BPK 409
Wearable Technology and Human Physiology

BPK | WEARABLES

Data Acquisition

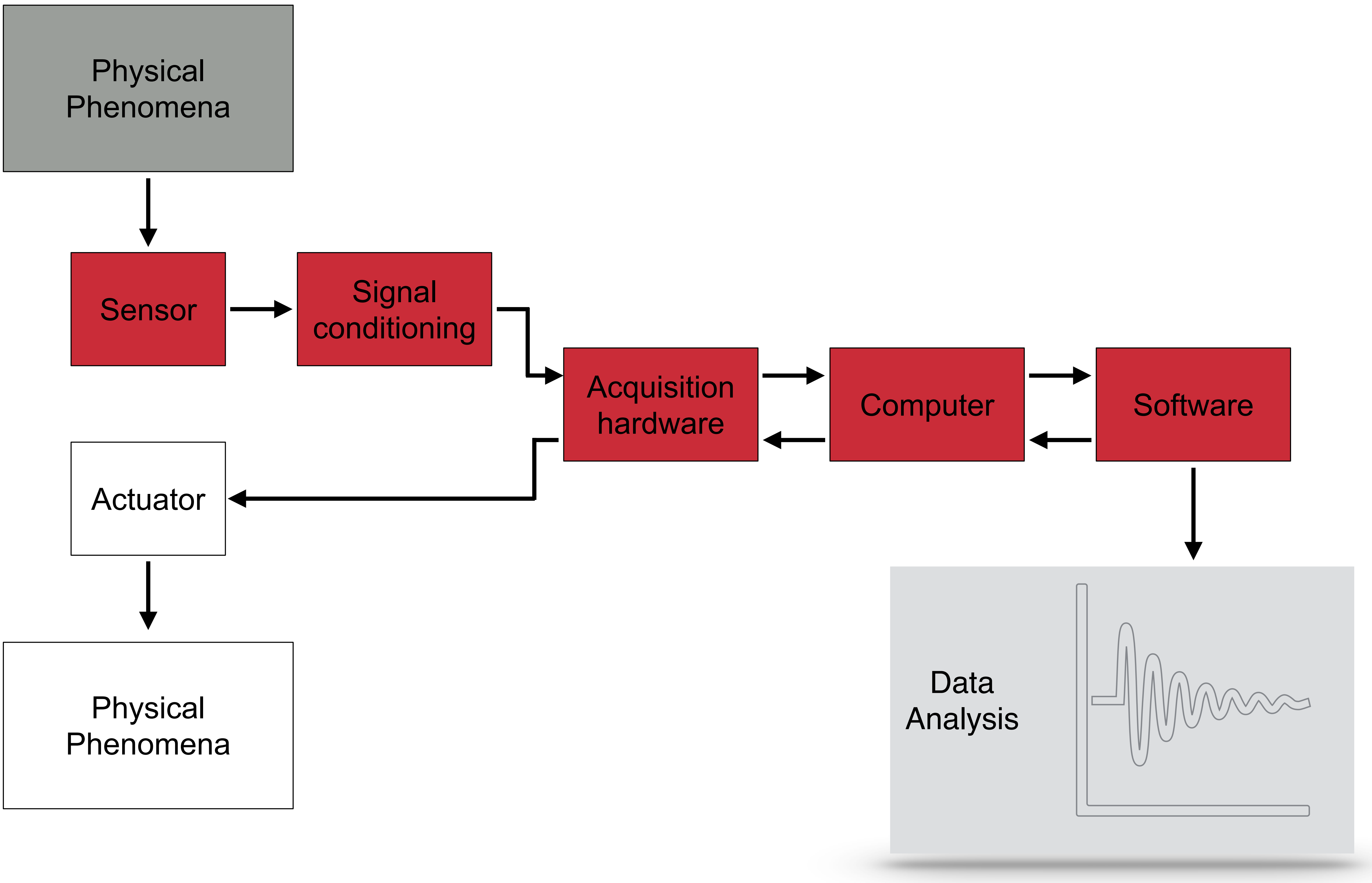
Learning Objectives

How do we make measurements from the real world?

What important principles govern how we make these measurements?

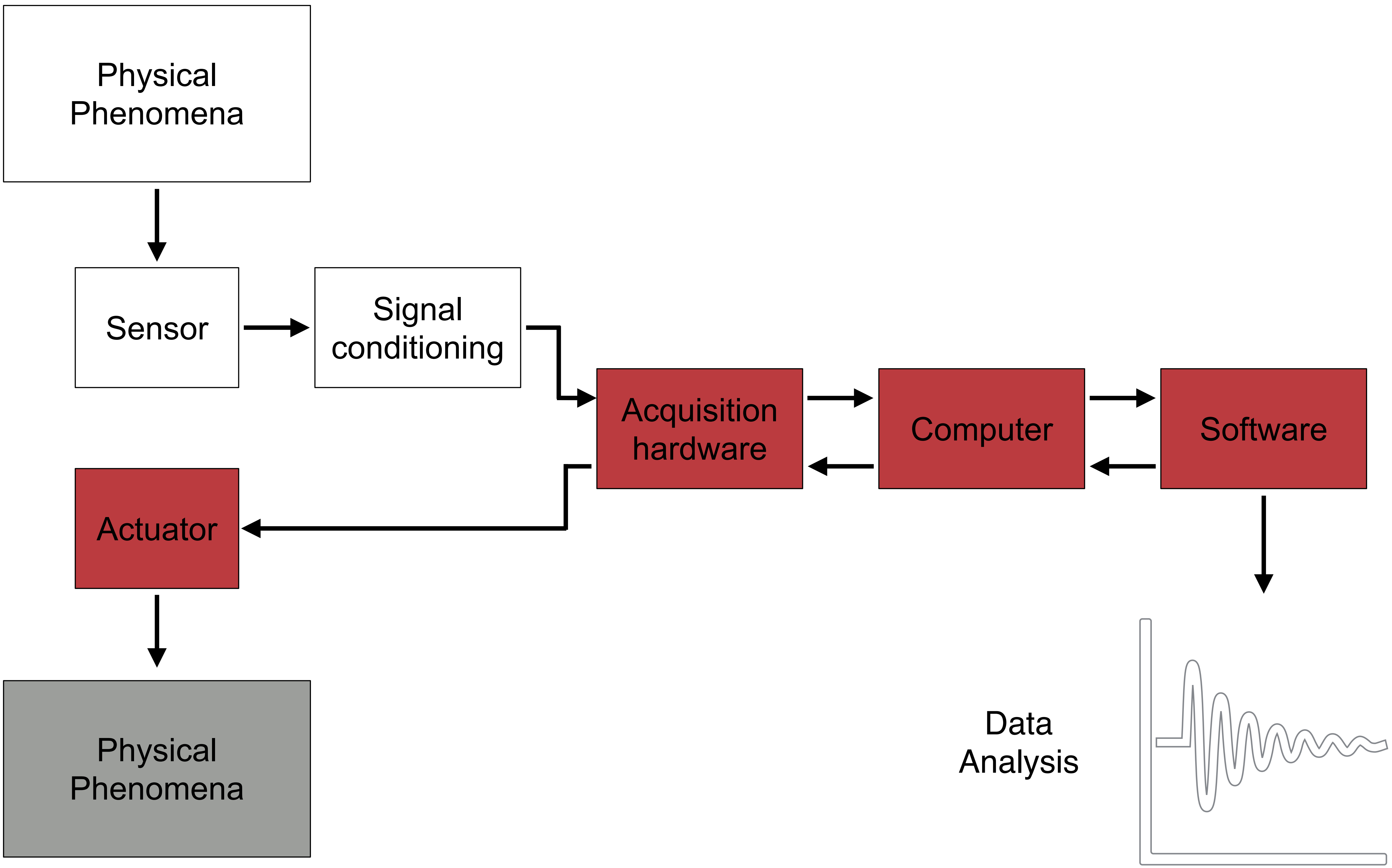
What are the characteristics of these measurements?

Overview



(Mathworks Data Acquisition Toolbox Manual)

Overview



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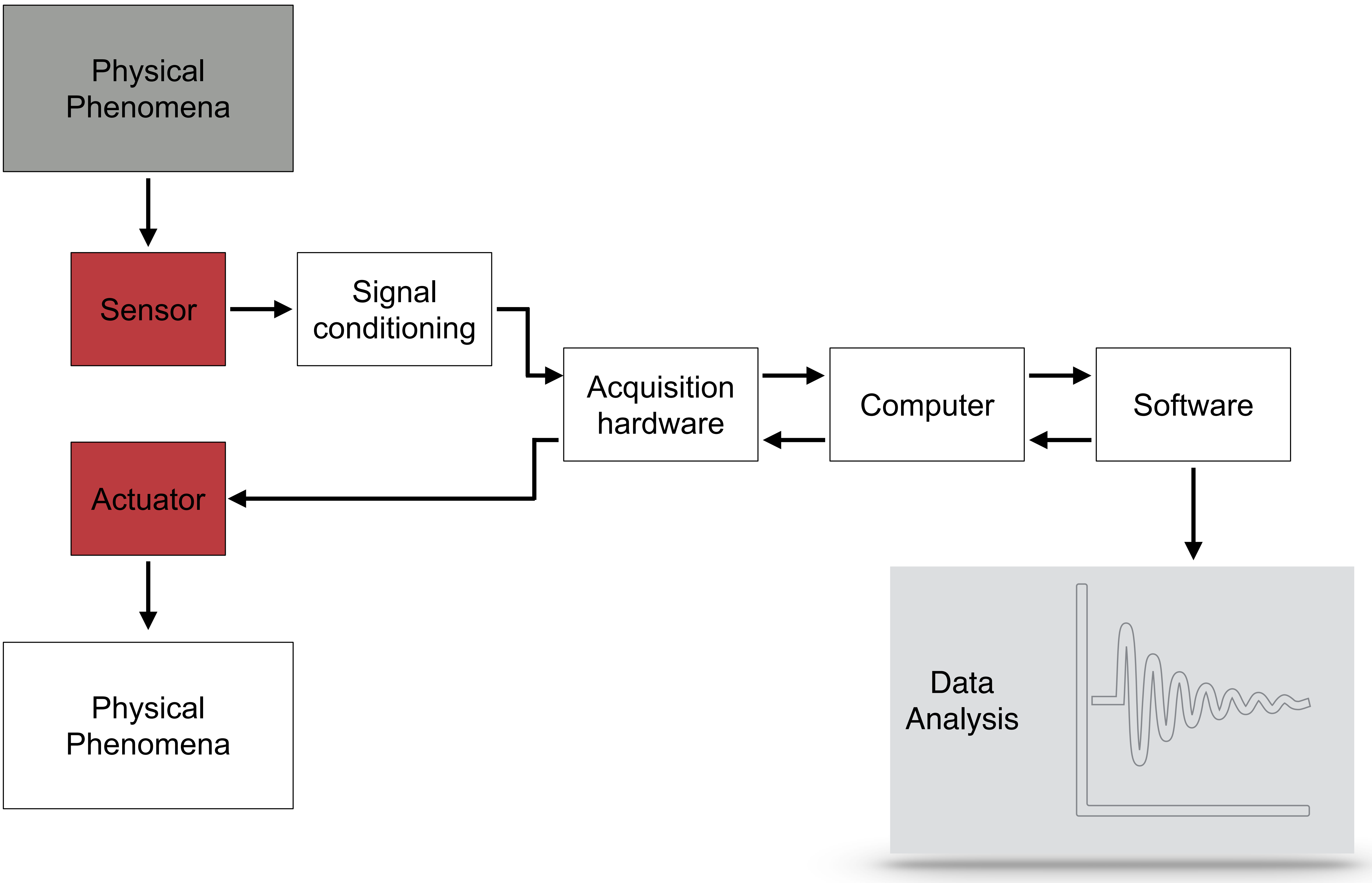

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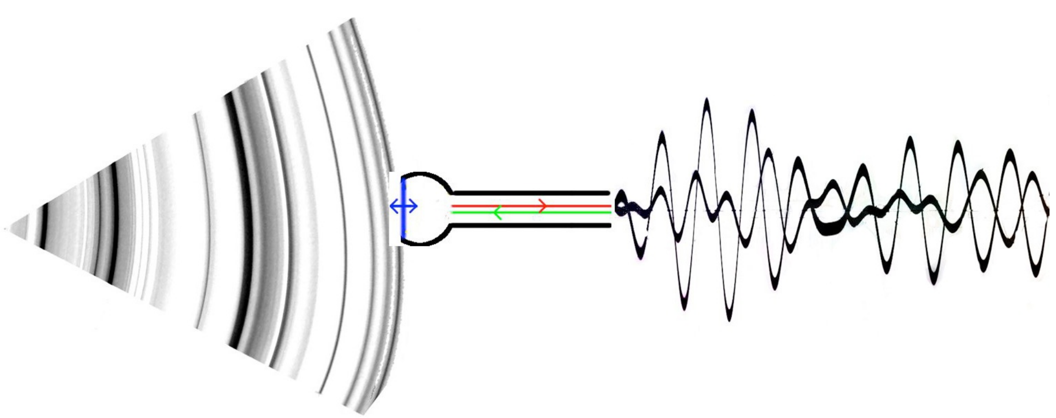
Transducers

A transducer is a device that **converts input energy of one form into output energy of another form**.

Sensors and actuators can **both** be **transducers**.

A sensor converts the physical phenomena of interest into a signal that is input into your data acquisition hardware (typically a voltage).



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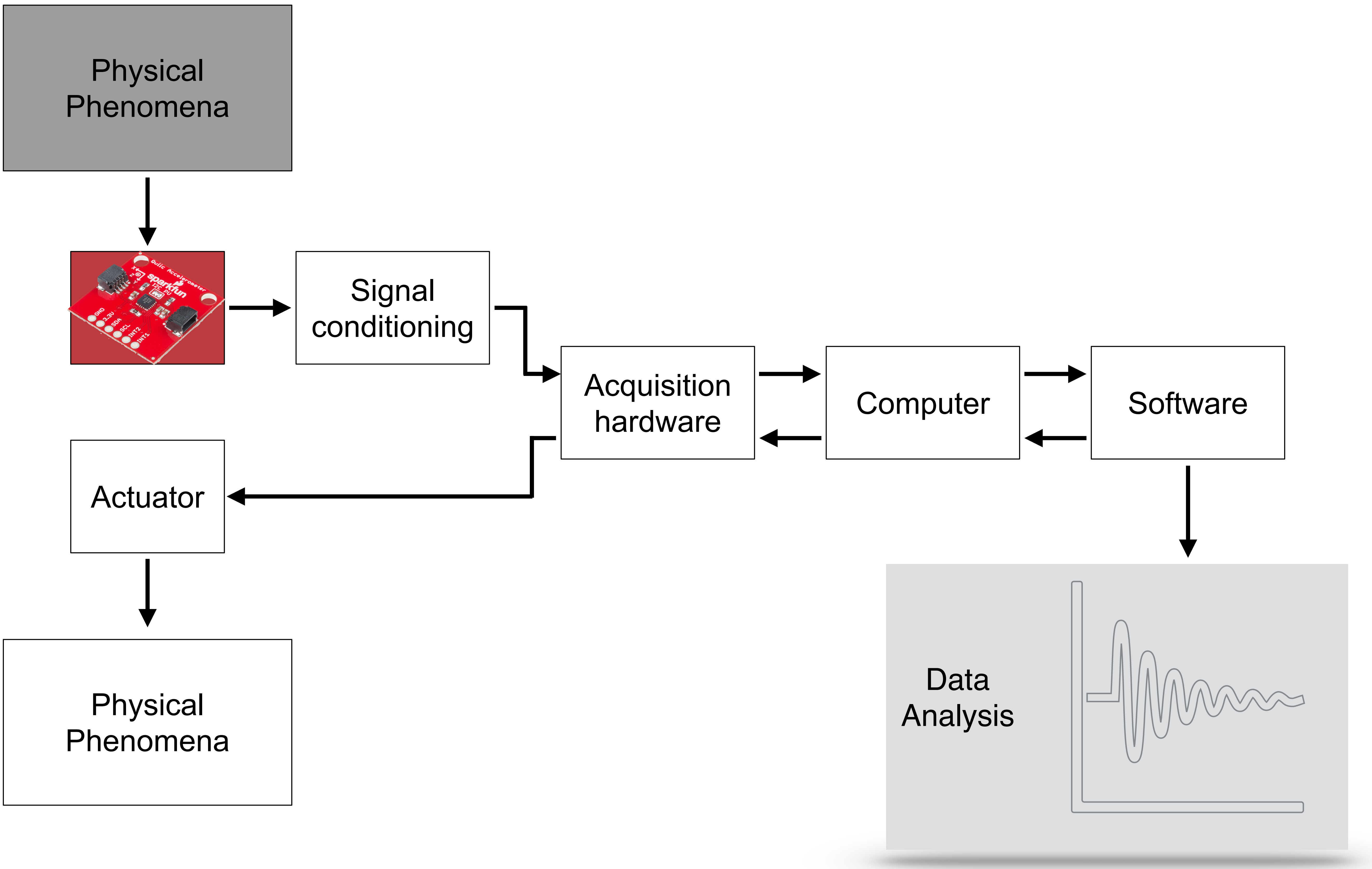

(SparkFun, Mathworks Data Acquisition Toolbox Manual)

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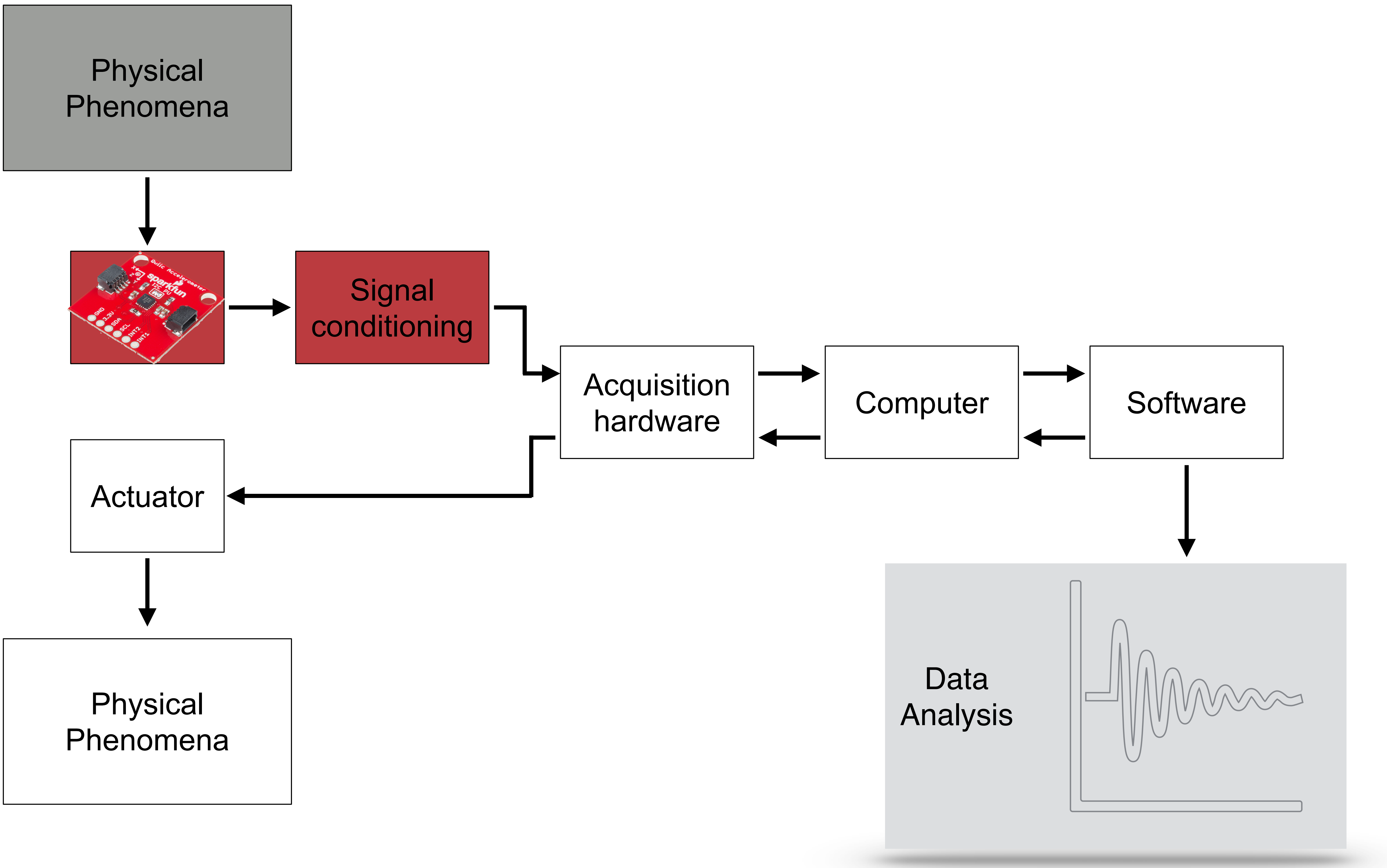

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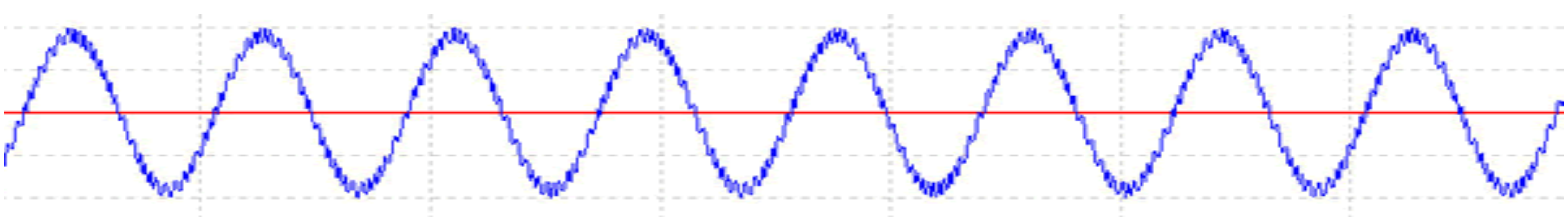
Signal Conditioning

We often need to alter signals from our transducers before passing them to our acquisition hardware. A primary reason for doing so is to minimize the effects of unwanted 'noise'.

Internal noise
Noise that arises from inside our equipment

External noise
Noise that arises from the external environment



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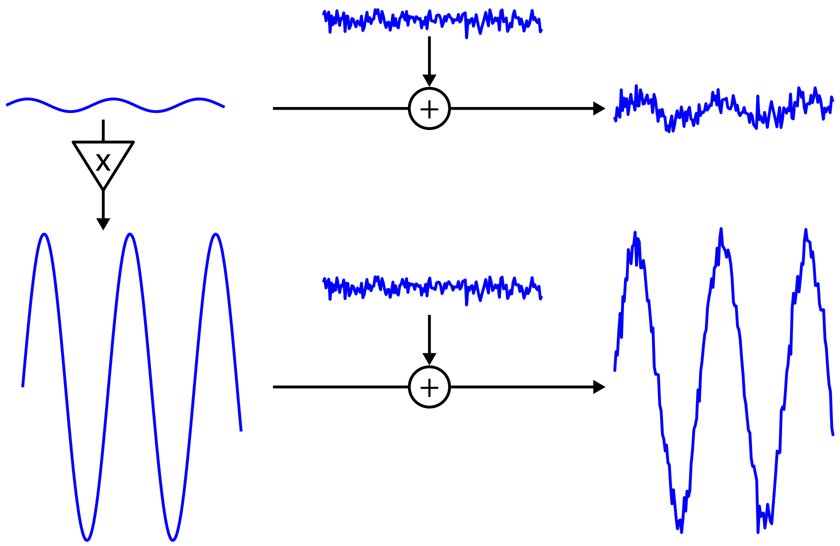
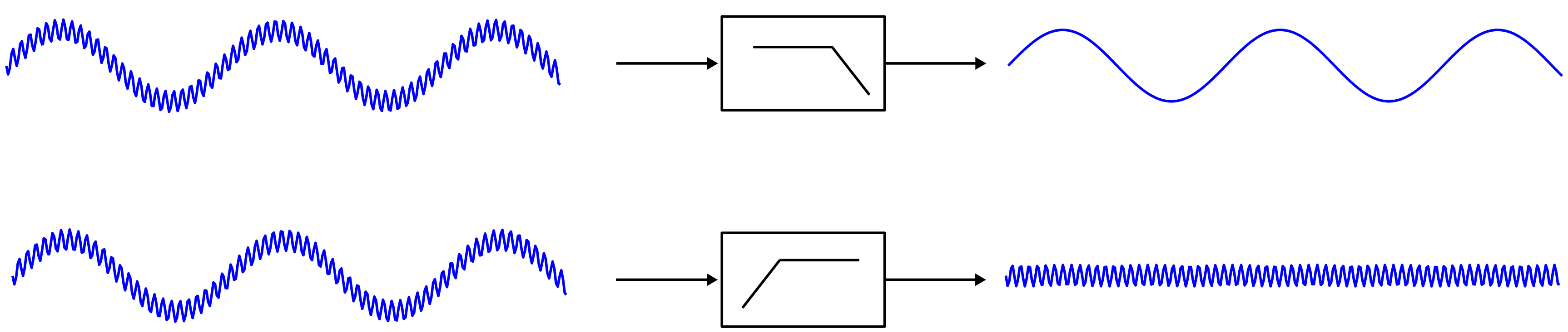
Signal Conditioning

We can remove noise with:

Amplification:
Amplify the signal before noise can be added.



Filtering:
Removes unwanted noise from the signal.



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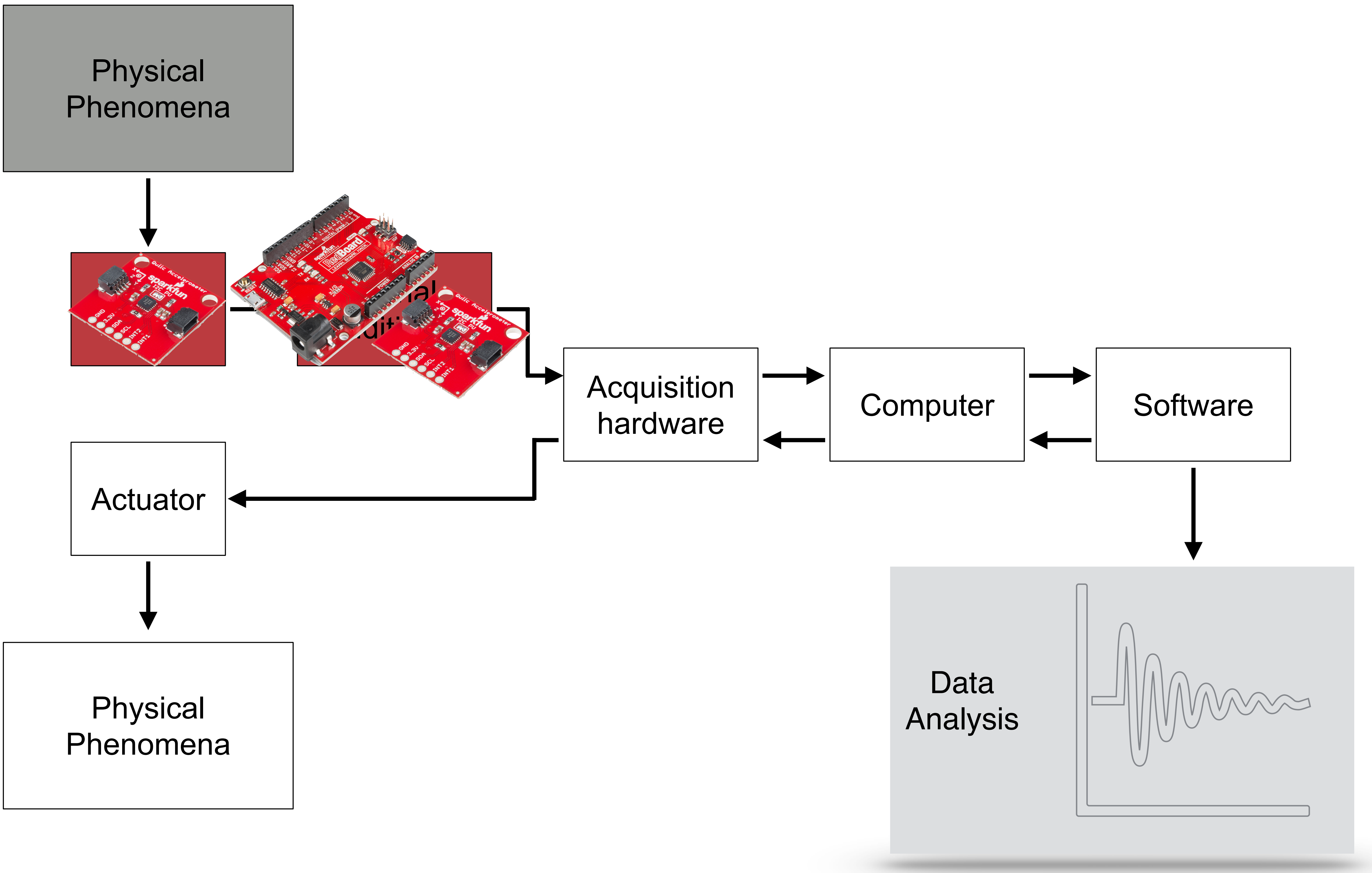

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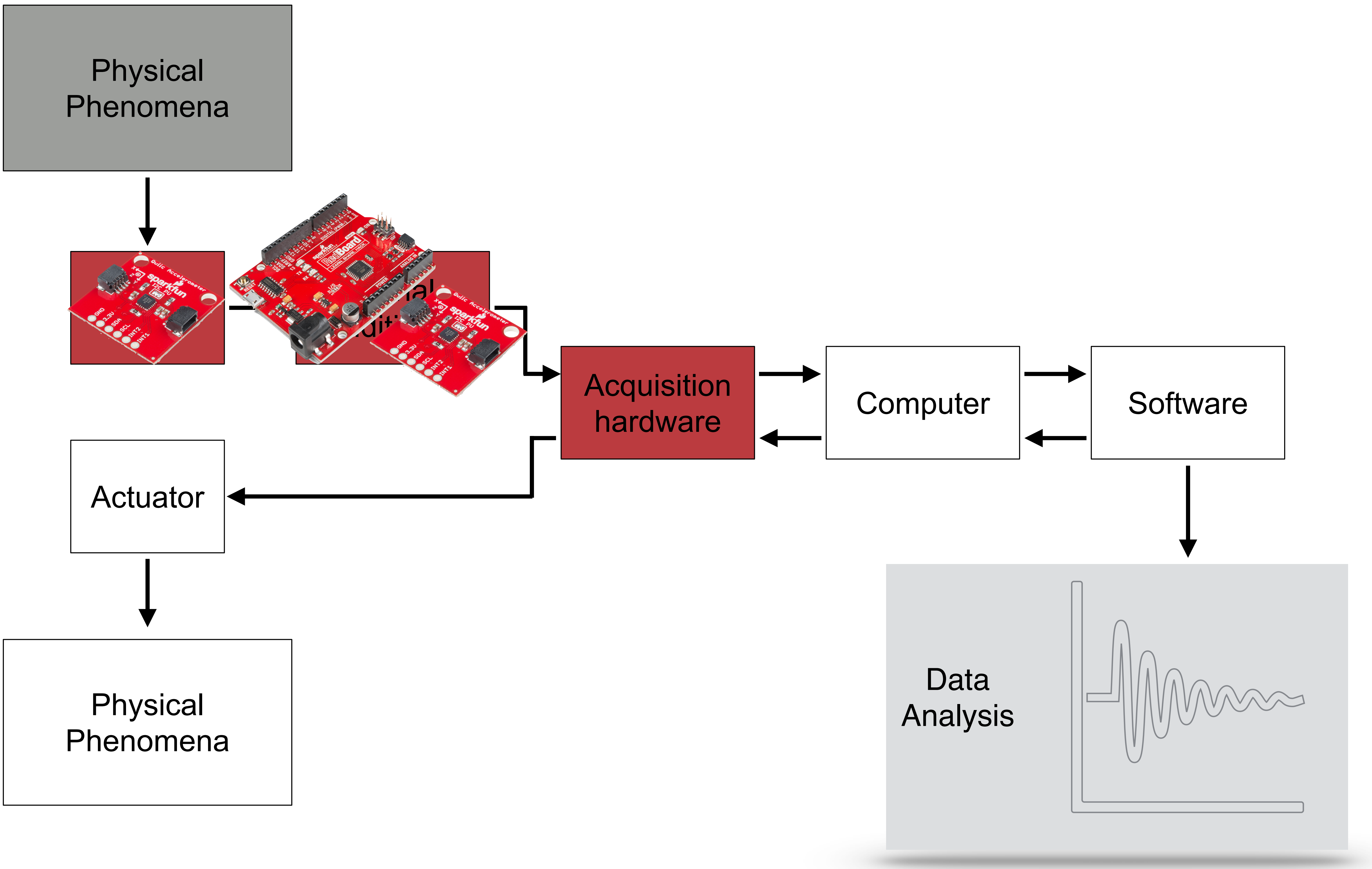

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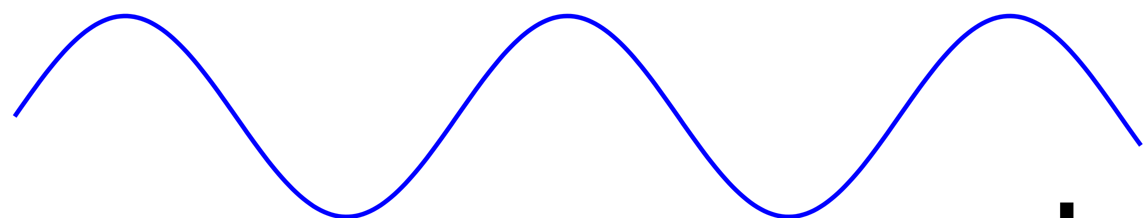
Analog and Digital Worlds

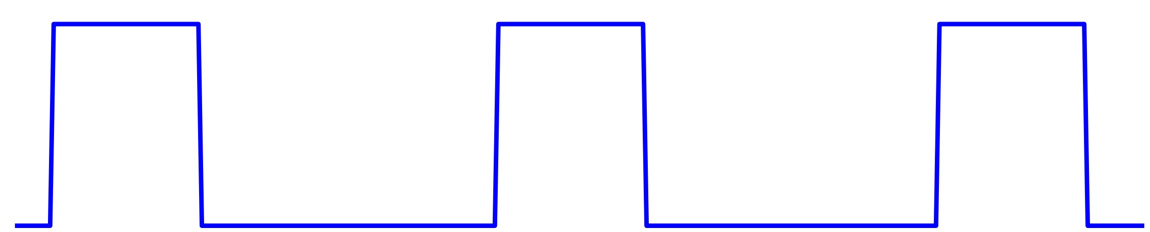
Analog

Continuous in time and space



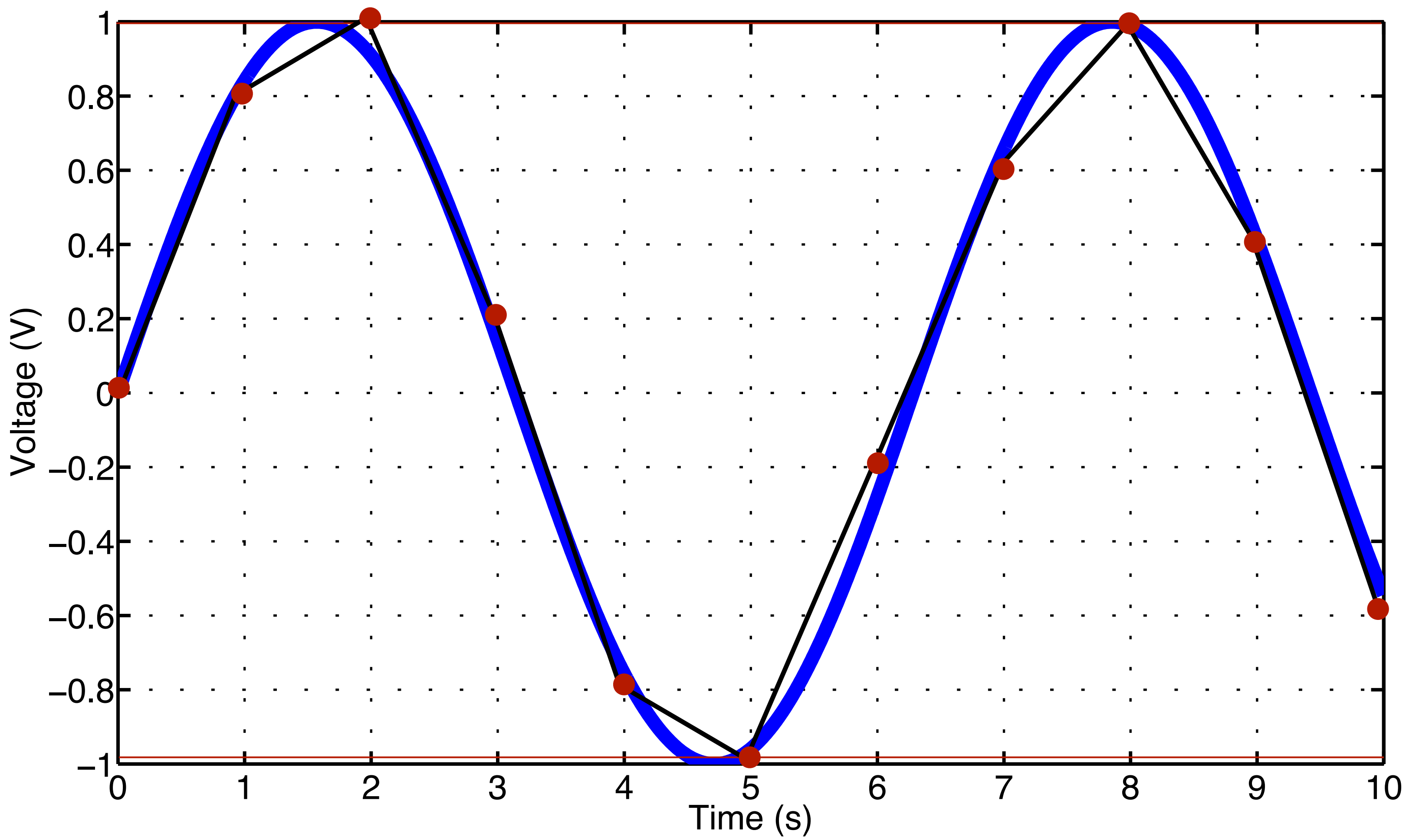
Digital

Discrete in time and space



Digitization

Conversion of continuous analog data in to digital data via the combination of *sampling* and *quantization*.



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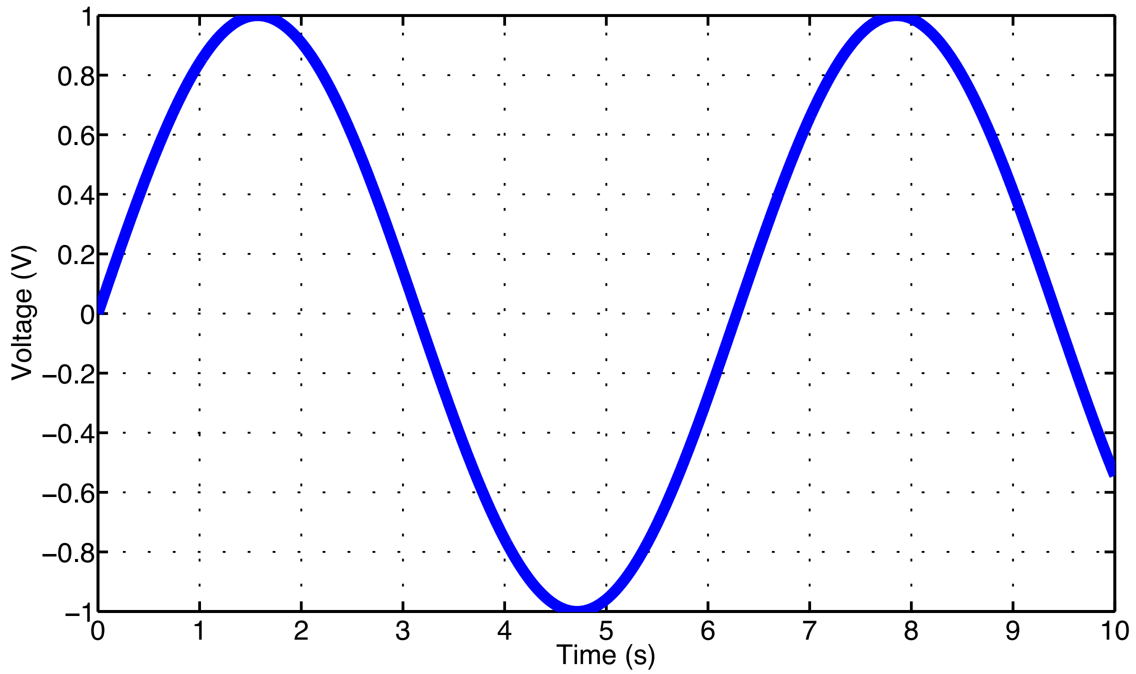

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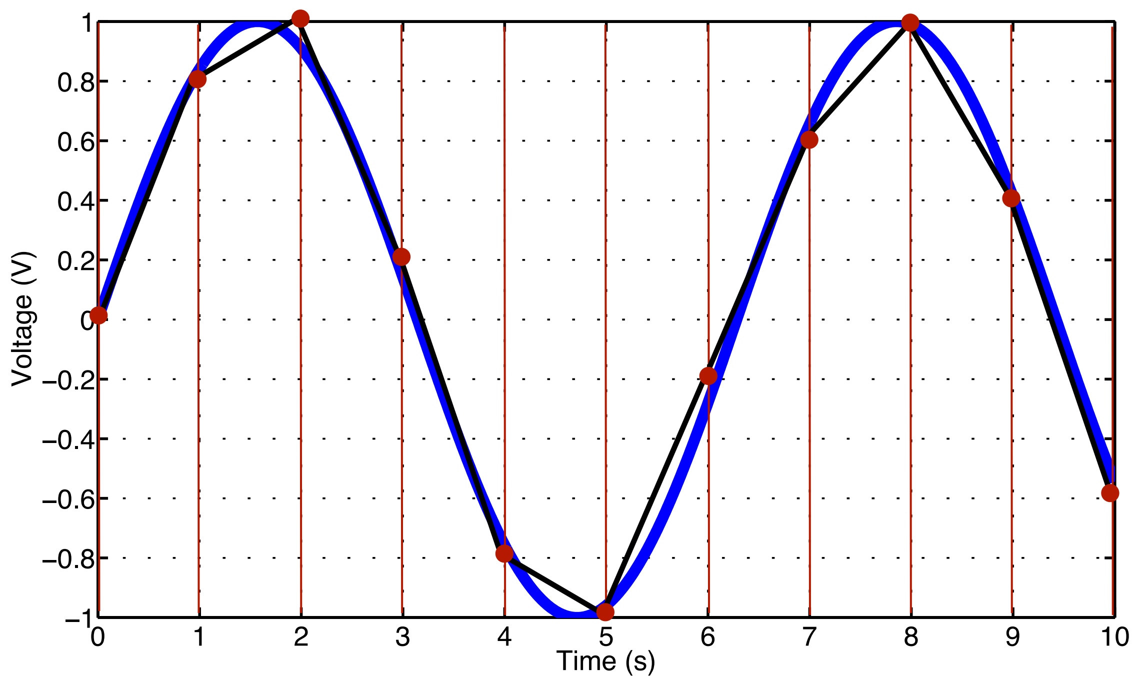
Sampling: Snapshot of the continuously varying sensor signal at discrete times.



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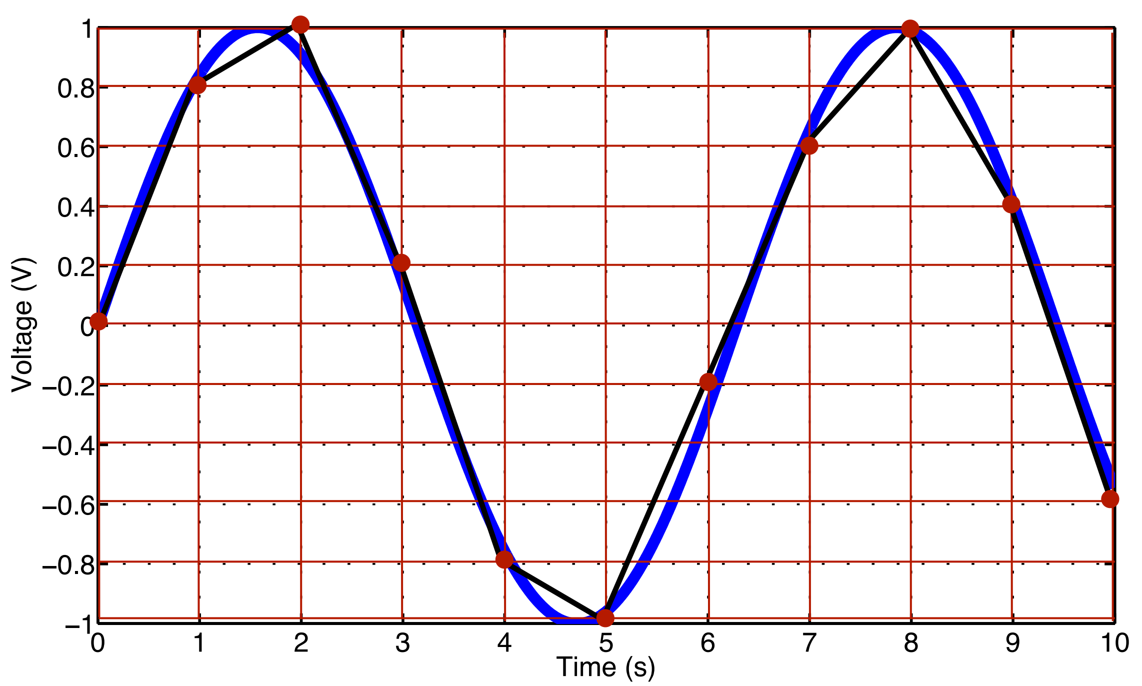

Quantization: Divides indefinitely precise values into discrete amplitudes.

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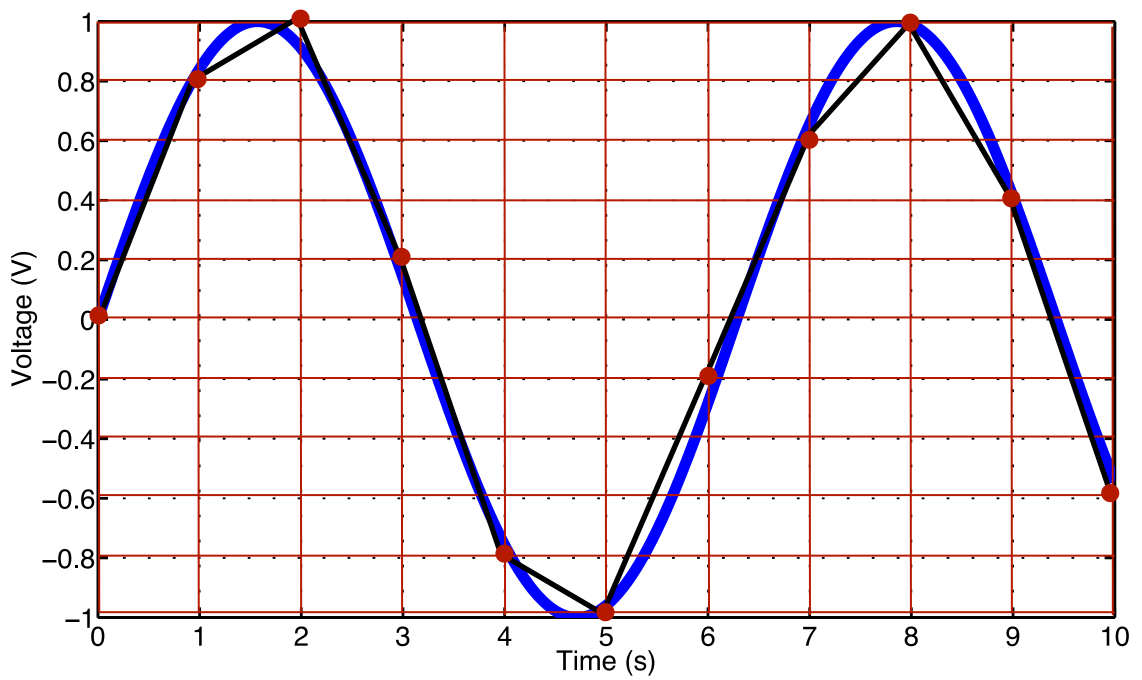

Sampling Frequency (Hz): 1 over the time between samples.

Resolution: Minimum difference between the discrete amplitudes.

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Digital Information

We use a base 10 system to count: 0 to 9.

Computers use binary system with base 2 to count.

This system only consists of two different values: 0s and 1s

A bit is one binary digit.

Bit	Binary Digit
Byte	8 Bits, **2^8** or 256 combinations
ASCII	American Standard Code for Information Interchange e.g. A = 01000001
Kilobyte (KB)	**2^{10}** = 1024 bytes
Megabyte (MB)	**2^{20}** = 1,048,576 bytes
Gigabyte (GB)	**2^{30}** = 1,073,741,824 bytes

Decimal - Base of 10							
# = 42							
				1000	100	10	1
				10^3	10^2	10^1	10^0
				0	0	4	2

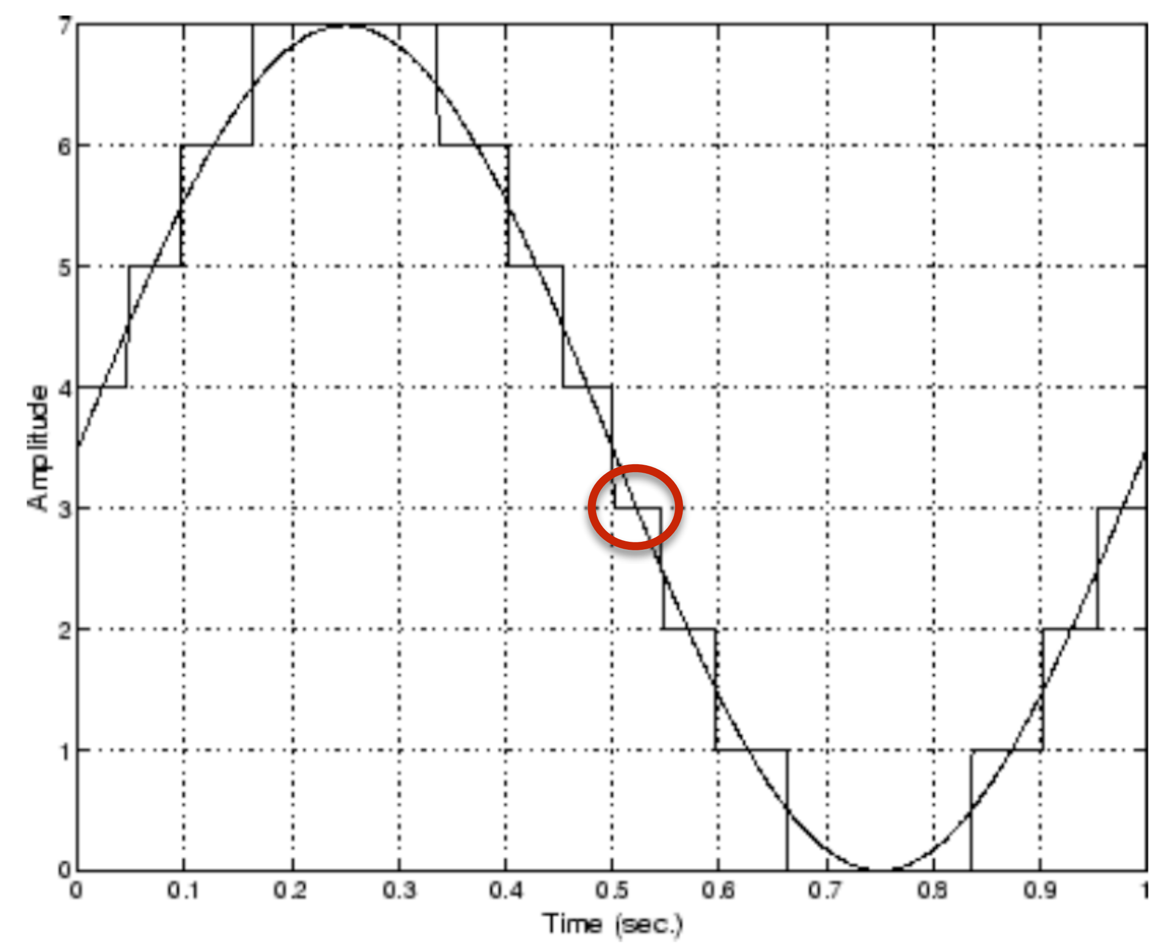
Binary - Base of 2							
# = 42							
128	64	32	16	8	4	2	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	0	1	0	1	0	1	0

Quantization

Quantization: Divides indefinitely precise values into discrete amplitudes.

Resolution: Defines the number of different values that can be stored.

The resolution depends on the number of bits used for the conversion.



A 1 Hz sine wave quantized by a 3 bit A/D converter: $2^3 = 8$ values

2^2	2^1	2^0
4	2	1
0	1	1

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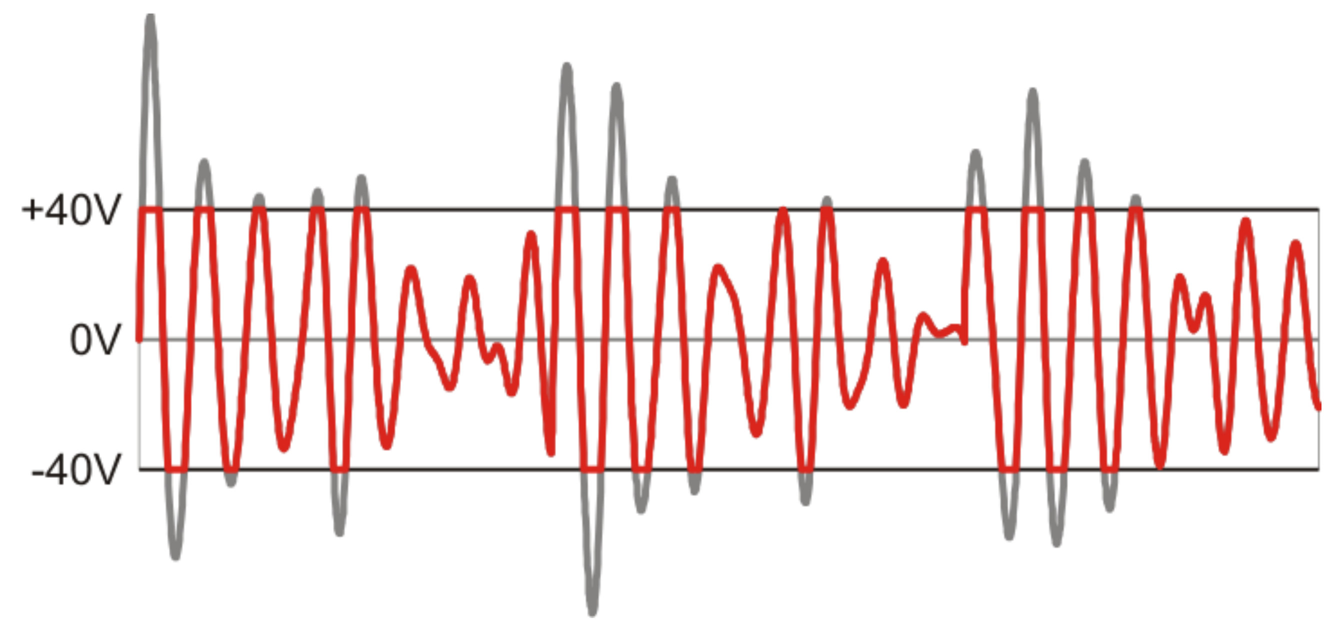
Input Range

The *input range* is the span of values for which a conversion is valid.

Needs to be appropriate.

If the input range is too wide:
Waste of resolution.

If the input range is not wide enough:
Signal exceeds capturable range. This is called clipping.



Here, the input range is not wide enough. The measured signal clips, and you lose information.

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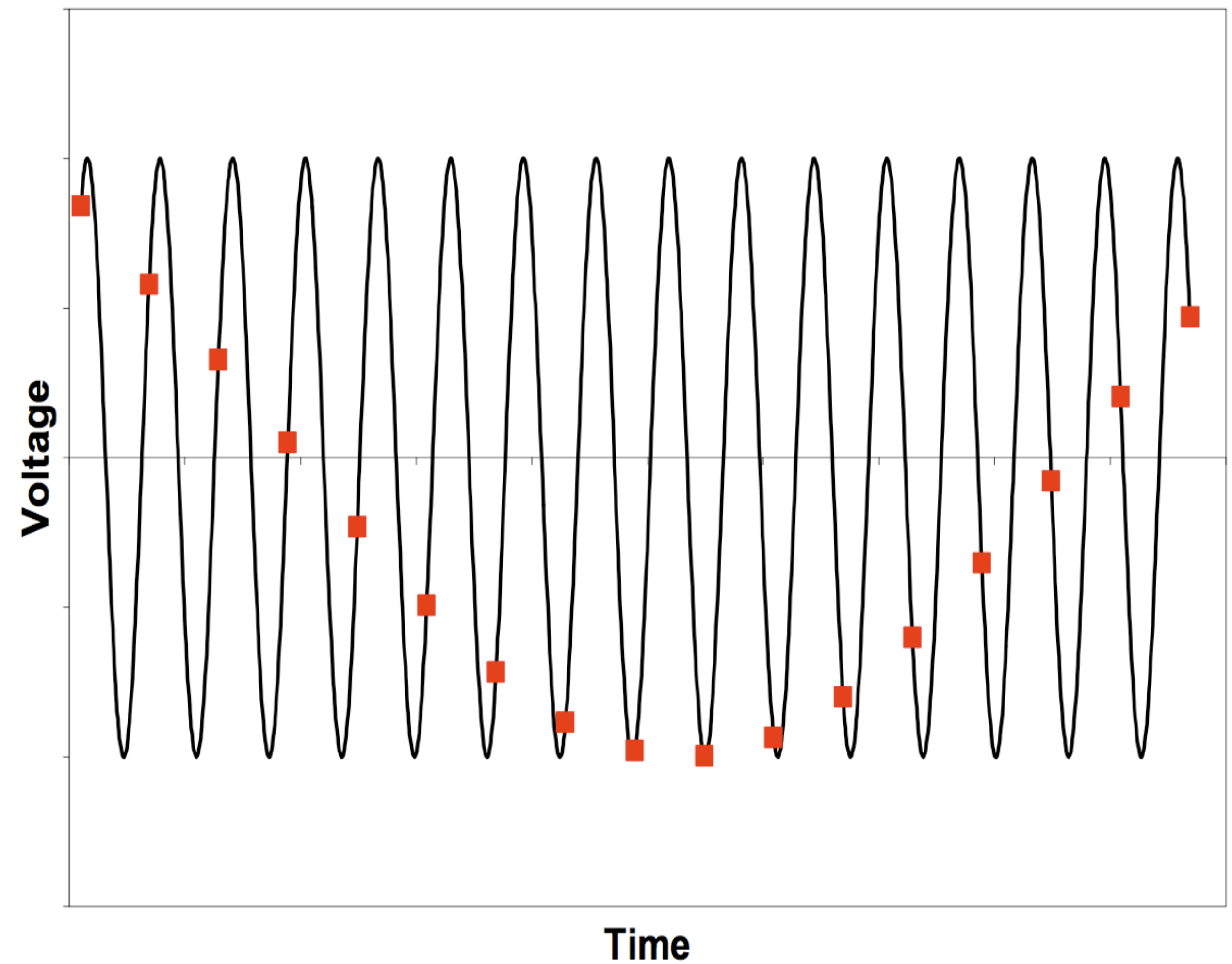
Sampling Frequency

Sampling frequency needs to be high enough to keep characteristics of signal.



Nyquist Theorem:
The sampling rate must be equal to or greater than twice the highest frequency component in the analog signal.

Aliasing: Happens when sampled signal contains frequency components that are greater than one-half the sampling rate.

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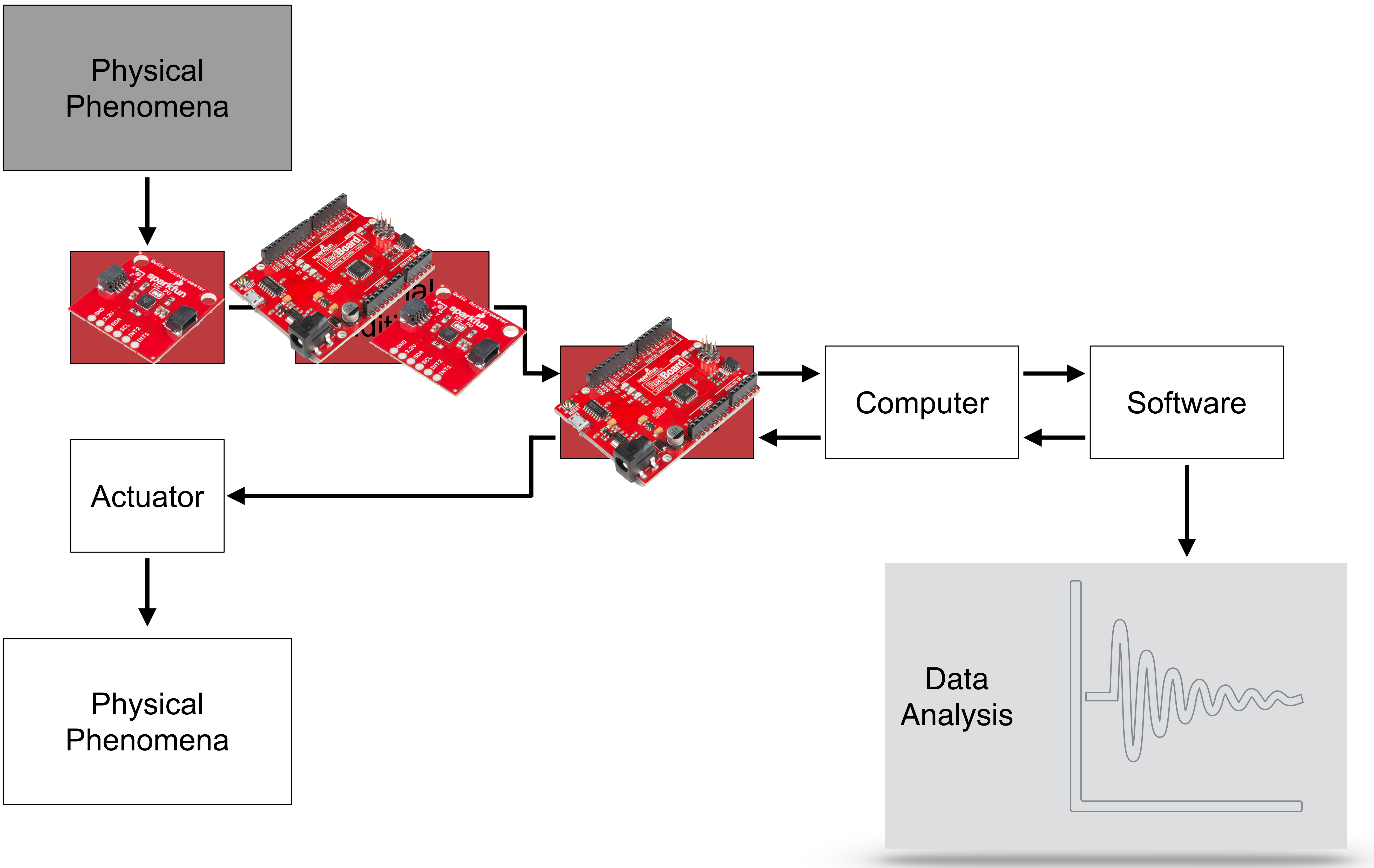

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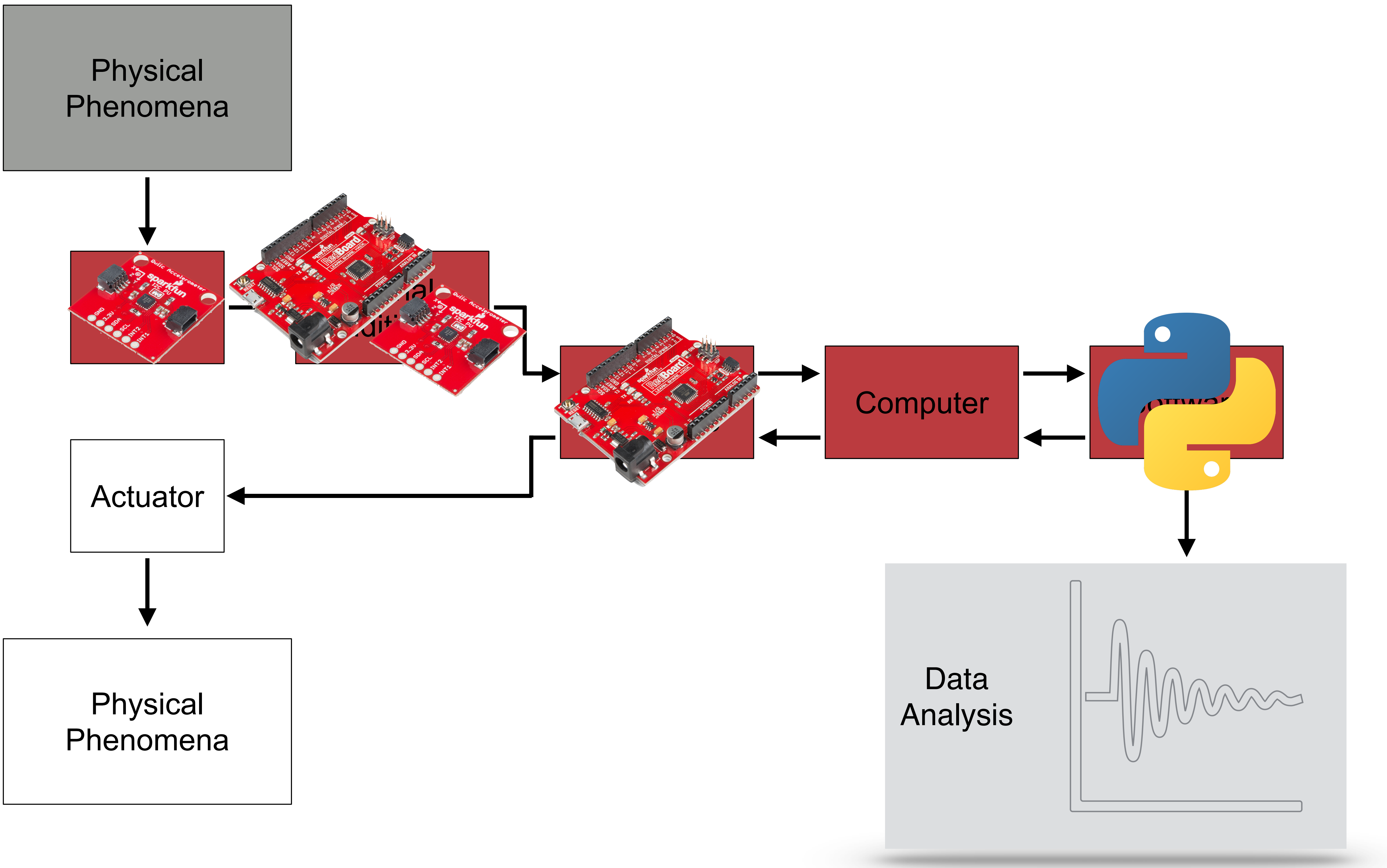

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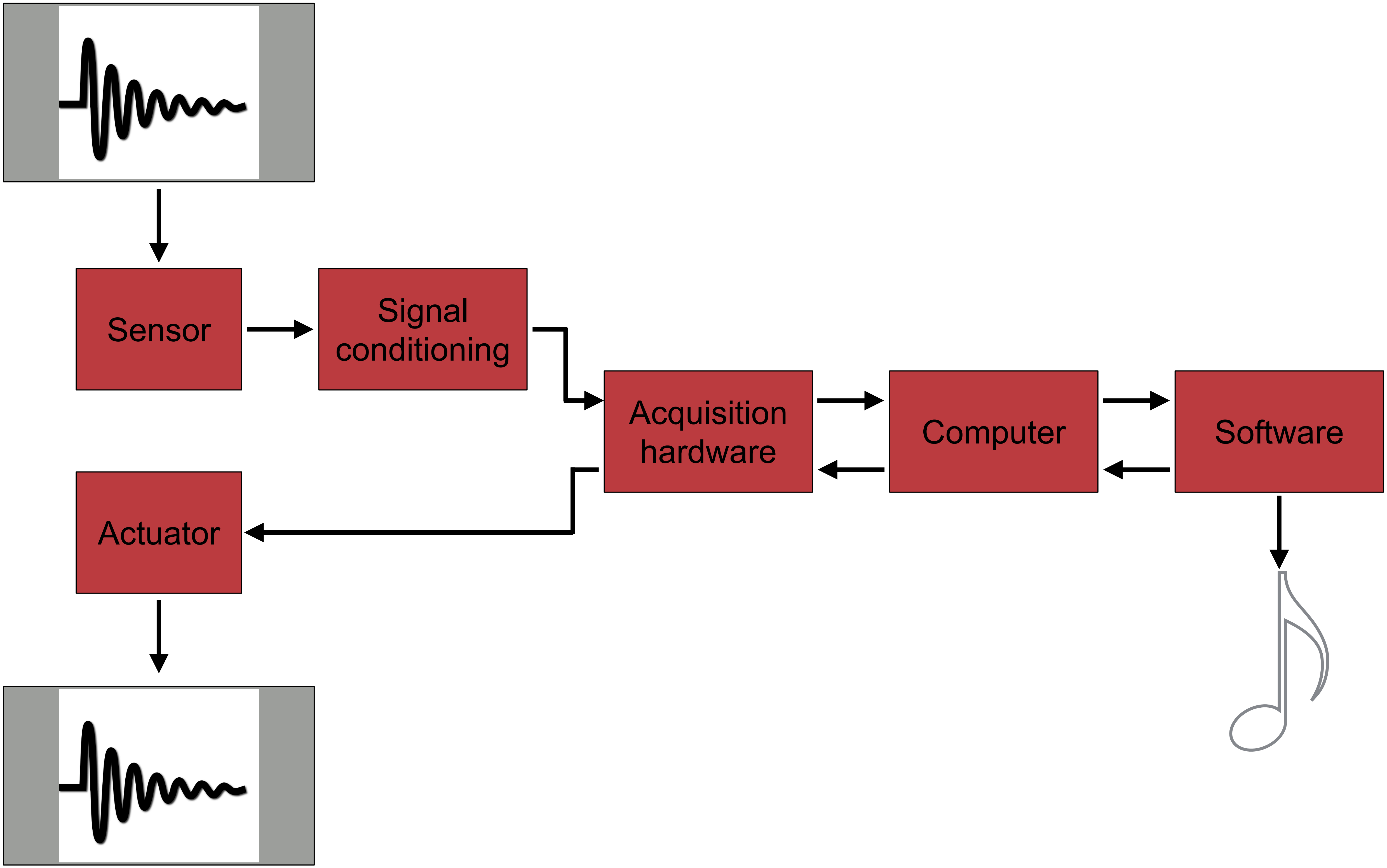
DAQ and Physiological Equivalents



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