Last lecture!

Architecture of mechatronic systems (all systems)

```
┌────────┐     ┌──────────┐          ┌─────────────────┐      ┌──────────┐
│ Sensor │ ──→ │ Signal   │ ──────→  │ ┌─────┐         │ ───→ │ Readout  │
│        │     │processing│          │ │ ADC │         │      │  (PC)    │
└────────┘     └──────────┘          │ └─────┘         │      └──────────┘
                                     │ Microprocessor  │
┌──────────┐   ┌────────┐  ←──────── │                 │
│ Actuator │ ← │ Driver │  ←──┐      └─────────────────┘
└──────────┘   └────────┘     └──────
                                          └───── Lab 2            └── Lab 1
      ↖        ↑      ↗
        Lab 3
```
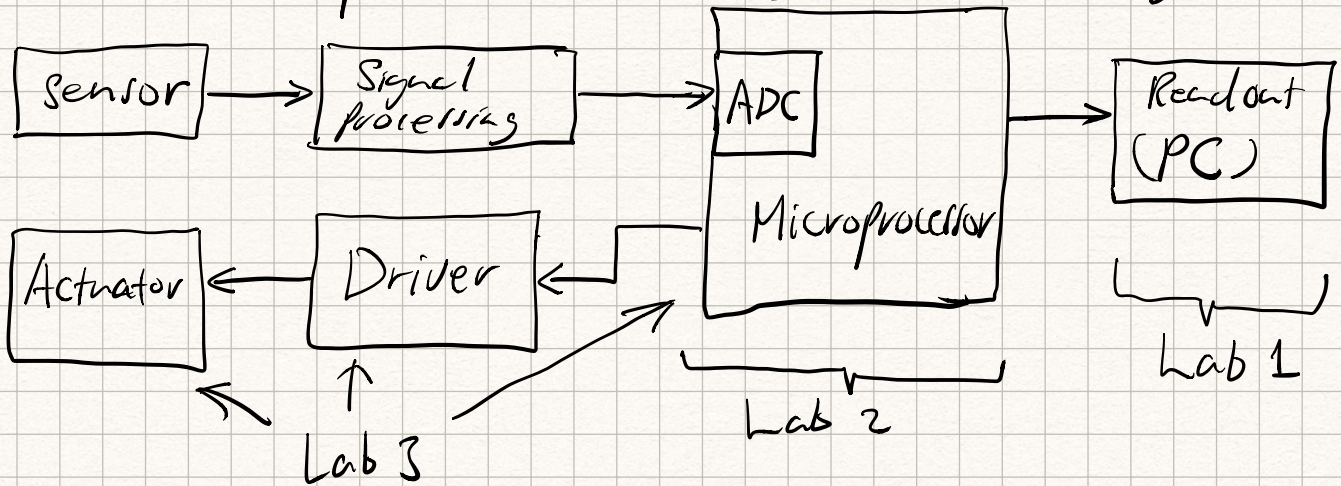
Lab 1: Data Acquisition using C#

What we learned:

  ① Need for readout   — For engineers
                                       — Options
  ② Users interface design (UI/UX)   — adjustments
  ③ Libraries (i.e. .NET framework) — For users
                 WinForms app model   — Simple
  ④ CPUs can only do <u>one thing</u> at time.

```
Serial  ═══>  serial  ═══>  Concurrent  ═══>  Data Processing
data          buffer        Queue
      Auto           serial data  (RAM)      Timer
                     received event          Tick
                     handler
```
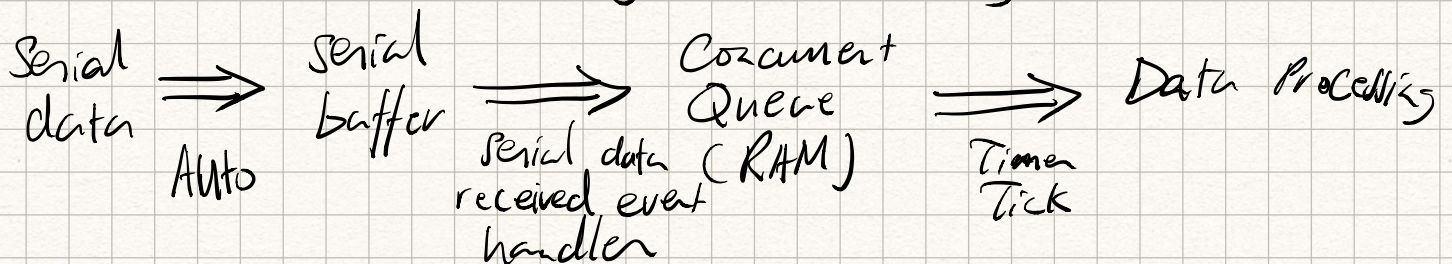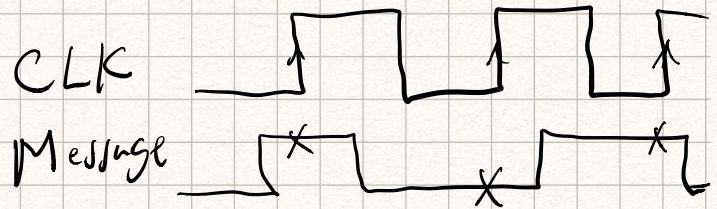
"Hidden" messages

  (1) Syntax / language is irrelevant

  (2) Libraries matter.

  (3) You can code.

Lab 2: MCU Programming

Why MCU?   (1) Autonomous decision-making (if...then)
                (2) Fast & precise timing (timers)

- Clocks
- Interrupts — If enabled, must have ISR
- Timers — PWM, track time ...
- ADC
- UART
- Packet Communications

What we didn't learn

CLK ⌐‾⌐‾⌐‾

Message ⌐‾⌐‾⌐

- Synchronous Comm.
- Direct memory access (DMA)
- Write to flash
- Boot loader
- Computation vs. Memory. ⟶ Look up table
- DSP (digital signal processors)
    — MCU with specialized co-processors.

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} \cdot \begin{pmatrix} a \\ b \\ c \end{pmatrix} = ax + by + cz$$

Single instruction multiple data

Other MCU

- Microchip — PIC series
- Atmel — Arduino
- Motorola — 68000, HC11, HC12
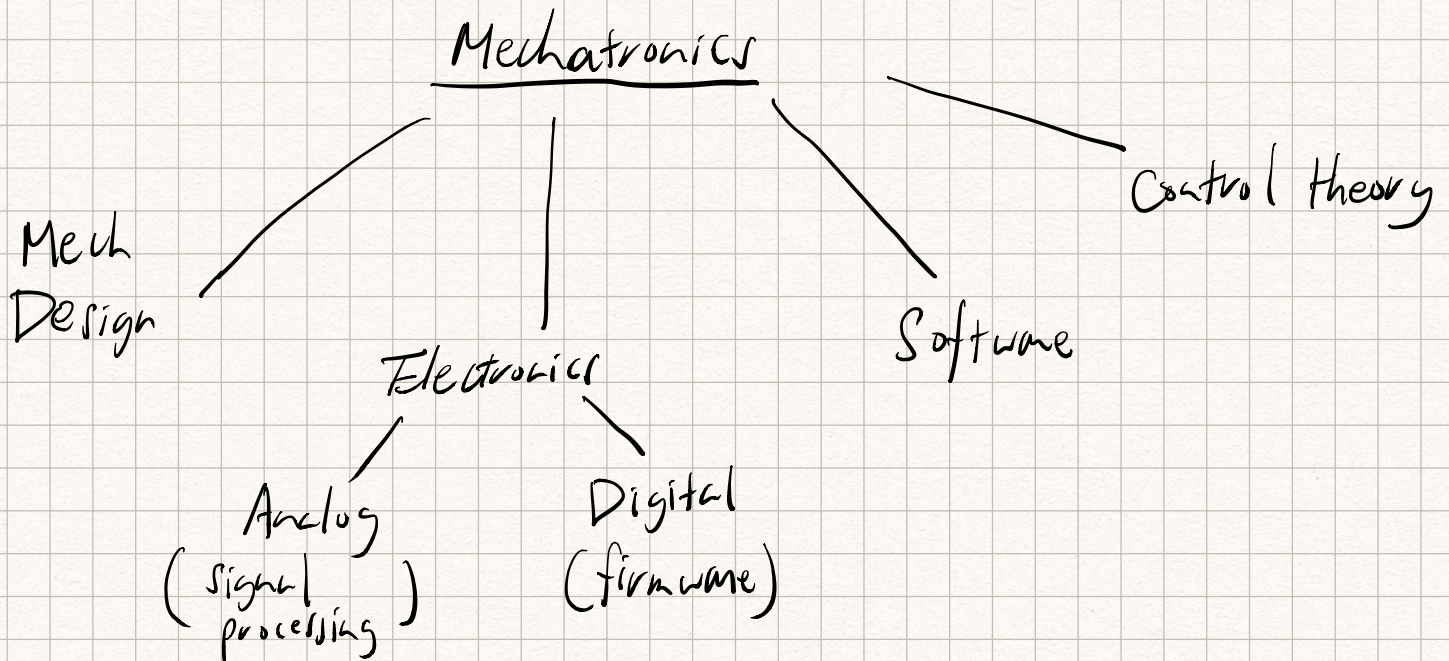- Intel — 8051
- Cypress

- ST
- TI — MSP430, TMS320 — DSP MCUs.

MCU vs. Computer
- Fast
  - Large amount of data
  - Not real-time.

Need both.

Mechatronics

Mech Design

Control theory

Software

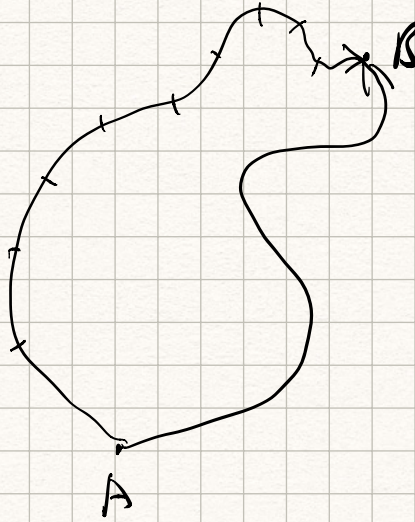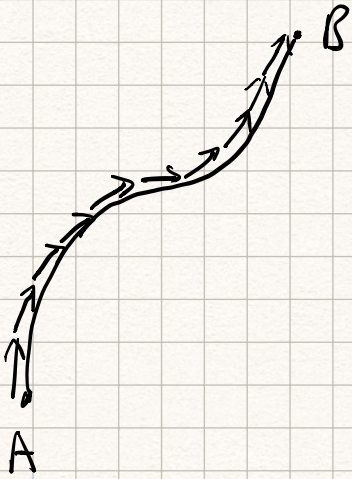Electronics

Analog (signal processing)

Digital (firmware)

Job titles
- Instrumentation Engineer
- Automation / control engineer
- Sensors & Sensing systems
- Embeded systems — MCU systems
- Internet-of-Thing.
- Test engineer

Undergrad /Technician   Junior Engineer/Grad school   Product Architect
                                                                    Enterpreneure

B   B   ? B

A   A   A