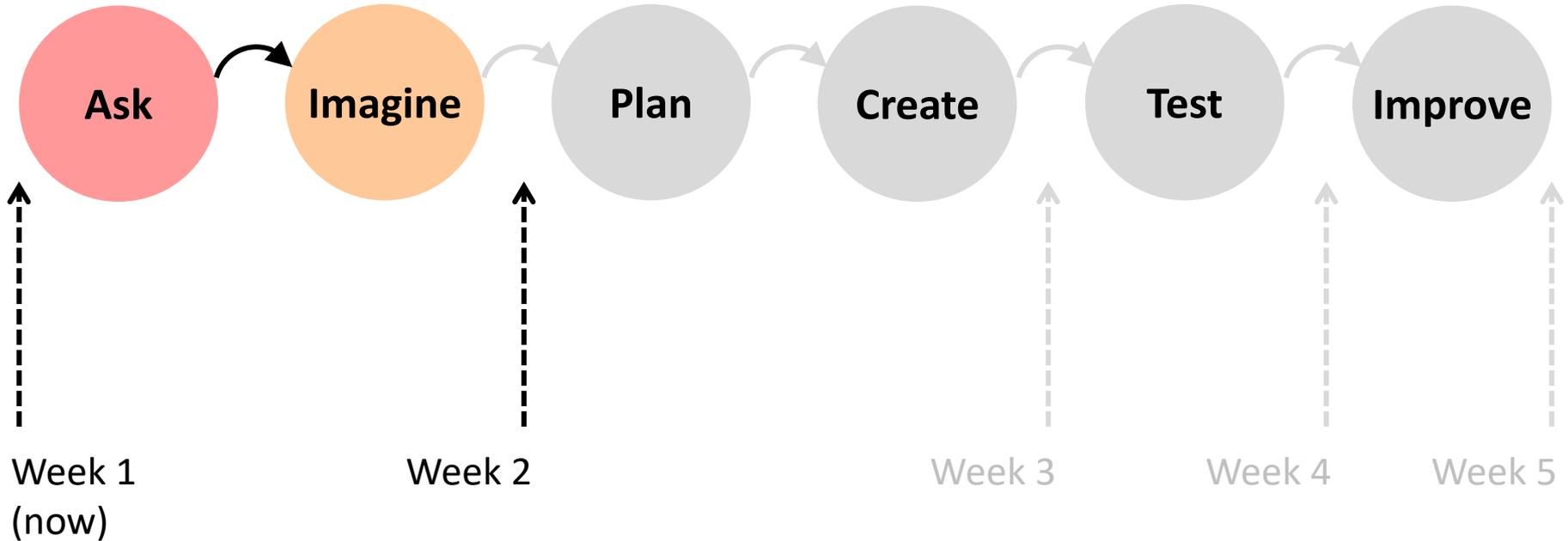
Project 3 – Schedule



Weeks 2 through 4 will have a group exercise and memo due.

Week 5 will conclude with your technical report and presentation.

Project 3 – Week 1 to Week 2



Over the next week you should identify your project and write a problem statement and requirements.

This week's exercise worksheet will help guide your way.

Defining the Problem or Need



Ask

Problem formulation is very important to the design.

What is the impact of a good understanding of the problem?

- Poor definition of the problem can lead to delays figuring out what to do, or even working on the wrong thing.
- Good definition of the problem often requires research beyond common knowledge.
- *“A problem well defined is a problem half-solved.”* – John Dewey

The Problem Statement

Ask

Thorough understanding of the problem or need will allow you to define the reasoning of the design in a **problem statement**.

A problem statement:

- Clearly defines the need
- Should be descriptive but concise
- Tries to avoid describing the solution

One easy way to start writing a problem statement is use this form:

_____ **needs** _____ **because** _____ .

Sensors – Force and Acceleration

As their name suggests, accelerometers measure acceleration, which has direct mathematical relationships to force, velocity, and position.



Accelerometer



Gyroscope

The Physics Toolbox Suite has two modes for the accelerometer:

- g-force meter
- linear accelerometer

The g-force meter measures the ratio of forces in all three directions with respect to gravity (e.g. F_x/F_g).

The linear accelerometer measures acceleration in all three directions, but with the effect of gravity calculated out.

The calculation is done with the aid of a gyroscope, which can be used to identify the orientation of the smartphone.

Sensors – GPS

The GPS sensor uses satellite signals from the global positioning system to calculate accurate location and time.



Calculating position, velocity, and even acceleration with GPS is significantly more accurate than using accelerometer data.

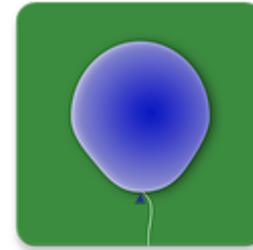
However, the calculations, which must account for the spherical geometry of the Earth, are also a lot more complicated.

The best feature of the GPS sensor is that it also reports a very accurate reading of speed, which can be used in many applications.

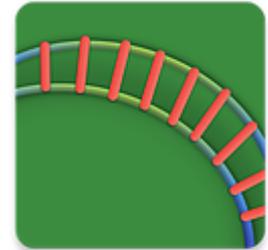
Sensors – Air Pressure

Barometers measures atmospheric pressure.

While it's not advised to put your phone in a hot air balloon or submerge it under water, you can still use air pressure for significant calculations without a large change in elevation.



Barometer



Roller Coaster

In fact, many devices use barometric pressure to determine when you have changed floors within a building.

The roller coaster mode of the Physics Toolbox on Android OS pulls in data from the accelerometer, gyroscope, and barometer simultaneously. In fact, on Android you can customize the sensor recording to record your own combination of multiple sensors.

Sensors – Temperature, Light, and Sound

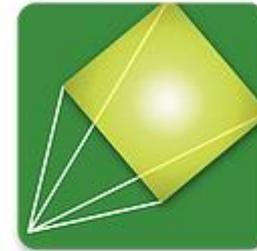
Physics Toolbox can tie in measurement related to the perception of temperature, light, and sound.

The thermometer is not available on most devices, and can be highly affected by the heat of the phone.

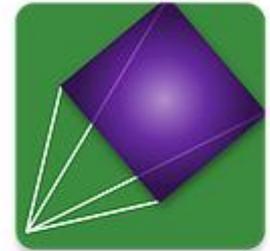


Thermometer

The light meter (and UV meter where available) measure illuminance on one of the optical inputs to the phone (e.g. camera).



Light Meter

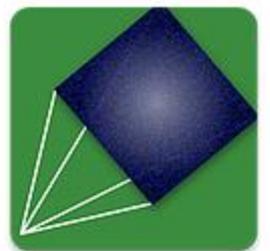


UV Meter

The tone detector and sound meter use the microphone to measure and record audio. The tone generator can be used to create a tone to be measured from a second device.



Tone Detector

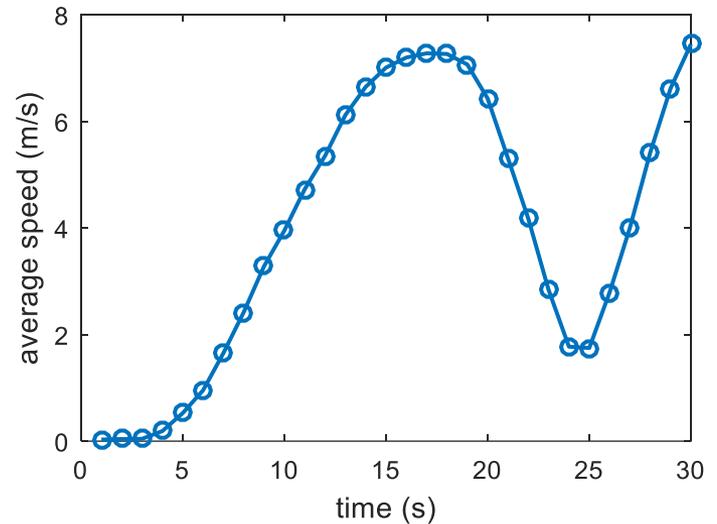
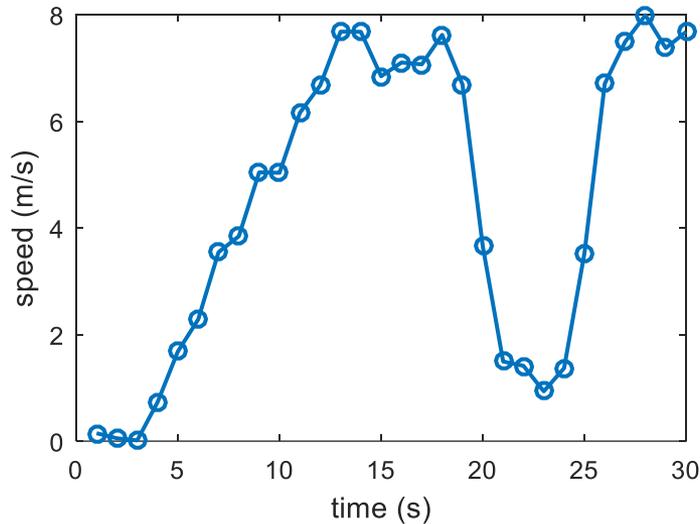


Sound Meter

Sensors – Conditioning

Most raw data collected from sensors require **conditioning** – mathematical adjustments to make the data more useful.

The most common adjustment is **filtering** – a form of averaging. The idea of filtering is to remove noise and error from the data, which is quite common in sensor measurements.

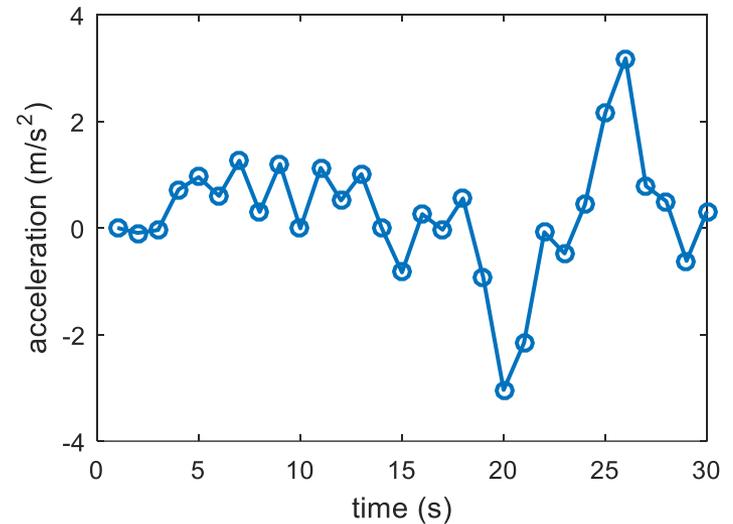
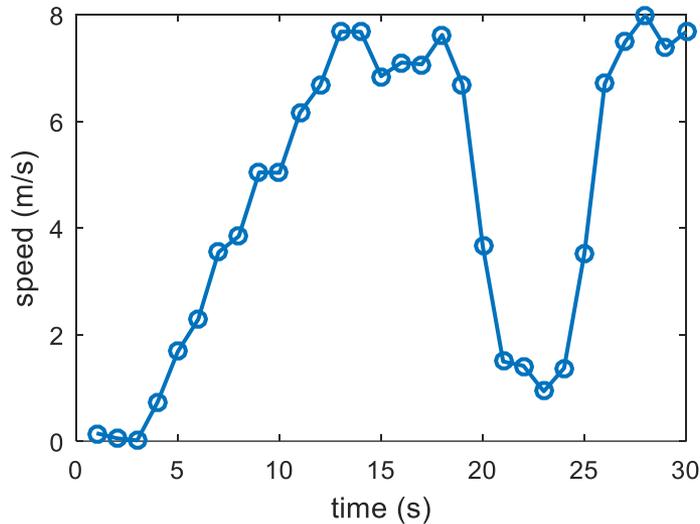


Sensors – Conditioning

Most raw data collected from sensors require **conditioning** – mathematical adjustments to make the data more useful.

Another available conditioning method is **differentiation**.

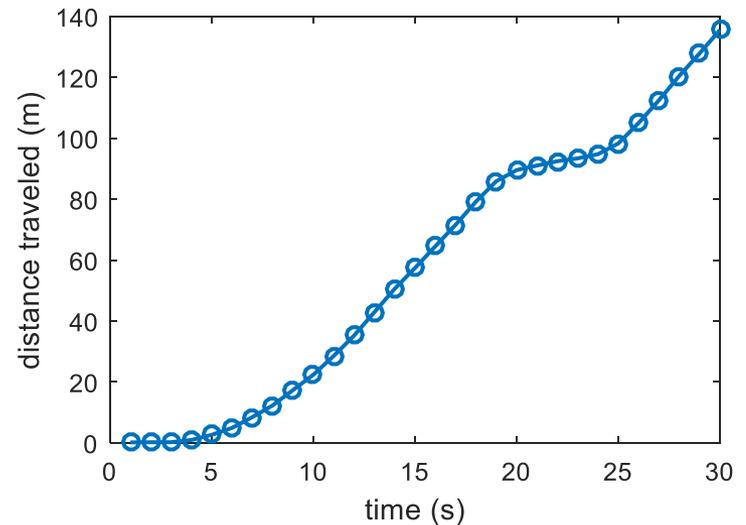
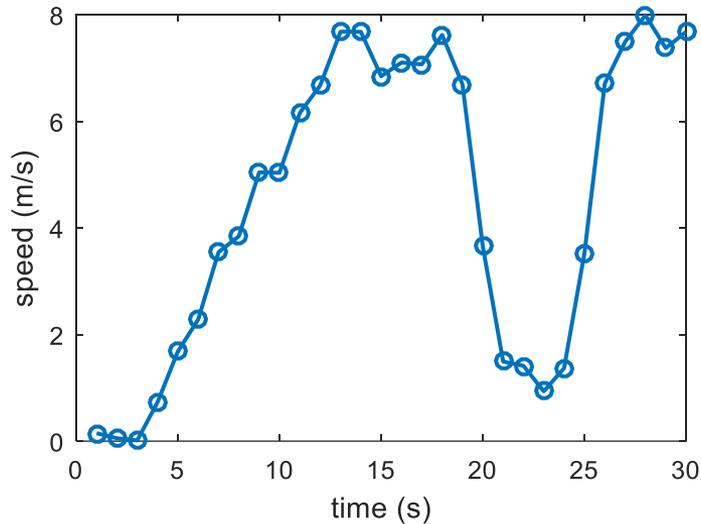
Measuring the change between samples is like taking a derivative and is useful in tracking the sensors change over time.



Sensors – Conditioning

Most raw data collected from sensors require **conditioning** – mathematical adjustments to make the data more useful.

The other available conditioning method is **integration**. Integration measures the cumulative sum of the data samples to observe the accumulation over time.



Writing Good Requirements



Ask

Project 3 will be your first opportunity to write requirements.

Writing good requirements is not easy and requires revision and practice, so don't be disheartened if you need to keep improving your own requirements.

An important key to writing good requirements is to remember that they specify what your design does, not what your end-user does.

For example:

(OK) The user will turn the device on by pressing a button.

(Better) The device will turn on when the user presses the power button.

Quantifiable and Testable Requirements

Ask

Good requirements are also quantifiable and testable:

- Quantifiable means that the performance can be specified numerically.
- Testable means that the numerical performance can actually be measured and checked.



["City Slickers," 1991](https://www.youtube.com/watch?v=4pbVxyL-OeM)

<https://www.youtube.com/watch?v=4pbVxyL-OeM>

If you can't specify the expected performance of your design or how to measure the actual performance, how do you know that the design works?

This Week's Assignments

Exercise

Complete the worksheet distributed by your instructor.

- Follow the directions to determine your design problem and write your design requirements.
- Submit the completed worksheet and memo as directed by your instructor **before the start of the next Studio.**

With any extra time this week, your team can get started on planning the development of your design.

This means:

- Assigning tasks to the team using the Task Tracker
- Scheduling the task and milestones using the Project Schedule