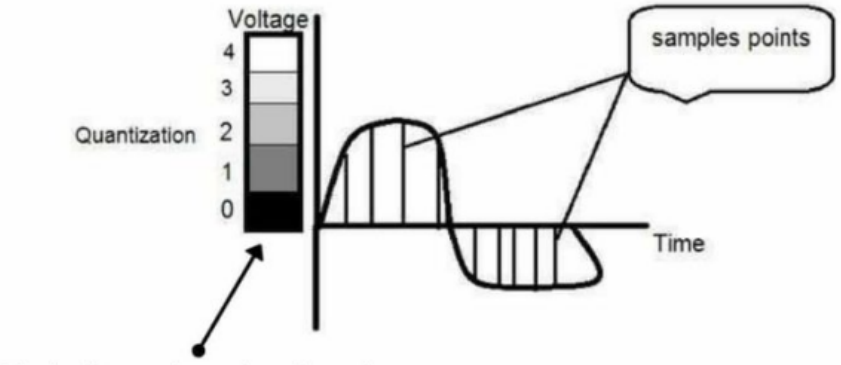
Build Your Own Data Logger
Module 3: Proof of Concept
Submodule 3 – Battery Sensing using the Analogue to Digital Converter (ADC)

Terminology Starter Guide

Video	Intro
Analogue to Digital Converter (ADC) Process	An ADC has to covert an analog signal to an digital signal in two steps: 1) capture the analog signal at a discrete point in time (sampling) on the x axis. 2) convert the analog signal into a numerical representation (quantization) on the y axis.
 Vertically ranging values have been quantized into 5 different levels or partitions.	
Sample (in the context of an ADC)	The value of the analog signal (voltage) captured at a specific moment in time. For example, sound is often sampled at 44.1 kHz or once every 0.023 milliseconds.
Sample frequency / rate / speed (in the context of an ADC)	The number of samples the ADC will take per second.

	Specified as samples per second (SPS).
Quantization	Process of rounding the samples up or down, and mapping them to the nearest voltage 'level' or 'step'. The difference between the actual voltage and the rounded voltage is called the quantization error.
Voltage Range	The range the voltage readings fall within. For devices like ours, usually 0v - 3.3v or 0V - 5v.
Voltage Level / Steps (referred to as ADC Units in Lab 2a)	In the context of an analog to digital converter, it's the number of levels a voltage range is divided into. In quantization, samples are rounded up or down to a voltage step or level.
Voltage Input (V_{IN})	The analog value that the ADC has received, eg. the sample value.
Reference voltage (V_{REF})	The maximum voltage value that the ADC can convert a sample to. eg. The highest reading on the y axis. Divided into 'quantization levels' or 'steps' based on the bit length.
Bit depth / length	The number of bits of the ADC. This translates to the number of levels the voltage range is divided into during quantization. Higher = more accurate mapping Lower = less accurate mapping

	For example, a 4-bit ADC divides the voltage range to 2^4 or 16 levels. A 10-bit ADC divides it into 2^10 or 1024 levels.
ADC Resolution	The resolution of an ADC is defined by dividing V_{REF} by the total number of possible conversion steps / levels

Bit Length	Levels	Step Size (5V Range)
8-bits	256	19.53 mV
10-bits	1024	4.88 mV
12-bits	4096	1.22 mV
16-bits	65536	76.29 µV
18-bits	262144	19.07 µV
20-bits	1048576	4.76 µV
24-bits	16777216	0.298 µV

CAD (Computer-aided design)	Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design.
Speaker coil / Voice coil	Voice coil is a winding of wire around a cylinder that is attached to the main part of a speaker. A voice coil produces sound pressure waves.
Potentiometer	A type of variable resistor. Its main function is to resist (i.e. reduce) electric current. Turning the potentiometer varies the resistance and causes a change in voltage. This in turn adjusts the brightness of an LED, the volume of a speaker etc.

Resistor	A component that regulates the flow of electrons. It can reduce and increase the flow of electric current in the circuit.
Oscilloscope	A machine that visually shows the analog signal and voltage level changing over time.
Video	**Lab 2**
Battery	An electrical component that is designed to store electrical charge (or electric current) within it and powers a 'load'.
Electrical Load / Load (in the context of batteries)	Something that connects to the battery and draws electrical charge from it. eg. A camera trap that uses the power from the battery is considered an electrical load on the battery.
Battery Voltage	The amount of voltage available to supply to the load at any given point, while the battery is discharging. The voltage of a battery gradually decreases as it discharges.
Battery Discharge	When the electric charge stored in the battery is used or drawn out by the 'load'. Battery discharge also occurs when the battery is idle. This is called self-discharge and varies with the battery chemistry. A battery is said to be idle when it is still connected to the circuit board (load), but there is no current being drawn from it. The greater the current drawn by the load, faster the battery discharges.

Battery Discharge Current	This is the amount of current being drawn from the battery by the load.
Battery Discharge Rate	This is how quickly the battery is being discharged. At higher currents, the discharge rate has an initial exponential fall, then plateaus, then exponentially falls when it is close to being depleted. Battery discharge performance depends on the load the battery has to supply. The discharge rate provides you with the starting point for determining the capacity of a battery necessary to power your system. At low discharge currents, the rate is almost linear so you can calculate the battery lifetime using a simple formula: Battery Life (hours) = Capacity (milliamp-hours) / discharge current (milliamps).
Battery Discharge Curve	A graphical curve of the discharge rate over time.
Battery Discharge / Charge Cycle	The amount of time a battery takes to discharge and recharge its power.
Sloping Discharge Curve	Where the supply voltage falls / drops progressively throughout the discharge cycle, especially towards the end where there's not much power supply left (it reaches a cliff, and drops dramatically). For low power devices like a data logger, which need a stable supply voltage from the battery, this can be a problem.
Flat Discharge Curve	Where the supply voltage stays reasonably constant throughout the discharge cycle.

	This is what we want for low power applications like ours.
Service Hours (in context of a battery)	The number of hours a battery will last with no load attached.
Nominal Voltage	The voltage of a battery at half charge. Alkaline batteries have a nominal voltage of 1.5V but fresh batteries are usually around 1.8V.
Self Discharge	Batteries generate electricity due to a chemical reaction inside the cell. Ideally, this happens when it is connected to a device that needs power. However, the chemical reaction which produces charge will also happen at a smaller scale, even when the battery is not connected, or having a load draw power from it. That means that the battery's charge gradually reduces over time. This is called self-discharge.
Output Voltage Accuracy	How accurate and stable the regulated voltage is. A battery's voltage changes over time, but we need stable voltages to operate. A battery's voltage is fed into a "voltage regulator" which keeps the voltage stable (for example at 3.3V) while the battery's voltage decreases over time. The accuracy of this regulated voltage is the output voltage accuracy.
# define	#define is a useful C++ component that allows the programmer to give a name to a

Syntax `#define constantName value`	constant value before the program is compiled. Eg. If we need to use 3.3 as the voltage, rather than keep typing 3.3 we can define it at the top of the program as ADC_REF_VOLTAGE which is easier to read. Most people usually follow a standard coding convention of writing their defined constants in all caps to indicate that it's a constant value, rather than a variable.

Tutorials / Useful Links

Battery University (the name says it all!)	https://batteryuniversity.com/